/

142, a confidence score is determined for areas within the location center service area. More particularly, if a function, "f", is a function of the confidence(s) of location hypotheses, and f is a monotonic function in its parameters and $f(cf_1, cf_2, cf_3, \ldots, cf_N) = CS_A$ for confidences cf_i of location hypotheses H_i, i=1,2,...,N, with CS_A contained in the area estimate for H_i, then "f" is denoted a confidence score function. [ ]Accordingly, there are many embodiments for a confidence score function f that may be utilized in computing confidence scores with the present invention; e.g.,

(a) $f(cf_1, cf_2, \ldots, cf_N) = [S]\Sigma\, cf_i = CS_A$;

(b) $f(cf_1, cf_2, \ldots, cf_N) = [S]\Sigma\, cf_i^n = CS_A$, n = 1, 3, 5, ...;

(c) $f(cf_1, cf_2, \ldots, cf_N) = [S]\Sigma\, (K_i * cf_i) = CS_A$, wherein K_i, i = 1, 2, ... are positive system (tunable) constants (possibly dependent on environmental characteristics such as topography, time, date, traffic, weather, and/or the type of base station(s) 122 from which location signatures with the target MS 140 are being generated, etc.).

The paragraph beginning on page 43, line 27 and ending on page 44, line 23 has been replaced with the following paragraph:

In one embodiment of a method and system for determining such (transmission) area type approximations, a partition (denoted hereinafter as P_0) is imposed upon the radio coverage area 120 for partitioning for radio coverage area into subareas, wherein each subarea is an estimate of an area having included MS 140 locations that are likely to have is at least a minimal amount of similarity in their wireless signaling characteristics. To obtain the partition P_0 of the radio coverage area 120, the following steps are performed:

(23.8.4.1) Partition the radio coverage area 120 into subareas, wherein in each subarea is: (a) connected, (b) variations in the lengths of chords sectioning the subarea through the centroid of the subarea are below a predetermined threshold, (c) the subarea has an area below a predetermined value, and (d) for most locations (e.g., within a first or second <u>standard</u> deviation) within the subarea whose wireless signaling characteristics have been verified, it is likely (e.g., within a first or second <u>standard</u> deviation) that an MS 140 at one of these locations will detect (forward transmission path) and/or will be detected (reverse transmission path) by a same collection of base stations 122. For example, in a CDMA context, a first such collection may be (for the forward transmission path) the active set of base stations 122, or, the union of the active and candidate sets, or, the union of the active, candidate and/or remaining sets of base stations 122 detected by "most" MSs 140 in the subarea. Additionally (or alternatively), a second such collection may be the base stations 122 that are expected to detect MSs 140 at locations within the subarea. Of course, the union or intersection of the first and second collections is also within the scope of the present invention for partitioning the radio coverage area 120 according to (d) above. It is worth noting that it is believed that base station 122 power levels will be substantially constant. However, even if this is not the case, one or more collections for (d) above may be determined empirically and/or by computationally simulating the power output of each base station 122 at a predetermined level. Moreover, it is also worth mentioning that this step is relatively straightforward to implement using the data stored in the location signature data base 1320 (i.e., the verified location signature clusters discussed in detail hereinbelow). Denote the resulting partition here as P_1.

(23.8.4.2) Partition the radio coverage area 120 into subareas, wherein each subarea appears to have substantially homogeneous terrain characteristics. Note, this may be performed periodically substantially automatically by scanning radio coverage area images obtained from aerial or satellite imaging. For example, EarthWatch Inc. of Longmont, CO can provide geographic with 3 meter resolution from satellite imaging data. Denote the resulting partition here as P_2.

(23.8.4.3) Overlay both of the above partitions of the radio coverage area 120 to obtain new subareas that are intersections of the subareas from each of the above partitions. This new partition is P_0 (i.e., $P_0 = P_1$ intersect P_2), and the subareas of it are denoted as "P_0 subareas".

The paragraph beginning on page 47, line 4 and ending on page 47, line 22 has been replaced with the following paragraph:

There are four fundamental entity types (or object classes in an object oriented programming paradigm) utilized in the location signature data base 1320. Briefly, these data entities are described in the items (24.1) through (24.4) that follow:

(24.1) (verified) location signatures: Each such (verified) location signature describes the wireless signal characteristic measurements between a given base station (e.g., BS 122 or LBS 152) and an MS 140 at a (verified or known) location associated with the (verified) location signature. That is, a verified location signature corresponds to a location whose coordinates such as latitude-longitude coordinates are known, while simply a location signature may have a known or unknown location corresponding with it. Note that the term (verified) location signature is also denoted by the abbreviation, "(verified) loc sig" hereinbelow;

(24.2) (verified) location signature clusters: Each such (verified) location signature cluster includes a collection of (verified) location signatures corresponding to all the location signatures between a target MS 140 at a (possibly verified) presumed substantially stationary location and each BS (e.g., 122 or 152) from which the target MS 140 can detect the BS's pilot channel [gardless]<u>regardless</u> of the classification of the BS in the target MS (i.e., for CDMA, regardless of whether a BS is in the MS's active, candidate or remaining base station sets, as one skilled in the art will understand). Note that for simplicity here, it is presumed that each location signature cluster has a single fixed primary base station to which the target MS 140 synchronizes or obtains its timing;

(24.3) "composite location objects (or entities)": Each such entity is a more general entity than the verified location signature cluster. An object of this type is a collection of (verified) location signatures that are associated with the same MS 140 at substantially the same location at the same time and each such loc sig is associated with a different base station. However, [ ]there is no requirement that a loc sig from each BS 122 for which the MS 140 can detect the BS's pilot channel is included in the "composite location object (or entity)"; and

(24.4) MS location estimation data that includes MS location estimates output by one or more MS location estimating first order models 1224, such MS location estimate data is described in detail hereinbelow.

The paragraph beginning on page 47, line 30 has been replaced with the following paragraph:

In particular, for each (verified) loc sig includes the following:

(25.1) MS_type: the make and model of the target MS 140 associated with a location signature instantiation; note that the type of MS 140 can also be derived from this entry; e.g., whether MS 140 is a handset MS, car-set MS, or an MS for location only. Note as an aside, for at least CDMA, the type of MS 140 provides information as to the number of fingers that may be measured by the MS[.], as one skilled in the will appreciate.

The paragraph beginning on page 48, line 24 has been replaced with the following paragraph:

(25.7) signal topography characteristics: In one embodiment, the signal topography characteristics retained can be represented as characteristics of at least a two-dimensional generated surface. That is, such a surface is generated by the signal processing subsystem 1220 from signal characteristics accumulated over (a relatively short) time interval. For example, in the two-dimensional surface case, the dimensions for the generated surface may be, for example, signal strength and time delay. That is, the accumulations over a brief time interval of signal characteristic measurements between the BS 122 and the MS 140 (associated with the loc sig) may be classified according to the two signal characteristic dimensions (e.g., signal strength and corresponding time delay). That is, by sampling the signal characteristics and classifying the samples according to a mesh of discrete cells or bins, wherein each cell [correspondi]corresponds to a different range of signal strengths and time delays a tally of the number of samples falling in the range of each cell can be maintained. Accordingly, for each cell, its corresponding tally may be interpreted as height of the cell, so that when the heights of all cells are considered, an undulating or mountainous surface is provided. In particular, for a cell mesh of appropriate fineness, the "mountainous surface", is believed to, under most circumstances, provide a contour that is substantially unique to the location of the target MS 140. Note that in one embodiment, the signal samples are typically obtained throughout a predetermined signal sampling time interval of 2-5 seconds [ ]as is discussed elsewhere in this specification. In particular, the signal topography characteristics retained for a loc sig include certain topographical characteristics of such a generated mountainous surface. For example, each loc sig may include: for each local maximum (of the loc sig surface) above a predetermined noise ceiling threshold, the (signal strength, time delay) coordinates of the cell of the local maximum and the corresponding height of the local maximum. Additionally, certain gradients may also be included for characterizing the "steepness" of the surface mountains. Moreover, note that in some embodiments, a frequency may also be associated with each local maximum. Thus, the data retained for each selected local maximum can include a quadruple of signal strength, time delay, height and frequency. Further note that the data types here may [ ]vary. However, for simplicity, in parts of the description of loc sig processing related to the signal characteristics here, it is assumed that the signal characteristic topography data structure here is a vector;

The paragraph beginning on page 49, line 19 has been replaced with the following paragraph:

(25.13) repeatable: TRUE iff the loc sig is "repeatable" (as described hereinafter), FALSE otherwise. Note that each verified loc sig is designated as either "repeatable" or "random". A loc sig is repeatable if the (verified/known) location associated with the loc sig is such that signal characteristic measurements between the associated BS 122 and this MS can be either replaced at periodic time intervals, or updated substantially on demand by most recent signal characteristic measurements between the associated base station and the associated MS 140 (or a comparable MS) at the verified/known location. Repeatable loc sigs may be, for example, provided by stationary or fixed location MSs 140 (e.g., fixed location transceivers) distributed within certain areas of a geographical region serviced by the location center 142 for providing MS location estimates. That is, it is an aspect of the present invention that each such stationary MS 140 can be contacted by the location center 142 (via the base stations of the wireless infrastructure) at substantially any time for providing a new collection (i.e., cluster) of wireless signal characteristics to be associated with the verified location for the transceiver. Alternatively, repeatable loc sigs may be obtained by, for example, obtaining location signal measurements manually from workers who regularly traverse a predetermined route through some portion of the radio coverage area; i.e., postal workers[(as will be described in more detail hereinbelow)].

Please replace the paragraph beginning on page 50, line 17 with the following paragraph:

(26.1) A "normalization" method for normalizing loc sig data according to the associated MS 140 and/or BS 122 signal processing and generating characteristics. That is, the signal processing subsystem 1220, one embodiment being described in the PCT patent application <u>PCT/US97/15933,</u> titled, "Wireless Location Using A Plurality of Commercial Network Infrastructures," by F. W. LeBlanc and the present inventors, <u>filed September 8, 1997 (which has a U.S. national filing that is now U.S. Patent No. 6,236,365, filed July 8, 1999, note, both PCT/US97/15933 and U.S. Patent No. 6,236,365 are incorporated fully by reference herein)</u> provides (methods for loc sig objects) for "normalizing" each loc sig so that variations in signal characteristics resulting from variations in (for example) MS signal processing and generating characteristics of different types of MS's may be reduced. In particular, since wireless network designers are typically designing networks for effective use of hand set MS's 140 having a substantially common minimum set of performance characteristics, the normalization methods provided here transform the loc sig data so that it appears as though the loc sig was provided by a common hand set MS 140. However, other methods may also be provided to "normalize" a loc sig so that it may be compared with loc sigs obtained from other types of MS's as well. Note that such normalization techniques include, for example, interpolating and extrapolating according to power levels so that loc sigs may be normalized to the same power level for, e.g., comparison purposes.

Normalization for the BS 122 associated with a loc sig is similar to the normalization for MS signal processing and generating characteristics. Just as with the MS normalization, the signal processing subsystem 1220 provides a loc sig method for "normalizing" loc sigs according to base station signal processing and generating characteristics.

The paragraph beginning on page 52, line 10 has been replaced with the following paragraph:

A first functional group of location engine 139 modules is for performing signal processing and filtering of MS location signal data received from a conventional wireless (e.g., CDMA) infrastructure, as discussed in the steps (23.1) and (23.2) above. This group is denoted the signal processing subsystem 1220 herein. One embodiment of such a subsystem is described in the PCT patent application titled, "Wireless Location Using A Plurality of Commercial Network Infrastructures," by F. W. LeBlanc and the present inventors.[(s). .]

The paragraph beginning on page 52, line 15 has been replaced with the following paragraph:

A second functional group of location engine 139 modules is for generating various target MS 140 location initial estimates, as described in step (23.3). Accordingly, the modules here use input provided by the signal processing subsystem 1220. This second functional group includes one or more signal analysis modules or models, each hereinafter denoted as a first order model 1224 (FOM), for generating location hypotheses for a target MS 140 to be located. Note that it is intended that each such FOM 1224 use a different technique for determining a location area estimate for the target MS 140. A brief description of some types of first order models is provided immediately below. Note that [Fig.]Figs. 8 illustrates another, more [detail]detailed view of the location system for the present invention. In particular, this figure illustrates some of the FOMs 1224 contemplated by the present invention, and additionally illustrates the primary communications with other modules of the location system for the present invention. However, it is important to note that the present invention is not limited to the FOMs 1224 shown and discussed herein. That is, it is a primary aspect of the present invention to easily incorporate FOMs using other signal processing and/or computational location estimating techniques than those presented herein. Further, note that each FOM type may have a plurality of its models incorporated into an embodiment of the present invention.

The following paragraph as been inserted immediately before the paragraph beginning on page 53, line 10:

In one embodiment, such a distance model may perform the following steps:

(a) Determines a minimum distance between the target MS and each BS using TOA, TDOA, signal strength on both forward and reverse paths;

(b) Generates an estimated error;

(c) Outputs a location hypothesis for estimating a location of a MS: each such hypothesis having: (i) one or more (nested) location area estimates for the MS, each location estimate having a confidence value (e.g., provided using the estimated error) indicating a perceived accuracy, and (ii) a reason for both the location estimate (e.g., substantial multipath, etc) and the confidence.

The paragraph beginning on page 53, line 10 has been replaced with the following paragraph:

Another type of FOM 1224 is a statistically based first order model 1224, wherein a statistical technique, such as regression techniques (e.g., least squares, partial least squares, principle decomposition), or e.g., Bollenger Bands (e.g., for computing minimum and maximum base station offsets). In general, models of this type output location hypotheses that are determined by performing one or more statistical techniques or comparisons between the verified location signatures in location signature data base 1320, and the wireless signal measurements from a target MS. Models of this type are also referred to hereinafter as [ ]a "stochastic signal (first order) model" or a "stochastic FOM" or a "statistical model."

The following paragraph has been inserted immediately before the paragraph beginning on page 53, line 16:

In one embodiment, such a stochastic signal model may output location hypotheses determined by one or more statistical comparisons with loc sigs in the Location Signature database 1320 (e.g., comparing MS location signals with verified signal characteristics for predetermined geographical areas).

The following paragraph has been inserted immediately before the paragraph beginning on page 53, line 24:

In one embodiment, an adaptive learning model such as a model based on an artificial neural network may determine an MS 140 location estimate using base station IDs, data on signal-to-noise, other signal data (e.g., a number of signal characteristics including, e.g., all CDMA fingers). Moreover, the output from such a model may include: a latitude and longitude for a center of a circle having radius R (R may be an input to such an artificial neural network), and is in the output format of the distance model(s).

The paragraph beginning on page 53, line 24 has been replaced with the following paragraph:

Yet another type of FOM 1224 can be based on a collection of dispersed low power, low cost fixed location wireless transceivers (also denoted "location base stations 152" hereinabove) that are provided for detecting a target MS 140 in areas where, e.g., there is insufficient base station 122 infrastructure coverage for providing a desired level of MS 140 location accuracy. For example, it may uneconomical to provide high traffic wireless voice coverage of a typical wireless base station 122 in a nature preserve or at a fair ground that is only populated a few days out of the year. However, if such low cost location base stations 152 can be directed to activate and deactivate via the direction of a FOM 1224 of the present type, then these location base stations can be used to both [location]locate a target MS 140 and also provide indications of where the target MS is not. For example, if there are location base stations 152 populating an area where the target MS 140 is presumed to be, then by activating these location base stations 152, evidence may be obtained as to whether or not the target MS is actually in the area; e.g., if the target MS 140 is detected by a location base station 152, then a corresponding location hypothesis having a location estimate corresponding to the coverage area of the location base station may have a very high confidence value. Alternatively, if the target MS 140 is not detected by a location base station 152, then a corresponding location hypothesis having a location estimate corresponding to the coverage area of the location base station may have a very low confidence value. Models of this type are referred to hereinafter as "location base station models."

The following paragraph has been inserted immediately before the paragraph beginning on page 54, line 3:

In one embodiment, such a location base station model may perform the following steps:

(a) If an input is received then the target MS 140 is detected by a location base station 152 (i.e., a LBS being a unit having a reduced power BS and a MS).

(b) If an input is obtained, then the output is a hypothesis data structure having a small area of the highest confidence.
(c) If no input is received from a LBS then a hypothesis having an area with highest negative confidence is output.

The paragraph beginning on page 54, line 3 has been replaced with the following paragraph:

Yet another type of FOM 1224 can be based on input from a mobile base station 148, wherein location hypotheses may be generated from target MS 140 location data received from the mobile base station 148. In one embodiment, such a mobile base station model may provide output similar to the distance FOM 1224 described hereinabove.

The paragraph beginning on page 54, line 8 and ending on page 54, line 23 has been replaced with the following paragraphs. Note the commencement of two new paragraphs inserted at – Additionally, FOMS 1224—, and at –Moreover, other FOMs—.

Note that the FOM types mentioned here as well as other FOM types are discussed in detail hereinbelow. Moreover, it is [ ]important to keep in mind that a novel aspect of the present invention is the simultaneous use or activation of a potentially large number of such first order models 1224, wherein such FOMs are not limited to those described herein. Thus, the present invention provides a framework for incorporating MS location estimators to be subsequently provided as new FOMs in a straightforward manner. For example, a FOM 1224 based on wireless signal time delay measurements from a distributed antenna system 168 for wireless communication may be incorporated into the present invention for locating a target MS 140 in an enclosed area serviced by the distributed antenna system (such a FOM is more fully described in the U.S. Patent 6,236,365 filed July 8, 1999 which is incorporated fully by reference herein). Accordingly, by using such a distributed antenna FOM 1224 (Fig. 8(1)), the present invention may determine the floor of a multi-story building from which a target MS is transmitting. Thus, MSs 140 can be located in three dimensions using such a distributed antenna FOM 1224.

In one embodiment, such a distributed antenna model may perform the following steps:

(a) Receives input only from a distributed antenna system.
(b) If an input is received, then the output includes a lat-long and height of highest confidence.

Additionally, FOMs 1224 for detecting certain registration changes within, for example, a public switched telephone network 124 can also be used for locating a target MS 140. For example, for some MSs 140 there may be an associated or dedicated device for each such MS that allows the MS to function as a cordless phone to a line based telephone network when the device detects that the MS is within signaling range. In one use of such a device (also denoted herein as a "home base station"), the device registers with a home location register of the public switched telephone network 124 when there is a status change such as from not detecting the corresponding MS to detecting the MS, or visa versa, as one skilled in the art will understand. Accordingly, by providing a FOM 1224 (denoted the "Home Base Station First Order Model" in Fig. 8(1)) that accesses the MS status in the home location register, the location engine 139 can determine whether the MS is within signaling range of the home base station or not, and generate location hypotheses accordingly.

In one embodiment, such a home base station model may perform the following steps:

(a) Receives an input only from the Public Telephone Switching Network.

(b) If an input is received then the target MS 140 is detected by a home base station associated with the target MS.

(c) If an input is obtained, then the output is a hypothesis data structure having a small area of the highest confidence.

(d) If no input and there is a home base station then a hypothesis having a negative area is of highest confidence is output.

Moreover, other FOMs based on, for example, chaos theory and/or fractal theory are also within the scope of the present invention.

The paragraph beginning on page 54, line 24 has been replaced with the following paragraph:

It is important to note the following aspects of the present invention relating to FOMs 1224:
(28.1) Each such first order model 1224 may be relatively easily incorporated into and/or removed from the present invention. For example, assuming that the signal processing subsystem 1220 provides uniform input interface to the FOMs, and there is a uniform FOM output interface, it is believed that a large majority (if not substantially all) viable MS location estimation strategies may be accommodated. Thus, it is straightforward to add or delete such FOMs 1224.

The paragraph beginning on page 56, line 1 has been replaced with the following paragraph:

(30.2) it enhances the accuracy of an initial location hypothesis generated by [an]a FOM by using the initial location hypothesis as, essentially, a query or index into the location signature data base 1320 for obtaining a corresponding enhanced location hypothesis, wherein the enhanced location hypothesis has both an adjusted target MS location area estimate and an adjusted confidence based on past performance of the FOM in the location service surrounding the target MS location estimate of the initial location hypothesis;

The paragraph beginning on page 61, line 8 and ending on page 61, line 24 has been replaced with the following paragraph:

A fourth functional group of location engine 139 modules is the control and output gating modules which includes the location center control subsystem 1350, and the output gateway 1356. The location control subsystem 1350 provides the highest level of control and monitoring of the data processing performed by the location center 142. In particular, this subsystem performs the following functions:

(a) controls and monitors location estimating processing for each target MS 140. Note that this includes high level exception or error handling functions;

(b) receives and routes external information as necessary. For instance, this subsystem may receive (via, e.g., the public telephone switching network 124 and Internet [1362]468) such environmental information as increased signal noise in a particular service [are]area due to increase traffic, a change in weather conditions, a base station 122 (or other infrastructure provisioning), change in operation status (e.g., operational to inactive);

(c) receives and directs location processing requests from other location centers 142 (via, e.g., the Internet 468);

(d) performs accounting and billing procedures;

(e)interacts with location center operators by, for example, receiving operator commands and providing output indicative of processing resources being utilized and malfunctions;

(f) provides access to output requirements for various applications requesting location estimates. For example, an Internet 468 location request from a trucking company in Los Angeles to a location center 142 in Denver may only want to know if a particular truck or driver is within the Denver area. Alternatively, a local medical rescue unit is likely to request a precise a location estimate as possible.

The paragraph beginning on page 61, line 25 has been replaced with the following paragraph:

Note that in Fig. 6, (a) - (d) above are, at least at a high level, performed by utilizing the operator interface 1374[ ].

The paragraph beginning on page 61, line 26 has been replaced with the following paragraph:

Referring now to the output gateway 1356, this module routes target MS 140 location estimates to the appropriate location application(s). For instance, upon receiving a location estimate from the most likelihood estimator 1344, the output gateway 1356 may determine that the location estimate is for an automobile being tracked by the police and therefore must be provided [must be provided]according to [the]a particular protocol.

The paragraph beginning on page 63, line 8 has been replaced with the following paragraph:

Taking a CDMA or TDMA base station network as an example, each base station (BS) 122 is required to emit a constant signal-strength pilot channel pseudo-noise (PN) sequence on the forward link channel identified uniquely in the network by a pilot sequence offset and frequency assignment. It is possible to use the pilot channels of the active, candidate, neighboring and remaining sets, maintained in the target MS, for obtaining signal characteristic measurements (e.g., TOA and/or TDOA measurements) between the target MS 140 and the base stations in one or more of these sets.

The paragraph beginning on page 63, line 26 has been replaced with the following paragraph:

Accordingly, some embodiments of distance FOMs may attempt to mitigate such ambiguity or inaccuracies by, e.g., identifying discrepancies (or consistencies) between arrival time measurements and other measurements (e.g., signal strength), these discrepancies (or consistencies) may be used to filter out at least those signal measurements and/or generated location estimates that appear less accurate. In particular, such identifying [may]by filtering can be performed by, for example, an expert system residing in the distance FOM.

The paragraph beginning on page 65, line 1 has been replaced with the following paragraph:

[One]In one embodiment, a coverage area model utilizes both the detection and non-detection of base stations 122 by the target MS 140 (conversely, of the MS by one or more base stations 122) to define an area where the target MS 140 may likely be. A relatively straightforward application of this technique is to:

(a) find all areas of intersection for base station RF coverage area representations, wherein: (i) the corresponding base stations are on-line for communicating with MSs 140; (ii) the RF coverage area representations are deemed reliable for the power levels of the on-line base stations; (iii) the on-line base stations having reliable coverage area representations can be detected by the target MS; and (iv) each intersection must include a predetermined number of the reliable RF coverage area representations (e.g., 2 or 3); and

(b) obtain new location estimates by subtracting from each of the areas of intersection any of the reliable RF coverage area representations for base stations 122 that can not be detected by the target MS.

The paragraph beginning on page 66, line 2 has been replaced with the following paragraph:

The stochastic first order models may use statistical prediction techniques such as [ ]principle decomposition, [ ]partial least squares, [partial least squares,]or other regression techniques for predicting, for example, expected minimum and maximum distances of the target MS from one or more base stations 122, e.g., Bollenger Bands. Additionally, some embodiments may use Markov processes and Random Walks (predicted incremental MS movement) for determining an expected area within which the target MS 140 is likely to be. _That is, such a process measures the incremental time differences of each pilot as the MS moves for predicting a size of a location area estimate using past MS estimates such as the verified location signatures in the location signature data base 1320.

The paragraph beginning on page 66, line 15 has been replaced with the following paragraph:

Regarding FOMs 1224 using pattern recognition or associativity techniques, there are many such techniques available. For example, there are statistically based systems such as "CART" (an_acronym for Classification and Regression Trees) by ANGOSS Software International Limited of Toronto, Canada that may be used for automatically [for]detecting or recognizing patterns in data that were unprovided (and likely previously unknown). Accordingly, by imposing a relatively fine mesh or grid of cells [of]<u>on</u> the radio coverage area, wherein each cell is entirely within a particular area type categorization such as the transmission area types (discussed in the section, "Coverage Area: Area Types And Their Determination" above), the verified location signature clusters within the cells of each area type may be analyzed for signal characteristic patterns. If such patterns are found, then they can be used to identify at least a likely area type in which a target MS is likely to be located. That is, one or more location hypotheses may be generated having target MS 140 location estimates that cover an area having the likely area type wherein the target MS 140 is located. [ ]Further note that such statistically based pattern recognition systems as "CART" include software code generators for generating expert system software embodiments for recognizing the patterns detected within a training set (e.g., the verified location signature clusters).

The paragraph beginning on page 67, line 1 has been replaced with the following paragraph:

A similar statistically based FOM 1224 to the one above may be provided wherein the radio coverage area is decomposed substantially as above, but in addition to using the signal characteristics for detecting useful signal patterns, the specific identifications of the base station 122 providing the signal characteristics may also be used. Thus, assuming there is a sufficient density of verified location signature clusters in some of the mesh cells so that the statistical pattern recognizer can detect patterns in the signal characteristic measurements, an expert system may be generated that outputs a target MS 140 location estimate that may provide both a reliable and accurate location estimate of a target MS 140.

The paragraph beginning on page 69, line 10 has been replaced with the following paragraph:

It is worthwhile to discuss the data representations for the inputs and outputs of a ANN used for generating MS location estimates. Regarding ANN input representations, recall that the signal processing subsystem 1220 may provide various RF signal measurements as input to an ANN (such as the RF signal measurements derived from verified location signatures in the location signature data base 1320). For example, a representation of a histogram [ ]of the frequency of occurrence of CDMA fingers in a time delay [vs.]versus signal strength 2-dimensional domain may be provided as input to such an ANN. In particular, a 2-dimensional grid of signal strength versus time delay bins may be provided so that received signal measurements are slotted into an appropriate bin of the grid. In one embodiment, such a grid is a six by six array of bins such as illustrated in the left portion of Fig. 14. That is, each of the signal strength and time delay [axises]axes are partitioned into six ranges so that both the signal strength and the time delay of RF signal measurements can be slotted into an appropriate range, thus determining the bin.

The paragraph beginning on page 70, line 10 has been replaced with the following paragraph:

Accordingly, the technique described herein limits the number of input neurons in each ANN constructed and generates a larger number of these smaller ANNs. That is, each ANN is trained on location signature data (or, more precisely, portions of location signature clusters) in an area A_{ANN} (hereinafter also denoted the "net area"), wherein each input neuron receives a unique input from [either]one of:

(A1) location signature data (e.g., signal strength/time delay bin tallies) corresponding to transmissions between an MS 140 and a relatively small number of base stations 122 in the area A_{ANN}. For instance, location signature data obtained from, for example, a collection B of four base stations 122 (or antenna sectors) in the area A_{ANN}., Note, each location signature data cluster includes fields describing the wireless communication devices used; e.g., (i) the make and model of the target MS; (ii) the current and maximum transmission power; (iii) the MS battery power (instantaneous or current); (iv) the base station (sector) current power level; (v) the base station make and model and revision level; (vi) the air interface type and revision level (of, e.g., CDMA, TDMA or AMPS).

The paragraph beginning on page 71, line 7 has been replaced with the following paragraph:

Moreover, [ ]for each of the smaller ANNs, it is likely that the number of input neurons is on the order of 330; (i.e., [ ]70 inputs per each of four location signatures (i.e., 35 inputs for the forward wireless communications and 35 for the reverse wireless communications), plus 40 additional discrete inputs for an appropriate area surrounding A_{ANN}, plus 10 inputs related to: the type of MS, power levels, etc.). However, it is important to note that the number of base stations (or antenna sectors 130) having corresponding location signature data to be provided to such an ANN may vary. Thus, in some subareas of the coverage area 120, location signature data from five or more base stations (antenna sectors) may be used, whereas in other subareas three (or less) may be used.[,]

The paragraph beginning on page 72, line 26 has been replaced with the following paragraph:

In one traditional artificial neural network training process, a relatively tedious set of trial and error steps may be performed for configuring an ANN so that training produces effective learning. In particular, an ANN may require configuring parameters related to, for example, input data scaling, test/training set classification, detecting and removing unnecessary input variable selection. However, the present invention reduces this tedium. That is, the present invention uses mechanisms such as genetic algorithms or other mechanisms for avoiding non-optimal but locally appealing (i.e., local minimum) solutions, and locating near-optimal solutions instead. In particular, such mechanism may be used to adjust the matrix of weights for the ANNs so that very good, near optimal ANN configurations may be found efficiently. [ ]Furthermore, since the signal processing system 1220 uses various types of signal processing filters for filtering the RF measurements received from transmissions between an MS 140 and one or more base stations (antenna sectors 130), such mechanisms for finding near-optimal solutions may be applied to selecting appropriate filters as well. Accordingly, in one embodiment of the present invention, such filters are paired with particular ANNs so that the location signature data supplied to each ANN is filtered according to a corresponding "filter description" for the ANN, wherein the filter description specifies the filters to be used on location signature data prior to inputting this data to the ANN. In particular, the filter description can define a pipeline of filters having a sequence of filters wherein for each two consecutive filters, f_1 and f_2 (f_1 preceding f_2), in a filter description, the output of f_1 flows as input to f_2. Accordingly, by encoding such a filter description together with its corresponding ANN so that the encoding can be provided to a near optimal solution finding mechanism such as a genetic algorithm, it is believed that enhanced ANN locating performance can be obtained. That is, the combined genetic codes of the filter description and the ANN are manipulated by the genetic algorithm in a search for a satisfactory solution (i.e., location error estimates within a desired range). This process and system provides a mechanism for optimizing not only the artificial neural network architecture, but also identifying a near optimal match between the ANN and one or more signal processing filters. Accordingly, the following filters may be used in a filter pipeline of a filter description: Sobel, median, mean, histogram normalization, input cropping, neighbor, [Gaussion]Gaussian, Weiner filters.

The paragraph beginning on page 79, line 9 has been replaced with the following paragraph. Note the only change herein is the removal of the underlining of the phrase 'there is a "error_rec" here for each loc sig in "loc_sig_bag".'

error_rec_set: A set of error records (objects), denoted "error_recs", providing information as to how much each loc sig in "loc_sig_bag" disagrees with comparable loc sigs in the location signature data base. That is, there is a "error_rec" here for each loc sig in "loc_sig_bag".

The paragraph beginning on page 79, line 22 and ending on page 80, line 9 has been replaced with the following paragraph:

DB_Loc_Sig_Error_Fit(hypothesis, measured_loc_sig_bag, search_criteria)

/* This function determines how well the collection of loc sigs in "measured_loc_sig_bag" fit with the loc sigs in the location signature data base 1320 wherein the data base loc sigs must satisfy the criteria of the input parameter "search_criteria" and are relatively close to the MS location estimate of the location hypothesis, "hypothesis".

Input: hypothesis: MS location hypothesis;

measured_loc_sig_bag: A collection of measured location signatures ("loc sigs" for short) obtained from the MS (the data structure here is an aggregation such as an array or list). Note, it is assumed that there is at most one loc sig here per Base Station in this collection. Additionally, note that the input data structure here may be a location signature cluster such as the "loc_sig_cluster" field of a location hypothesis (cf. Figs. 9A and 9B). Note that variations in input data structures may be accepted here by utilization of flag or tag bits as one skilled in the art will appreciate;

search_criteria: The criteria for searching the verified location signature data base for various categories of loc sigs. The only limitation on the types of categories that may be provided here is that, to be useful, each category should have meaningful number of loc sigs in the location signature data base. The following categories included here are illustrative, but others are contemplated:

(a) "USE ALL LOC SIGS IN DB" (the default),
(b) "USE ONLY REPEATABLE LOC SIGS",
(c) "USE ONLY LOC SIGS WITH SIMILAR TIME OF DAY".

The paragraph beginning on page 80, line 19 has been replaced with the following paragraph:

The following program compares: (a1) loc sigs that are contained in (or derived from) the loc sigs in "target_loc_sig_bag" with (b1) loc sigs computed from verified loc sigs in the location signature data base 1320. That is, each loc sig from (a1) is compared with a corresponding loc sig from (b1) to obtain a measurement of the discrepancy between the two loc sigs. In particular, assuming each of the loc sigs for "target_loc_sig_bag" correspond to the same target MS location, wherein this location is "target_loc", this program determines how well the loc sigs in "target_loc_sig_bag" fit with a computed or estimated loc sig for the location, "target_loc" that is derived from the verified loc sigs in the location signature data base 1320. Thus, this program may be used: (a2) for determining how well the loc sigs in the location signature cluster for a target MS ("target_loc_sig_bag") compares with loc sigs derived from verified location signatures in the location signature data base, and (b2) for determining how consistent a given collection of loc sigs ("target_loc_sig_bag") from the location signature data base is with other loc sigs in the location signature data base. Note that in (b2) each of the one or more loc sigs in "target_loc_sig_bag" have an error computed here that can be used in determining if the loc sig is becoming inapplicable for predicting target MS locations.

The paragraph beginning on page 85, line 5 has been replaced with the following paragraph:

This function creates a new list of location hypotheses from the input list, "loc_hyp_list", wherein the location hypotheses on the new list are modified versions of those on the input list. For each location hypothesis on the input list, one or more corresponding location hypotheses will be on the output list. Such corresponding output location hypotheses will differ from their associated input location hypothesis by one or more of the following: (a) the "image_area" field (see Figs. 9A and 9B) may be assigned an area indicative of where the target MS is estimated to be, (b) if "image_area" is assigned, then the "confidence" field will be the confidence that the target MS is located in the area for "image_area", (c) if there are not sufficient "nearby" verified location signature clusters in the location signature data base 1320 to entirely rely on a computed confidence using such verified location signature clusters, then two location hypotheses (having reduced confidences) will be returned, one having a reduced computed confidence (for "image_area") using the verified clusters in the Location Signature data base, and one being substantially the same as the associated input location hypothesis except that the confidence (for the field "area_est") is reduced to reflect the confidence in its paired location hypothesis having a computed confidence for "image_area". Note also, in some cases, the location hypotheses on the input list, may have no change to its confidence or the area to which the confidence applies.
Get_adjusted_loc_hyp_list_for(loc_hyp)

The paragraph beginning on page 85, line 30 has been replaced with the following paragraph:

[ ]The function, "get_adjusted_loc_hyp_list_for," and functions called by this function presuppose a framework or paradigm that requires some discussion as well as the defining of some terms. Note that some of the terms defined hereinbelow are illustrated in Fig. [243]24.

The paragraph beginning on page 86, line 6 has been replaced with the following paragraph. Note the only change here is the removal of the underlining of the word 'verified.'

Define the term "image cluster set" (for a given First Order Model identified by "loc_hyp.FOM_ID") to mean the set of verified location signature clusters whose MS location point estimates are in "the cluster set".

The paragraph beginning on page 86, line 25 has been replaced with the following paragraph. Note the removal of the underlining in the phrase 'per unit of area.'

Define the term[ ] "mapped cluster density" to be the number of the verified location signature clusters in an "image cluster set" per unit of area in the "image cluster set area".

The paragraph beginning on page 89, line 18 has been replaced with the following paragraph:

(35.5) A location extrapolator module 1432 for use in updating previous location estimates for a target MS when a more recent location hypothesis is provided to the location hypothesis analyzer 1332. That is, assume that the control module 1400 receives a new location hypothesis for a target MS for which there are also one or more previous location hypotheses that either have been recently processed (i.e., they reside in the MS status repository 1338, as shown best in Fig. 6), or are currently being processed (i.e., they reside in the run-time location hypothesis storage area 1410). Accordingly, if the active_timestamp (see Figs. 9A and 9B regarding location hypothesis data fields) of the newly received location hypothesis is sufficiently more recent than the active_timestamp of one of these previous location hypotheses, then an extrapolation may be performed by the location extrapolator module 1432 on such previous location hypotheses so that all target MS location hypotheses being concurrently analyzed are presumed to include target MS location estimates for substantially the same point in time. Thus, initial location estimates generated by the FOMs using different wireless signal measurements, from different signal transmission time intervals, may have their corresponding dependent location hypotheses utilized simultaneously for determining a most likely target MS location estimate. Note that this module may also be daemon or expert system rule base.

Please replace the paragraph beginning on page 100, line 30 through page 101, line 2 with the following paragraph:

Accordingly, if a new currently active location hypothesis (e.g., supplied by the context adjuster) is received by the blackboard, then the target MS location estimate of the new location hypothesis may be compared with the predicted location. Consequently, a confidence adjustment value can be determined according to how well [if] the new location hypothesis "i" fits with the predicted location. That is, this confidence adjustment value will be larger as the new MS estimate and the predicted estimate become closer together.

The paragraph beginning on page 102, line 3 has been replaced with the following paragraph:

Any collection of mobile electronics (denoted mobile location unit) that is able to both estimate a location of a target MS 140 and communicate with the base station network may be utilized by the present invention to more accurately locate the target MS. Such mobile location units may provide greater target MS location accuracy by, for example, homing in on the target MS and by transmitting additional MS location information to the location center 142. There are a number of embodiments for such a mobile location unit contemplated by the present invention. For example, in a minimal version, such the electronics of the mobile location unit may be little more than an onboard MS 140, a sectored/directional antenna and a controller for communicating between them. Thus, the onboard MS is used to communicate with the location center 142 and possibly the target MS 140, while the antenna monitors signals for homing in on the target MS 140. In an enhanced version of the mobile location unit, a GPS receiver may also be incorporated so that the location of the mobile location unit may be determined and consequently an estimate of the location of the target MS may also be determined. However, such a mobile location unit is unlikely to be able to determine substantially more than a direction of the target MS 140 via the sectored/directional antenna without further base station infrastructure cooperation in, for example, determining the transmission power level of the target MS or varying this power level. Thus, if the target MS or the mobile location unit leaves the coverage area 120 or resides in a poor communication area, it may be difficult to accurately determine where the target MS is located. None-the-less, such mobile location units may be sufficient for many situations, and in fact the present invention contemplates their use. However, in cases where direct communication with the target MS is desired without constant contact with the base station infrastructure, the present invention includes a mobile location unit that is also a scaled down version of a base station 122. Thus, given that such a mobile base station or MBS 148 includes at least an onboard MS 140, a sectored/directional antenna, a GPS receiver, a scaled down base station 122 and sufficient components (including a controller) for integrating the capabilities of these devices, an enhanced autonomous MS mobile location system can be provided that can be effectively used in, for example, emergency vehicles, [air planes]airplanes and boats. Accordingly, the description that follows below describes an embodiment of an MBS 148 having the above mentioned components and capabilities for use in a vehicle.

The paragraph beginning on page 104, line 23 has been replaced with the following paragraph:

Thus, while in the ready state 1708, as the MBS 148 moves, it has its location repeatedly (re)-estimated via, for example, GPS signals, location center [142S]142 location estimates from the base stations 122 (and 152), and an on-board deadreckoning subsystem 1527 having an MBS location estimator according to the programs described hereinbelow. However, note that the accuracy of the base station time synchronization (via the ribidium oscillator 1520) and the accuracy of the MBS 148 location may need to both be periodically recalibrated according to (1a) and (1b) above.

The paragraph beginning on page 106, line 20 has been replaced with the following paragraph:

In one embodiment, the MBS 148 (Fig. 11) includes an MBS controller 1533 for controlling the location capabilities of the MBS 148. In particular, the MBS controller 1533 initiates and controls the MBS state changes as described in Fig. 12 above. Additionally, the MBS controller 1533 also communicates with the location controller 1535, wherein this latter controller controls MBS activities related to MBS location and target MS location; e.g., this performs the program, "mobile_base_station_controller" described in APPENDIX A hereinbelow. The location controller 1535 receives data input from an event generator 1537 for generating event records to be provided to the location controller 1535. For example, [ ]records may be generated from data input received from: (a) the vehicle movement detector 1539 indicating that the MBS 148 has moved at least a predetermined amount and/or has changed direction by at least a predetermined angle, or (b) the MBS signal processing subsystem 1541 indicating that the additional signal measurement data has been received from either the location center 142 or the target MS 140. Note that the MBS signal processing subsystem 1541, in one embodiment, is similar to the signal processing subsystem 1220 of the location center 142. [may have]<u>Moreover, also note that there may be </u>multiple command schedulers. In particular, a scheduler 1528 for commands related to communicating with the location center 142, a scheduler 1530 for commands related to GPS communication (via GPS receiver 1531), a [ ]scheduler 1529 for commands related to the frequency and granularity of the reporting of MBS changes in direction and/or position via the MBS [dead reckoning]<u>deadreckoning </u>subsystem 1527 (note that this scheduler is potentially optional and that such commands may be provided directly to the deadreckoning estimator 1544), and a scheduler 1532 for communicating with the target MS(s) 140 being located. Further, it is assumed that there is sufficient hardware and/or software [to appear]to perform commands in different schedulers substantially concurrently.

The paragraph beginning on page 109, line 32 has been replaced with the following paragraph:

It is assumed that the error with [dead reckoning]<u>deadreckoning </u>increases with deadreckoning distance. Accordingly, it is an aspect of the embodiment of the MBS location subsystem 1508 that when incrementally updating the location of the MBS 148 using deadreckoning and applying deadreckoning location change estimates to a "most likely area" in which the MBS 148 is believed to be, this area is incrementally enlarged as well as shifted. The enlargement of the area is used to account for the inaccuracy in the deadreckoning capability. Note, however, that the deadreckoning [ ]MBS location estimator is periodically reset so that the error accumulation in its outputs can be decreased. In particular, such resetting occurs when there is a high probability that the location of the MBS is known. For example, the deadreckoning MBS location estimator may be reset when an MBS operator manually enters an MBS location or verifies an MBS location, or a computed MBS location has sufficiently high confidence.

The paragraph beginning on page 110, line 32 has been replaced with the following paragraph:

Further, the MBS 148 may constrain any location estimates to streets on a street map using the MBS location snap to street module 1562. For example, an estimated MBS location not on a street may be "snapped to" a nearest street location. Note that a nearest street location determiner may use "normal" orientations of vehicles on streets as a constraint on the nearest street location, p[. P]articularly, if an MBS 148 is moving at typical rates of speed and acceleration, and without abrupt changes in direction. For example, if the deadreckoning MBS location estimator 1544 indicates that the MBS 148 is moving in a northerly direction, then the street snapped to should be a north-south running street. Moreover, the MBS location snap to street module 1562 may also be used to enhance target MS location estimates when, for example, it is known or suspected that the target MS 140 is in a vehicle and the vehicle is moving at typical rates of speed. Furthermore, the snap to street location module 1562 may also be used in enhancing the location of a target MS 140 by either the MBS 148 or by the location engine 139. In particular, the location estimator 1344 or an additional module between the location estimator 1344 and the output gateway 1356 may utilize an embodiment of the snap to street location module 1562 to enhance the accuracy of target MS 140 location estimates that are known to be in vehicles. Note that this may be especially useful in locating stolen vehicles that have embedded wireless location transceivers (MSs 140), wherein appropriate wireless signal measurements can be provided to the location center 142.

The paragraph beginning on page 111, line 29 has been replaced with the following paragraph:

There is an MBS location track for storing MBS location entries obtained from MBS location estimation information from each of the MBS baseline location estimators described above (i.e., a GPS location track 1750 for storing MBS location estimations obtained from the GPS location estimator 1540, a location center location track 1754 for storing MBS location estimations obtained from the location estimator 1540 deriving its MBS location estimates from the location center 142, an LBS location track

1758 for storing MBS location estimations obtained from the location estimator 1540 deriving its MBS location estimates from base stations 122 and/or 152, and a manual location track 1762 for MBS operator entered MBS locations). Additionally, there is one further location track, denoted the "current location track" 1766 whose location track entries may be derived from the entries in the other location tracks (described further hereinbelow). Further, for each location track, there is a location track head that is the head of the queue for the location track. The location track head is the most recent (and presumably the most accurate) MBS location estimate residing in the location track. Thus, [for]the GPS location track 1750 has location track head 1770; the location center location track 1754 has location track head 1774; the LBS location track 1758 has location track head 1778; the manual location track 1762 has location track head 1782; and the current location track 1766 has location track head 1786. Additionally, for notational convenience, for each location track, the time series of previous MBS location estimations (i.e., location track entries) in the location track will herein be denoted the "path for the location track." Such paths are typically the length of the location track queue containing the path. Note that the length of each such queue may be determined using at least the following considerations:

The paragraph beginning on page 115, line 15 and ending on page 115, line 18 has been replaced with the following paragraph:

MBS_new_est <--- *get_new_MBS_location_using_estimate*(event);

/* Note, whenever a new MBS location estimate is entered as a baseline estimate into <u>one of</u> the location tracks, the other location tracks must be immediately updated with any deadreckoning location change estimates so that all location tracks are substantially updated at the same time. */

The paragraph beginning on page 120, line 19 has been replaced with the following paragraph:

/* This information includes error or reliability estimates that may be used in subsequent attempts to determine an [MBS]<u>MS</u> location estimate when there is no communication with the LC and no exact (GPS) location can be obtained. That is, if the reliability of the target MS's location is deemed highly reliable, then subsequent less reliable location estimates should be used only to the degree that more highly reliable estimates become less relevant due to the [MBS]<u>MS</u> moving to other locations. */

The paragraph beginning on page 122, line 28 has been replaced with the following paragraph. Note the only change here is the insertion of --)--immediately after "events."

MBS_new_est <--- *get_new_MBS_location_est_from_operator*(event); /* The estimate may be obtained, for example, using a light pen on a displayed map */

The paragraph beginning on page 124, line 1 and ending on page 124, line 12 has been replaced with the following paragraph:

The confidence value for each MBS location estimate is a measurement of the likelihood of the MBS location estimate being correct. More precisely, a confidence value for a new MBS location estimate is a measurement that is adjusted according to the following criteria:

(a) the confidence value increases with the perceived accuracy of the new MBS location estimate (independent of any current MBS location estimate used by the MBS),

(b) the confidence value decreases as the location discrepancy with the current MBS location increases,

(c) the confidence value for the current MBS location increases when the new location estimate is contained in the current location estimate,

(d) the confidence value for the current MBS location [decrease]decreases when the new location estimate is not contained in the current location estimate, and

Therefore, the confidence value is an MBS location likelihood measurement which takes into account the history of previous MBS location estimates.

The paragraph beginning on page 132, line 27 and ending on page 132, line 31 has been replaced with the following paragraph. Note inserted text has been *italicized*, since there is underlining as part of the text.

Input:	**MBS_new_est**	The newest MBS location estimate record.
	adjusted_curr_est	The version of "MBS_curr_est" adjusted by the deadreckoning location change estimate paired with "MBS_new_est". .
	MBS_curr_est	The location track entry that is the head of the "current" location track. Note that "MBS_new_est.confidence" > "MBS_curr_[est.cofidence]*est.confidence*".

The paragraph beginning on page 143, line 14 and ending on page 143, line 19 has been replaced with the following paragraph:

measured_loc_sig_bag: A collection of measured location signatures ("loc sigs" for short) obtained from the MS (the data structure here is an aggregation such as an array or list). Note, it is assumed that there is at most one loc sig here per Base Station in this collection. Additionally, note that the input data structure here may be a location signature cluster such as the "loc_sig_cluster" field of a location hypothesis (cf. Figs. 9A and 9B). Note that variations in input data structures may be accepted here by utilization of flag or tag bits as one skilled in the art will appreciate;

The paragraph beginning on page 147, line 28 has been replaced with the following paragraph. Note the only change herein is the removal of the underlining of the phrase '*there is an "error_rec" here for each loc sig in "loc_sig_bag".*'. Note the change is in bold rather than underlined.

error_rec_set: The set of "error_recs" providing information as to how much each loc sig in "loc_sig_bag" disagrees with comparable loc sigs in the DB. That is, ***there is an "error_rec" here for each loc sig in "loc_sig_bag".***

The paragraph beginning on page 161, line 9 has been replaced with the following paragraph. Note the only change is the replacement of "Fig. 9" with –Figs. 9A and 9B–.

This function creates a new list of location hypotheses from the input list, "loc_hyp_list", wherein the location hypotheses on the new list are modified versions of those on the input list. For each location hypothesis on the input list, one or more corresponding location hypotheses will be on the output list. Such corresponding output location hypotheses will differ from their associated input location hypothesis by one or more of the following: (a) the "image_area" field (see Figs. 9A and 9B) may be assigned an area indicative of where the target MS is estimated to be, (b) if "image_area" is assigned, then the "confidence" field will be the confidence that the target MS is located in the area for "image_area", (c) if there are not sufficient "nearby" verified location signature clusters in the location signature data base to entirely rely on a computed confidence using such verified location signature clusters, then two location hypotheses (having reduced confidences) will be returned, one having a reduced computed confidence (for "image_area") using the verified clusters in the Location Signature DB, and one being substantially the same as the associated input location hypothesis except that the confidence (for the field "area_est") is reduced to reflect the confidence in its paired location hypothesis having a computed confidence for "image_area". Note also, in some cases, the location hypotheses on the input list, may have no change to its confidence or the area to which the confidence applies. Note that the steps herein are also provided in flowchart form in Figs. 25a and 25b.

The paragraph beginning on page 161, line 29 and ending on page 162, line 6 has been replaced with the following paragraph. Note the only change is the replacement of "Mobil" with –Mobile–.

if (NOT loc_hyp[i].adjust) then /* no adjustments will be made to the "area_est" or the "confidence" fields since the "adjust" field indicates that there is assurance that these other fields are correct; note that such designations indicating that no adjustment are presently contemplated are only for the location hypotheses generated by the Home Base Station First Order Model, the Location Base Station First Order Model and the Mobil<u>e</u> Base Station First Order Model. In particular, location hypotheses from the Home Base Station model will have confidences of 1.0 indicating with highest confidence that the target MS is within the area estimate for the location hypothesis. Alternatively, in the Location Base Station model, generated location hypotheses may have confidences of (substantially) +1.0 (indicating that the target MS is absolutely in the area for "area_est"), or, -1.0 (indicating that the target MS is NOT in the area estimate for the generated location hypothesis).*/

The paragraph beginning on page 162, line 10 has been replaced with the following paragraph. Note the only change here is the replacement of "FIG. 9" with –Figs. 9A and 9B–.

else /* the location hypothesis can (and will) be modified; in particular, an "image_area" may be assigned, the "confidence" changed to reflect a confidence in the target MS being in the "image_area". Additionally, in some cases, more than one location hypothesis may be generated from "loc_hyp[i]". See the comments on [FIG. 9]<u>Figs. 9A and 9B</u> and the comments for "get_adjusted_loc_hyp_list_for" for a description of the terms here. */

The paragraph beginning on page 163, line 8 has been replaced with the following paragraph. Please note that the only change is the removal of underlining of text of the word –verified–.

Define the term "**image cluster set**" (for a given First Order Model identified by "loc_hyp.FOM_ID") to mean the set of verified location signature clusters whose MS location point estimates are in "the cluster set".

The paragraph beginning on page 164, line 1 has been replaced with the following paragraph. Note the only change herein is the removal of the underlining in the phrase 'identifier may also be dependent on the area type.' This phrase is identified in bold hereinbelow.

pt_max_area <--- *get_max_area_surrounding_pt*(loc_hyp, mesh); /* Get the maximum area about "pt_est" that is deemed worthwhile for examining the behavior of the "loc_hyp.FOM_ID" First Order Model (FOM) about "pt_est". Note that in at least one embodiment, this value of this **identifier may also be dependent on the area type** within which "loc_hyp.pt_est" resides. Further, this function may provide values according to an algorithm allowing periodic tuning or adjusting of the values output, via, e.g., a Monte Carlo simulation (more generally, a statistical simulation or regression) or a Genetic Algorithm. In some embodiments of the present invention, the value determined here may be a relatively large proportion of the entire radio coverage area region. However, the tuning process may be used to shrink this value for (for example) various area types as location signature clusters for verified MS location estimates are accumulated in the location signature data base. */

The paragraph beginning on page 164, line 10 has been replaced with the following paragraph. Note the removal of the underlining in the phrase 'vary according to area type and/or area size (of "area")'. This phrase is identified by bold rather than underlining below.

min_clusters <--- *get_min_nbr_of_clusters*(loc_hyp.FOM_ID, area); /* For the area, "area", get the minimum number ("min_clusters") of archived MS estimates, L, desired in generating a new target MS location estimate and a related confidence, wherein this minimum number is likely to provide a high probability that this new target MS location estimate and a related confidence are meaningful enough to use in subsequent Location Center processing for outputting a target MS location estimate.

More precisely, this minimum number, "min_clusters," is an estimate of the archived MS location estimates, L, required to provide the above mentioned high probability wherein each L satisfies the following conditions: (a) L is in the area for "area"; (b) L is archived in the location signature data base; (c) L has a corresponding verified location signature cluster in the location signature data base; and (d) L is generated by the FOM identified by "loc_hyp.FOM_ID"). In one embodiment, "min_clusters" may be a constant; however, in another it may **vary according to area type and/or area size (of "area")**, in some it may also vary according to the FOM indicated by "loc_hyp.FOM_ID". */

The paragraph beginning on page 168, line 15 has been replaced with the following paragraph. Note the only change is the removal of underlining from –per unit of area–.

Define the term **"mapped cluster density"** to be the number of the verified location signature clusters in an "image cluster set" per unit of area in the "image cluster set area".

The paragraph beginning on page 170, line 1 has been replaced with the following paragraph. Note the only change herein is the removal of the underlining in the phrase '*positive* confidence.' This phrase is identified by bold rather than underlining below.

/* Given the above two values, a ***positive* confidence** value for the area, "image_area", can be calculated based on empirical data.

The paragraph beginning on page 171, line 3 has been replaced with the following paragraph. Note there are square brackets that do not denote deletions herein. Square brackets denoting deletions are in 16 point font and in bold.

Note that the product of [CA1.1] and [CA1.2] provide the above desired characteristics for calculating the confidence. However, there is no guarantee that the range of resulting values from such products is consistent with the interpretation that has been placed on (positive) confidence values; e.g., that a confidence of near 1.0 has a very high likelihood that the target MS is in the corresponding area. For example, it can be that this product rarely is greater than 0.8, even in the areas of highest confidence. Accordingly, a "tuning" function is contemplated which provides an additional factor for adjusting of the confidence. This factor is, for example, a function of the area types and the size of each area type in "image_area"[ ]. Moreover, such a tuning function may be dependent on a "tuning coefficient" per area type. Thus, one such tuning function may be:

$$\min\left([S]\sum_{i=1}^{\text{number of area types}} [tc_i * \text{sizeof(area type}_i \text{ in "image\_area")} / \text{sizeof("image\_area")}], 1.0\right)$$

where tc_i is a tuning coefficient (determined in background or off-line processing; e.g., by a Genetic Algorithm or Monte Carlo simulation or regression) for the area type indexed by "i".

WIRELESS LOCATION USING MULTIPLE SIMULTANEOUS LOCATION ESTIMATORS

FIELD OF THE INVENTION

The present invention is directed generally to a system and method for locating people or objects, and in particular, to a system and method for locating a wireless mobile station using a plurality of simultaneously activated mobile station location estimators.

BACKGROUND OF THE INVENTION

Introduction

Wireless communications systems are becoming increasingly important worldwide. Wireless cellular telecommunications systems are rapidly replacing conventional wire-based telecommunications systems in many applications. Cellular radio telephone networks ("CRT"), and specialized mobile radio and mobile data radio networks are examples. The general principles of wireless cellular telephony have been described variously, for example in U. S. Patent 5,295,180 to Vendetti, et al, which is incorporated herein by reference.

There is great interest in using existing infrastructures for wireless communication systems for locating people and/or objects in a cost effective manner. Such a capability would be invaluable in a variety of situations, especially in emergency or crime situations. Due to the substantial benefits of such a location system, several attempts have been made to design and implement such a system.

Systems have been proposed that rely upon signal strength and trilateralization techniques to permit location include those disclosed in U.S. Patents 4,818,998 and 4,908,629 to Apsell et al. ("the Apsell patents") and 4,891,650 to Sheffer ("the Sheffer patent"). However, these systems have drawbacks that include high expense in that special purpose electronics are required. Furthermore, the systems are generally only effective in line-of-sight conditions, such as rural settings. Radio wave surface reflections, refractions and ground clutter cause significant distortion, in determining the location of a signal source in most geographical areas that are more than sparsely populated. Moreover, these drawbacks are particularly exacerbated in dense urban canyon (city) areas, where errors and/or conflicts in location measurements can result in substantial inaccuracies.

Another example of a location system using time of arrival and triangulation for location are satellite-based systems, such as the military and commercial versions of the Global Positioning Satellite system ("GPS"). GPS can provide accurate position determination (i.e., about 100 meters error for the commercial version of GPS) from a time-based signal received simultaneously from at least three satellites. A ground-based GPS receiver at or near the object to be located determines the difference between the time at which each satellite transmits a time signal and the time at which the signal is received and, based on the time differentials, determines the object's location. However, the GPS is impractical in many applications. The signal power levels from the satellites are low and the GPS receiver requires a clear, line-of-sight path to at least three satellites above a horizon of about 60 degrees for effective operation. Accordingly, inclement weather conditions, such as clouds, terrain features, such as hills and trees, and buildings restrict the ability of the GPS receiver to determine its position. Furthermore, the initial GPS signal detection process for a GPS receiver is relatively long (i.e., several minutes) for determining the receiver's position. Such delays are unacceptable in many applications such as, for example, emergency response and vehicle tracking.

Differential GPS, or DGPS systems offer correction schemes to account for time synchronization drift. Such correction schemes include the transmission of correction signals over a two-way radio link or broadcast via FM radio station subcarriers. These systems have been found to be awkward and have met with limited success.

Additionally, GPS-based location systems have been attempted in which the received GPS signals are transmitted to a central data center for performing location calculations. Such systems have also met with limited success. In brief, each of the various GPS embodiments have the same fundamental problems of limited reception of the satellite signals and added expense and complexity of the electronics required for an inexpensive location mobile station or handset for detecting and receiving the GPS signals from the satellites.

Radio Propagation Background

The behavior of a mobile radio signal in the general environment is unique and complicated. Efforts to perform correlations between radio signals and distance between a base station and a mobile station are similarly complex. Repeated attempts to solve this problem in the past have been met with only marginal success. Factors include terrain undulations, fixed and variable clutter, atmospheric conditions, internal radio characteristics of cellular and PCS systems, such as frequencies, antenna configurations, modulation schemes, diversity methods, and the physical geometries of direct, refracted and reflected waves between the base stations and the mobile. Noise, such as man-made externally sources (e.g., auto ignitions) and radio system co-channel and adjacent channel interference also affect radio reception and related performance measurements, such as the analog carrier-to-interference ratio (C/I), or digital energy-per-bit/Noise density ratio (E_{b/N_o}) and are particular to various points in time and space domains.

RF Propagation in Free Space

Before discussing real world correlations between signals and distance, it is useful to review the theoretical premise, that of radio energy path loss across a pure isotropic vacuum propagation channel, and its dependencies within and among various communications channel types. Fig. 1 illustrates a definition of channel types arising in communications:

Over the last forty years various mathematical expressions have been developed to assist the radio mobile cell designer in establishing the proper balance between base station capital investment and the quality of the radio link, typically using radio energy field-strength, usually measured in microvolts/meter, or decibels.

First consider Hata's single ray model. A simplified radio channel can be described as:

$$G_s = L_p + F + L_f + L_m + L_b - G_t + G_r \qquad \text{(Equation 1)}$$

where G_s = system gain in decibels

L_p = free space path loss in dB,

F = fade margin in dB,

L_f = transmission line loss from coaxials used to connect radio to antenna, in dB,

L_m = miscellaneous losses such as minor antenna misalignment, coaxial corrosion, increase in the receiver noise figure due to aging, in dB,

L_b = branching loss due to filter and circulator used to combine or split transmitter and receiver signals in a single antenna

G_t = gain of transmitting antenna

G_r = gain of receiving antenna

Free space path loss[1] L_p as discussed in Mobile Communications Design Fundamentals, William C. Y. Lee, 2nd, Ed across the propagation channel is a function of distance d, frequency f (for f values < 1 GHz, such as the 890-950 mHz cellular band):

$$\frac{P_{or}}{P_t} = \frac{1}{(4\pi df c)^2} \qquad \text{(equation 2)}$$

where P_{or} = received power in free space

P_t = transmitting power

c = speed of light,

The difference between two received signal powers in free space,

$$\Delta_p = (10)\log\left(\frac{p_{or2}}{P_{or1}}\right) = (20)\log\left(\frac{d_1}{d_2}\right)(dB) \qquad \text{(equation 3)}$$

---

indicates that the free propagation path loss is 20 dB per decade. Frequencies between 1 GHz and 2GHz experience increased values in the exponent, ranging from 2 to 4, or 20 to 40 dB/decade, which would be predicted for the new PCS 1.8 - 1.9 GHz band.

This suggests that the free propagation path loss is 20 dB per decade. However, frequencies between 1 GHz and 2 GHz experience increased values in the exponent, ranging from 2 to 4, or 20 to 40 dB/decade, which would be predicted for the new PCS 1.8 - 1.9 GHz band. One consequence from a location perspective is that the effective range of values for higher exponents is an increased at higher frequencies, thus providing improved granularity of ranging correlation.

Environmental Clutter and RF Propagation Effects

Actual data collected in real-world environments uncovered huge variations with respect to the free space path loss equation, giving rise to the creation of many empirical formulas for radio signal coverage prediction. Clutter, either fixed or stationary in geometric relation to the propagation of the radio signals, causes a shadow effect of blocking that perturbs the free space loss effect. Perhaps the best known model set that characterizes the average path loss is Hata's, "Empirical Formula for Propagation Loss in Land Mobile Radio", M. Hata, IEEE Transactions VT-29, pp. 317-325, August 1980, three pathloss models, based on Okumura's measurements in and around Tokyo, "Field Strength and its Variability in VHF and UHF Land Mobile Service", Y. Okumura, et al, Review of the Electrical Communications laboratory, Vol 16, pp 825-873, Sept. - Oct. 1968.

The typical urban Hata model for L_p was defined as $L_p = L_{Hu}$:

$$L_{Hu} = 69.55 + 26.16\log(f) - 13.82\log(h_{BS}) - a(h_{MS}) + ((44.9 - 6.55\log(H_{BS})\log(d)[dB])$$

(Equation 4)

where L_{Hu} = path loss, Hata urban

h_{BS} = base station antenna height

h_{MS} = mobile station antenna height

d = distance BS-MS in km

$a(h_{MS})$ is a correction factor for small and medium sized cities, found to be:

$$1\log(f-0.7)h_{MS} - 1.56\log(f-0.8) = a(h_{MS})$$

(Equation 5)

For large cities the correction factor was found to be:

$$a(h_{MS}) = 3.2\,[\log 11.75h_{MS}]^2 - 4.97$$

(Equation 6)

assuming f is equal to or greater than 400 mHz.

The typical suburban model correction was found to be:

$$L_{H_{suburban}} = L_{Hu} - 2\left[\log\left(\frac{f}{28}\right)^2\right] - 5.4[dB]$$

(Equation 7)

The typical rural model modified the urban formula differently, as seen below:

$$L_{Hrural} = L_{Hu} - 4.78\,(\log f)^2 + 18.33\log f - 40.94\,[dB]$$

(Equation 8)

Although the Hata model was found to be useful for generalized RF wave prediction in frequencies under 1 GHz in certain suburban and rural settings, as either the frequency and/or clutter increased, predictability decreased. In current practice, however, field technicians often have to make a guess for dense urban an suburban areas (applying whatever model seems best), then installing a base stations and begin taking manual measurements. Coverage problems can take up to a year to resolve.

Relating Received Signal Strength to Location

Having previously established a relationship between d and P_{or}, reference equation 2 above: d represents the distance between the mobile station (MS) and the base station (BS); P_{or} represents the received power in free space) for a given set of unchanging environmental conditions, it may be possible to dynamically measure P_{or} and then determine d.

In 1991, U.S. Patent 5,055,851 to Sheffer taught that if three or more relationships have been established in a triangular space of three or more base stations (BSs) with a location database constructed having data related to possible mobile station (MS) locations, then arculation calculations may be performed, which use three distinct P_{or} measurements to determine an X,Y, two dimensional location, which can then be projected onto an area map. The triangulation calculation is based on the fact that the approximate distance of the mobile station (MS) from any base station (BS) cell can be calculated based on the received signal strength. Sheffer acknowledges that terrain variations affect accuracy, although as noted above, Sheffer's disclosure does not account for a sufficient number of variables, such as fixed and variable location shadow fading, which are typical in dense urban areas with moving traffic.

Most field research before about 1988 has focused on characterizing (with the objective of RF coverage prediction) the RF propagation channel (i.e., electromagnetic radio waves) using a single-ray model, although standard fit errors in regressions proved dismal (e.g., 40-80 dB). Later, multi-ray models were proposed, and much later, certain behaviors were studied with radio and digital channels. In 1981, Vogler proposed that radio waves at higher frequencies could be modeled using optics principles. In 1988 Walfisch and Bertoni applied optical methods to develop a two-ray model, which when compared to certain highly specific, controlled field data, provided extremely good regression fit standard errors of within 1.2 dB.

In the Bertoni two ray model it was assumed that most cities would consist of a core of high-rise buildings surrounded by a much larger area having buildings of uniform height spread over regions comprising many square blocks, with street grids organizing buildings into rows that are nearly parallel. Rays penetrating buildings then emanating outside a building were neglected. Fig. 2 provides a basis for the variables.

After a lengthy analysis it was concluded that path loss was a function of three factors: (1) the path loss between antennas in free space; (2) the reduction of rooftop wave fields due to settling; and (3) the effect of diffraction of the rooftop fields down to ground level. The last two factors were summarily termed L_{ex}, given by:

$$L_{ex} = 57.1 + A + \log(f) + R - ((18\log(H)) - 18\log\left[1 - \frac{R^2}{17H}\right] \quad \text{(Equation 9)}$$

The influence of building geometry is contained in A:

$$A = 5\log\left[\frac{d}{2}^{2}\right] - 9\log d + 20\log\{\tan[2(h - H_{MS})]^{-1}\}$$

(Equation 10)

However, a substantial difficulty with the two-ray model in practice is that it requires a substantial amount of data regarding building dimensions, geometries, street widths, antenna gain characteristics for every possible ray path, etc. Additionally, it requires an inordinate amount of computational resources and such a model is not easily updated or maintained.

Unfortunately, in practice clutter geometries and building heights are random. Moreover, data of sufficient detail has been extremely difficult to acquire, and regression standard fit errors are poor; i.e., in the general case, these errors were found to be 40-60 dB. Thus the two-ray model approach, although sometimes providing an improvement over single ray techniques, still did not predict RF signal characteristics in the general case to level of accuracy desired (< 10dB).

Work by Greenstein has since developed from the perspective of measurement-based regression models, as opposed to the previous approach of predicting-first, then performing measurement comparisons. Apparently yielding to the fact that low-power, low antenna (e.g., 12-25 feet above ground) height PCS microcell coverage was insufficient in urban buildings, Greenstein, et al, authored "Performance Evaluations for Urban Line-of-sight Microcells Using a Multi-ray Propagation Model", in IEEE Globecom Proceedings, 12/91. This paper proposed the idea of formulating regressions based on field measurements using small PCS microcells in a lineal microcell geometry (i.e., geometries in which there is always a line-of-sight (LOS) path between a subscriber's mobile and its current microsite).

Additionally, Greenstein studied the communication channels variable Bit-Error-Rate (BER) in a spatial domain, which was a departure from previous research that limited field measurements to the RF propagation channel signal strength alone. However, Greenstein based his finding on two suspicious assumptions: 1) he assumed that distance correlation estimates were identical for uplink and downlink transmission paths; and 2) modulation techniques would be transparent in terms of improved distance correlation conclusions. Although some data held very correlations, other data and environments produced poor results. Accordingly, his results appear unreliable for use in general location context.

In 1993 Greenstein, et al, authored "A Measurement-Based Model for Predicting Coverage Areas of Urban Microcells", in the IEEE Journal On Selected Areas in Communications, Vol. 11, No. 7, 9/93. Greenstein reported a generic measurement-based model of RF attenuation in terms of constant-value contours surrounding a given low-power, low antenna microcell environment in a dense, rectilinear neighborhood, such as New York City. However, these contours were for the cellular frequency band. In this case, LOS and non-LOS clutter were considered for a given microcell site. A result of this analysis was that RF propagation losses (or attenuations), when cell antenna heights were relatively low, provided attenuation contours resembling a spline plane curve depicted as an asteroid, aligned with major street grid patterns. Further, Greenstein found that convex diamond-shaped RF propagation loss contours were a common occurrence in field measurements in a rectilinear urban area. The special plane curve asteroid is represented by the formula $x^{2/3} + y^{2/3} = r^{2/3}$. However, these results alone have not been sufficiently robust and general to accurately locate an MS, due to the variable nature of urban clutter spatial arrangements.

At Telesis Technology in 1994 Howard Xia, et al, authored "Microcellular Propagation Characteristics for Personal Communications in Urban and Suburban Environments", in IEEE Transactions of Vehicular Technology, Vol. 43, No. 3, 8/94, which performed measurements specifically in the PCS 1.8 to 1.9 GHz frequency band. Xia found corresponding but more variable outcome results in San Francisco, Oakland (urban) and the Sunset and Mission Districts (suburban).

Summary of Factors Affecting RF Propagation

The physical radio propagation channel perturbs signal strength, frequency (causing rate changes, phase delay, signal to noise ratios (e.g., C/I for the analog case, or E_b/N_o, RF energy per bit, over average noise density ratio for the digital case) and Doppler-shift. Signal strength is usually characterized by:

· Free Space Path Loss (L_p)

· Slow fading loss or margin (L_{slow})

· Fast fading loss or margin (L_{fast})

Loss due to slow fading includes shadowing due to clutter blockage (sometimes included in Lp). Fast fading is composed of multipath reflections which cause: 1) delay spread; 2) random phase shift or Rayleigh fading; and 3) random frequency modulation due to different Doppler shifts on different paths.

Summing the path loss and the two fading margin loss components from the above yields a total path loss of:

$$L_{total} = L_p + L_{slow} + L_{fast}$$

Referring to Fig. 3, the figure illustrates key components of a typical cellular and PCS power budget design process. The cell designer increases the transmitted power P_{TX} by the shadow fading margin L_{slow} which is usually chosen to be within the 1-2 percentile of the slow fading probability density function (PDF) to minimize the probability of unsatisfactorily low received power level P_{RX} at the receiver. The P_{RX} level must have enough signal to noise energy level (e.g., 10 dB) to overcome the receiver's internal noise level (e.g., -118dBm in the case of cellular 0.9 GHz), for a minimum voice quality standard. Thus in the example P_{RX} must never be below -108 dBm, in order to maintain the quality standard.

Additionally the short term fast signal fading due to multipath propagation is taken into account by deploying fast fading margin L_{fast}, which is typically also chosen to be a few percentiles of the fast fading distribution. The 1 to 2 percentiles compliment other network blockage guidelines. For example the cell base station traffic loading capacity and network transport facilities are usually designed for a 1-2 percentile blockage factor as well. However, in the worst-case scenario both fading margins are simultaneously exceeded, thus causing a fading margin overload.

In Roy , Steele's, text, Mobile Radio Communications, IEEE Press, 1992, estimates for a GSM system operating in the 1.8 GHz band with a transmitter antenna height of 6.4m and an MS receiver antenna height of 2m, and assumptions regarding total path loss, transmitter power would be calculated as follows:

Table I: GSM Power Budget Example

Parameter	dBm value	Will require
L_{slow}	14	
L_{fast}	7	
L_{path}	110	
Min. RX pwr required	-104	
		TXpwr = 27 dBm

Steele's sample size in a specific urban London area of 80,000 LOS measurements and data reduction found a slow fading variance of

$$\sigma = 7dB$$

assuming lognormal slow fading PDF and allowing for a 1.4% slow fading margin overload, thus

$$L_{slow} = 2\sigma = 14dB$$

The fast fading margin was determined to be:

$$L_{fast} = 7dB$$

In contrast, Xia's measurements in urban and suburban California at 1.8 GHz uncovered flat-land shadow fades on the order of 25-30 dB when the mobile station (MS) receiver was traveling from LOS to non-LOS geometries. In hilly terrain fades of +5 to -50 dB were experienced. Thus it is evident that attempts to correlate signal strength with MS ranging distance suggest that error ranges could not be expected to improve below 14 dB, with a high side of 25 to 50 dB. Based on 20 to 40 dB per decade, Corresponding error ranges for the distance variable would then be on the order of 900 feet to several thousand feet, depending upon the particular environmental topology and the transmitter and receiver geometries.

SUMMARY OF THE INVENTION

OBJECTS OF THE INVENTION

It is an objective of the present invention to provide a system and method for to wireless telecommunication systems for accurately locating people and/or objects in a cost effective manner. Additionally, it is an objective of the present invention to provide such location capabilities using the measurements from wireless signals communicated between mobile stations and a network of base stations, wherein the same communication standard or protocol is utilized for location as is used by the network of base stations for providing wireless communications with mobile stations for other purposes such as voice communication and/or visual communication (such as text paging, graphical or video communications). Related objectives for the present invention include providing a system and method that:

(1.1) can be readily incorporated into existing commercial wireless telephony systems with few, if any, modifications of a typical telephony wireless infrastructure;

(1.2) can use the native electronics of typical commercially available telephony wireless mobile stations (e.g., handsets) as location devices;

(1.3) can be used for effectively locating people and/or objects wherein there are few (if any) line-of-sight wireless receivers for receiving location signals from a mobile station (herein also denoted MS);

(1.4) can be used not only for decreasing location determining difficulties due to multipath phenomena but in fact uses such multipath for providing more accurate location estimates;

(1.5) can be used for integrating a wide variety of location techniques in a straight-forward manner; and

(1.6) can substantially automatically adapt and/or (re)train and/or (re)calibrate itself according to changes in the environment and/or terrain of a geographical area where the present invention is utilized.

Yet another objective is to provide a low cost location system and method, adaptable to wireless telephony systems, for using simultaneously a plurality of location techniques for synergistically increasing MS location accuracy and consistency. In particular, at least some of the following MS location techniques can be utilized by various embodiments of the present invention:

(2.1) time-of-arrival wireless signal processing techniques;

(2.2) time-difference-of-arrival wireless signal processing techniques;

(2.3) adaptive wireless signal processing techniques having, for example, learning capabilities and including, for instance, artificial neural net and genetic algorithm processing;

(2.4) signal processing techniques for matching MS location signals with wireless signal characteristics of known areas;

(2.5) conflict resolution techniques for resolving conflicts in hypotheses for MS location estimates;

(2.6) enhancement of MS location estimates through the use of both heuristics and historical data associating MS wireless signal characteristics with known locations and/or environmental conditions.

Yet another objective is to provide location estimates in terms of time vectors, which can be used to establish motion, speed, and an extrapolated next location in cases where the MS signal subsequently becomes unavailable.

DEFINITIONS

The following definitions are provided for convenience. In general, the definitions here are also defined elsewhere in this document as well.

(3.1) The term "wireless" herein is, in general, an abbreviation for "digital wireless", and in particular, "wireless" refers to digital radio signaling using one of standard digital protocols such as CDMA, NAMPS, AMPS, TDMA and GSM, as one skilled in the art will understand.

(3.2) As used herein, the term "mobile station" (equivalently, MS) refers to a wireless device that is at least a transmitting device, and in most cases is also a wireless receiving device, such as a portable radio telephony handset. Note that in some contexts herein instead or in addition to MS, the following terms are also used: "personal station" (PS), and "location unit" (LU). In general, these terms may be considered synonymous. However, the later two terms may be used when referring to reduced functionality communication devices in comparison to a typical digital wireless mobile telephone.

(3.3) The term, "infrastructure", denotes the network of telephony communication services, and more particularly, that portion of such a network that receives and processes wireless communications with wireless mobile stations. In particular, this infrastructure includes telephony wireless base stations (BS) such as those for radio mobile communication systems based on CDMA, AMPS, NAMPS, TDMA, and GSM wherein the base stations provide a network of cooperative communication channels with an air interface with the MS, and a conventional telecommunications interface with a Mobile Switch Center (MSC). Thus, an MS user within an area serviced by the base stations may be provided with wireless communication throughout the area by user transparent communication transfers (i.e., "handoffs") between the user's MS and these base stations in order to maintain effective telephony service. The mobile switch center (MSC) provides communications and control connectivity among base stations and the public telephone network.

(3.4) The phrase, "composite wireless signal characteristic values" denotes the result of aggregating and filtering a collection of measurements of wireless signal samples, wherein these samples are obtained from the wireless communication between an MS to be located and the base station infrastructure (e.g., a plurality of networked base stations). However, other phrases are also used herein to denote this collection of derived characteristic values depending on the context and the likely orientation of the reader. For example, when viewing these values from a wireless signal processing perspective of radio engineering, as in the descriptions of the subsequent Detailed Description sections concerned with the aspects of the present invention for receiving MS signal measurements from the base station infrastructure, the phrase typically used is: "RF signal measurements". Alternatively, from a data processing perspective, the phrases: "location signature cluster" and "location signal data" are used to describe signal characteristic values between the MS and the plurality of infrastructure base stations substantially simultaneously detecting MS transmissions. Moreover, since the location communications between an MS and the base station infrastructure typically include simultaneous communications with more than one base station, a related useful notion is that of a "location signature" which is the composite wireless signal characteristic values for signal samples between an MS to be located and a single base station. Also, in some contexts, the phrases: "signal characteristic values" or "signal characteristic data" are used when either or both a location signature(s) and/or a location signature cluster(s) are intended.

SUMMARY DISCUSSION

The present invention relates to a wireless mobile station location system. In particular, such a wireless mobile station location system may be decomposed into: (i) a first low level wireless signal processing subsystem for receiving, organizing and conditioning low level wireless signal measurements from a network of base stations cooperatively linked for providing wireless communications with mobile stations (MSs); and (ii) a second high level signal processing subsystem for performing high level data processing for providing most likelihood location estimates for mobile stations.

More precisely, the present invention is a novel signal processor that includes at least the functionality for the high signal processing subsystem mentioned hereinabove. Accordingly, assuming an appropriate ensemble of wireless signal measurements characterizing the wireless signal communications between a particular MS and a networked wireless base station infrastructure have been received and appropriately filtered of noise and transitory values (such as by an embodiment of the low level signal processing subsystem disclosed in a copending PCT patent application titled, "Wireless Location Using A Plurality of Commercial Network. Infrastructures," by F. W. LeBlanc, and the present applicant(s); this copending patent application being herein incorporated by reference), the present invention uses the output from such a low level signal processing system for determining a most likely location estimate of an MS.

That is, once the following steps are appropriately performed (e.g., by the LeBlanc copending application):

(4.1) receiving signal data measurements corresponding to wireless communications between an MS to be located (herein also denoted the "target MS") and a wireless telephony infrastructure;

(4.2) organizing and processing the signal data measurements received from a given target MS and surrounding BSs so that composite wireless signal characteristic values may be obtained from which target MS location estimates may be subsequently derived. In particular, the signal data measurements are ensembles of samples from the wireless signals received from the target MS by the base station infrastructure, wherein these samples are subsequently filtered using analog and digital spectral filtering.

the present invention accomplishes the objectives mentioned above by the following steps:

(4.3) providing the composite signal characteristic values to one or more MS location hypothesizing computational models (also denoted herein as "first order models" and also "location estimating models"), wherein each such model subsequently determines one or more initial estimates of the location of the target MS based on, for example, the signal processing techniques 2.1 through 2.3 above. Moreover, each of the models output MS location estimates having substantially identical data structures (each such data structure denoted a "location hypothesis"). Additionally, each location hypothesis may also includes a confidence value indicating the likelihood or probability that the target MS whose location is desired resides in a corresponding location estimate for the target MS;

(4.4) adjusting or modifying location hypotheses output by the models according to, for example, 2.4 through 2.6 above so that the adjusted location hypotheses provide better target MS location estimates. In particular, such adjustments are performed on both the target MS location estimates of the location hypotheses as well as their corresponding confidences; and

(4.4) subsequently computing a "most likely" target MS location estimate for outputting to a location requesting application such as 911 emergency, the fire or police departments, taxi services, etc. Note that in computing the most likely target MS location estimate a plurality of location hypotheses may be taken into account. In fact, it is an important aspect of the present invention that the most likely MS location estimate is determined by computationally forming a composite MS location estimate utilizing such a plurality of location hypotheses so that, for example, location estimate similarities between location hypotheses can be effectively utilized.

Referring now to (4.3) above, the filtered and aggregated wireless signal characteristic values are provided to a number of location hypothesizing models (denoted First Order Models, or FOMs), each of which yields a location estimate or location hypothesis related to the location of the target MS. In particular, there are location hypotheses for both providing estimates of where the target MS likely to be and where the target MS is not likely to be. Moreover, it is an aspect of the present invention that confidence values of the location hypotheses are provided as a continuous range of real numbers from, e.g., -1 to 1, wherein the most unlikely areas for locating the target MS are given a confidence value of -1, and the most likely areas for locating the target MS are given a confidence value of 1. That is, confidence values that are larger indicate a higher likelihood that the target MS is in the corresponding MS estimated area, wherein 1 indicates that the target MS is absolutely NOT in the estimated area, 0 indicates a substantially neutral or unknown likelihood of the target MS being in the corresponding estimated area, and 1 indicates that the target MS is absolutely within the corresponding estimated area.

Referring to (4.4) above, it is an aspect of the present invention to provide location hypothesis enhancing and evaluation techniques that can adjust target MS location estimates according to historical MS location data and/or adjust the confidence values of location hypotheses according to how consistent the corresponding target MS location estimate is: (a) with historical MS signal characteristic values, (b) with various physical constraints, and (c) with various heuristics. In particular, the following capabilities are provided by the present invention:

(5.1) a capability for enhancing the accuracy of an initial location hypothesis, H, generated by a first order model, FOM_H, by using H as, essentially, a query or index into an historical data base (denoted herein as the location signature data base), wherein this data base includes: (a) a plurality of previously obtained location signature clusters (i.e., composite wireless signal characteristic values) such that for each such cluster there is an associated actual or verified MS locations where an MS communicated with the base station infrastructure for locating the MS, and (b) previous MS location hypothesis estimates from FOM_s derived from each of the location signature clusters stored according to (a);

(5.2) a capability for analyzing composite signal characteristic values of wireless communications between the target MS and the base station infrastructure, wherein such values are compared with composite signal characteristics values of known MS locations (these latter values being archived in the location signature data base). In one instance, the composite signal characteristic values used to generate various location hypotheses for the target MS are compared against wireless signal data of known MS locations stored in the location signature data base for determining the reliability of the location hypothesizing models for particular geographic areas and/or environmental conditions;

(5.3) a capability for reasoning about the likeliness of a location hypothesis wherein this reasoning capability uses heuristics and constraints based on physics and physical properties of the location geography;

(5.4) an hypothesis generating capability for generating new location hypotheses from previous hypotheses.

As also mentioned above in (2.3), the present invention utilizes adaptive signal processing techniques. One particularly important utilization of such techniques includes the automatic tuning of the present invention so that, e.g., such tuning can be applied to adjusting the values of location processing system parameters that affect the processing performed by the present invention. For example, such system parameters as those used for determining the size of a geographical area to be specified when retrieving location signal data of known MS locations from the historical (location signature) data base can substantially affect the location processing. In particular, a system parameter specifying a minimum size for such a geographical area may, if too large, cause unnecessary inaccuracies in locating an MS. Accordingly, to accomplish a tuning of such system parameters, an adaptation engine is included in the present invention for automatically adjusting or tuning parameters used by the present invention. Note that in one embodiment, the adaptation engine is based on genetic algorithm techniques.

A novel aspect of the present invention relies on the discovery that in many areas where MS location services are desired, the wireless signal measurements obtained from communications between the target MS and the base station infrastructure are extensive enough to provide sufficiently unique or peculiar values so that the pattern of values alone may identify the location of the target MS. Further, assuming a sufficient amount of such location identifying pattern information is captured in the composite wireless signal characteristic values for a target MS, and that there is a technique for matching such wireless signal patterns to geographical locations, then a FOM based on this technique may generate a reasonably accurate target MS location estimate. Moreover, if the present invention (e.g., the location signature data base) has captured sufficient wireless signal data from location communications between MSs and the base station infrastructure wherein the locations of the MSs are also verified and captured, then this captured data (e.g., location signatures) can be used to train or calibrate such models to associate the location of a target MS with the distinctive signal characteristics between the target MS and one or more base stations. Accordingly, the present invention includes one or more FOMs that may be generally denoted as classification models wherein such FOMs are trained or calibrated to associate particular composite wireless signal characteristic values with a geographical location where a target MS could likely generate the wireless signal samples from which the composite wireless signal characteristic values are derived. Further, the present invention includes the capability for training (calibrating) and retraining (recalibrating) such classification FOMs to automatically maintain the accuracy of these models even though substantial changes to the radio coverage area may occur, such as the construction of a new high rise building or seasonal variations (due to, for example, foliage variations).

Note that such classification FOMs that are trained or calibrated to identify target MS locations by the wireless signal patterns produced constitute a particularly novel aspect of the present invention. It is well known in the wireless telephony art that the phenomenon of signal multipath and shadow fading renders most analytical location computational techniques such as time-of-arrival (TOA) or time-difference-of-arrival (TDOA) substantially useless in urban areas and particularly in dense urban areas. However, this same multipath phenomenon also may produce substantially distinct or peculiar signal measurement patterns, wherein such a pattern coincides with a relatively small geographical area. Thus, the present invention utilizes multipath as an advantage for increasing accuracy where for previous location systems multipath has been a source of substantial inaccuracies. Moreover, it is worthwhile to note that the utilization of classification FOMs in high multipath environments is especially advantageous in that high multipath environments are typically densely populated. Thus, since such environments are also capable of yielding a greater density of MS location signal data from MSs whose actual locations can be obtained, there can be a substantial amount of training or calibration data captured by the present invention for training or calibrating such classification FOMs and for progressively improving the MS location accuracy of such models. Moreover, since it is also a related aspect of the present invention to include a plurality stationary, low cost, low power "location detection base stations" (LBS), each having both restricted range MS detection capabilities and a built-in MS, a grid of such LBSs can be utilized for providing location signal data (from the built-in MS) for (re)training or (re)calibrating such classification FOMs.

In one embodiment of the present invention, one or more classification FOMs may each include a learning module such as an artificial neural network (ANN) for associating target MS location signal data with a target MS location estimate. Additionally, one or more classification FOMs may be statistical prediction models based on such statistical techniques as, for example, principle decomposition, partial least squares, or other regression techniques.

It is a further aspect of the present invention that the personal communication system (PCS) infrastructures currently being developed by telecommunication providers offer an appropriate localized infrastructure base upon which to build various personal location systems (PLS) employing the present invention and/or utilizing the techniques disclosed herein. In particular, the present invention is especially suitable for the location of people and/or objects using code division multiple access (CDMA) wireless infrastructures, although other wireless infrastructures, such as, time division multiple access (TDMA) infrastructures and GSM are also contemplated. Note that CDMA personal communications systems are described in the Telephone Industries Association standard IS-95, for frequencies below 1 GHz, and in the Wideband Spread- Spectrum Digital Cellular System Dual-Mode Mobile Station-Base Station Compatibility Standard, for frequencies in the 1.8-1.9 GHz frequency bands, both of which are incorporated herein by reference. Furthermore, CDMA general principles have also been described, for example, in U. S. Patent 5,109,390, to Gilhausen, et al, and CDMA Network Engineering Handbook by Qualcomm, Inc., each of which is also incorporated herein by reference.

Notwithstanding the above mentioned CDMA references, a brief introduction of CDMA is given here. Briefly, CDMA is an electromagnetic signal modulation and multiple access scheme based on spread spectrum communication. Each CDMA signal corresponds to an unambiguous pseudorandom binary sequence for modulating the carrier signal throughout a predetermined spectrum of bandwidth frequencies. Transmissions of individual CDMA signals are selected by correlation processing of a pseudonoise waveform. In particular, the CDMA signals are separately detected in a receiver by using a correlator, which accepts only signal energy from the selected binary sequence and despreads its spectrum. Thus, when a first CDMA signal is transmitted, the transmissions of unrelated CDMA signals correspond to pseudorandom sequences that do not match the first signal. Therefore, these other signals contribute only to the noise and represent a self-interference generated by the personal communications system.

As mentioned in (1.7) and in the discussion of classification FOMs above, the present invention can substantially automatically retrain and/or recalibrate itself to compensate for variations in wireless signal characteristics (e.g., multipath) due to environmental and/or topographic changes to a geographic area serviced by the present invention. For example, in one embodiment, the present invention optionally includes low cost, low power base stations, denoted location base stations (LBS) above, providing, for example, CDMA pilot channels to a very limited area about each such LBS. The location base stations may provide limited voice traffic capabilities, but each is capable of gathering sufficient wireless signal characteristics from an MS within the location base station's range to facilitate locating the MS. Thus, by positioning the location base stations at known locations in a geographic region such as, for instance, on street lamp poles and road signs, additional MS location accuracy can be obtained. That is, due to the low power signal output by such location base stations, for there to be signaling control communication (e.g., pilot signaling and other control signals) between a location base station and a target MS, the MS must be relatively near the location base station. Additionally, for each location base station not in communication with the target MS, it is likely that the MS is not near to this location base station. Thus, by utilizing information received from both location base stations in communication with the target MS and those that are not in communication with the target MS, the present invention can substantially narrow the possible geographic areas within which the target MS is likely to be. Further, by providing each location base station (LBS) with a co-located stationary wireless transceiver (denoted a built-in MS above) having similar functionality to an MS, the following advantages are provided:

(6.1) assuming that the co-located base station capabilities and the stationary transceiver of an LBS are such that the base station capabilities and the stationary transceiver communicate with one another, the stationary transceiver can be signaled by another component(s) of the present invention to activate or deactivate its associated base station capability, thereby conserving power for the LBS that operate on a restricted power such as solar electrical power;

(6.2) the stationary transceiver of an LBS can be used for transferring target MS location information obtained by the LBS to a conventional telephony base station;

(6.3) since the location of each LBS is known and can be used in location processing, the present invention is able to (re)train and/or (re)calibrate itself in geographical areas having such LBSs. That is, by activating each LBS stationary transceiver so that there is signal communication between the stationary transceiver and surrounding base stations within range, wireless signal characteristic values for the location of the stationary transceiver are obtained for each such base station. Accordingly, such characteristic values can then be associated with the known location of the stationary transceiver for training and/or calibrating various of the location processing modules of the present invention such as the classification FOMs discussed above. In particular, such training and/or calibrating may include:

(i) (re)training and/or (re)calibrating FOMs;

(ii) adjusting the confidence value initially assigned to a location hypothesis according to how accurate the generating FOM is in estimating the location of the stationary transceiver using data obtained from wireless signal characteristics of signals between the stationary transceiver and base stations with which the stationary transceiver is capable of communicating;

(iii) automatically updating the previously mentioned historical data base (i.e., the location signature data base), wherein the stored signal characteristic data for each stationary transceiver can be used for detecting environmental and/or topographical changes (e.g., a newly built high rise or other structures capable of altering the multipath characteristics of a given geographical area); and

(iv) tuning of the location system parameters, wherein the steps of: (a) modifying various system parameters and (b) testing the performance of the modified location system on verified mobile station location data (including the stationary transceiver signal characteristic data), these steps being interleaved and repeatedly performed for obtaining better system location accuracy within useful time constraints.

It is also an aspect of the present invention to automatically (re)calibrate as in (6.3) above with signal characteristics from other known or verified locations. In one embodiment of the present invention, portable location verifying electronics are provided so that when such electronics are sufficiently near a located target MS, the electronics: (I) detect the proximity of the target MS; (ii) determine a highly reliable measurement of the location of the target MS; (iii) provide this measurement to other location determining components of the present invention so that the location measurement can be associated and archived with related signal characteristic data received from the target MS at the location where the location measurement is performed. Thus, the use of such portable location verifying electronics allows the present invention to capture and utilize signal characteristic data from verified, substantially random locations for location system calibration as in (6.3) above. Moreover, it is important to note that such location verifying electronics can verify locations automatically wherein it is unnecessary for manual activation of a location verifying process.

One embodiment of the present invention includes the location verifying electronics as a "mobile (location) base station" (MBS) that can be, for example, incorporated into a vehicle, such as an ambulance, police car, or taxi. Such a vehicle can travel to sites having a transmitting target MS, wherein such sites may be randomly located and the signal characteristic data from the transmitting target MS at such a location can consequently be archived with a verified location measurement performed at the site by the mobile location base station. Moreover, it is important to note that such a mobile location base station as its name implies also includes base station electronics for communicating with mobile stations, though not necessarily in the manner of a conventional infrastructure base station. In particular, a mobile location base station may only monitor signal characteristics, such as MS signal strength, from a target MS without transmitting signals to the target MS. Alternatively, a mobile location base station can periodically be in bi-directional communication with a target MS for determining a signal time-of-arrival (or time-difference-of-arrival) measurement between the mobile location base station and the target MS. Additionally, each such mobile location base station includes components for estimating the location of the mobile location base station, such mobile location base station location estimates being important when the mobile location base station is used for locating a target MS via, for example, time-of-arrival or time-difference-of-arrival measurements as one skilled in the art will appreciate. In particular, a mobile location base station can include:

(7.1) a mobile station (MS) for both communicating with other components of the present invention (such as a location processing center included in the present invention);

(7.2) a GPS receiver for determining a location of the mobile location base station;

(7.3) a gyroscope and other dead reckoning devices; and

(7.4) devices for operator manual entry of a mobile location base station location.

Furthermore, a mobile location base station includes modules for integrating or reconciling distinct mobile location base station location estimates that, for example, can be obtained using the components and devices of (7.1) through (7.4) above. That is, location estimates for the mobile location base station may be obtained from: GPS satellite data, mobile location base station data provided by the location processing center, dead reckoning data obtained from the mobile location base station vehicle dead reckoning devices, and location data manually input by an operator of the mobile location base station.

The location estimating system of the present invention offers many advantages over existing location systems. The system of the present invention, for example, is readily adaptable to existing wireless communication systems and can accurately locate people and/or objects in a cost effective manner. In particular, the present invention requires few, if any, modifications to commercial wireless communication systems for implementation. Thus, existing personal communication system infrastructure base stations and other components of, for example, commercial CDMA infrastructures are readily adapted to the present invention. The present invention can be used to locate people and/or objects that are not in the line-of-sight of a wireless receiver or transmitter, can reduce the detrimental effects of multipath on the accuracy of the location estimate, can potentially locate people and/or objects located indoors as well as outdoors, and uses a number of wireless stationary transceivers for location. The present invention employs a number of distinctly different location computational models for location which provides a greater degree of accuracy, robustness and versatility than is possible with existing systems. For instance, the location models provided include not only the radius-radius/TOA and TDOA techniques but also adaptive artificial neural net techniques. Further, the present invention is able to adapt to the topography of an area in which location service is desired. The present invention is also able to adapt to environmental changes substantially as frequently as desired. Thus, the present invention is able to take into account changes in the location topography over time without extensive manual data manipulation. Moreover, the present invention can be utilized with varying amounts of signal measurement inputs. Thus, if a location estimate is desired in a very short time interval (e.g., less than approximately one to two seconds), then the present location estimating system can be used with only as much signal measurement data as is possible to acquire during an initial portion of this time interval. Subsequently, after a greater amount of signal measurement data has been acquired, additional more accurate location estimates may be obtained. Note that this capability can be useful in the context of 911 emergency response in that a first quick course wireless mobile station location estimate can be used to route a 911 call from the mobile station to a 911 emergency response center that has responsibility for the area containing the mobile station and the 911 caller. Subsequently, once the 911 call has been routed according to this first quick location estimate, by continuing to receive additional wireless signal measurements, more reliable and accurate location estimates of the mobile station can be obtained.

Moreover, there are numerous additional advantages of the system of the present invention when applied in CDMA communication systems. The location system of the present invention readily benefits from the distinct advantages of the CDMA spread spectrum scheme, namely, these advantages include the exploitation of radio frequency spectral efficiency and isolation by (a) monitoring voice activity, (b) management of two-way power control, (c) provisioning of advanced variable-rate modems and error correcting signal encoding, (d) inherent resistance to fading, (e) enhanced privacy, and (f) multiple "rake" digital data receivers and searcher receivers for correlation of signal multipaths.

At a more general level, it is an aspect of the present invention to demonstrate the utilization of various novel computational paradigms such as:

(8.1) providing a multiple hypothesis computational architecture (as illustrated best in Fig. 8) wherein the hypotheses are:

(8.1.1) generated by modular independent hypothesizing computational models;

(8.1.2) the models are embedded in the computational architecture in a manner wherein the architecture allows for substantial amounts of application specific processing common or generic to a plurality of the models to be straightforwardly incorporated into the computational architecture;

(8.1.3) the computational architecture enhances the hypotheses generated by the models both according to past performance of the models and according to application specific constraints and heuristics without requiring feedback loops for adjusting the models;

(8.1.4) the models are relatively easily integrated into, modified and extracted from the computational architecture;

(8.2) providing a computational paradigm for enhancing an initial estimated solution to a problem by using this initial estimated solution as, effectively, a query or index into an historical data base of previous solution estimates and corresponding actual solutions for deriving an enhanced solution estimate based on past performance of the module that generated the initial estimated solution.

Note that the multiple hypothesis architecture provided herein is useful in implementing solutions in a wide range of applications. For example, the following additional applications are within the scope of the present invention:

(9.1) document scanning applications for transforming physical documents in to electronic forms of the documents. Note that in many cases the scanning of certain documents (books, publications, etc.) may have a 20% character recognition error rate. Thus, the novel computation architecture of the present invention can be utilized by (I) providing a plurality of document scanning models as the first order models, (ii) building a character recognition data base for archiving a correspondence between characteristics of actual printed character variations and the intended characters (according to, for example, font types), and additionally archiving a correspondence of performance of each of the models on previously encountered actual printed character variations (note, this is analogous to the Signature Data Base of the MS location application described herein), and (iii) determining any generic constraints and/or heuristics that are desirable to be satisfied by a plurality of the models. Accordingly, by comparing outputs from the first order document scanning models, a determination can be made as to whether further processing is desirable due to, for example, discrepancies between the output of the models. If further processing is desirable, then an embodiment of the multiple hypothesis architecture provided herein may be utilized to correct such discrepancies. Note that in comparing outputs from the first order document scanning models, these outputs may be compared at various granularities; e.g., character, sentence, paragraph or page;

(9.2) diagnosis and monitoring applications such as medical diagnosis/monitoring, communication network diagnosis/monitoring;

(9.3) robotics applications such as scene and/or object recognition;

(9.4) seismic and/or geologic signal processing applications such as for locating oil and gas deposits;

(9.5) Additionally, note that this architecture need not have all modules co-located. In particular, it is an additional aspect of the present invention that various modules can be remotely located from one another and communicate with one another via telecommunication transmissions such as telephony technologies and/or the Internet. Accordingly, the present invention is particularly adaptable to such distributed computing environments. For example, some number of the first order models may reside in remote locations and communicate their generated hypotheses via the Internet.

For instance, in weather prediction applications it is not uncommon for computational models to require large amounts of computational resources. Thus, such models running at various remote computational facilities can transfer weather prediction hypotheses (e.g., the likely path of a hurricane) to a site that performs hypothesis adjustments according to: (i) past performance of the each model; (ii) particular constraints and/or heuristics, and subsequently outputs a most likely estimate for a particular weather condition.

In an alternative embodiment of the present invention, the processing following the generation of location hypotheses (each having an initial location estimate) by the first order models may be such that this processing can be provided on Internet user nodes and the first order models may reside at Internet server sites. In this configuration, an Internet user may request hypotheses from such remote first order models and perform the remaining processing at his/her node.

In other embodiments of the present invention, a fast, abeit less accurate location estimate may be initially performed for very time critical location applications where approximate location information may be required. For example, less than 1 second response for a mobile station location embodiment of the present invention may be desired for 911 emergency response location requests. Subsequently, once a relatively course location estimate has been provided, a more accurate most likely location estimate can be performed by repeating the location estimation processing a second time with, e.g., additional with measurements of wireless signals transmitted between a mobile station to be located and a network of base stations with which the mobile station is communicating, thus providing a second, more accurate location estimate of the mobile station.

Additionally, note that it is within the scope of the present invention to provide one or more central location development sites that may be networked to, for example, geographically dispersed location centers providing location services according to the present invention, wherein the FOMs may be accessed, substituted, enhanced or removed dynamically via network connections (via, e.g., the Internet) with a central location development site. Thus, a small but rapidly growing municipality in substantially flat low density area might initially be provided with access to, for example, two or three FOMs for generating location hypotheses in the municipality's relatively uncluttered radio signaling environment. However, as the population density increases and the radio signaling environment becomes cluttered by, for example, thermal noise and multipath, additional or alternative FOMs may be transferred via the network to the location center for the municipality.

Note that in some embodiments of the present invention, since there a lack of sequencing between the FOMs and subsequent processing of location hypotheses, the FOMs can be incorporated into an expert system, if desired. For example, each FOM may be activated from an antecedent of an expert system rule. Thus, the antecedent for such a rule can evaluate to TRUE if the FOM outputs a location hypothesis, and the consequent portion of such a rule may put the output location hypothesis on a list of location hypotheses occurring in a particular time window for subsequent processing by the location center. Alternatively, activation of the FOMs may be in the consequents of such expert system rules. That is, the antecedent of such an expert system rule may determine if the conditions are appropriate for invoking the FOM(s) in the rule's consequent.

Of course, other software architectures may also to used in implementing the processing of the location center without departing from scope of the present invention. In particular, object-oriented architectures are also within the scope of the present invention. For example, the FOMs may be object methods on an MS location estimator object, wherein the estimator object receives substantially all target MS location signal data output by the signal filtering subsystem. Alternatively, software bus architectures are contemplated by the present invention, as one skilled in the art will understand, wherein the software architecture may be modular and facilitate parallel processing. Further features and advantages of the present invention are provided by the figures and detailed description accompanying this invention summary.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates various perspectives of radio propagation opportunities which may be considered in addressing correlation with mobile to base station ranging.

Fig. 2 shows aspects of the two-ray radio propagation model and the effects of urban clutter.

Fig. 3 provides a typical example of how the statistical power budget is calculated in design of a Commercial Mobile Radio Service Provider network.

Fig. 4 illustrates an overall view of a wireless radio location network architecture, based on AIN principles.

Fig. 5 is a high level block diagram of an embodiment of the present invention for locating a mobile station (MS) within a radio coverage area for the present invention.

Fig. 6 is a high level block diagram of the location center 142.

Fig. 7 is a high level block diagram of the hypothesis evaluator for the location center.

Fig. 8 is a substantially comprehensive high level block diagram illustrating data and control flows between the components of the location center, as well the functionality of the components.

Fig. 9 is a high level data structure diagram describing the fields of a location hypothesis object generated by the first order models 1224 of the location center.

Fig. 10 is a graphical illustration of the computation performed by the most likelihood estimator 1344 of the hypothesis evaluator.

Fig. 11 is a high level block diagram of the mobile base station (MBS).

Fig. 12 is a high level state transition diagram describing computational states the Mobile Base station enters during operation.

Fig. 13 is a high level diagram illustrating the data structural organization of the Mobile Base station capability for autonomously determining a most likely MBS location from a plurality of potentially conflicting MBS location estimating sources.

Fig. 14 shows one method of modeling CDMA delay spread measurement ensembles and interfacing such signals to a typical artificial neural network based FOM.

Fig. 15 illustrates the nature of RF "Dead Zones", notch area, and the importance of including location data signatures from the back side of radiating elements.

Figs. 16a through 16c present a table providing a brief description of the attributes of the location signature data type stored in the location signature data base 1320.

Figs. 17a through 17c present a high level flowchart of the steps performed by function, "UPDATE_LOC_SIG_DB," for updating location signatures in the location signature data base 1320; note, this flowchart corresponds to the description of this function in APPENDIX C.

Figs. 18a through 18b present a high level flowchart of the steps performed by function, "REDUCE_BAD_DB_LOC_SIGS," for updating location signatures in the location signature data base 1320; note, this flowchart corresponds to the description of this function in APPENDIX C.

Figs. 19a through 19b present a high level flowchart of the steps performed by function, "INCREASE_CONFIDENCE_OF_GOOD_DB_LOC_SIGS," for updating location signatures in the location signature data base 1320; note, this flowchart corresponds to the description of this function in APPENDIX C.

Figs. 20a through 20d present a high level flowchart of the steps performed by function, "DETERMINE_LOCATION_SIGNATURE_FIT_ERRORS," for updating location signatures in the location signature data base 1320; note, this flowchart corresponds to the description of this function in APPENDIX C.

Fig. 21 presents a high level flowchart of the steps performed by function, "ESTIMATE_LOC_SIG_FROM_DB," for updating location signatures in the location signature data base 1320; note, this flowchart corresponds to the description of this function in APPENDIX C.

Figs. 22a through 22b present a high level flowchart of the steps performed by function, "GET_AREA_TO_SEARCH," for updating location signatures in the location signature data base 1320; note, this flowchart corresponds to the description of this function in APPENDIX C.

Figs. 23a through 23b present a high level flowchart of the steps performed by function, "GET_DIFFERENCE_MEASUREMENT," for updating location signatures in the location signature data base 1320; note, this flowchart corresponds to the description of this function in APPENDIX C.

Fig. 24 is a high level illustration of context adjuster data structures and their relationship to the radio coverage area for the present invention;

Figs. 25a through 25b present a high level flowchart of the steps performed by the function, "CONTEXT_ADJUSTER," used in the context adjuster 1326 for adjusting mobile station estimates provided by the first order models 1224; this flowchart corresponds to the description of this function in APPENDIX D.

Figs. 26a through 26c present a high level flowchart of the steps performed by the function, "GET_ADJUSTED_LOC_HYP_LIST_FOR," used in the context adjuster 1326 for adjusting mobile station estimates provided by the first order models 1224; this flowchart corresponds to the description of this function in APPENDIX D.

Figs. 27a through 27b present a high level flowchart of the steps performed by the function, "CONFIDENCE_ADJUSTER," used in the context adjuster 1326 for adjusting mobile station estimates provided by the first order models 1224; this flowchart corresponds to the description of this function in APPENDIX D.

Fig. 28a and 28b presents a high level flowchart of the steps performed by the function, "GET_COMPOSITE_PREDICTION_MAPPED_CLUSTER_DENSITY," used in the context adjuster 1326 for adjusting mobile station estimates provided by the first order models 1224; this flowchart corresponds to the description of this function in APPENDIX D.

Figs. 29a through 29h present a high level flowchart of the steps performed by the function, "GET_PREDICTION_MAPPED_CLUSTER_DENSITY_FOR," used in the context adjuster 1326 for adjusting mobile station estimates provided by the first order models 1224; this flowchart corresponds to the description of this function in APPENDIX D.

Fig. 30 illustrates the primary components of the signal processing subsystem.

Fig. 31 illustrates how automatic provisioning of mobile station information from multiple CMRS occurs.

DETAILED DESCRIPTION

Detailed Description Introduction

Various digital wireless communication standards have been introduced such as Advanced Mobile Phone Service (AMPS), Narrowband Advanced Mobile Phone Service (NAMPS), code division multiple access (CDMA) and Time Division Multiple Access (TDMA) (e.g., Global Systems Mobile (GSM). These standards provide numerous enhancements for advancing the quality and communication capacity for wireless applications. Referring to CDMA, this standard is described in the Telephone Industries Association standard IS-95, for frequencies below 1 GHz, and in J-STD-008, the Wideband Spread-Spectrum Digital Cellular System Dual-Mode Mobile Station-Base station Compatibility Standard, for frequencies in the 1.8 - 1.9 GHz frequency bands. Additionally, CDMA general principles have been described, for example, in U.S. Patent 5,109,390, Diversity Receiver in a CDMA Cellular Telephone System by Gilhousen. There are numerous advantages of such digital wireless technologies such as CDMA radio technology. For example, the CDMA spread spectrum scheme exploits radio frequency spectral efficiency and isolation by monitoring voice activity, managing two-way power control, provision of advanced variable-rate modems and error correcting signal design, and includes inherent resistance to fading, enhanced privacy, and provides for multiple "rake" digital data receivers and searcher receivers for correlation of multiple physical propagation paths, resembling maximum likelihood detection, as well as support for multiple base station communication with a mobile station, i.e., soft or softer hand-off capability. When coupled with a location center as described herein, substantial improvements in radio location can be achieved. For example, the CDMA spread spectrum scheme exploits radio frequency spectral efficiency and isolation by monitoring voice activity, managing two-way power control, provision of advanced variable-rate modems and error correcting signal design, and includes inherent resistance to fading, enhanced privacy, and provides for multiple "rake" digital data receivers and searcher receivers for correlation of multiple physical propagation paths, resembling maximum likelihood detection, as well as support for multiple base station communication with a mobile station, i.e., soft hand-off capability. Moreover, this same advanced radio communication infrastructure can also be used for enhanced radio location. As a further example, the capabilities of IS-41 and AIN already provide a broad-granularity of wireless location, as is necessary to, for example, properly direct a terminating call to an MS. Such information, originally intended for call processing usage, can be re-used in conjunction with the location center described herein to provide wireless location in the large (i.e., to determine which country, state and city a particular MS is located) and wireless location in the small (i.e., which location, plus or minus a few hundred feet within one or more base stations a given MS is located).

Fig. 4 is a high level diagram of a wireless digital radiolocation intelligent network architecture for the present invention. Accordingly, this figure illustrates the interconnections between the components, for example, of a typical PCS network configuration and various components that are specific to the present invention. In particular, as one skilled in the art will understand, a typical wireless (PCS) network includes:

(a) a (large) plurality of conventional wireless mobile stations (MSs) 140 for at least one of voice related communication, visual (e.g., text) related communication, and according to present invention, location related communication;

(b) a mobile switching center (MSC) 112;

(c) a plurality of wireless cell sites in a radio coverage area 120, wherein each cell site includes an infrastructure base station such as those labeled 122 (or variations thereof such as 122A - 122D). In particular, the base stations 122 denote the standard high traffic, fixed location base stations used for voice and data communication with a plurality of MSs 140, and, according to the present invention, also used for communication of information related to locating such MSs 140. Additionally, note that the base stations labeled 152 are more directly related to wireless location enablement. For example, as described in greater detail hereinbelow, the base stations 152 may be low cost, low functionality transponders that are used primarily in communicating MS location related information to the location center 142 (via base stations 122 and the MSC 112). Note that unless stated otherwise, the base stations 152 will be referred to hereinafter as "location base station(s) 152" or simply "LBS(s) 152");

(d) a public switched telephone network (PSTN) 124 (which may include signaling system links 106 having network control components such as: a service control point (SCP) 104 , one or more signaling transfer points (STPs) 110.

Added to this wireless network, the present invention provides the following additional components:

(10.1) a location center 142 which is required for determining a location of a target MS 140 using signal characteristic values for this target MS;

(10.2) one or more mobile base stations 148 (MBS) which are optional, for physically traveling toward the target MS 140 or tracking the target MS;

(10.3) a plurality of location base stations 152 (LBS) which are optional, distributed within the radio coverage areas 120, each LBS 152 having a relatively small MS 140 detection area 154;

Since location base stations can be located on potentially each floor of a multi-story building, the wireless location technology described herein can be used to perform location in terms of height as well as by latitude and longitude.

In operation, the MS 140 may utilize one of the wireless technologies, CDMA, TDMA, AMPS, NAMPS or GSM techniques for radio communication with: (a) one or more infrastructure base stations 122, (b) mobile base station(s) 148 , (c) an LBS 152.

Referring to Fig. 4 again, additional detail is provided of typical base station coverage areas, sectorization, and high level components within a radio coverage area 120, including the MSC 112. Although base stations may be placed in any configuration, a typical deployment configuration is approximately in a cellular honeycomb pattern, although many practical tradeoffs exist, such as site availability, versus the requirement for maximal terrain coverage area. To illustrate, three such exemplary base stations (BSs) are 122A, 122B and 122C, each of which radiate referencing signals within their area of coverage 169 to facilitate mobile station (MS) 140 radio frequency connectivity, and various timing and synchronization functions. Note that some base stations may contain no sectors 130 (e.g. 122E), thus radiating and receiving signals in a 360 degree omnidirectional coverage area pattern, or the base station may contain "smart antennas" which have specialized coverage area patterns. However, the generally most frequent base stations 122 have three sector 130 coverage area patterns. For example, base station 122A includes sectors 130, additionally labeled a, b and c. Accordingly, each of the sectors 130 radiate and receive signals in an approximate 120 degree arc, from an overhead view. As one skilled in the art will understand, actual base station coverage areas 169 (stylistically represented by hexagons about the base stations 122) generally are designed to overlap to some extent, thus ensuring seamless coverage in a geographical area. Control electronics within each base station 122 are used to communicate with a mobile stations 140. Information regarding the coverage area for each sector 130, such as its range, area, and "holes" or areas of no coverage (within the radio coverage area 120), may be known and used by the location center 142 to facilitate location determination. Further, during communication with a mobile station 140, the identification of each base station 122 communicating with the MS 140 as well, as any sector identification information, may be known and provided to the location center 142.

In the case of the base station types 122, 148, and 152 communication of location information, a base station or mobility controller 174 (BSC) controls, processes and provides an interface between originating and terminating telephone calls from/to mobile station (MS) 140, and the mobile switch center (MSC) 112. The MSC 122, on-the-other-hand, performs various administration functions such as mobile station 140 registration, authentication and the relaying of various system parameters, as one skilled in the art will understand.

The base stations 122 may be coupled by various transport facilities 176 such as leased lines, frame relay, T-Carrier links, optical fiber links or by microwave communication links.

When a mobile station 140 (such as a CDMA, AMPS, NAMPS mobile telephone) is powered on and in the idle state, it constantly monitors the pilot signal transmissions from each of the base stations 122 located at nearby cell sites. Since base station/sector coverage areas may often overlap, such overlapping enables mobile stations 140 to detect, and, in the case of certain wireless technologies, communicate simultaneously along both the forward and reverse paths, with multiple base stations 122 and/or sectors 130. In Fig. 4 the constantly radiating pilot signals from base station sectors 130, such as sectors a, b and c of BS 122A, are detectable by mobile stations 140 within the coverage area 169 for BS 122A. That is, the mobile stations 140 scan for pilot channels, corresponding to a given base station/sector identifiers (IDs), for determining which coverage area 169 (i.e., cell) it is contained. This is performed by comparing signals strengths of pilot signals transmitted from these particular cell-sites.

The mobile station 140 then initiates a registration request with the MSC 112, via the base station controller 174. The MSC 112 determines whether or not the mobile station 140 is allowed to proceed with the registration process (except in the case of a 911 call, wherein no registration process is required). At this point calls may be originated from the mobile station 140 or calls or short message service messages can be received from the network. The MSC 112 communicates as appropriate, with a class 4/5 wireline telephony circuit switch or other central offices, connected to the PSTN 124 network. Such central offices connect to wireline terminals, such as telephones, or any communication device compatible with the line. The PSTN 124 may also provide connections to long distance networks and other networks.

The MSC 112 may also utilize IS/41 data circuits or trunks connecting to signal transfer point 110, which in turn connects to a service control point 104, via Signaling System #7 (SS7) signaling links (e.g., trunks) for intelligent call processing, as one skilled in the art will understand. In the case of wireless AIN services such links are used for call routing instructions of calls interacting with the MSC 112 or any switch capable of providing service switching point functions, and the public switched telephone network (PSTN) 124, with possible termination back to the wireless network.

Referring to Fig. 4 again, the location center (LC) 142 interfaces with the MSC 112 either via dedicated transport facilities 178, using for example, any number of LAN/WAN technologies, such as Ethernet, fast Ethernet, frame relay, virtual private networks, etc., or via the PSTN 124. The LC 142 receives autonomous (e.g., unsolicited) command/response messages regarding, for example: (a) the state of the wireless network of each service provider, (b) MS 140 and BS 122 radio frequency (RF) measurements, (c) any MBSs 148, (d) location applications requesting MS locations using the location center. Conversely, the LC 142 provides data and control information to each of the above components in (a) - (d). Additionally, the LC 142 may provide location information to an MS 140, via a BS 122. Moreover, in the case of the use of a mobile base station (MBS) 148, several communications paths may exist with the LC 142.

The MBS 148 acts as a low cost, partially-functional, moving base station, and is, in one embodiment, situated in a vehicle where an operator may engage in MS 140 searching and tracking activities. In providing these activities using CDMA, the MBS 148 provides a forward link pilot channel for a target MS 140, and subsequently receives unique BS pilot strength measurements from the MS 140. The MBS 148 also includes a mobile station for data communication with the LC 142, via a BS 122. In particular, such data communication includes telemetering the geographic position of the MBS 148 as well as various RF measurements related to signals received from the target MS 140. In some embodiments, the MBS 148 may also utilize multiple-beam fixed antenna array elements and/or a moveable narrow beam antenna, such as a microwave dish 182. The antennas for such embodiments may have a known orientation in order to further deduce a radio location of the target MS 140 with respect to an estimated current location of the MBS 148. As will be described in more detail herein below, the MBS 148 may further contain a global positioning system (GPS), distance sensors, dead-reckoning electronics, as well as an on-board computing system and display devices for locating both the MBS 148 of itself as well as tracking and locating the target MS 140. The computing and display provides a means for communicating the position of the target MS 140 on a map display to an operator of the MBS 148.

Each location base station (LBS) 152 is a low cost location device. Each such LBS 152 communicates with one or more of the infrastructure base stations 122 using one or more wireless technology interface standards. In some embodiments, to provide such LBS's cost effectively, each LBS 152 only partially or minimally supports the air-interface standards of the one or more wireless technologies used in communicating with both the BSs 122 and the MSs 140. Each LBS 152, when put in service, is placed at a fixed location, such as at a traffic signal, lamp post, etc., and wherein the location of the LBS may be determined as accurately as, for example, the accuracy of the locations of the infrastructure BSs 122. Assuming the wireless technology CDMA is used, each BS 122 uses a time offset of the pilot PN sequence to identify a forward CDMA pilot channel. In one embodiment, each LBS 152 emits a unique, time-offset pilot PN sequence channel in accordance with the CDMA standard in the RF spectrum designated for BSs 122, such that the channel does not interfere with neighboring BSs 122 cell site channels, nor would it interfere with neighboring LBSs 152. However, as one skilled in the art will understand, time offsets, in CDMA chip sizes, may be re-used within a PCS system, thus providing efficient use of pilot time offset chips, thereby achieving spectrum efficiency. Each LBS 152 may also contain multiple wireless receivers in order to monitor transmissions from a target MS 140. Additionally, each LBS 152 contains mobile station 140 electronics, thereby allowing the LBS to both be controlled by the LC 142, and to transmit information to the LC 142, via at least one neighboring BS 122.

As mentioned above, when the location of a particular target MS 140 is desired, the LC 142 can request location information about the target MS 140 from, for instance, one or more activated LBSs 152 in a geographical area of interest. Accordingly, whenever the target MS 140 is in such an area, or is suspected of being in the area, either upon command from the LC 142, or in a substantially continuous fashion, the LBS's pilot channel appears to the target MS 140 as a potential neighboring base station channel, and consequently, is placed, for example, in the CDMA neighboring set, or the CDMA remaining set, of the target MS 140 (as one familiar with the CDMA standards will understand).

During the normal CDMA pilot search sequence of the mobile station initialization state (in the target MS), the target MS 140 will, if within range of such an activated LBS 152, detect the LBS pilot presence during the CDMA pilot channel acquisition substate. Consequently, the target MS 140 performs RF measurements on the signal from each detected LBS 152. Similarly, an activated LBS 152 can perform RF measurements on the wireless signals from the target MS 140. Accordingly, each LBS 152 detecting the target MS 140 may subsequently telemeter back to the LC 142 measurement results related to signals from/to the target MS 140. Moreover, upon command, the target MS 140 will telemeter back to the LC 142 its own measurements of the detected LBSs 152, and consequently, this new location information, in conjunction with location related information received from the BSs 122, can be used to locate the target MS 140.

It should be noted that an LBS 152 will normally deny hand-off requests, since typically the LBS does not require the added complexity of handling voice or traffic bearer channels, although economics and peak traffic load conditions would dictate preference here. GPS timing information, needed by any CDMA base station, is either achieved via a the inclusion of a local GPS receiver or via a telemetry process from a neighboring conventional BS 122, which contains a GPS receiver and timing information. Since energy requirements are minimal in such an LBS 152, (rechargeable) batteries or solar cells may be used to power the LBS. No expensive terrestrial transport link is typically required since two-way communication is provided by the included MS 140 (or an electronic variation thereof). Thus, LBSs 152 may be placed in numerous locations, such as:

(a) in dense urban canyon areas (e.g., where signal reception may be poor and/or very noisy);

(b) in remote areas (e.g., hiking, camping and skiing areas);

(c) along highways (e.g., for emergency as well as monitoring traffic flow), and their rest stations; or

(d) in general, wherever more location precision is required than is obtainable using other wireless infrastruction network components.

Location Center - Network Elements API Description

A location application programming interface 136 (Fig. 4), or L-API, is required between the location center 142 (LC) and the mobile switch center (MSC) network element type, in order to send and receive various control, signals and data messages. The L-API should be implemented using a preferably high-capacity physical layer communications interface, such as IEEE standard 802.3 (10 baseT Ethernet), although other physical layer interfaces could be used, such as fiber optic ATM, frame relay, etc. Two forms of API implementation are possible. In the first case the signals control and data messages are realized using the MSC 112 vendor's native operations messages inherent in the product offering, without any special modifications. In the second case the L-API includes a full suite of commands and messaging content specifically optimized for wireless location purposes, which may require some, although minor development on the part of the MSC vendor.

Signal Processor Description

Referring to Fig. 30, the signal processing subsystem receives control messages and signal measurements and transmits appropriate control messages to the wireless network via the location applications programming interface referenced earlier, for wireless location purposes. The signal processing subsystem additionally provides various signal idintification, conditioning and pre-processing functions, including buffering, signal type classification, signal filtering, message control and routing functions to the location estimate modules.

There can be several combinations of Delay Spread/Signal Strength sets of measurements made available to the signal processing subsystem 20. In some cases the mobile station 140 (Fig. 1) may be able to detect up to three or four Pilot Channels representing three to four Base Stations, or as few as one Pilot Channel, depending upon the environment. Similarly, possibly more than one BS 122 can detect a mobile station 140 transmitter signal, as evidenced by the provision of cell diversity or soft hand-off in the CDMA standards, and the fact that multiple CMRS' base station equipment commonly will overlap coverage areas. For each mobile station 140 or BS 122 transmitted signal detected by a receiver group at a station, multiple delayed signals, or "fingers" may be detected and tracked resulting from multipath radio propagation conditions, from a given transmitter.

In typical spread spectrum diversity CDMA receiver design, the "first" finger represents the most direct, or least delayed multipath signal. Second or possibly third or fourth fingers may also be detected and tracked, assuming the mobile station contains a sufficient number of data receivers. Although traditional TOA and TDOA methods would discard subsequent fingers related to the same transmitted finger, collection and use of these additional values can prove useful to reduce location ambiguity, and are thus collected by the Signal Processing subsystem in the Location Center 142.

From the mobile receiver's perspective, a number of combinations of measurements could be made available to the Location Center. Due to the disperse and near-random nature of CDMA radio signals and propagation characteristics, traditional TOA/TDOA location methods have failed in the past, because the number of signals received in different locations area different. In a particularly small urban area, say less than 500 square feet, the number of RF signals and there multipath components may vary by over 100 percent.

Due to the large capital outlay costs associated with providing three or more overlapping base station coverage signals in every possible location, most practical digital PCS deployments result in fewer than three base station pilot channels being reportable in the majority of location areas, thus resulting in a larger, more amorphous location estimate. This consequence requires a family of location estimate location modules, each firing whenever suitable data has been presented to a model, thus providing a location estimate to a backend subsystem which resolves ambiguities.

In one embodiment of this invention using backend hypothesis resolution, by utilizing existing knowledge concerning base station coverage area boundaries (such as via the compilation a RF coverage database - either via RF coverage area simulations or field tests), the location error space is decreased. Negative logic Venn diagrams can be generated which deductively rule out certain location estimate hypotheses.

Although the forward link mobile station's received relative signal strength ($RRSS_{BS}$) of detected nearby base station transmitter signals can be used directly by the location estimate modules, the CDMA base station's reverse link received relative signal strength ($RRSS_{MS}$) of the detected mobile station transmitter signal must be modified prior to location estimate model use, since the mobile station transmitter power level changes nearly continuously, and would thus render relative signal strength useless for location purposes.

One adjustment variable and one factor value are required by the signal processing subsystem in the CDMA air interface case: 1.) instantaneous relative power level in dBm (IRPL) of the mobile station transmitter, and 2.) the mobile station Power Class. By adding the IRPL to the $RRSS_{MS}$, a synthetic relative signal strength ($SRSS_{MS}$) of the mobile station 140 signal detected at the BS 122 is derived, which can be used by location estimate model analysis, as shown below:

$$SRSS_{MS} = RRSS_{MS} + IRPL \qquad \text{(in dBm)}$$

$SRSS_{MS}$, a corrected indication of the effective path loss in the reverse direction (mobile station to BS), is now comparable with $RRSS_{BS}$ and can be used to provide a correlation with either distance or shadow fading because it now accounts for the change of the mobile station transmitter's power level. The two signals $RRSS_{BS}$ and $SRSS_{MS}$ can now be processed in a variety of ways to achieve a more robust correlation with distance or shadow fading.

Although Rayleigh fading appears as a generally random noise generator, essentially destroying the correlation value of either $RRSS_{BS}$ or $SRSS_{MS}$ measurements with distance individually, several mathematical operations or signal processing functions can be performed on each measurement to derive a more robust relative signal strength value, overcoming the adverse Rayleigh fading effects. Examples include averaging, taking the strongest value and weighting the strongest value with a greater coefficient than the weaker value, then averaging the results. This signal processing technique takes advantage of the fact that although a Rayleigh fade may often exist in either the forward or reverse path, it is much less probable that a Rayleigh fade also exists in the reverse or forward path, respectively. A shadow fade however, similiarly affects the signal strength in both paths.

At this point a CDMA radio signal direction-independent "net relative signal strength measurement" is derived which is used to establish a correlation with either distance or shadow fading, or both. Although the ambiguity of either shadow fading or distance cannot be determined, other means can be used in conjunction, such as the fingers of the CDMA delay spread measurement, and any other TOA/TDOA calculations from other geographical points. In the case of a mobile station with a certain amount of shadow fading between its BS 122 (Fig. 2), the first finger of a CDMA delay spread signal is most likely to be a relatively shorter duration than the case where the mobile station 140 and BS 122 are separated by a greater distance, since shadow fading does not materially affect the arrival time delay of the radio signal.

By performing a small modification in the control electronics of the CDMA base station and mobile station receiver circuitry, it is possible to provide the signal processing subsystem 20 (reference Fig. 30) within the Location scenter 142 (Fig. 1) with data that exceed the one-to-one CDMA delay-spread fingers to data receiver correspondence. Such additional information, in the form of additional CDMA fingers (additional multipath) and all associated detectable pilot channels, provides new information which is used to enhance to accuracy of the Location Center's location estimate location estimate modules.

This enhanced capability is provided via a control message, sent from the Location center 142 to the mobile switch center 12, and then to the base station(s) in communication with, or in close proximity with, mobile stations 140 to be located. Two types of location measurement request control messages are needed: one to instruct a target mobile station 140 (i.e., the mobile station to be located) to telemeter its BS pilot channel measurements back to the primary BS 122 and from there to the mobile switch center 112 and then to the location system 42. The second control message is sent from the location system 42 to the mobile switch center 112, then to first the primary BS, instructing the primary BS' searcher receiver to output (i.e., return to the initiating request message source) the detected target mobile station 140 transmitter CDMA pilot channel offset signal and their corresponding delay spread finger (peak) values and related relative signal strengths.

The control messages are implemented in standard mobile station 140 and BS 122 CDMA receivers such that all data results from the search receiver and multiplexed results from the associated data receivers are available for transmission back to the Location Center 142. Appropriate value ranges are required regarding mobile station 140 parameters T_ADD,, T_DROP,, and the ranges and values for the Active, Neighboring and Remaining Pilot sets registers, held within the mobile station 140 memory. Further mobile station 140 receiver details have been discussed above.

In the normal case without any specific multiplexing means to provide location measurements, exactly how many CDMA pilot channels and delay spread fingers can or should be measured vary according to the number of data receivers contained in each mobile station 140. As a guide, it is preferred that whenever RF characteristics permit, at least three pilot channels and the strongest first three fingers, are collected and processed. From the BS 122 perspective, it is preferred that the strongest first four CDMA delay spread fingers and the mobile station power level be collected and sent to the location system 42, for each of preferably three BSs 122 which can detect the mobile station 140. A much larger combination of measurements is potentially feasible using the extended data collection capability of the CDMA receivers.

Fig. 30 illustrates the components of the Signal Processing Subsystem. The main components consist of the input queue(s) 7, signal classifier/filter 9, digital signaling processor 17, imaging filters 19, output queue(s) 21, router/distributor 23, a signal processor database 26 and a signal processing controller 15.

Input queues 7 are required in order to stage the rapid acceptance of a significant amount of RF signal measurement data, used for either location estimate purposes or to accept autonomous location data. Each location request using fixed base stations may, in one embodiment, contain from 1 to 128 radio frequency measurements from the mobile station, which translates to approximately 61.44 kilobytes of signal measurement data to be collected within 10 seconds and 128 measurements from each of possibly four base stations, or 245.76 kilobytes for all base stations, for a total of approximately 640 signal measurements from the five sources, or 307.2 kilobytes to arrive per mobile station location request in 10 seconds. An input queue storage space is assigned at the moment a location request begins, in order to establish a formatted data structure in persistent store. Depending upon the urgency of the time required to render a location estimate, fewer or more signal measurement samples can be taken and stored in the input queue(s) 7 accordingly.

The signal processing subsystem supports a variety of wireless network signaling measurement capabilities by detecting the capabilities of the mobile and base station through messaging structures provided bt the location application programming interface. Detection is accomplished in the signal classifier 9 (Fig. 30) by referencing a mobile station database table within the signal processor database 26, which provides, given a mobile station identification number, mobile station revision code, other mobile station charactersitics. Similiarly, a mobile switch center table 31 provides MSC characteristics and identifications to the signal classifier/filter 9. The signal classifier/filter adds additional message header information that further classifies the measurement data which allows the digital signal processor and image filter components to select the proper internal processing subcomponents to perform operations on the signal measurement data, for use by the location estimate modules.

Regarding service control point messages autonomously received from the input queue 7, the signal classifier/filter 9 detemines via a signal processing database 26 query that the message is to be associated with a home base station module. Thus appropriate header information is added to the message, thus enabling the message to pass through the digital signal processor 17 unaffected to the output queu 21, and then to the router/distributor 23. The router/distributor 23 then routes the message to the HBS first order model. Those skilled in the art will understand that associating location requests from Home Base Station configurations require substantially less data: the mobile identification number and the associated wireline telephone number transmission from the home location register are on the order of less than 32 bytes. Consequentially the home base station message type could be routed without any digital signal processing.

Output queue(s) 21 are required for similar reasons as input queues 7: relatively large amounts of data must be held in a specific format for further location processing by the location estimate modules.

The router and distributor component 23 is responsible to directing specific signal measurement data types and structures to their appropriate modules. For example, the HBS FOM has no use for digital filtering structures, whereas the TDOA module would not be able to process an HBS response message.

The controller 15 is responsible for staging the movement of data among the signal processing subsystem 20 components input queue 7, digital signal processor 17, router/distributor 23 and the output queue 21, and to initiate signal measurments within the wireless network, in response from an internet 168 location request message in Fig. 1, via the location application programming interface.

In addition the controller 15 receives autonomous messages from the MSC, via the location applications programming interface (Fig. 1) or L-API and the input queue 7, whenever a 9-1-1 wireless call is originated. The mobile switch center provides this autonomous notification to the location system as follows: By specifiying the appropriate mobile switch center operations and maintenance commands to surveil calls based on certain digits dialed such as 9-1-1, the location applications programming interface, in communications with the MSCs, receives an autonomous notification whenever a mobile station user dials 9-1-1. Specifically, a bi-directional authorized communications port is configured, usually at the operations and maintenance subsystem of the MSCs, or with their associated network element manager system(s), with a data circuit, such as a DS-1, with the location applications programming interface in Fig. 1. Next, the "call trace" capability of the mobile switch center is activated for the respective communications port. The exact implementation of the vendor-specific man-machine or Open Systems Interface (OSI) commands(s) and their associated data structures generally vary among MSC vendors, however the trace function is generally available in various forms, and is required in order to comply with Federal Bureau of Investigation authorities for wire tap purposes. After the appropriate surveillance commands are established on the MSC, such 9-1-1 call notifications messages containing the mobile station identification number (MIN) and, in phase 1 E9-1-1 implementations, a pseudo-automatic number identication (a.k.a. pANI) which provides an association with the primary base station in which the 9-1-1 caller is in communicaiton. In cases where the pANI is known from the onset, the signal processing subsystem avoids querying the MSC in question to determine the primary base station identification associated with the 9-1-1 mobile station caller.

After the signal processing controller 15 receives the first message type, the autonomous notification message from the mobile switch center 112 to the location system 42, containing the mobile identification number and optionally the primary base station identification, the controller 15 queries the base station table 13 in the signal processor database 26 to determine the status and availability of any neighboring base stations, including those base stations of other CMRS in the area. The definition of neighboring base stations include not only those within a provisionable "hop" based on the cell design reuse factor, but also includes, in the case of CDMA, results from remaining set information autonomously queried to mobile stations, with results stored in the base station table. Remaining set information indicates that mobile stations can detect other base station (sector) pilot channels which may exceed the "hop" distance, yet are nevertheless candidate base stations (or sectors) for wireless location purposes. Although cellular and digital cell design may vary, "hop" distance is usually one or two cell coverage areas away from the primary base station's cell coverage area.

Having determined a likely set of base stations which may both detect the mobile station's transmitter signal, as well as to determine the set of likely pilot channels (i.e., base stations and their associated physical antenna sectors) detectable by the mobile station in the area surrounding the primary base station (sector), the controller 15 initiates messages to both the mobile station and appropriate base stations (sectors) to perform signal measurements and to return the results of such measurements to the signal processing system regarding the mobile station to be located. This step may be accomplished via several interface means. In a first case the controller 15 utilizes, for a given MSC, predetermined storage information in the MSC table 31 to determine which type of commands, such as man-machine or OSI commands are needed to request such signal measrurements for a given MSC. The controller generates the mobile and base station signal measurement commands appropriate for the MSC and passes the commands via the input queue 7 and the locations application programming interface in Fig.1, to the appropriate MSC, using the authorized communications port mentioned earlier. In a second case the controller 15 communicates directly with base stations within having to interface directly with the MSC for signal measurement extraction.

Upon receipt of the signal measurements, the signal classifier 9 in Fig. 30 examines location application programming interface-provided message header information from the source of the location measurement (for example, from a fixed BS 122, a mobile station 140, a distributed antenna system 168 in Fig. 1 or message location data related to a home base station), provided by the location applications programming interface (L-API) via the input queue 7 in Fig. 30 and determines whether or not device filters 17 or image filters 19 are needed, and assesses a relative priority in processing, such as an emergency versus a background location task, in terms of grouping like data associated with a given location request. In the case where multiple signal measurement requests are outstanding for various base stations, some of which may be associated with a different CMRS network, and additional signal classifier function includes sorting and associating the appropriate incoming signal measurements together such that the digital signal processor 17 processes related measurements in order to build ensemble data sets. Such ensembles allow for a variety of functions such as averaging, outlier removal over a timeperiod, and related filtering functions, and further prevent association errors from occuring in location estimate processing.

Another function of the signal classifier/low pass filter component 9 is to filter information that is not useable, or information that could introduce noise or the effect of noise in the location estimate modules. Consequently low pass matching filters are used to match the in-common signal processing components to the characteristics of the incoming signals. Low pass filters match: Mobile Station, base station, CMRS and MSC characteristics, as wall as to classify Home Base Station messages.

The signal processing subsystemcontains a base station database table 13 (Fig. 30) which captures the maximum number of CDMA delay spread fingers for a given base station.

The base station identification code, or CLLI or common language level identification code is useful in identifying or relating a human-labeled name descriptor to the Base Station. Latitude, Longitude and elevation values are used by other subsystems in the location system for calibration and estimation purposes. As base stations and/or receiver characteristics are added, deleted, or changed with respect to the network used for location purposes, this database table must be modified to reflect the current network configuration.

Just as an upgraded base station may detect additional CDMA delay spread signals, newer or modified mobile stations may detect additional pilot channels or CDMA delay spread fingers. Additionally different makes and models of mobile stations may acquire improved receiver sensitivities, suggesting a greater coverage capability. The table below establishes the relationships among various mobile station equipment suppliers and certain technical data relevant to this location invention.

Although not strictly necessary, The MIN can be populated in this table from the PCS Service Provider's Customer Care system during subscriber activation and fulfillment, and could be changed at deactivation, or anytime the end-user changes mobile stations. Alternatively, since the MIN, manufacturer, model number, and software revision level information is available during a telephone call, this information could extracted during the call, and the remaining fields populated dynamically, based on manufacturer's' specifications information previously stored in the signal processing subsystem 20. Default values are used in cases where the MIN is not found, or where certain information must be estimated.

A low pass mobile station filter, contained within the signal classifier/low pass filter 9 of the signal processing subsystem 20, uses the above table data to perform the following functions: 1) act as a low pass filter to adjust the nominal assumptions related to the maximum number of CDMA fingers, pilots detectable; and 2) to determine the transmit power class and the receiver thermal noise floor. Given the detected reverse path signal strength, the required value of $SRSS_{MS}$, a corrected indication of the effective path loss in the reverse direction (mobile station to BS), can be calculated based data contained within the mobile station table 11, stored in the signal processing database 26.

The effects of the maximum Number of CDMA fingers allowed and the maximum number of pilot channels allowed essentially form a low pass filter effect, wherein the least common denominator of characteristics are used to filter the incoming RF signal measurements such that a one for one matching occurs. The effect of the transmit power class and receiver thermal noise floor values is to normalize the characteristics of the incoming RF signals with respect to those RF signals used.

The signal classifier/filter 20 is in communication with both the input queue 7 and the signal processing database 26. In the early stage of a location request the signal processing subsystem 142 in Fig. 4, will receive the initiating location request from either an autonomous 9-1-1 notification message from a given MSC, or from a location application (for example, see Fig. 36), for which mobile station characteristics about the target mobile station 140 (Fig. 1) is required. Referring to Fig. 30, a query is made from the signal processing controller 15 to the signal processning database 26, specifically the mobile station table 11, to determine if the mobile station characteristics associated with the MIN to be located is available in table 11. if the data exists then there is no need for the controller 15 to query the wireless network in order to determine the mobile station characteristics, thus avoiding additional real-time processing which would otherwise be required across the air interface, in order to determine the mobile station MIN characteristics. The resulting mobile station information my be provided either via the signal processing database 26 or alternatively a query may be performed directly from the signal processing subsystem 20 to the MSC in order to determine the mobile station characteristics.

Referring now to Fig. 31, a location application programming interface, L-API-CCS 139 to the appropriate CMRS customer care system provides the mechanism to populate and update the mobile station table 11 within the database 26. The L-API-CCS 139 contains its own set of separate input and output queues or similar implementations and security controls to ensure that provisioning data is not sent to the incorrect CMRS, and that a given CMRS cannot access any other CMRS' data. The interface 1155a to the customer care system for CMRS-A 1150a provides an autonomous or periodic notification and response application layer protocol type, consisting of add, delete, change and verify message functions in order to update the mobile station table 11 within the signal processing database 26, via the controller 15. A similar interface 1155b is used to enable provisioning updates to be received from CMRS-B customer care system 1150b.

Although the L-API-CCS application message set may be any protocol type which supports the autonomous notification message with positive acknowledgment type, the T1M1.5 group within the American National Standards Institute has defined a good starting point in which the L-API-CCS could be implemented, using the robust OSI TMN X-interface at the service management layer. The object model defined in Standards proposal number T1M1.5/96-22R9, Operations Administration, Maintenance, and Provisioning (OAM&P) - Model for Interface Across Jurisdictional Boundaries to Support Electronic Access Service Ordering: Inquiry Function, can be extended to support the L-API-CCS information elements as required and further discussed below. Other choices in which the L-API-CCS application message set may be implemented include ASCII, binary, or any encrypted message set encoding using the Internet protocols, such as TCP/IP, simple network management protocol, http, https, and email protocols.

Referring to the digital signal processor (DSP) 17, in communication with the signal classifier/LP filter 9, the DSP 17 provides a time series expansion method to convert non-HBS data from a format of an signal measure data ensemble of time-series based radio frequency data measurements, collected as discrete time-slice samples, to a three dimensional matrix location data value image representation. Other techniques further filter the resultant image in order to furnish a less noisy training and actual data sample to the location estimate modules.

After 128 samples (in one embodiment) of data are collected of the delay spread-relative signal strength RF data measurement sample: mobile station RX for BS-1 and grouped into a quantization matrix, where rows constitute relative signal strength intervals and columns define delay intervals. As each measurement row, column pair (which could be represented as a complex number or Cartesian point pair) is added to their respective values to generate a Z direction of frequency of recurring measurement value pairs or a density recurrence function. By next applying a grid function to each x, y, and z value, a three-dimensional surface grid is generated, which represents a location data value or unique print of that 128-sample measurement.

In the general case where a mobile station is located in an environment with varied clutter patterns, such as terrain undulations, unique man-made structure geometries (thus creating varied multipath signal behaviors), such as a city or suburb, although the first CDMA delay spread finger may be the same value for a fixed distance between the mobile station and BS antennas, as the mobile station moves across such an arc, different finger-data are measured. In the right image for the defined BS antenna sector, location classes, or squares numbered one through seven, are shown across a particular range of line of position (LOP).

A traditional TOA/TDOA ranging method between a given BS and mobile station only provides a range along the arc, thus introducing ambiguity error. However a unique three dimensional image can be used in this method to specifically identify, with recurring probability, a particular unique location class along the same Line Of Position, as long as the multipath is unique by position but generally repeatable, thus establishing a method of not only ranging, but also of complete latitude, longitude location estimation in a Cartesian space. In other words, the unique shape of the "mountain image" enables a correspondence to a given unique location class along a line of position, thereby eliminating traditional ambiguity error.

Although man-made external sources of interference, Rayleigh fades, adjacent and co-channel interference, and variable clutter, such as moving traffic introduce unpredictability (thus no "mountain image" would ever be exactly alike), three basic types of filtering methods can be used to reduce matching/comparison error from a training case to a location request case: 1.) select only the strongest signals from the forward path (BS to mobile station) and reverse path (mobile station to BS), 2.) Convolute the forward path 128 sample image with the reverse path 128 sample image, and 3.) process all image samples through various digital image filters to discard noise components.

In one embodiment, convolution of forward and reverse images is performed to drive out noise. This is one embodiment that essentially nulls noise completely, even if strong and recurring, as long as that same noise characteristic does not occur in the opposite path.

The third embodiment or technique of processing CDMA delay spread profile images through various digital image filters, provides a resultant "image enhancement" in the sense of providing a more stable pattern recognition paradigm to the neural net location estimate model. For example, image histogram equalization can be used to rearrange the images' intensity values, or density recurrence values, so that the image's cumulative histogram is approximately linear.

Other methods which can be used to compensate for a concentrated histogram include: 1) Input Cropping, 2) Output Cropping and 3) Gamma Correction. Equalization and input cropping can provide particularly striking benefits to a CDMA delay spread profile image. Input cropping removes a large percentage of random signal characteristics that are non-recurring.

Other filters and/or filter combinations can be used to help distinguish between stationary and variable clutter affecting multipath signals. For example, it is desirable to reject multipath fingers associated with variable clutter, since over a period of a few minutes such fingers would not likely recur. Further filtering can be used to remove recurring (at least during the sample period), and possibly strong but narrow "pencils" of RF energy. A narrow pencil image component could be represented by a near perfect reflective surface, such as a nearby metal panel truck stopped at a traffic light.

On the other hand, stationary clutter objects, such as concrete and glass building surfaces, adsorb some radiation before continuing with a reflected ray at some delay. Such stationary clutter-affected CDMA fingers are more likely to pass a 4X4 neighbor Median filter as well as a 40 to 50 percent Input Crop filter, and are thus more suited to neural net pattern recognition.. However when subjected to a 4X4 neighbor Median filter and 40 percent clipping, pencil-shaped fingers are deleted. Other combinations include, for example, a 50 percent cropping and 4X4 neighbor median filtering. Other filtering methods include custom linear filtering, adaptive (Weiner) filtering, and custom nonlinear filtering.

The DSP 17 may provide data emsemble results, such as extracting the shortest time delay with a detectable relative signal strength, to the router/distributor 23, or alternatively results may be processed via one or more image filters 19, with subsequent transmission to the router/distributor 23. The router/distributor 23 examines the processed message data from the DSP 17 and stores routing and distribution information in the message header. The router/distributor 23 then forwards the data messages to the output queue 21, for subsequent queuing then transmission to the appropriate location estimator FOMs.

LOCATION CENTER HIGH LEVEL FUNCTIONALITY

At a very high level the location center 142 computes location estimates for a wireless Mobile Station 140 (denoted the "target MS" or "MS") by performing the following steps:

(23.1) receiving signal transmission characteristics of communications communicated between the target MS 140 and one or more wireless infrastructure base stations 122;

(23.2) filtering the received signal transmission characteristics (by a signal processing subsystem 1220 illustrated in Fig. 5) as needed so that target MS location data can be generated that is uniform and consistent with location data generated from other target MSs 140. In particular, such uniformity and consistency is both in terms of data structures and interpretation of signal characteristic values provided by the MS location data;

(23.3) inputting the generated target MS location data to one or more MS location estimating models (denoted First order models or FOMs, and labeled collectively as 1224 in Fig. 5), so that each such model may use the input target MS location data for generating a "location hypothesis" providing an estimate of the location of the target MS 140;

(23.4) providing the generated location hypotheses to an hypothesis evaluation module (denoted the hypothesis evaluator 1228 in Fig. 5):

(a) for adjusting at least one of the target MS location estimates of the generated location hypotheses and related confidence values indicating the confidence given to each location estimate, wherein such adjusting uses archival information related to the accuracy of previously generated location hypotheses,

(b) for evaluating the location hypotheses according to various heuristics related to, for example, the radio coverage area 120 terrain, the laws of physics, characteristics of likely movement of the target MS 140; and

(c) for determining a most likely location area for the target MS 140, wherein the measurement of confidence associated with each input MS location area estimate is used for determining a "most likely location area"; and

(23.5) outputting a most likely target MS location estimate to one or more applications 1232 (Fig. 2.0) requesting an estimate of the location of the target MS 140.

Location Hypothesis Data Representation

In order to describe how the steps (23.1) through (23.5) are performed in the sections below, some introductory remarks related to the data denoted above as location hypotheses will be helpful. Additionally, it will also be helpful to provide introductory remarks related to historical location data and the data base management programs associated therewith.

For each target MS location estimate generated and utilized by the present invention, the location estimate is provided in a data structure (or object class) denoted as a "location hypothesis" (illustrated in Table LH-1). Although brief descriptions of the data fields for a location hypothesis is provided in the Table LH-1, many fields require additional explanation. Accordingly, location hypothesis data fields are further described as noted below.

Table LH-1

FOM_ID	First order model ID (providing this Location Hypothesis); note, since it is possible for location hypotheses to be generated by other than the FOMs 1224, in general, this field identifies the module that generated this location hypothesis.
MS_ID	The identification of the target MS 140 to this location hypothesis applies.
pt_est	The most likely location point estimate of the target MS 140.
valid_pt	Boolean indicating the validity of "pt_est".

area_est	Location Area Estimate of the target MS 140 provided by the FOM. This area estimate will be used whenever "image_area" below is NULL.
valid_area	Boolean indicating the validity of "area_est" (one of "pt_est" and "area_est" must be valid).
adjust	Boolean (true if adjustments to the fields of this location hypothesis are to be performed in the Context adjuster Module).
pt_covering	Reference to a substantially minimal area (e.g., mesh cell) covering of "pt_est". Note, since this MS 140 may be substantially on a cell boundary, this covering may, in some cases, include more than one cell.
image_area	Reference to a substantially minimal area (e.g., mesh cell) covering of "pt_covering" (see detailed description of the function, "confidence_adjuster"). Note that if this field is not NULL, then this is the target MS location estimate used by the location center 142 instead of "area_est".
extrapolation_area	Reference to (if non-NULL) an extrapolated MS target estimate area provided by the location extrapolator submodule 1432 of the hypothesis analyzer 1332. That is, this field, if non-NULL, is an extrapolation of the "image_area" field if it exists, otherwise this field is an extrapolation of the "area_est" field. Note other extrapolation fields may also be provided depending on the embodiment of the present invention, such as an extrapolation of the "pt_covering".
confidence	A real value in the range [-1.0, +1.0] indicating a likelihood that the target MS 140 is in (or out) of a particular area. If positive: if "image_area" exists, then this is a measure of the likelihood that the target MS 140 is within the area represented by "image_area", or if "image_area" has not been computed (e.g., "adjust" is FALSE), then "area_est" must be valid and this is a measure of the likelihood that the target MS 140 is within the area represented by "area_est". If negative, then "area_est" must be valid and this is a measure of the likelihood that the target MS 140 is NOT in the area represented by "area_est". If it is zero (near zero), then the likelihood is unknown.
Original_Timestamp	Date and time that the location signature cluster (defined hereinbelow) for this location hypothesis was received by the signal processing subsystem 1220.
Active_Timestamp	Run-time field providing the time to which this location hypothesis has had its MS location [illegible]

	estimate(s) extrapolated (in the location extrapolator 1432 of the hypothesis analyzer 1332). Note that this field is initialized with the value from the "Original_Timestamp" field.
Processing Tags and environmental categorizations	For indicating particular types of environmental classifications not readily determined by the "Original_Timestamp" field (e.g., weather, traffic), and restrictions on location hypothesis processing.
loc_sig_cluster	Provides access to the collection of location signature signal characteristics derived from communications between the target MS 140 and the base station(s) detected by this MS (discussed in detail hereinbelow); in particular, the location data accessed here is provided to the first order models by the signal processing subsystem 1220; i.e., access to the "loc sigs" (received at "timestamp" regarding the location of the target MS)
descriptor	Original descriptor (from the First order model indicating why/how the Location Area Estimate and Confidence Value were determined).

As can be seen in the Table LH-1, each location hypothesis data structure includes at least one measurement, denoted hereinafter as a confidence value (or simply confidence), that is a measurement of the perceived likelihood that an MS location estimate in the location hypothesis is an accurate location estimate of the target MS 140. Since such confidence values are an important aspect of the present invention, much of the description and use of such confidence values are described below; however, a brief description is provided here. Each such confidence value is in the range -1.0 to 1.0, wherein the larger the value, the greater the perceived likelihood that the target MS 140 is in (or at) a corresponding MS location estimate of the location hypothesis to which the confidence value applies. As an aside, note that a location hypothesis may have more than one MS location estimate (as will be discussed in detail below) and the confidence value will typically only correspond or apply to one of the MS location estimates in the location hypothesis. Further, values for the confidence value field may be interpreted as: (a) -1.0 may be interpreted to mean that the target MS 140 is NOT in such a corresponding MS area estimate of the location hypothesis area, (b) 0 may be interpreted to mean that it is unknown as to the likelihood of whether the MS 140 in the corresponding MS area estimate, and (c) +1.0 may be interpreted to mean that the MS 140 is perceived to positively be in the corresponding MS area estimate.

Additionally, note that it is within the scope of the present invention that the location hypothesis data structure may also include other related "perception" measurements related to a likelihood of the target MS 140 being in a particular MS location area estimate. For example, it is within the scope of the present invention to also utilize measurements such as, (a) "sufficiency factors" for indicating the likelihood that an MS location estimate of a location hypothesis is sufficient for locating the target MS 140; (b) "necessity factors" for indicating the necessity that the target MS be in an particular area estimate. However, to more easily describe the present invention, a single confidence field is used having the interpretation given above.

Additionally, in utilizing location hypotheses in, for example, the location evaluator 1228 as in (23.4) above, it is important to keep in mind that each location hypothesis confidence value is a relative measurement. That is, for confidences, cf_1 and cf_2, if $cf_1 <= cf_2$, then for a location hypotheses H_1 and H_2 having cf_1 and cf_2, respectively, the target MS 140 is expected to more likely reside in a target MS estimate of H_2 than a target MS estimate of H_1. Moreover, if an area, A, is such that it is included in a plurality of location hypothesis target MS estimates, then a confidence score, CS_A, can be assigned to A, wherein the confidence score for such an area is a function of the confidences (both positive and negative) for all the location hypotheses whose (most pertinent) target MS location estimates contain A. That is, in order to determine a most likely target MS location area estimate for outputting from the location center 142, a confidence score is determined for areas within the location center service area. More particularly, if a function, "f", is a function of the confidence(s) of location hypotheses, and f is a monotonic function in its parameters and $f(cf_1, cf_2, cf_3, \ldots, cf_N) = CS_A$ for confidences cf_i of location hypotheses H_i, $i=1,2,\ldots,N$, with CS_A contained in the area estimate for H_i, then "f" is denoted a confidence score function. Accordingly, there are many embodiments for a confidence score function f that may be utilized in computing confidence scores with the present invention; e.g.,

(a) $f(cf_1, cf_2, \ldots, cf_N) = S\, cf_i = CS_A$;

(b) $f(cf_1, cf_2, \ldots, cf_N) = S\, cf_i^n = CS_A$, $n = 1, 3, 5, \ldots$;

(c) $f(cf_1, cf_2, \ldots, cf_N) = S\, (K_i * cf_i) = CS_A$, wherein K_i, $i = 1, 2, \ldots$ are positive system (tunable) constants (possibly dependent on environmental characteristics such as topography, time, date, traffic, weather, and/or the type of base station(s) 122 from which location signatures with the target MS 140 are being generated, etc.).

For the present description of the invention, the function f as defined in (c) immediately above is utilized. However, for obtaining a general understanding of the present invention, the simpler confidence score function of (a) may be more useful. It is important to note, though, that it is within the scope of the present invention to use other functions for the confidence score function.

Coverage Area: Area Types And Their Determination

The notion of "area type" as related to wireless signal transmission characteristics has been used in many investigations of radio signal transmission characteristics. Some investigators, when investigating such signal characteristics of areas have used somewhat naive area classifications such as urban, suburban, rural, etc. However, it is desirable for the purposes of the present invention to have a more operational definition of area types that is more closely associated with wireless signal transmission behaviors.

To describe embodiments of the an area type scheme used in the present invention, some introductory remarks are first provided. Note that the wireless signal transmission behavior for an area depends on at least the following criteria:

(23.8.1) substantially invariant terrain characteristics (both natural and man-made) of the area; e.g., mountains, buildings, lakes, highways, bridges, building density;

(23.8.2) time varying environmental characteristics (both natural and man-made) of the area; e.g., foliage, traffic, weather, special events such as baseball games;

(23.8.3) wireless communication components or infrastructure in the area; e.g., the arrangement and signal communication characteristics of the base stations 122 in the area. Further, the antenna characteristics at the base stations 122 may be important criteria.

Accordingly, a description of wireless signal characteristics for determining area types could potentially include a characterization of wireless signaling attributes as they relate to each of the above criteria. Thus, an area type might be: hilly, treed, suburban, having no buildings above 50 feet, with base stations spaced apart by two miles. However, a categorization of area types is desired that is both more closely tied to the wireless signaling characteristics of the area, and is capable of being computed substantially automatically and repeatedly over time. Moreover, for a wireless location system, the primary wireless signaling characteristics for categorizing areas into at least minimally similar area types are: thermal noise and, more importantly, multipath characteristics (e.g., multipath fade and time delay).

Focusing for the moment on the multipath characteristics, it is believed that (23.8.1) and (23.8.3) immediately above are, in general, more important criteria for accurately locating an MS 140 than (23.8.2). That is, regarding (23.8.1), multipath tends to increase as the density of nearby vertical area changes increases. For example, multipath is particularly problematic where there is a high density of high rise buildings and/or where there are closely spaced geographic undulations. In both cases, the amount of change in vertical area per unit of area in a horizontal plane (for some horizontal reference plane) may be high. Regarding (23.8.3), the greater the density of base stations 122, the less problematic multipath may become in locating an MS 140. Moreover, the arrangement of the base stations 122 in the radio coverage area 120 in Fig. 4 may affect the amount and severity of multipath.

Accordingly, it would be desirable to have a method and system for straightforwardly determining area type classifications related to multipath, and in particular, multipath due to (23.8.1) and (23.8.3). The present invention provides such a determination by utilizing a novel notion of area type, hereinafter denoted "transmission area type" (or, "(transmission) area type" when both a generic area type classification scheme and the transmission area type discussed hereinafter are intended) for classifying "similar" areas, wherein each transmission area type class or category is intended to describe an area having at least minimally similar wireless signal transmission characteristics. That is, the novel transmission area type scheme of the present invention is based on: (a) the terrain area classifications; e.g., the terrain of an area surrounding a target MS 140, (b) the configuration of base stations 122 in the radio coverage area 120, and (c) characterizations of the wireless signal transmission paths between a target MS 140 location and the base stations 122.

In one embodiment of a method and system for determining such (transmission) area type approximations, a partition (denoted hereinafter as P_0) is imposed upon the radio coverage area 120 for partitioning for radio coverage area into subareas, wherein each subarea is an estimate of an area having included MS 140 locations that are likely to have is at least a minimal amount of similarity in their wireless signaling characteristics. To obtain the partition P_0 of the radio coverage area 120, the following steps are performed:

(23.8.4.1) Partition the radio coverage area 120 into subareas, wherein in each subarea is: (a) connected, (b) variations in the lengths of chords sectioning the subarea through the centroid of the subarea are below a predetermined threshold, (c) the subarea has an area below a predetermined value, and (d) for most locations (e.g., within a first or second deviation) within the subarea whose wireless signaling characteristics have been verified, it is likely (e.g., within a first or second deviation) that an MS 140 at one of these locations will detect (forward transmission path) and/or will be detected (reverse transmission path) by a same collection of base stations 122. For example, in a CDMA context, a first such collection may be (for the forward transmission path) the active set of base stations 122, or, the union of the active and candidate sets, or, the union of the active, candidate and/or remaining sets of base stations 122 detected by "most" MSs 140 in . Additionally (or alternatively), a second such collection may be the base stations 122 that are expected to detect MSs 140 at locations within the subarea. Of course, the union or intersection of the first and second collections is also within the scope of the present invention for partitioning the radio coverage area 120 according to (d) above. It is worth noting that it is believed that base station 122 power levels will be substantially constant. However, even if this is not the case, one or more collections for (d) above may be determined empirically and/or by computationally simulating the power output of each base station 122 at a predetermined level. Moreover, it is also worth mentioning that this step is relatively straightforward to implement using the data stored in the location signature data base 1320 (i.e., the verified location signature clusters discussed in detail hereinbelow). Denote the resulting partition here as P_1.

(23.8.4.2) Partition the radio coverage area 120 into subareas, wherein each subarea appears to have substantially homogeneous terrain characteristics. Note, this may be performed periodically substantially automatically by scanning radio coverage area images obtained from aerial or satellite imaging. For example, EarthWatch Inc. of Longmont, CO can provide geographic with 3 meter resolution from satellite imaging data. Denote the resulting partition here as P_2.

(23.8.4.3) Overlay both of the above partitions of the radio coverage area 120 to obtain new subareas that are intersections of the subareas from each of the above partitions. This new partition is P_0 (i.e., $P_0 = P_1$ intersect P_2), and the subareas of it are denoted as "P_0 subareas".

Now assuming P_0 has been obtained, the subareas of P_0 are provided with a first classification or categorization as follows:

(23.8.4.4) Determine an area type categorization scheme for the subareas of P_1. For example, a subarea, A, of P_1, may be categorized or labeled according to the number of base stations 122 in each of the collections used in (23.8.4.1)(d) above for determining subareas of P_1. Thus, in one such categorization scheme, each category may correspond to a single number x (such as 3), wherein for a subarea, A, of this category, there is a group of x (e.g., three) base stations 122 that are expected to be detected by a most target MSs 140 in the area A. Other embodiments are also possible, such as a categorization scheme wherein each category may correspond to a triple: of numbers such as (5, 2, 1), wherein for a subarea A of this category, there is a common group of 5 base stations 122 with two-way signal detection expected with most locations (e.g., within a first or second deviation) within A, there are 2 base stations that are expected to be detected by a target MS 140 in A but these base stations can not detect the target MS, and there is one base station 122 that is expected to be able to detect a target MS in A but not be detected.

(23.8.4.5) Determine an area type categorization scheme for the subareas of P_2. Note that the subareas of P_2 may be categorized according to their similarities. In one embodiment, such categories may be somewhat similar to the naive area types mentioned above (e.g., dense urban, urban, suburban, rural, mountain, etc.). However, it is also an aspect of the present invention that more precise categorizations may be used, such as a category for all areas having between 20,000 and 30,000 square feet of vertical area change per 11,000 square feet of horizontal area and also having a high traffic volume (such a category likely corresponding to a "moderately dense urban" area type).

(23.8.4.6) Categorize subareas of P_0 with a categorization scheme denoted the "P_0 categorization," wherein for each P_0 subarea, A, of P_0 a "P_0 area type" is determined for A according to the following substep(s):

(a) Categorize A by the two categories from (23.8.4.4) and (23.8.5) with which it is identified. Thus, A is categorized (in a corresponding P_0 area type) both according to its terrain and the base station infrastructure configuration in the radio coverage area 120.

(23.8.4.7) For each P_0 subarea, A, of P_0 perform the following step(s):

(a) Determine a centroid, C(A), for A;

(b) Determine an approximation to a wireless transmission path between C(A) and each base station 122 of a predetermined group of base stations expected to be in (one and/or two-way) signal communication with most target MS 140 locations in A. For example, one such approximation is a straight line between C(A) and each of the base stations 122 in the group. However, other such approximations are within the scope of the present invention, such as, a generally triangular shaped area as the transmission path, wherein a first vertex of this area is at the corresponding base station for the transmission path, and the sides of the generally triangular shaped defining the first vertex have a smallest angle between them that allows A to be completely between these sides.

(c) For each base station 122, BS_i, in the group mentioned in (b) above, create an empty list, BS_i-list, and put on this list at least the P_0 area types for the "significant" P_0 subareas crossed by the transmission path between C(A) and BS_i. Note that "significant" P_0 subareas may be defined as, for example, the P_0 subareas through which at least a minimal length of the transmission path traverses. Alternatively, such "significant" P_0 subareas may be defined as those P_0 subareas that additionally are know or expected to generate substantial multipath.

(d) Assign as the transmission area type for A as the collection of BS_i-lists. Thus, any other P_0 subarea having the same (or substantially similar) collection of lists of P_0 area types will be viewed as having approximately the same radio transmission characteristics.

Note that other transmission signal characteristics may be incorporated into the transmission area types. For example, thermal noise characteristics may be included by providing a third radio coverage area 120 partition, P_3, in addition to the partitions of P_1 and P_2 generated in (23.8.4.1) and (23.8.4.2) respectively. Moreover, the time varying characteristics of (23.8.2) may be incorporated in the transmission area type frame work by generating multiple versions of the transmission area types such that the transmission area type for a given subarea of P_0 may change depending on the combination of time varying environmental characteristics to be considered in the transmission area types. For instance, to account for seasonality, four versions of the partitions P_1 and P_2 may be generated, one for each of the seasons, and subsequently generate a (potentially) different partition P_0 for each season. Further, the type and/or characteristics of base station 122 antennas may also be included in an embodiment of the transmission area type.

Accordingly, in one embodiment of the present invention, whenever the term "area type" is used hereinbelow, transmission area types as described hereinabove are intended.

Location Information Data Bases And Data

Location Data Bases Introduction

It is an aspect of the present invention that MS location processing performed by the location center 142 should become increasingly better at locating a target MS 140 both by (a) building an increasingly more detailed model of the signal characteristics of locations in the service area for the present invention, and also (b) by providing capabilities for the location center processing to adapt to environmental changes.

One way these aspects of the present invention are realized is by providing one or more data base management systems and data bases for:

(a) storing and associating wireless MS signal characteristics with known locations of MSs 140 used in providing the signal characteristics. Such stored associations may not only provide an increasingly better model of the signal characteristics of the geography of the service area, but also provide an increasingly better model of more changeable signal characteristic affecting environmental factors such as weather, seasons, and/or traffic patterns;

(b) adaptively updating the signal characteristic data stored so that it reflects changes in the environment of the service area such as, for example, a new high rise building or a new highway.

Referring again to Fig. 5 of the collective representation of these data bases is the location information data bases 1232. Included among these data bases is a data base for providing training and/or calibration data to one or more trainable/calibratable FOMs 1224, as well as an archival data base for archiving historical MS location information related to the performance of the FOMs. These data bases will be discussed as necessary hereinbelow. However, a further brief introduction to the archival data base is provided here. Accordingly, the term, "location signature data base" is used hereinafter to denote the archival data base and/or data base management system depending on the context of the discussion. The location signature data base (shown in, for example, Fig. 6 and labeled 1320) is a repository for wireless signal characteristic data derived from wireless signal communications between an MS 140 and one or more base stations 122, wherein the corresponding location of the MS 140 is known and also stored in the location signature data base 1320. More particularly, the location signature data base 1320 associates each such known MS location with the wireless signal characteristic data derived from wireless signal communications between the MS 140 and one or more base stations 122 at this MS location. Accordingly, it is an aspect of the present invention to utilize such historical MS signal location data for enhancing the correctness and/or confidence of certain location hypotheses as will be described in detail in other sections below.

Data Representations for the Location Signature Data Base

There are four fundamental entity types (or object classes in an object oriented programming paradigm) utilized in the location signature data base 1320. Briefly, these data entities are described in the items (24.1) through (24.4) that follow:

(24.1) (verified) location signatures: Each such (verified) location signature describes the wireless signal characteristic measurements between a given base station (e.g., BS 122 or LBS 152) and an MS 140 at a (verified or known) location associated with the (verified) location signature. That is, a verified location signature corresponds to a location whose coordinates such as latitude-longitude coordinates are known, while simply a location signature may have a known or unknown location corresponding with it. Note that the term (verified) location signature is also denoted by the abbreviation, "(verified) loc sig" hereinbelow;

(24.2) (verified) location signature clusters: Each such (verified) location signature cluster includes a collection of (verified) location signatures corresponding to all the location signatures between a target MS 140 at a (possibly verified) presumed substantially stationary location and each BS (e.g., 122 or 152) from which the target MS 140 can detect the BS's pilot channel gardless of the classification of the BS in the target MS (i.e., for CDMA, regardless of whether a BS is in the MS's active, candidate or remaining base station sets, as one skilled in the art will understand). Note that for simplicity here, it is presumed that each location signature cluster has a single fixed primary base station to which the target MS 140 synchronizes or obtains its timing;

(24.3) "composite location objects (or entities)": Each such entity is a more general entity than the verified location signature cluster. An object of this type is a collection of (verified) location signatures that are associated with the same MS 140 at substantially the same location at the same time and each such loc sig is associated with a different base station. However, there is no requirement that a loc sig from each BS 122 for which the MS 140 can detect the BS's pilot channel is included in the "composite location object (or entity)"; and

(24.4) MS location estimation data that includes MS location estimates output by one or more MS location estimating first order models 1224, such MS location estimate data is described in detail hereinbelow.

It is important to note that a loc sig is, in one embodiment, an instance of the data structure containing the signal characteristic measurements output by the signal filtering and normalizing subsystem also denoted as the signal processing subsystem 1220 describing the signals between: (i) a specific base station 122 (BS) and (ii) a mobile station 140 (MS), wherein the BS's location is known and the MS's location is assumed to be substantially constant (during a 2-5 second interval in one embodiment of the present invention), during communication with the MS 140 for obtaining a single instance of loc sig data, although the MS location may or may not be known. Further, for notational purposes, the BS 122 and the MS 140 for a loc sig hereinafter will be denoted the "BS associated with the loc sig", and the "MS associated with the loc sig" respectively. Moreover, the location of the MS 140 at the time the loc sig data is obtained will be denoted the "location associated with the loc sig" (this location possibly being unknown).

In particular, for each (verified) loc sig includes the following:

(25.1) MS_type: the make and model of the target MS 140 associated with a location signature instantiation; note that the type of MS 140 can also be derived from this entry; e.g., whether MS 140 is a handset MS, car-set MS, or an MS for location only. Note as an aside, for at least CDMA, the type of MS 140 provides information as to the number of fingers that may be measured by the MS., as one skilled in the will appreciate.

(25.2) BS_id: an identification of the base station 122 (or, location base station 152) communicating with the target MS;

(25.3) MS_loc: a representation of a geographic location (e.g., latitude-longitude) or area representing a verified/known MS location where signal characteristics between the associated (location) base station and MS 140 were received. That is, if the "verified_flag" attribute (discussed below) is TRUE, then this attribute includes an estimated location of the target MS. If verified_flag is FALSE, then this attribute has a value indicating "location unknown".

Note "MS_loc" may include the following two subfields: an area within which the target MS is presumed to be, and a point location (e.g., a latitude and longitude pair) where the target MS is presumed to be (in one embodiment this is the centroid of the area);

(25.4) verified_flag: a flag for determining whether the loc sig has been verified; i.e., the value here is TRUE iff a location of MS_loc has been verified, FALSE otherwise. Note, if this field is TRUE (i.e., the loc sig is verified), then the base station identified by BS_id is the current primary base station for the target MS;

(25.5) confidence: a value indicating how consistent this loc sig is with other loc sigs in the location signature data base 1320; the value for this entry is in the range [0, 1] with 0 corresponding to the lowest (i.e., no) confidence and 1 corresponding to the highest confidence. That is, the confidence factor is used for determining how consistent the loc sig is with other "similar" verified loc sigs in the location signature data base 1320, wherein the greater the confidence value, the better the consistency with other loc sigs in the data base. Note that similarity in this context may be operationalized by at least designating a geographic proximity of a loc sig in which to determine if it is similar to other loc sigs in this designated geographic proximity and/or area type (e.g., transmission area type as elsewhere herein). Thus, environmental characteristics may also be used in determining similarities such as: similar time of occurrence (e.g., of day, and/or of month), similar weather (e.g., snowing, raining, etc.). Note, these latter characteristics are different from the notion of geographic proximity since proximity may be only a distance measurement about a location. Note also that a loc sig having a confidence factor value below a predetermined threshold may not be used in evaluating MS location hypotheses generated by the FOMs 1224.

(25.6) timestamp: the time and date the loc sig was received by the associated base station of BS_id;

(25.7) signal topography characteristics: In one embodiment, the signal topography characteristics retained can be represented as characteristics of at least a two-dimensional generated surface. That is, such a surface is generated by the signal processing subsystem 1220 from signal characteristics accumulated over (a relatively short) time interval. For example, in the two-dimensional surface case, the dimensions for the generated surface may be, for example, signal strength and time delay. That is, the accumulations over a brief time interval of signal characteristic measurements between the BS 122 and the MS 140 (associated with the loc sig) may be classified according to the two signal characteristic dimensions (e.g., signal strength and corresponding time delay). That is, by sampling the signal characteristics and classifying the samples according to a mesh of discrete cells or bins, wherein each cell correspondi to a different range of signal strengths and time delays a tally of the number of samples falling in the range of each cell can be maintained. Accordingly, for each cell, its corresponding tally may be interpreted as height of the cell, so that when the heights of all cells are considered, an undulating or mountainous surface is provided. In particular, for a cell mesh of appropriate fineness, the "mountainous surface", is believed to, under most circumstances, provide a contour that is substantially unique to the location of the target MS 140. Note that in one embodiment, the signal samples are typically obtained throughout a predetermined signal sampling time interval of 2-5 seconds as is discussed elsewhere in this specification. In particular, the signal topography characteristics retained for a loc sig include certain topographical characteristics of such a generated mountainous surface. For example, each loc sig may include: for each local maximum (of the loc sig surface) above a predetermined noise ceiling threshold, the (signal strength, time delay) coordinates of the cell of the local maximum and the corresponding height of the local maximum. Additionally, certain gradients may also be included for characterizing the "steepness" of the surface mountains. Moreover, note that in some embodiments, a frequency may also be associated with each local maximum. Thus, the data retained for each selected local maximum can include a quadruple of signal strength, time delay, height and frequency. Further note that the data types here may vary. However, for simplicity, in parts of the description of loc sig processing related to the signal characteristics here, it is assumed that the signal characteristic topography data structure here is a vector;

(25.8) quality_obj: signal quality (or error) measurements, e.g., Eb/No values, as one skilled in the art will understand;

(25.9) noise_ceiling: noise ceiling values used in the initial filtering of noise from the signal topography characteristics as provided by the signal processing subsystem 1220;

(25.10) power_level: power levels of the base station (e.g., 122 or 152) and MS 140 for the signal measurements;

(25.11) timing_error: an estimated (or maximum) timing error between the present (associated) BS (e.g., an infrastructure base station 122 or a location base station 152) detecting the target MS 140 and the current primary BS 122 for the target MS 140. Note that if the BS 122 associated with the loc sig is the primary base station, then the value here will be zero;

(25.12) cluster_ptr: a pointer to the location signature composite entity to which this loc sig belongs.

(25.13) repeatable: TRUE iff the loc sig is "repeatable" (as described hereinafter), FALSE otherwise. Note that each verified loc sig is designated as either "repeatable" or "random". A loc sig is repeatable if the (verified/known) location associated with the loc sig is such that signal characteristic measurements between the associated BS 122 and this MS can be either replaced at periodic time intervals, or updated substantially on demand by most recent signal characteristic measurements between the associated base station and the associated MS 140 (or a comparable MS) at the verified/known location. Repeatable loc sigs may be, for example, provided by stationary or fixed location MSs 140 (e.g., fixed location transceivers) distributed within certain areas of a geographical region serviced by the location center 142 for providing MS location estimates. That is, it is an aspect of the present invention that each such stationary MS 140 can be contacted by the location center 142 (via the base stations of the wireless infrastructure) at substantially any time for providing a new collection (i.e., cluster) of wireless signal characteristics to be associated with the verified location for the transceiver. Alternatively, repeatable loc sigs may be obtained by, for example, obtaining location signal measurements manually from workers who regularly traverse a predetermined route through some portion of the radio coverage area; i.e., postal workers (as will be described in more detail hereinbelow).

A loc sig is random if the loc sig is not repeatable. Random loc sigs are obtained, for example, from verifying a previously unknown target MS location once the MS 140 has been located. Such verifications may be accomplished by, for example, a vehicle having one or more location verifying devices such as a GPS receiver and/or a manual location input capability becoming sufficiently close to the located target MS 140 so that the location of the vehicle may be associated with the wireless signal characteristics of the MS 140.

Vehicles having such location detection devices may include: (a) vehicles that travel to locations that are primarily for another purpose than to verify loc sigs, e.g., police cars, ambulances, fire trucks, rescue units, courier services and taxis; and/or (b) vehicles whose primary purpose is to verify loc sigs; e.g., location signal calibration vehicles. Additionally, vehicles having both wireless transceivers and location verifying devices may provide the location center 142 with random loc sigs. Note, a repeatable loc sig may become a random loc sig if an MS 140 at the location associated with the loc sig becomes undetectable such as, for example, when the MS 140 is removed from its verified location and therefore the loc sig for the location can not be readily updated.

Additionally, note that at least in one embodiment of the signal topography characteristics (25.7) above, such a first surface may be generated for the (forward) signals from the base station 122 to the target MS 140 and a second such surface may be generated for (or alternatively, the first surface may be enhanced by increasing its dimensionality with) the signals from the MS 140 to the base station 122 (denoted the reverse signals).

Additionally, in some embodiments the location hypothesis may include an estimated error as a measurement of perceived accuracy in addition to or as a substitute for the confidence field discussed hereinabove. Moreover, location hypotheses may also include a text field for providing a reason for the values of one or more of the location hypothesis fields. For example, this text field may provide a reason as to why the confidence value is low, or provide an indication that the wireless signal measurements used had a low signal to noise ratio.

Loc sigs have the following functions or object methods associated therewith:

(26.1) A "normalization" method for normalizing loc sig data according to the associated MS 140 and/or BS 122 signal processing and generating characteristics. That is, the signal processing subsystem 1220, one embodiment being described in the PCT patent application titled, "Wireless Location Using A Plurality of Commercial Network Infrastructures," by F. W. LeBlanc and the present inventor(s), provides (methods for loc sig objects) for "normalizing" each loc sig so that variations in signal characteristics resulting from variations in (for example) MS signal processing and generating characteristics of different types of MS's may be reduced. In particular, since wireless network designers are typically designing networks for effective use of hand set MS's 140 having a substantially common minimum set of performance characteristics, the normalization methods provided here transform the loc sig data so that it appears as though the loc sig was provided by a common hand set MS 140. However, other methods may also be provided to "normalize" a loc sig so that it may be compared with loc sigs obtained from other types of MS's as well. Note that such normalization techniques include, for example, interpolating and extrapolating according to power levels so that loc sigs may be normalized to the same power level for, e.g., comparison purposes.

Normalization for the BS 122 associated with a loc sig is similar to the normalization for MS signal processing and generating characteristics. Just as with the MS normalization, the signal processing subsystem 1220 provides a loc sig method for "normalizing" loc sigs according to base station signal processing and generating characteristics.

Note, however, loc sigs stored in the location signature data base 1320 are NOT "normalized" according to either MS or BS signal processing and generating characteristics. That is, "raw" values of the wireless signal characteristics are stored with each loc sig in the location signature data base 1320.

(26.2) A method for determining the "area type" corresponding to the signal transmission characteristics of the area(s) between the associated BS 122 and the associated MS 140 location for the loc sig. Note, such an area type may be designated by, for example, the techniques for determining transmission area types as described hereinabove.

(26.3) Other methods are contemplated for determining additional environmental characteristics of the geographical area between the associated BS 122 and the associated MS 140 location for the loc sig; e.g., a noise value indicating the amount of noise likely in such an area.

Referring now to the composite location objects and verified location signature clusters of (24.3) and (24.2) respectively, the following information is contained in these aggregation objects:

(27.1.1) an identification of the BS 122 designated as the primary base station for communicating with the target MS 140;

(27.1.2) a reference to each loc sig in the location signature data base 1320 that is for the same MS location at substantially the same time with the primary BS as identified in (27.1);

(27.1.3) an identification of each base station (e.g., 122 and 152) that can be detected by the MS 140 at the time the location signal measurements are obtained. Note that in one embodiment, each composite location object includes a bit string having a corresponding bit for each base station, wherein a "1" for such a bit indicates that the corresponding base station was identified by the MS, and a "0" indicates that the base station was not identified. In an alternative embodiment, additional location signal measurements may also be included from other non-primary base stations. For example, the target MS 140 may communicate with other base stations than it's primary base station. However, since the timing for the MS 140 is typically derived from it's primary base station and since timing synchronization between base stations is not exact (e.g., in the case of CDMA, timing variations may be plus or minus 1 microsecond)at least some of the location signal measurements may be less reliable that the measurements from the primary base station, unless a forced hand-off technique is used to eliminate system timing errors among relevant base stations;

(27.1.4) a completeness designation that indicates whether any loc sigs for the composite location object have been removed from (or invalidated in) the location signature data base 1320.

Note, a verified composite location object is designated as "incomplete" if a loc sig initially referenced by the verified composite location object is deleted from the location signature data base 1320 (e.g., because of a confidence that is too low). Further note that if all loc sigs for a composite location object are deleted, then the composite object is also deleted from the location signature data base 1320. Also note that common fields between loc sigs referenced by the same composite location object may be provided in the composite location object only (e.g., timestamp, etc.).

Accordingly, a composite location object that is complete (i.e., not incomplete) is a verified location signature cluster as described in (24.2).

Location Center Architecture

Overview of Location Center Functional Components

Fig. 5 presents a high level diagram of the location center 142 and the location engine 139 in the context of the infrastructure for the entire location system of the present invention.

It is important to note that the architecture for the location center 142 and the location engine 139 provided by the present invention is designed for extensibility and flexibility so that MS 140 location accuracy and reliability may be enhanced as further location data become available and as enhanced MS location techniques become available. In addressing the design goals of extensibility and flexibility, the high level architecture for generating and processing MS location estimates may be considered as divided into the following high level functional groups described hereinbelow.

Low Level Wireless Signal Processing Subsystem for Receiving and Conditioning Wireless Signal Measurements

A first functional group of location engine 139 modules is for performing signal processing and filtering of MS location signal data received from a conventional wireless (e.g., CDMA) infrastructure, as discussed in the steps (23.1) and (23.2) above. This group is denoted the signal processing subsystem 1220 herein. One embodiment of such a subsystem is described in the PCT patent application titled, "Wireless Location Using A Plurality of Commercial Network Infrastructures," by F. W. LeBlanc and the present inventor(s)..

Initial Location Estimators: First Order Models

A second functional group of location engine 139 modules is for generating various target MS 140 location initial estimates, as described in step (23.3). Accordingly, the modules here use input provided by the signal processing subsystem 1220. This second functional group includes one or more signal analysis modules or models, each hereinafter denoted as a first order model 1224 (FOM), for generating location hypotheses for a target MS 140 to be located. Note that it is intended that each such FOM 1224 use a different technique for determining a location area estimate for the target MS 140. A brief description of some types of first order models is provided immediately below. Note that Fig. 8 illustrates another, more detail view of the location system for the present invention. In particular, this figure illustrates some of the FOMs 1224 contemplated by the present invention, and additionally illustrates the primary communications with other modules of the location system for the present invention. However, it is important to note that the present invention is not limited to the FOMs 1224 shown and discussed herein. That is, it is a primary aspect of the present invention to easily incorporate FOMs using other signal processing and/or computational location estimating techniques than those presented herein. Further, note that each FOM type may have a plurality of its models incorporated into an embodiment of the present invention.

For example, (as will be described in further detail below), one such type of model or FOM 1224 (hereinafter models of this type are referred to as "distance models") may be based on a range or distance computation and/or on a base station signal reception angle determination between the target MS 140 from each of one or more base stations. Basically, such distance models 1224 determine a location estimate of the target MS 140 by determining a distance offset from each of one or more base stations 122, possibly in a particular direction from each (some of) the base stations, so that an intersection of each area locus defined by the base station offsets may provide an estimate of the location of the target MS. Distance model FOMs 1224 may compute such offsets based on:

(a) signal timing measurements between the target mobile station 140 and one or more base stations 122; e.g., timing measurements such as time difference of arrival (TDOA), or time of arrival (TOA). Note that both forward and reverse signal path timing measurements may be utilized;

(b) signal strength measurements (e.g., relative to power control settings of the MS 140 and/or one or more BS 122); and/or

(c) signal angle of arrival measurements, or ranges thereof, at one or more base stations 122 (such angles and/or angular ranges provided by, e.g., base station antenna sectors having angular ranges of 120° or 60°, or, so called "SMART antennas" with variable angular transmission ranges of 2° to 120°).

Accordingly, a distance model may utilize triangulation or trilateration to compute a location hypothesis having either an area location or a point location for an estimate of the target MS 140. Additionally, in some embodiments location hypothesis may include an estimated error

Another type of FOM 1224 is a statistically based first order model 1224, wherein a statistical technique, such as regression techniques (e.g., least squares, partial least squares, principle decomposition), or e.g., Bollenger Bands (e.g., for computing minimum and maximum base station offsets). In general, models of this type output location hypotheses determined by performing one or more statistical techniques or comparisons between the verified location signatures in location signature data base 1320, and the wireless signal measurements from a target MS. Models of this type are also referred to hereinafter as a "stochastic signal (first order) model" or a "stochastic FOM" or a "statistical model."

Still another type of FOM 1224 is an adaptive learning model, such as an artificial neural net or a genetic algorithm, wherein the FOM may be trained to recognize or associate each of a plurality of locations with a corresponding set of signal characteristics for communications between the target MS 140 (at the location) and the base stations 122. Moreover, typically such a FOM is expected to accurately interpolate/extrapolate target MS 140 location estimates from a set of signal characteristics from an unknown target MS 140 location. Models of this type are also referred to hereinafter variously as "artificial neural net models" or "neural net models" or "trainable models" or "learning models." Note that a related type of FOM 1224 is based on pattern recognition. These FOMs can recognize patterns in the signal characteristics of communications between the target MS 140 (at the location) and the base stations 122 and thereby estimate a location area of the target MS. However, such FOMs may not be trainable.

Yet another type of FOM 1224 can be based on a collection of dispersed low power, low cost fixed location wireless transceivers (also denoted "location base stations 152" hereinabove) that are provided for detecting a target MS 140 in areas where, e.g., there is insufficient base station 122 infrastructure coverage for providing a desired level of MS 140 location accuracy. For example, it may uneconomical to provide high traffic wireless voice coverage of a typical wireless base station 122 in a nature preserve or at a fair ground that is only populated a few days out of the year. However, if such low cost location base stations 152 can be directed to activate and deactivate via the direction of a FOM 1224 of the present type, then these location base stations can be used to both location a target MS 140 and also provide indications of where the target MS is not. For example, if there are location base stations 152 populating an area where the target MS 140 is presumed to be, then by activating these location base stations 152, evidence may be obtained as to whether or not the target MS is actually in the area; e.g., if the target MS 140 is detected by a location base station 152, then a corresponding location hypothesis having a location estimate corresponding to the coverage area of the location base station may have a very high confidence value. Alternatively, if the target MS 140 is not detected by a location base station

152, then a corresponding location hypothesis having a location estimate corresponding to the coverage area of the location base station may have a very low confidence value. Models of this type are referred to hereinafter as "location base station models."

Yet another type of FOM 1224 can be based on input from a mobile base station 148, wherein location hypotheses may be generated from target MS 140 location data received from the mobile base station 148.

Still other types of FOM 1224 can be based on various techniques for recognizing wireless signal measurement patterns and associating particular patterns with locations in the coverage area 120. For example, artificial neural networks or other learning models can used as the basis for various FOMs.

Note that the FOM types mentioned here as well as other FOM types are discussed in detail hereinbelow. Moreover, it is important to keep in mind that a novel aspect of the present invention is the simultaneous use or activation of a potentially large number of such first order models 1224, wherein such FOMs are not limited to those described herein. Thus, the present invention provides a framework for incorporating MS location estimators to be subsequently provided as new FOMs in a straightforward manner. For example, a FOM 1224 based on wireless signal time delay measurements from a distributed antenna system for wireless communication may be incorporated into the present invention for locating a target MS 140 in an enclosed area serviced by the distributed antenna system. Accordingly, by using such a distributed antenna FOM, the present invention may determine the floor of a multi-story building from which a target MS is transmitting. Thus, MSs 140 can be located in three dimensions using such a distributed antenna FOM. Additionally, FOMs for detecting certain registration changes within, for example, a public switched telephone network can also be used for locating a target MS 140. For example, for some MSs 140 there may be an associated or dedicated device for each such MS that allows the MS to function as a cordless phone to a line based telephone network when the device detects that the MS is within signaling range. In one use of such a device (also denoted herein as a "home base station"), the device registers with a home location register of the public switched telephone network when there is a status change such as from not detecting the corresponding MS to detecting the MS, or visa versa, as one skilled in the art will understand. Accordingly, by providing a FOM that accesses the MS status in the home location register, the location engine 139 can determine whether the MS is within signaling range of the home base station or not, and generate location hypotheses accordingly. Moreover, other FOMs based on, for example, chaos theory and/or fractal theory are also within the scope of the present invention.

It is important to note the following aspects of the present invention relating to FOMs 1224:

(28.1) Each such first order model 1224 may be relatively easily incorporated into and/or removed from the present invention. For example, assuming that the signal processing subsystem 1220 provides uniform input to the FOMs, and there is a uniform FOM output interface, it is believed that a large majority (if not substantially all) viable MS location estimation strategies may be accommodated. Thus, it is straightforward to add or delete such FOMs 1224.

(28.2) Each such first order model 1224 may be relatively simple and still provide significant MS 140 locating functionality and predictability. For example, much of what is believed to be common or generic MS location processing has been coalesced into, for example: a location hypothesis evaluation subsystem, denoted the hypotheses evaluator 1228 and described immediately below. Thus, the present invention is modular and extensible such that, for example, (and importantly) different first order models 1224 may be utilized depending on the signal transmission characteristics of the geographic region serviced by an embodiment of the present invention. Thus, a simple configuration of the present invention may have a small number of FOMs 1224 for a simple wireless signal environment (e.g., flat terrain, no urban canyons and low population density). Alternatively, for complex wireless signal environments such as in cities like San Francisco, Tokyo or New York, a large number of FOMs 1224 may be simultaneously utilized for generating MS location hypotheses.

An Introduction to an Evaluator for Location Hypotheses: Hypothesis Evaluator

A third functional group of location engine 139 modules evaluates location hypotheses output by the first order models 1224 and thereby provides a "most likely" target MS location estimate. The modules for this functional group are collectively denoted the hypothesis evaluator 1228.

Hypothesis Evaluator Introduction

A primary purpose of the hypothesis evaluator 1228 is to mitigate conflicts and ambiguities related to location hypotheses output by the first order models 1224 and thereby output a "most likely" estimate of an MS for which there is a request for it to be located. In providing this capability, there are various related embodiments of the hypothesis evaluator that are within the scope of the present invention. Since each location hypothesis includes both an MS location area estimate and a corresponding confidence value indicating a perceived confidence or likelihood of the target MS being within the corresponding location area estimate, there is a monotonic relationship between MS location area estimates and confidence values. That is, by increasing an MS location area estimate, the corresponding confidence value may also be increased (in an extreme case, the location area estimate could be the entire coverage area 120 and thus the confidence value may likely correspond to the highest level of certainty; i.e., +1.0). Accordingly, given a target MS location area estimate (of a location hypothesis), an adjustment to its accuracy may be performed by adjusting the MS location area estimate and/or the corresponding confidence value. Thus, if the confidence value is, for example, excessively low then the area estimate may be increased as a technique for increasing the confidence value. Alternatively, if the estimated area is excessively large, and there is flexibility in the corresponding confidence value, then the estimated area may be decreased and the confidence value also decreased. Thus, if at some point in the processing of a location hypothesis, if the location hypothesis is judged to be more (less) accurate than initially determined, then (i) the confidence value of the location hypothesis can be increased (decreased), and/or (ii) the MS location area estimate can be decreased (increased).

In a first class of embodiments, the hypothesis evaluator 1228 evaluates location hypotheses and adjusts or modifies only their confidence values for MS location area estimates and subsequently uses these MS location estimates with the adjusted confidence values for determining a "most likely" MS location estimate for outputting. Accordingly, the MS location area estimates are not substantially modified. Alternatively, in a second class of embodiments for the hypothesis evaluator 1228, MS location area estimates can be adjusted while confidence values remain substantially fixed. Of course, hybrids between the first two embodiments can also be provided. Note that the present embodiment provided herein adjusts both the areas and the confidence values.

More particularly, the hypothesis evaluator 1228 may perform any or most of the following tasks:

(30.1) it utilizes environmental information to improve and reconcile location hypotheses supplied by the first order models 1224. A basic premise in this context is that the accuracy of the individual first order models may be affected by various environmental factors such as, for example, the season of the year, the time of day, the weather conditions, the presence of buildings, base station failures, etc.;

(30.2) it enhances the accuracy of an initial location hypothesis generated by an FOM by using the initial location hypothesis as, essentially, a query or index into the location signature data base 1320 for obtaining a corresponding enhanced location hypothesis, wherein the enhanced location hypothesis has both an adjusted target MS location area estimate and an adjusted confidence based on past performance of the FOM in the location service surrounding the target MS location estimate of the initial location hypothesis;

(30.3) it determines how well the associated signal characteristics used for locating a target MS compare with particular verified loc sigs stored in the location signature data base 1320 (see the location signature data base section for further discussion regarding this aspect of the invention). That is, for a given location hypothesis, verified loc sigs (which were previously obtained from one or more verified locations of one or more MS's) are retrieved for an area corresponding to the location area estimate of the location hypothesis, and the signal characteristics of these verified loc sigs are compared with the signal characteristics used to generate the location hypothesis for determining their similarities and subsequently an adjustment to the confidence of the location hypothesis (and/or the size of the location area estimate);

(30.4) the hypothesis evaluator 1228 determines if (or how well) such location hypotheses are consistent with well known physical constraints such as the laws of physics. For example, if the difference between a previous (most likely) location estimate of a target MS and a location estimate by a current location hypothesis requires the MS to:

(a1) move at an unreasonably high rate of speed (e.g., 200 mph), or

(b1) move at an unreasonably high rate of speed for an area (e.g., 80 mph in a corn patch), or

(c1) make unreasonably sharp velocity changes (e.g., from 60 mph in one direction to 60 mph in the opposite direction in 4 sec), then the confidence in the current Location Hypothesis is likely to be reduced.

Alternatively, if for example, the difference between a previous location estimate of a target MS and a current location hypothesis indicates that the MS is:

(a2) moving at an appropriate velocity for the area being traversed, or

(b2) moving along an established path (e.g., a freeway),

then the confidence in the current location hypothesis may be increased.

(30.5) the hypothesis evaluator 1228 determines consistencies and inconsistencies between location hypotheses obtained from different first order models. For example, if two such location hypotheses, for substantially the same timestamp, have estimated location areas where the target MS is likely to be and these areas substantially overlap, then the confidence in both such location hypotheses may be increased. Additionally, note that a velocity of an MS may be determined (via deltas of successive location hypotheses from one or more first order models) even when there is low confidence in the location estimates for the MS, since such deltas may, in some cases, be more reliable than the actual target MS location estimates;

(30.6) the hypothesis evaluator 1228 determines new (more accurate) location hypotheses from other location hypotheses. For example, this module may generate new hypotheses from currently active ones by decomposing a location hypothesis having a target MS location estimate intersecting two radically different area types. Additionally, this module may generate location hypotheses indicating areas of poor reception; and

(30.7) the hypothesis evaluator 1228 determines and outputs a most likely location hypothesis for a target MS.

Note that the hypothesis evaluator may accomplish the above tasks, (30.1) - (30.7), by employing various data processing tools including, but not limited to, fuzzy mathematics, genetic algorithms, neural networks, expert systems and/or blackboard systems.

Note that, as can be seen in Figs. 6 and 7, the hypothesis evaluator 1228 includes the following four high level modules for processing output location hypotheses from the first order models 1224: a context adjuster 1326, a hypothesis analyzer 1332, an MS status repository 1338 and a most likelihood estimator 1334. These four modules are briefly described hereinbelow.

Context Adjuster Introduction.

The context adjuster 1326 module enhances both the comparability and predictability of the location hypotheses output by the first order models 1224. In particular, this module modifies location hypotheses received from the FOMs 1224 so that the resulting location hypotheses output by the context adjuster 1326 may be further processed uniformly and substantially without concern as to differences in accuracy between the first order models from which location hypotheses originate. In providing this capability, the context adjuster 1326 may adjust or modify various fields of the input location hypotheses. In particular, fields giving target MS 140 location estimates and/or confidence values for such estimates may be modified by the context adjuster 1326. Further, this module may determine those factors that are perceived to impact the perceived accuracy (e.g., confidence) of the location hypotheses: (a) differently between FOMs, and/or (b) with substantial effect. For instance, environmental characteristics may be taken into account here, such as time of day, season, month, weather, geographical area categorizations (e.g., dense urban, urban, suburban, rural, mountain, etc.), area subcategorizations (e.g., heavily treed, hilly, high traffic area, etc.). A detailed description of one embodiment of this module is provided in APPENDIX D hereinbelow. Note that, the embodiment described herein is simplified for illustration purposes such that only the geographical area categorizations are utilized in adjusting (i.e., modifying) location hypotheses. But, it is an important aspect of the present invention that various categorizations, such as those mentioned immediately above, may be used for adjusting the location hypotheses. That is, categories such as, for example:

(a) urban, hilly, high traffic at 5pm, or

(b) rural, flat, heavy tree foliage density in summer may be utilized as one skilled in the art will understand from the descriptions contained hereinbelow.

Accordingly, the present invention is not limited to the factors explicitly mentioned here. That is, it is an aspect of the present invention to be extensible so that other environmental factors of the coverage area 120 affecting the accuracy of location hypotheses may also be incorporated into the context adjuster 1326.

It is also an important and novel aspect of the context adjuster 1326 that the methods for adjusting location hypotheses provided in this module may be generalized and thereby also utilized with multiple hypothesis computational architectures related to various applications wherein a terrain, surface, volume or other "geometric" interpretation (e.g., a metric space of statistical samples) may be placed on a large body of stored application data for relating hypothesized data to verified data. Moreover, it is important to note that various techniques for "visualizing data" may provide such a geometric interpretation. Thus, the methods herein may be utilized in applications such as:

(a) sonar, radar, x-ray or infrared identification of objects such as occurs in robotic navigation, medical image analysis, geological, and radar imaging.

More generally, the novel computational paradigm of the context adjuster 1326 may be utilized in a number of applications wherein there is a large body of archived information providing verified or actual application process data related to the past performance of the application process.

It is worth mentioning that the computational paradigm used in the context adjuster 1326 is a hybrid of a hypothesis adjuster and a data base query mechanism. For example, the context adjuster 1326 uses an input (location) hypothesis both as an hypothesis and as a data base query or index into the location signature data base 1320 for constructing a related but more accurate location hypothesis. Accordingly, substantial advantages are provided by this hybrid architecture, such as the following two advantages.

As a first advantage, the context adjuster 1326 reduces the likelihood that a feedback mechanism is necessary to the initial hypothesis generators (i.e., FOMs 1224) for periodically adjusting default evaluations of the goodness or confidence in the hypotheses generated. That is, since each hypothesis generated is, in effect, an index into a data base or archive of verified application (e.g., location) data, the context adjuster 1326, in turn, generates new corresponding hypotheses based on the actual or verified data retrieved from an archival data base. Thus, as a result, this architecture tends to separate the computations of the initial hypothesis generators (e.g., the FOMs 1224 in the present MS location application) from any further processing and thereby provide a more modular, maintainable and flexible computational system.

As a second advantage, the context adjuster 1326 tends to create hypotheses that are more accurate than the hypotheses generated by the initial hypotheses generators. That is, for each hypothesis, H, provided by one of the initial hypothesis generators, G (e.g., a FOM 1224), a corresponding enhanced hypothesis, provided by the context adjuster 1326, is generated by mapping the past performance of G into the archived verified application data (as will be discussed in detail hereinbelow). In particular, the context adjuster hypothesis generation is based on the archived verified (or known) performance application data that is related to both G and H. For example, in the present wireless location application, if a FOM 1224, G, substantially consistently generates, in a particular geographical area, location hypotheses that are biased approximately 1000 feet north of the actual verified MS 140 location, then the context adjuster 1326 can generate corresponding hypotheses without this bias. Thus, the context adjuster 1326 tends to filter out inaccuracies in the initially generated hypotheses.

Therefore in a multiple hypothesis architecture where typically the generated hypotheses may be evaluated and/or combined for providing a "most likely" result, it is believed that a plurality of relatively simple (and possibly inexact) initial hypothesis generators may be used in conjunction with the hybrid computational paradigm represented by the context adjuster 1326 for providing enhanced hypotheses with substantially greater accuracy.

Additionally, note that this hybrid paradigm applies to other domains that are not geographically based. For instance, this hybrid paradigm applies to many prediction and/or diagnostic applications for which:

(a) the application data and the application are dependent on a number of parameters whose values characterize the range of outputs for the application. That is, there is a set of parameters, $p_1, p_2, p_3, \ldots, p_N$ from which a parameter space $p_1 \times p_2 \times p_3 \times \ldots \times p_N$ is derived whose points characterize the actual and estimated (or predicted) outcomes. As examples, in the MS location system, p_1 = latitude and p_2 = longitude;

(b) there is historical data from which points for the parameter space, $p_1 \times p_2 \times p_3 \times \ldots \times p_n$ can be obtained, wherein this data relates to (or indicates) the performance of the application, and the points obtained from this data are relatively dense in the space (at least around the likely future actual outcomes that the application is expected to predict or diagnose). For example, such historical data may associate the predicted outcomes of the application with corresponding actual outcomes;

(c) there is a metric or distance-like evaluation function that can be applied to the parameter space for indicating relative closeness or accuracy of points in the parameter space, wherein the evaluation function provides a measurement of closeness that is related to the actual performance of the application.

Note that there are numerous applications for which the above criteria are applicable. For instance, computer aided control of chemical processing plants are likely to satisfy the above criteria. Certain robotic applications may also satisfy this criteria. In fact, it is believed that a wide range of signal processing applications satisfy this criteria.

MS Status Repository Introduction

The MS status repository 1338 is a run-time storage manager for storing location hypotheses from previous activations of the location engine 139 (as well as for storing the output "most likely" target MS location estimate(s)) so that a target MS 140 may be tracked using target MS location hypotheses from previous location engine 139 activations to determine, for example, a movement of the target MS 140 between evaluations of the target MS location.

Location Hypothesis Analyzer Introduction.

The location hypothesis analyzer 1332, adjusts confidence values of the location hypotheses, according to:

(a) heuristics and/or statistical methods related to how well the signal characteristics for the generated target MS location hypothesis matches with previously obtained signal characteristics for verified MS locations.

(b) heuristics related to how consistent the location hypothesis is with physical laws, and/or highly probable reasonableness conditions relating to the location of the target MS and its movement characteristics. For example, such heuristics may utilize knowledge of the geographical terrain in which the MS is estimated to be, and/or, for instance, the MS velocity, acceleration or extrapolation of an MS position, velocity, or acceleration.

(c) generation of additional location hypotheses whose MS locations are consistent with, for example, previous estimated locations for the target MS.

As shown in Figs. 6 and 7, the hypothesis analyzer 1332 module receives (potentially) modified location hypotheses from the context adjuster 1326 and performs additional location hypothesis processing that is likely to be common and generic in analyzing most location hypotheses. More specifically, the hypothesis analyzer 1332 may adjust either or both of the target MS 140 estimated location and/or the confidence of a location hypothesis. In brief, the hypothesis analyzer 1332 receives target MS 140 location hypotheses from the context analyzer 1336, and depending on the time stamps of newly received location hypotheses and any previous (i.e., older) target MS location hypotheses that may still be currently available to the hypothesis analyzer 1332, the hypothesis analyzer may:

(a) update some of the older hypotheses by an extrapolation module,

(b) utilize some of the old hypotheses as previous target MS estimates for use in tracking the target MS 140, and/or

(c) if sufficiently old, then delete the older location hypotheses.

Note that both the newly received location hypotheses and the previous location hypotheses that are updated (i.e., extrapolated) and still remain in the hypothesis analyzer 1332 will be denoted as "current location hypotheses" or "currently active location hypotheses".

The modules within the location hypothesis analyzer 1332 use various types of application specific knowledge likely substantially independent from the computations by the FOMs 1224 when providing the corresponding original location hypotheses. That is, since it is aspect of at least one embodiment of the present invention that the FOMs 1224 be relatively straightforward so that they may be easily to modified as well as added or deleted, the processing, for example, in the hypothesis analyzer 1332 (as with the context adjuster 1326) is intended to compensate, when necessary, for this straightforwardness by providing substantially generic MS location processing capabilities that can require a greater breadth of application understanding related to wireless signal characteristics of the coverage area 120.

Accordingly, the hypothesis analyzer 1332 may apply various heuristics that, for example, change the confidence in a location hypothesis depending on how well the location hypothesis (and/or a series of location hypotheses from e.g., the same FOM 1224): (a) conforms with the laws of physics, (b) conforms with known characteristics of location signature clusters in an area of the location hypothesis MS 140 estimate, and (c) conforms with highly likely heuristic constraint knowledge. In particular, as illustrated best in Fig. 7, the location hypothesis analyzer 1332 may utilize at least one of a blackboard system and/or an expert system for applying various application specific heuristics to the location hypotheses output by the context adjuster 1326. More precisely, the location hypothesis analyzer 1332 includes, in one embodiment, a blackboard manager for managing processes and data of a blackboard system. Additionally, note that in a second embodiment, where an expert system is utilized instead of a blackboard system, the location hypothesis analyzer provides an expert system inference engine for the expert system. Note that additional detail on these aspects of the invention are provided hereinbelow.

Additionally, note that the hypothesis analyzer 1332 may activate one or more extrapolation procedures to extrapolate target MS 140 location hypotheses already processed. Thus, when one or more new location hypotheses are supplied (by the context adjuster 1224) having a substantially more recent timestamp, the hypothesis analyzer may invoke an extrapolation module (i.e., location extrapolator 1432, Fig. 7) for adjusting any previous location hypotheses for the same target MS 140 that are still being used by the location hypothesis analyzer so that all target MS location hypotheses (for the same target MS) being concurrently analyzed are presumed to be for substantially the same time. Accordingly, such a previous location hypothesis that is, for example, 15 seconds older than a newly supplied location hypothesis (from perhaps a different FOM 1224) may have both: (a) an MS location estimate changed (e.g., to account for a movement of the target MS), and (b) its confidence changed (e.g., to reflect a reduced confidence in the accuracy of the location hypothesis).

It is important to note that the architecture of the present invention is such that the hypothesis analyzer 1332 has an extensible architecture. That is, additional location hypothesis analysis modules may be easily integrated into the hypothesis analyzer 1332 as further understanding regarding the behavior of wireless signals within the service area 120 becomes available. Conversely, some analysis modules may not be required in areas having relatively predictable signal patterns. Thus, in such service areas, such unnecessary modules may be easily removed or not even developed.

Most Likelihood Estimator Introduction

The most likelihood estimator 1344 is a module for determining a "most likely" location estimate for a target MS being located by the location engine 139. The most likelihood estimator 1344 receives a collection of active or relevant location hypotheses from the hypothesis analyzer 1332 and uses these location hypotheses to determine one or more most likely estimates for the target MS 140. Still referring to the hypothesis evaluator 1228, it is important to note that not all the above mentioned modules are required in all embodiments of the present invention. In particular, for some coverage areas 120, the hypothesis analyzer 1332 may be unnecessary. Accordingly, in such an embodiment, the enhanced location hypothesis output by the context adjuster 1326 are provided directly to the most likelihood estimator 1344.

Control and Output Gating Modules

A fourth functional group of location engine 139 modules is the control and output gating modules which includes the location center control subsystem 1350, and the output gateway 1356. The location control subsystem 1350 provides the highest level of control and monitoring of the data processing performed by the location center 142. In particular, this subsystem performs the following functions:

(a) controls and monitors location estimating processing for each target MS 140. Note that this includes high level exception or error handling functions;

(b) receives and routes external information as necessary. For instance, this subsystem may receive (via, e.g., the public telephone switching network and Internet 1362) such environmental information as increased signal noise in a particular service are due to increase traffic, a change in weather conditions, a base station 122 (or other infrastructure provisioning), change in operation status (e.g., operational to inactive);

(c) receives and directs location processing requests from other location centers 142 (via, e.g., the Internet);

(d) performs accounting and billing procedures;

(e) interacts with location center operators by, for example, receiving operator commands and providing output indicative of processing resources being utilized and malfunctions;

(f) provides access to output requirements for various applications requesting location estimates. For example, an Internet location request from a trucking company in Los Angeles to a location center 142 in Denver may only want to know if a particular truck or driver is within the Denver area. Alternatively, a local medical rescue unit is likely to request a precise a location estimate as possible.

Note that in Fig. 6 (a) - (d) above are, at least at a high level, performed by utilizing the operator interface 1374.

Referring now to the output gateway 1356, this module routes target MS 140 location estimates to the appropriate location application(s). For instance, upon receiving a location estimate from the most likelihood estimator 1344, the output gateway 1356 may determine that the location estimate is for an automobile being tracked by the police and therefore must be provided must be provided according to the particular protocol.

System Tuning and Adaptation: The Adaptation Engine

A fifth functional group of location engine 139 modules provides the ability to enhance the MS locating reliability and/or accuracy of the present invention by providing it with the capability to adapt to particular operating configurations, operating conditions and wireless signaling environments without performing intensive manual analysis of the performance of various embodiments of the location engine 139. That is, this functional group automatically enhances the performance of the location engine for locating MSs 140 within a particular coverage area 120 using at least one wireless network infrastructure therein. More precisely, this functional group allows the present invention to adapt by tuning or optimizing certain system parameters according to location engine 139 location estimate accuracy and reliability.

There are a number location engine 139 system parameters whose values affect location estimation, and it is an aspect of the present invention that the MS location processing performed should become increasingly better at locating a target MS 140 not only through building an increasingly more detailed model of the signal characteristics of location in the coverage area 120 such as discussed above regarding the location signature data base 1320, but also by providing automated capabilities for the location center processing to adapt by adjusting or "tuning" the values of such location center system parameters.

Accordingly, the present invention includes a module, denoted herein as an "adaptation engine" 1382, that performs an optimization procedure on the location center 142 system parameters either periodically or concurrently with the operation of the location center in estimating MS locations. That is, the adaptation engine 1382 directs the modifications of the system parameters so that the location engine 139 increases in overall accuracy in locating target MSs 140. In one embodiment, the adaptation engine 1382 includes an embodiment of a genetic algorithm as the mechanism for modifying the system parameters. Genetic algorithms are basically search algorithms based on the mechanics of natural genetics. The genetic algorithm utilized herein is included in the form of pseudo code in APPENDIX B. Note that to apply this genetic algorithm in the context of the location engine 139 architecture only a "coding scheme" and a "fitness function" are required as one skilled in the art will appreciate. Moreover, it is also within the scope of the present invention to use modified or different adaptive and/or tuning mechanisms. For further information regarding such adaptive mechanisms, the following references are incorporated herein by reference: Goldberg, D. E. (1989). Genetic algorithms for search, optimization, and machine learning. Reading, MA: Addison-Wesley Publishing Company; and Holland, J. H. (1975) Adaptation in natural and artificial systems. Ann Arbor, MI: The University of Michigan Press.

Implementations of First Order Models

Further descriptions of various first order models 1224 are provided in this section.

Distance First Order Models (TOA/TDOA)

As discussed in the Location Center Architecture Overview section herein above, distance models determine a presumed direction and/or distance that a target MS 140 is from one or more base stations 122. In some embodiments of distance models, the target MS location estimate(s) generated are obtained using radio signal analysis techniques that are quite general and therefore are not capable of taking into account the peculiarities of the topography of a particular radio coverage area. For example, substantially all radio signal analysis techniques using conventional procedures (or formulas) are based on "signal characteristic measurements" such as:

(a) signal timing measurements (e.g., TOA and TDOA),

(b) signal strength measurements, and/or

(c) signal angle of arrival measurements.

Furthermore, such signal analysis techniques are likely predicated on certain very general assumptions that can not fully account for signal attenuation and multipath due to a particular radio coverage area topography.

Taking CDMA or TDMA base station network as an example, each base station (BS) 122 is required to emit a constant signal-strength pilot channel pseudo-noise (PN) sequence on the forward link channel identified uniquely in the network by a pilot sequence offset and frequency assignment. It is possible to use the pilot channels of the active, candidate, neighboring and remaining sets, maintained in the target MS, for obtaining signal characteristic measurements (e.g., TOA and/or TDOA measurements) between the target MS 140 and the base stations in one or more of these sets.

Based on such signal characteristic measurements and the speed of signal propagation, signal characteristic ranges or range differences related to the location of the target MS 140 can be calculated. Using TOA and/or TDOA ranges as exemplary, these ranges can then be input to either the radius-radius multilateration or the time difference multilateration algorithms along with the known positions of the corresponding base stations 122 to thereby obtain one or more location estimates of the target MS 140. For example, if there are, four base stations 122 in the active set, the target MS 140 may cooperate with each of the base stations in this set to provide signal arrival time measurements. Accordingly, each of the resulting four sets of three of these base stations 122 may be used to provide an estimate of the target MS 140 as one skilled in the art will understand. Thus, potentially (assuming the measurements for each set of three base stations yields a feasible location solution) there are four estimates for the location of the target MS 140. Further, since such measurements and BS 122 positions can be sent either to the network or the target MS 140, location can be determined in either entity.

Since many of the signal measurements utilized by embodiments of distance models are subject to signal attenuation and multipath due to a particular area topography. Many of the sets of base stations from which target MS location estimates are desired may result in either no location estimate, or an inaccurate location estimate.

Accordingly, some embodiments of distance FOMs may attempt to mitigate such ambiguity or inaccuracies by, e.g., identifying discrepancies (or consistencies) between arrival time measurements and other measurements (e.g., signal strength), these discrepancies (or consistencies) may be used to filter out at least those signal measurements and/or generated location estimates that appear less accurate. In particular, such identifying may filtering can be performed by, for example, an expert system residing in the distance FOM.

A second approach for mitigating such ambiguity or conflicting MS location estimates is particularly novel in that each of the target MS location estimates is used to generate a location hypothesis regardless of its apparent accuracy. Accordingly, these location hypotheses are input to an alternative embodiment of the context adjuster 1326 that is substantially (but not identical to) the context adjuster as described in detail in APPENDIX D so that each location hypothesis may be adjusted to enhance its accuracy.

In contradistinction to the embodiment of the context adjuster 1326 of APPENDIX D, where each location hypothesis is adjusted according to past performance of its generating FOM 1224 in an area of the initial location estimate of the location hypothesis (the area, e.g., determined as a function of distance from this initial location estimate), this alternative embodiment adjusts each of the location hypotheses generated by a distance first order model according to a past performance of the model as applied to signal characteristic measurements from the same set of base stations 122 as were used in generating the location hypothesis. That is, instead of only using only an identification of the distance model (i.e., its FOM_ID) to, for example, retrieve archived location estimates generated by the model in an area of the location hypothesis' estimate (when determining the model's past performance), the retrieval retrieves only the archived location estimates that are, in addition, derived from the signal characteristics measurement obtained from the same collection of base stations 122 as was used in generating the location hypothesis. Thus, the adjustment performed by this embodiment of the context adjuster 1326 adjusts according to the past performance of the distance model and the collection of base stations 122 used.

Coverage Area First Order Model

Radio coverage area of individual base stations 122 may be used to generate location estimates of the target MS 140. Although a first order model 1224 based on this notion may be less accurate than other techniques, if a reasonably accurate RF coverage area is known for each (or most) of the base stations 122, then such a FOM (denoted hereinafter as a "coverage area first order model" or simply "coverage area model") may be very reliable. To determine approximate maximum radio frequency (RF) location coverage areas, with respect to BSs 122, antennas and/or sector coverage areas, for a given class (or classes) of (e.g., CDMA or TDMA) mobile station(s) 140, location coverage should be based on an MS's ability to adequately detect the pilot channel, as opposed to adequate signal quality for purposes of carrying user-acceptable traffic in the voice channel. Note that more energy is necessary for traffic channel activity (typically on the order of at least -94 to -104 dBm received signal strength) to support voice, than energy needed to simply detect a pilot channel's presence for location purposes (typically a maximum weakest signal strength range of between -104 to -110 dBm), thus the "Location Coverage Area" will generally be a larger area than that of a typical "Voice Coverage Area", although industry studies have found some occurrences of "no-coverage" areas within a larger covered area. An example of a coverage area including both a "dead zone", i.e., area of no coverage, and a "notch" (of also no coverage) is shown in Fig. 15.

The approximate maximum RF coverage area for a given sector of (more generally angular range about) a base station 122 may be represented as a set of points representing a polygonal area (potentially with, e.g., holes therein to account for dead zones and/or notches). Note that if such polygonal RF coverage area representations can be reliably determined and maintained over time (for one or more BS signal power level settings), then such representations can be used in providing a set theoretic or Venn diagram approach to estimating the location of a target MS 140. Coverage area first order models utilize such an approach.

One embodiment, a coverage area model utilizes both the detection and non-detection of base stations 122 by the target MS 140 (conversely, of the MS by one or more base stations 122) to define an area where the target MS 140 may likely be. A relatively straightforward application of this technique is to:

(a) find all areas of intersection for base station RF coverage area representations, wherein: (i) the corresponding base stations are on-line for communicating with MSs 140; (ii) the RF coverage area representations are deemed reliable for the power levels of the on-line base stations; (iii) the on-line base stations having reliable coverage area representations can be detected by the target MS; and (iv) each intersection must include a predetermined number of the reliable RF coverage area representations (e.g., 2 or 3); and

(b) obtain new location estimates by subtracting from each of the areas of intersection any of the reliable RF coverage area representations for base stations 122 that can not be detected by the target MS.

Accordingly, the new areas may be used to generate location hypotheses.

Location Base Station First Order Model

In the location base station (LBS) model (FOM 1224), a database is accessed which contains electrical, radio propagation and coverage area characteristics of each of the location base stations in the radio coverage area. The LBS model is an active model, in that it can probe or excite one or more particular LBSs 152 in an area for which the target MS 140 to be located is suspected to be placed. Accordingly, the LBS model may receive as input a most likely target MS 140 location estimate previously output by the location engine 139 of the present invention, and use this location estimate to determine which (if any) LBSs 152 to activate and/or deactivate for enhancing a subsequent location estimate of the target MS. Moreover, the feedback from the activated LBSs 152 may be provided to other FOMs 1224, as appropriate, as well as to the LBS model. However, it is an important aspect of the LBS model that when it receives such feedback, it may output location hypotheses having relatively small target MS 140 location area estimates about the active LBSs 152 and each such location hypothesis also has a high confidence value indicative of the target MS 140 positively being in the corresponding location area estimate (e.g., a confidence value of .9 to +1), or having a high confidence value indicative of the target MS 140 not being in the corresponding location area estimate (i.e., a confidence value of -0.9 to -1). Note that in some embodiments of the LBS model, these embodiments may have functionality similar to that of the coverage area first order model described above. Further note that for LBSs within a neighborhood of the target MS wherein there is a reasonable chance that with movement of the target MS may be detected by these LBSs, such LBSs may be requested to periodically activate. (Note, that it is not assumed that such LBSs have an on-line external power source; e.g., some may be solar powered). Moreover, in the case where an LBS 152 includes sufficient electronics to carry voice communication with the target MS 140 and is the primary BS for the target MS (or alternatively, in the active or candidate set), then the LBS model will not deactivate this particular LBS during its procedure of activating and deactivating various LBSs 152.

Stochastic First Order Model

The stochastic first order models may use statistical prediction techniques such as principle decomposition, partial least squares, partial least squares, or other regression techniques for predicting, for example, expected minimum and maximum distances of the target MS from one or more base stations 122, e.g., Bollenger Bands. Additionally, some embodiments may use Markov processes and Random Walks (predicted incremental MS movement) for determining an expected area within which the target MS 140 is likely to be. That is, such a process measures the incremental time differences of each pilot as the MS moves for predicting a size of a location area estimate using past MS estimates such as the verified location signatures in the location signature data base 1320.

Pattern Recognition and Adaptive First Order Models

It is a particularly important aspect of the present invention to provide:

(a) one or more FOMs 1224 that generate target MS 140 location estimates by using pattern recognition or associativity techniques, and/or

(b) one or more FOMs 1224 that are adaptive or trainable so that such FOMs may generate increasingly more accurate target MS location estimates from additional training.

Statistically Based Pattern Recognition First Order Models

Regarding FOMs 1224 using pattern recognition or associativity techniques, there are many such techniques available. For example, there are statistically based systems such as "CART" (anacronym for Classification and Regression Trees) by ANGOSS Software International Limited of Toronto, Canada that may be used for automatically for detecting or recognizing patterns in data that were unprovided (and likely previously unknown). Accordingly, by imposing a relatively fine mesh or grid of cells of the radio coverage area, wherein each cell is entirely within a particular area type categorization such as the transmission area types (discussed in the section, "Coverage Area: Area Types And Their Determination" above), the verified location signature clusters within the cells of each area type may be analyzed for signal characteristic patterns. If such patterns are found, then they can be used to identify at least a likely area type in which a target MS is likely to be located. That is, one or more location hypotheses may be generated having target MS 140 location estimates that cover an area having the likely area type wherein the target MS 140 is located. Further note that such statistically based pattern recognition systems as "CART" include software code generators for generating expert system software embodiments for recognizing the patterns detected within a training set (e.g., the verified location signature clusters).

Accordingly, although an embodiment of a FOM as described here may not be exceedingly accurate, it may be very reliable. Thus, since a fundamental aspect of the present invention is to use a plurality MS location techniques for generating location estimates and to analyze the generated estimates (likely after being adjusted) to detect patterns of convergence or clustering among the estimates, even large MS location area estimates are useful. For example, it can be the case that four different and relatively large MS location estimates, each having very high reliability, have an area of intersection that is acceptably precise and inherits the very high reliability from each of the large MS location estimates from which the intersection area was derived.

A similar statistically based FOM 1224 to the one above may be provided wherein the radio coverage area is decomposed substantially as above, but addition to using the signal characteristics for detecting useful signal patterns, the specific identifications of the base station 122 providing the signal characteristics may also be used. Thus, assuming there is a sufficient density of verified location signature clusters in some of the mesh cells so that the statistical pattern recognizer can detect patterns in the signal characteristic measurements, an expert system may be generated that outputs a target MS 140 location estimate that may provide both a reliable and accurate location estimate of a target MS 140.

Adaptive/Trainable First Order Models

Adaptive/Trainable First Order Models

The term adaptive is used to describe a data processing component that can modify its data processing behavior in response to certain inputs that are used to change how subsequent inputs are processed by the component. Accordingly, a data processing component may be "explicitly adaptive" by modifying its behavior according to the input of explicit instructions or control data that is input for changing the component's subsequent behavior in ways that are predictable and expected. That is, the input encodes explicit instructions that are known by a user of the component. Alternatively, a data processing component may be "implicitly adaptive" in that its behavior is modified by other than instructions or control data whose meaning is known by a user of the component. For example, such implicitly adaptive data processors may learn by training on examples, by substantially unguided exploration of a solution space, or other data driven adaptive strategies such as statistically generated decision trees. Accordingly, it is an aspect of the present invention to utilize not only explicitly adaptive MS location estimators within FOMs 1224, but also implicitly adaptive MS location estimators. In particular, artificial neural networks (also denoted neural nets and ANNs herein) are used in some embodiments as implicitly adaptive MS location estimators within FOMs. Thus, in the sections below, neural net architectures and their application to locating an MS is described.

Artificial Neural Networks For MS Location

Artificial neural networks may be particularly useful in developing one or more first order models 1224 for locating an MS 140, since, for example, ANNs can be trained for classifying and/or associatively pattern matching of various RF signal measurements such as the location signatures. That is, by training one or more artificial neural nets using RF signal measurements from verified locations so that RF signal transmissions characteristics indicative of particular locations are associated with their corresponding locations, such trained artificial neural nets can be used to provide additional target MS 140 location hypotheses. Moreover, it is an aspect of the present invention that the training of such artificial neural net based FOMs (ANN FOMs) is provided without manual intervention as will be discussed hereinbelow.

Artificial Neural Networks That Converge on Near Optimal Solutions

It is as an aspect of the present invention to use an adaptive neural network architecture which has the ability to explore the parameter or matrix weight space corresponding to a ANN for determining new configurations of weights that reduce an objective or error function indicating the error in the output of the ANN over some aggregate set of input data ensembles. Accordingly, in one embodiment, a genetic algorithm is used to provide such an adaptation capability. However, it is also within the scope of the present invention to use other adaptive techniques such as, for example, simulated annealing, cascade correlation with multistarts, gradient descent with multistarts, and truncated Newton's method with multistarts, as one skilled in the art of neural network computing will understand.

Artificial Neural Networks as MS Location Estimators for First Order Models

Although there have been substantial advances in artificial neural net computing in both hardware and software, it can be difficult to choose a particular ANN architecture and appropriate training data for yielding high quality results. In choosing a ANN architecture at least the following three criteria are chosen (either implicitly or explicitly):

(a) a learning paradigm: i.e., does the ANN require supervised training (i.e., being provided with indications of correct and incorrect performance), unsupervised training, or a hybrid of both (sometimes referred to as reinforcement);

(b) a collection of learning rules for indicating how to update the ANN;

(c) a learning algorithm for using the learning rules for adjusting the ANN weights.

Furthermore, there are other implementation issues such as:

(d) how many layers a artificial neural net should have to effectively capture the patterns embedded within the training data. For example, the benefits of using small ANN are many. less costly to implement, faster, and tend to generalize better because they avoid overfitting weights to training patterns. That is, in general, more unknown parameters (weights) induce more local and global minima in the error surface or space. However, the error surface of smaller nets can be very rugged and have few good solutions, making it difficult for a local minimization algorithm to find a good solution from a random starting point as one skilled in the art will understand;

(e) how many units or neurons to provide per layer;

(f) how large should the training set be presented to provide effective generalization to non-training data

(g) what type of transfer functions should be used.

However, the architecture of the present invention allows substantial flexibility in the implementation of ANN for FOMs 1224. In particular, there is no need to choose only one artificial neural net architecture and/or implementation in that a plurality of ANNs may be accommodated by the architecture of the location engine 139. Furthermore, it is important to keep in mind that it may not be necessary to train a ANN for a FOM as rigorously as is done in typical ANN applications since the accuracy and reliability in estimating the location of a target MS 140 with the present invention comes from synergistically utilizing a plurality of different MS location estimators, each of which may be undesirable in terms of accuracy and/or reliability in some areas, but when their estimates are synergistically used as in the location engine 139, accurate and reliable location estimates can be attained. Accordingly, one embodiment of the present invention may have a plurality of moderately well trained ANNs having different neural net architectures such as: multilayer perceptrons, adaptive resonance theory models, and radial basis function networks.

Additionally, many of the above mentioned ANN architecture and implementation decisions can be addressed substantially automatically by various commercial artificial neural net development systems such as: "NEUROGENETIC OPTIMIZER" by BioComp Systems, wherein genetic algorithms are used to optimize and configure ANNs, and artificial neural network hardware and software products by Accurate Automation Corporation of Chattanooga, Tennessee, such as "ACCURATE AUTOMATION NEURAL NETWORK TOOLS.

Artificial Neural Network Input and Output

It is worthwhile to discuss the data representations for the inputs and outputs of a ANN used for generating MS location estimates. Regarding ANN input representations, recall that the signal processing subsystem 1220 may provide various RF signal measurements as input to an ANN (such as the RF signal measurements derived from verified location signatures in the location signature data base 1320). For example, a representation of a histogram of the frequency of occurrence of CDMA fingers in a time delay vs. signal strength 2-dimensional domain may be provided as input to such an ANN. In particular, a 2-dimensional grid of signal strength versus time delay bins may be provided so that received signal measurements are slotted into an appropriate bin of the grid. In one embodiment, such a grid is a six by six array of bins such as illustrated in the left portion of Fig. 14. That is, each of the signal strength and time delay axises are partitioned into six ranges so that both the signal strength and the time delay of RF signal measurements can be slotted into an appropriate range, thus determining the bin.

Note that RF signal measurement data (i.e., location signatures) slotted into a grid of bins provides a convenient mechanism for classifying RF measurements received over time so that when each new RF measurement data is assigned to its bin, a counter for the bin can be incremented. Thus in one embodiment, the RF measurements for each bin can be represented pictorially as a histogram. In any case, once the RF measurements have been slotted into a grid, various filters may be applied for filtering outliers and noise prior to inputting bin values to an ANN. Further, various amounts of data from such a grid may be provided to an ANN. In one embodiment, the tally from each bin is provided to an ANN. Thus, as many as 108 values could be input to the ANN (two values defining each bin, and a tally for the bin). However, other representations are also possible. For instance, by ordering the bin tallies linearly, only 36 need be provided as ANN input. Alternatively, only representations of bins having the highest tallies may be provided as ANN input. Thus, for example, if the highest 10 bins and their tallies were provided as ANN input, then only 20 inputs need be provided (i.e., 10 input pairs, each having a single bin identifier and a corresponding tally).

In addition, note that the signal processing subsystem 1220 may also obtain the identifications of other base stations 122 (152) for which their pilot channels can be detected by the target MS 140 (i.e., the forward path), or for which the base stations can detect a signal from the target MS (i.e., the reverse path). Thus, in order to effectively utilize substantially all pertinent location RF signal measurements (i.e., from location signature data derived from communications between the target MS 140 and the base station infrastructure), a technique is provided wherein a plurality of ANNs may be activated using various portions of an ensemble of location signature data obtained. However, before describing this technique, it is worthwhile to note that a naive strategy of providing input to a single ANN for locating target MSs throughout an area having a large number of base stations (e.g., 300) is likely to be undesirable. That is, given that each base station (antenna sector) nearby the target MS is potentially able to provide the ANN with location signature data, the ANN would have to be extremely large and therefore may require inordinate training and retraining. For example, since there may be approximately 30 to 60 ANN inputs per location signature, an ANN for an area having even twenty base stations 122 can require at least 600 input neurons, and potentially as many as 1,420 (i.e., 20 base stations with 70 inputs per base station and one input for every one of possibly 20 additional surrounding base stations in the radio coverage area 120 that might be able to detect, or be detected by, a target MS 140 in the area corresponding to the ANN).

Accordingly, the technique described herein limits the number of input neurons in each ANN constructed and generates a larger number of these smaller ANNs. That is, each ANN is trained on location signature data (or, more precisely, portions of location signature clusters) in an area A_{ANN} (hereinafter also denoted the "net area"), wherein each input neuron receives a unique input from either:

(A1) location signature data (e.g., signal strength/time delay bin tallies) corresponding to transmissions between an MS 140 and a relatively small number of base stations 122 in the area A_{ANN}. For instance, location signature data obtained from, for example, four base stations 122 (or antenna sectors) in the area A_{ANN}. Note, each location signature data cluster includes fields describing the wireless communication devices used; e.g., (i) the make and model of the target MS; (ii) the current and maximum transmission power; (iii) the MS battery power (instantaneous or current); (iv) the base station (sector) current power level; (v) the base station make and model and revision level; (vi) the air interface type and revision level (of, e.g., CDMA, TDMA or AMPS).

(A2) a discrete input corresponding to each base station 122 (or antenna sector 130) in a larger area containing A_{ANN}, wherein each such input here indicates whether the corresponding base station (sector):

- (i) is on-line (i.e., capable of wireless communication with MSs) and at least its pilot channel signal is detected by the target MS 140, but the base station (sector) does not detect the target MS;
- (ii) is on-line and the base station (sector) detects a wireless transmission from the target MS, but the target MS does not detect the base station (sector) pilot channel signal;
- (iii) is on-line and the base station (sector) detects the target MS and the base station (sector) is detected by the target MS;
- (iv) is on-line and the base station (sector) does not detect the target MS, the base station is not detected by the target MS; or
- (v) is off-line (i.e., incapable of wireless communication with one or more MSs).

Note that (i)-(v) are hereinafter referred to as the "detection states."

Thus, by generating an ANN for each of a plurality of net areas (potentially overlapping), a local environmental change in the wireless signal characteristics of one net area is unlikely to affect more than a small number of adjacent or overlapping net areas. Accordingly, such local environmental changes can be reflected in that only the ANNs having net areas affected by the local change need to be retrained. Additionally, note that in cases where RF measurements from a target MS 140 are received across multiple net areas, multiple ANNs may be activated, thus providing multiple MS location estimates. Further, multiple ANNs may be activated when a location signature cluster is received for a target MS 140 and location signature cluster includes location signature data corresponding to wireless transmissions between the MS and, e.g., more base stations (antenna sectors) than needed for the collection B described in the previous section. That is, if each collection B identifies four base stations 122 (antenna sectors), and a received location signature cluster includes location signature data corresponding to five base stations (antenna sectors), then there may be up to five ANNs activated to each generate a location estimate.

Moreover, for each of the smaller ANNs, it is likely that the number of input neurons is on the order of 330; (i.e., 70 inputs per each of four location signatures (i.e., 35 inputs for the forward wireless communications and 35 for the reverse wireless communications), plus 40 additional discrete inputs for an appropriate area surrounding A_{ANN}, plus 10 inputs related type of MS, power levels, etc. However, it is important to note that the number of base stations (or antenna sectors 130) having corresponding location signature data to be provided to such an ANN may vary. Thus, in some subareas of the coverage area 120, location signature data from five or more base stations (antenna sectors) may be used, whereas in other subareas three (or less) may be used.,

Regarding the output from ANNs used in generating MS location estimates, there are also numerous options. In one embodiment, two values corresponding to the latitude and longitude of the target MS are estimated. Alternatively, by applying a mesh to the coverage area 120, such ANN output may be in the form of a row value and a column value of a particular mesh cell (and its corresponding area) where the target MS is estimated to be. Note that the cell sizes of the mesh need not be of a particular shape nor of uniform size. However, simple non-oblong shapes are desirable. Moreover, such cells should be sized so that each cell has an area approximately the size of the maximum degree of location precision desired. Thus, assuming square mesh cells, 250 to 350 feet per cell side in an urban/suburban area, and 500 to 700 feet per cell side in a rural area may be desirable.

Artificial Neural Network Training

The following are steps provide one embodiment for training a location estimating ANN according to the present invention.

(a) Determine a collection, C, of clusters of RF signal measurements (i.e., location signatures) such that each cluster is for RF transmissions between an MS 140 and a common set, B, of base stations 122 (or antenna sectors 130) such the measurements are as described in (A1) above. In one embodiment, the collection C is determined by interrogating the location signature data base 1320 for verified location signature clusters stored therein having such a common set B of base stations (antenna sectors). Alternatively in another embodiment, note that the collection C may be determined from (i) the existing engineering and planning data from service providers who are planning wireless cell sites, or (ii) service provider test data obtained using mobile test sets, access probes or other RF field measuring devices. Note that such a collection B of base stations (antenna sectors) should only be created when the set C of verified location signature clusters is of a sufficient size so that it is expected that the ANN can be effectively trained.

(b) Determine a collection of base stations (or antenna sectors 130), B', from the common set B, wherein B' is small (e.g., four or five).

(c) Determine the area, A_{ANN}, to be associated with collection B' of base stations (antenna sectors). In one embodiment, this area is selected by determining an area containing the set L of locations of all verified location signature clusters determined in step (a) having location signature data from each of the base stations (antenna sectors) in the collection B'. More precisely, the area, A_{ANN}, may be determined by providing a covering of the locations of L, such as, e.g., by cells of a mesh of appropriately fine mesh size so that each cell is of a size not substantially larger than the maximum MS location accuracy desired.

(d) Determine an additional collection, b, of base stations that have been previously detected (and/or are likely to be detected) by at least one MS in the area A_{ANN}.

(e) Train the ANN on input data related to: (i) signal characteristic measurements of signal transmissions between MSs 140 at verified locations in A_{ANN}, and the base stations (antenna sectors) in the collection B', and (ii) discrete inputs of detection states from the base stations represented in the collection b. For example, train the ANN on input including: (i) data from verified location signatures from each of the base stations (antenna sectors) in the collection B', wherein each location signature is part of a cluster in the collection C; (ii) a collection of discrete values corresponding to other base stations (antenna sectors) in the area b containing the area, A_{ANN}.

Regarding (d) immediately above, it is important to note that it is believed that less accuracy is required in training a ANN used for generating a location hypothesis (in a FOM 1224) for the present invention than in most applications of ANNs (or other trainable/adaptive components) since, in most circumstances, when signal measurements are provided for locating a target MS 140, the location engine 139 will activate a plurality location hypothesis generating modules (corresponding to one or more FOMs 1224) for substantially simultaneously generating a plurality of different location estimates (i.e., hypotheses). Thus, instead of training each ANN so that it is expected to be, e.g., 92% or higher in accuracy, it is believed that synergies with MS location estimates from other location hypothesis generating components will effectively compensate for any reduced accuracy in such a ANN (or any other location hypothesis generating component). Accordingly, it is believed that training time for such ANNs may be reduced without substantially impacting the MS locating performance of the location engine 139.

Finding Near-Optimal Location Estimating Artificial Neural Networks

In one traditional artificial neural network training process, a relatively tedious set of trial and error steps may be performed for configuring an ANN so that training produces effective learning. In particular, an ANN may require configuring parameters related to, for example, input data scaling, test/training set classification, detecting and removing unnecessary input variable selection. However, the present invention reduces this tedium. That is, the present invention uses mechanisms such as genetic algorithms or other mechanisms for avoiding non-optimal but locally appealing (i.e., local minimum) solutions, and locating near-optimal solutions instead. In particular, such mechanism may be used to adjust the matrix of weights for the ANNs so that very good, near optimal ANN configurations may be found efficiently. Furthermore, since the signal processing system 1220 uses various types of signal processing filters for filtering the RF measurements received from transmissions between an MS 140 and one or more base stations (antenna sectors 130), such mechanisms for finding near-optimal solutions may be applied to selecting appropriate filters as well. Accordingly, in one embodiment of the present invention, such filters are paired with particular ANNs so that the location signature data supplied to each ANN is filtered according to a corresponding "filter description" for the ANN, wherein the filter description specifies the filters to be used on location signature data prior to inputting this data to the ANN. In particular, the filter description can define a pipeline of filters having a sequence of filters wherein for each two consecutive filters, f_1 and f_2 (f_1 preceding f_2), in a filter description, the output of f_1 flows as input to f_2. Accordingly, by encoding such a filter description together with its corresponding ANN so that the encoding can be provided to a near optimal solution finding mechanism such as a genetic algorithm, it is believed that enhanced ANN locating performance can be obtained. That is, the combined genetic codes of the filter description and the ANN are manipulated by the genetic algorithm in a search for a satisfactory solution (i.e., location error estimates within a desired range). This process and system provides a mechanism for optimizing not only the artificial neural network architecture, but also identifying a near optimal match between the ANN and one or more signal processing filters. Accordingly, the following filters may be used in a filter pipeline of a filter description: Sobel, median, mean, histogram normalization, input cropping, neighbor, Gaussion, Weiner filters.

One embodiment for implementing the genetic evolving of filter description and ANN pairs is provided by the following steps that may automatically performed without substantial manual effort:

1) Create an initial population of concatenated genotypes, or genetic representations for each pair of an artificial neural networks and corresponding filter description pair. Also, provide seed parameters which guide the scope and characterization of the artificial neural network architectures, filter selection and parameters, genetic parameters and system control parameters.

2) Prepare the input or training data, including, for example, any scaling and normalization of the data.

3) Build phenotypes, or artificial neural network/filter description combinations based on the genotypes.

4) Train and test the artificial neural network/filter description phenotype combinations to determine fitness; e.g., determine an aggregate location error .measurement for each network/filter description phenotype.

5) Compare the fitnesses and/or errors, and retain the best network/filter description phenotypes.

6) Select the best networks/filter descriptions in the phenotype population (i.e., the combinations with small errors).

7) Repopulate the population of genotypes for the artificial neural networks and the filter descriptions back to a predetermined size using the selected phenotypes.

8) Combine the artificial neural network genotypes and filter description genotypes thereby obtaining artificial neural network/filter combination genotypes.

9) Mate the combination genotypes by exchanging genes or characteristics/features of the network/ filter combinations.

10) If system parameter stopping criteria is not satisfied, return to step 3.

Note that artificial neural network genotypes may be formed by selecting various types of artificial neural network architectures suited to function approximation, such as fast back propagation, as well as characterizing several varieties of candidate transfer/activation functions, such as Tanh, logistic, linear, sigmoid and radial basis. Furthermore, ANNs having complex inputs may be selected (as determined by a filter type in the signal processing subsystem 1220) for the genotypes.

Examples of genetic parameters include: (a) maximum population size (typical default: 300), (b) generation limit (typical default: 50), (c) selection criteria, such as a certain percentage to survive (typical default: 0.5) or roulette wheel, (d) population refilling, such as random or cloning (default), (e) mating criteria, such as tail swapping (default) or two cut swapping, (f) rate for a choice of mutation criterion, such as random exchange (default: 0.25) or section reversal, (g) population size of the concatenated artificial neural network/ filter combinations, (h) use of statistical seeding on the initial population to bias the random initialization toward stronger first order relating variables, and (i) neural node influence factors, e.g., input nodes and hidden nodes. Such parameters can be used as weighting factors that influences the degree the system optimizes for accuracy versus network compactness. For example, an input node factor greater than 0 provides a means to reward artificial neural networks constructed that use fewer input variables (nodes). A reasonable default value is 0.1 for both input and hidden node factors.

Examples of neural net/filter description system control parameters include: (a) accuracy of modeling parameters, such as relative accuracy, R-squared, mean squared error, root mean squared error or average absolute error (default), and (b) stopping criteria parameters, such as generations run, elapsed time, best accuracy found and population convergence.

Locating a Mobile Station Using Artificial Neural Networks

When using an artificial neural network for estimating a location of an MS 140, it is important that the artificial neural network be provided with as much accurate RF signal measurement data regarding signal transmissions between the target MS 140 and the base station infrastructure as possible. In particular, assuming ANN inputs as described hereinabove, it is desirable to obtain the detection states of as many surrounding base stations as possible. Thus, whenever the location engine 139 is requested to locate a target MS 140 (and in particular in an emergency context such as an emergency 911 call), the location center 140 automatically transmits a request to the wireless infrastructure to which the target MS is assigned for instructing the MS to raise its transmission power to full power for a short period of time (e.g., 100 milliseconds in a base station infrastructure configuration an optimized for such requests to 2 seconds in a non-optimized configuration). Note that the request for a change in the transmission power level of the target MS has a further advantage for location requests such as emergency 911 that are initiated from the MS itself in that a first ensemble of RF signal measurements can be provided to the location engine 139 at the initial 911 calling power level and then a second ensemble of RF signal measurements can be provided at a second higher transmission power level. Thus, in one embodiment of the present invention, an artificial neural network can be trained not only on the location signature cluster derived from either the initial wireless 911 transmissions or the full power transmissions, but also on the differences between these two transmissions. In particular, the difference in the detection states of the discrete ANN inputs between the two transmission power levels may provide useful additional information for more accurately estimating a location of a target MS.

It is important to note that when gathering RF signal measurements from a wireless base station network for locating MSs, the network should not be overburdened with location related traffic. Accordingly, note that network location data requests for data particularly useful for ANN based FOMs is generally confined to the requests to the base stations in the immediate area of a target MS 140 whose location is desired. For instance, both collections of base stations B' and b discussed in the context of training an ANN are also the same collections of base stations from which MS location data would be requested. Thus, the wireless network MS location data requests are data driven in that the base stations to queried for location data (i.e., the collections B' and b) are determined by previous RF signal measurement characteristics recorded. Accordingly, the selection of the collections B' and b are adaptable to changes in the wireless environmental characteristics of the coverage area 120.

LOCATION SIGNATURE DATA BASE

Before proceeding with a description of other levels of the present invention as described in (24.1) through (24.3) above, in this section further detail is provided regarding the location signature data base 1320. Note that a brief description of the location signature data base was provided above indicating that this data base stores MS location data from verified and/or known locations (optionally with additional known environmental characteristic values) for use in enhancing current target MS location hypotheses and for comparing archived location data with location signal data obtained from a current target MS. However, the data base management system functionality incorporated into the location signature data base 1320 is an important aspect of the present invention, and is therefore described in this section. In particular, the data base management functionality described herein addresses a number of difficulties encountered in maintaining a large archive of signal processing data such as MS signal location data. Some of these difficulties can be described as follows:

(a) in many signal processing contexts, in order to effectively utilize archived signal processing data for enhancing the performance of a related signal processing application, there must be an large amount of signal related data in the archive, and this data must be adequately maintained so that as archived signal data becomes less useful to the corresponding signal processing application (i.e., the data becomes "inapplicable") its impact on the application should be correspondingly reduced. Moreover, as archive data becomes substantially inapplicable, it should be filtered from the archive altogether. However, the size of the data in the archive makes it prohibitive for such a process to be performed manually, and there may be no simple or straightforward techniques for automating such impact reduction or filtering processes for inapplicable signal data;

(b) it is sometimes difficult to determine the archived data to use in comparing with newly obtained signal processing application data; and

(c) it is sometimes difficult to determine a useful technique for comparing archived data with newly obtained signal processing application data.

It is an aspect of the present invention that the data base management functionality of the location signature data base 1320 addresses each of the difficulties mentioned immediately above. For example, regarding (a), the location signature data base is "self cleaning" in that by associating a confidence value with each loc sig in the data base and by reducing or increasing the confidences of archived verified loc sigs according to how well their signal characteristic data compares with newly received verified location signature data, the location signature data base 1320 maintains a consistency with newly verified loc sigs.

The following data base management functional descriptions describe some of the more noteworthy functions of the location signature data base 1320. Note that there are various ways that these functions may be embodied. So as to not overburden the reader here, the details for one embodiment is provided in APPENDIX C. Figs. 16a through 16c present a table providing a brief description of the attributes of the location signature data type stored in the location signature data base 1320.

LOCATION SIGNATURE PROGRAM DESCRIPTIONS

The following program updates the random loc sigs in the location signature data base 1320. In one embodiment, this program is invoked primarily by the Signal Processing Subsystem.

Update Location signature Database Program

Update_Loc_Sig_DB(new_loc_obj, selection_criteria, loc_sig_pop)

/* This program updates loc sigs in the location signature data base 1320. That is, this program updates, for example, at least the location information for verified random loc sigs residing in this data base. The general strategy here is to use information (i.e., "new_loc_obj") received from a newly verified location (that may not yet be entered into the location signature data base) to assist in determining if the previously stored random verified loc sigs are still reasonably valid to use for:

(29.1) estimating a location for a given collection (i.e., "bag") of wireless (e.g., CDMA) location related signal characteristics received from an MS,

(29.2) training (for example) adaptive location estimators (and location hypothesizing models), and

(29.3) comparing with wireless signal characteristics used in generating an MS location hypothesis by one of the MS location hypothesizing models (denoted First Order Models, or, FOMs).

More precisely, since it is assumed that it is more likely that the newest location information obtained is more indicative of the wireless (CDMA) signal characteristics within some area surrounding a newly verified location than the verified loc sigs (location signatures) previously entered into the Location Signature data base, such verified loc sigs are compared for signal characteristic consistency with the newly verified location information (object) input here for determining whether some of these "older" data base verified loc sigs still appropriately characterize their associated location.

In particular, comparisons are iteratively made here between each (target) loc sig "near" "new_loc_obj" and a population of loc sigs in the location signature data base 1320 (such population typically including the loc sig for "new_loc_obj) for:

(29.4) adjusting a confidence factor of the target loc sig. Note that each such confidence factor is in the range [0, 1] with 0 being the lowest and 1 being the highest. Further note that a confidence factor here can be raised as well as lowered depending on how well the target loc sig matches or is consistent with the population of loc sigs to which it is compared. Thus, the confidence in any particular verified loc sig, LS, can fluctuate with successive invocations of this program if the input to the successive invocations are with location information geographically "near" LS.

(29.5) remove older verified loc sigs from use whose confidence value is below a predetermined threshold. Note, it is intended that such predetermined thresholds be substantially automatically adjustable by periodically testing various confidence factor thresholds in a specified geographic area to determine how well the eligible data base loc sigs (for different thresholds) perform in agreeing with a number of verified loc sigs in a "loc sig test-bed", wherein the test bed may be composed of, for example, repeatable loc sigs and recent random verified loc sigs.

Note that this program may be invoked with a (verified/known) random and/or repeatable loc sig as input. Furthermore, the target loc sigs to be updated may be selected from a particular group of loc sigs such as the random loc sigs or the repeatable loc sigs, such selection being determined according to the input parameter, "selection_criteria" while the comparison population may be designated with the input parameter, "loc_sig_pop". For example, to update confidence factors of certain random loc sigs near "new_loc_obj", "selection_criteria" may be given a value indicating, "USE_RANDOM_LOC_SIGS", and "loc_sig_pop" may be given a value indicating, "USE_REPEATABLE_LOC_SIGS". Thus, if in a given geographic area, the repeatable loc sigs (from, e.g., stationary transceivers) in the area have recently been updated, then by successively providing "new_loc_obj" with a loc sig for each of these repeatable loc sigs, the stored random loc sigs can have their confidences adjusted.

Alternatively, in one embodiment of the present invention, the present function may be used for determining when it is desirable to update repeatable loc sigs in a particular area (instead of automatically and periodically updating such repeatable loc sigs). For example, by adjusting the confidence factors on repeatable loc sigs here provides a method for determining when repeatable loc sigs for a given area should be updated. That is, for example, when the area's average confidence factor for the repeatable loc sigs drops below a given (potentially high) threshold, then the MSs that provide the repeatable loc sigs can be requested to respond with new loc sigs for updating the data base. Note, however, that the approach presented in this function assumes that the repeatable location information in the location signature data base 1320 is maintained with high confidence by, for example, frequent data base updating. Thus, the random location signature data base verified location information may be effectively compared against the repeatable loc sigs in an area.

INPUT:

new_loc_obj: a data representation at least including a loc sig for an associated location about which Location Signature loc sigs are to have their confidences updated.

selection_criteria: a data representation designating the loc sigs to be selected to have their confidences updated (may be defaulted). The following groups of loc sigs may be selected: "USE_RANDOM_LOC_SIGS" (this is the default), USE_REPEATABLE_LOC_SIGS", "USE_ALL_LOC_SIGS". Note that each of these selections has values for the following values associated with it (although the values may be defaulted):

(a) a confidence reduction factor for reducing loc sig confidences,

(b) a big_error_threshold for determining the errors above which are considered too big to ignore,

(c) a confidence_increase_factor for increasing loc sig confidences,

(d) a small_error_threshold for determining the errors below which are considered too small (i.e., good) to ignore.

(e) a recent_time for specifying a time period for indicating the loc sigs here considered to be "recent".

loc_sig_pop: a data representation of the type of loc sig population to which the loc sigs to be updated are compared. The following values may be provided:

(a) "USE ALL LOC SIGS IN DB",

(b) "USE ONLY REPEATABLE LOC SIGS" (this is the default),

(c) "USE ONLY LOC SIGS WITH SIMILAR TIME OF DAY"

However, environmental characteristics such as: weather, traffic, season are also contemplated.

Confidence Aging Program

The following program reduces the confidence of verified loc sigs in the location signature data base 1320 that are likely to be no longer accurate (i.e., in agreement with comparable loc sigs in the data base). If the confidence is reduced low enough, then such loc sigs are removed from the data base. Further, if for a location signature data base verified location composite entity (i.e., a collection of loc sigs for the same location and time), this entity no longer references any valid loc sigs, then it is also removed from the data base. Note that this program is invoked by "Update_Loc_Sig_DB".

reduce_bad_DB_loc_sigs(loc_sig_bag , error_rec_set, big_error_threshold confidence_reduction_factor, recent_time)

Inputs:

loc_sig_bag: A collection or "bag" of loc sigs to be tested for determining if their confidences should be lowered and/or any of these loc sigs removed.

error_rec_set: A set of error records (objects), denoted "error_recs", providing information as to how much each loc sig in "loc_sig_bag" disagrees with comparable loc sigs in the data base. That is, there is a "error_rec" here for each loc sig in "loc_sig_bag".

big_error_threshold: The error threshold above which the errors are considered too big to ignore.

confidence_reduction_factor: The factor by which to reduce the confidence of loc sigs.

recent_time: Time period beyond which loc sigs are no longer considered recent. Note that "recent" loc sigs (i.e., more recent than "recent_time") are not subject to the confidence reduction and filtering of this actions of this function.

Confidence Enhancement Program

The following program increases the confidence of verified Location Signature loc sigs that are (seemingly) of higher accuracy (i.e., in agreement with comparable loc sigs in the location signature data base 1320). Note that this program is invoked by "Update_Loc_Sig_DB".

increase_confidence_of_good_DB_loc_sigs(nearby_loc_sig_bag, error_rec_set, small_error_threshold, confidence_increase_factor, recent_time);

Inputs:

loc_sig_bag: A collection or "bag" of to be tested for determining if their confidences should be increased.

error_rec_set: A set of error records (objects), denoted "error_recs", providing information as to how much each loc sig in "loc_sig_bag" disagrees with comparable loc sigs in the location signature data base. That is, there is a "error_rec" here for each loc sig in "loc_sig_bag".

small_error_threshold: The error threshold below which the errors are considered too small to ignore.

confidence_increase_factor: The factor by which to increase the confidence of loc sigs.

recent_time: Time period beyond which loc sigs are no longer considered recent. Note that "recent" loc sigs (i.e., more recent than "recent_time") are not subject to the confidence reduction and filtering of this actions of this function.

Location Hypotheses Consistency Program

The following program determines the consistency of location hypotheses with verified location information in the location signature data base 1320. Note that in the one embodiment of the present invention, this program is invoked primarily by a module denoted the historical location reasoner 1424 described sections hereinbelow. Moreover, the detailed description for this program is provided with the description of the historical location reasoner hereinbelow for completeness.

DB_Loc_Sig_Error_Fit(hypothesis, measured_loc_sig_bag, search_criteria)

/* This function determines how well the collection of loc sigs in "measured_loc_sig_bag" fit with the loc sigs in the location signature data base 1320 wherein the data base loc sigs must satisfy the criteria of the input parameter "search_criteria" and are relatively close to the MS location estimate of the location hypothesis, "hypothesis".

Input: hypothesis: MS location hypothesis;

measured_loc_sig_bag: A collection of measured location signatures ("loc sigs" for short) obtained from the MS (the data structure here is an aggregation such as an array or list). Note, it is assumed that there is at most one loc sig here per Base Station in this collection. Additionally, note that the input data structure here may be a location signature cluster such as the "loc_sig_cluster" field of a location hypothesis (cf. Fig. 9). Note that variations in input data structures may be accepted here by utilization of flag or tag bits as one skilled in the art will appreciate;

search_criteria: The criteria for searching the verified location signature data base for various categories of loc sigs. The only limitation on the types of categories that may be provided here is that, to be useful, each category should have meaningful number of loc sigs in the location signature data base. The following categories included here are illustrative, but others are contemplated:

(a) "USE ALL LOC SIGS IN DB" (the default),

(b) "USE ONLY REPEATABLE LOC SIGS",

(c) "USE ONLY LOC SIGS WITH SIMILAR TIME OF DAY".

Further categories of loc sigs close to the MS estimate of "hypothesis" contemplated are: all loc sigs for the same season and same time of day, all loc sigs during a specific weather condition (e.g., snowing) and at the same time of day, as well as other limitations for other environmental conditions such as traffic patterns. Note, if this parameter is NIL, then (a) is assumed.

Returns: An error object (data type: "error_object") having: (a) an "error" field with a measurement of the error in the fit of the location signatures from the MS with verified location signatures in the location signature data base 1320; and (b) a "confidence" field with a value indicating the perceived confidence that is to be given to the "error" value. */

Location Signature Comparison Program

The following program compares: (a1) loc sigs that are contained in (or derived from) the loc sigs in "target_loc_sig_bag" with (b1) loc sigs computed from verified loc sigs in the location signature data base 1320. That is, each loc sig from (a1) is compared with a corresponding loc sig from (b) to obtain a measurement of the discrepancy between the two loc sigs. In particular, assuming each of the loc sigs for "target_loc_sig_bag" correspond to the same target MS location, wherein this location is "target_loc", this program determines how well the loc sigs in "target_loc_sig_bag" fit with a computed or estimated loc sig for the location, "target_loc" that is derived from the verified loc sigs in the location signature data base 1320. Thus, this program may be used: (a2) for determining how well the loc sigs in the location signature cluster for a target MS ("target_loc_sig_bag") compares with loc sigs derived from verified location signatures in the location signature data base, and (b2) for determining how consistent a given collection of loc sigs ("target_loc_sig_bag") from the location signature data base is with other loc sigs in the location signature data base. Note that in (b2) each of the one or more loc sigs in "target_loc_sig_bag" have an error computed here that can be used in determining if the loc sig is becoming inapplicable for predicting target MS locations.

Determine_Location_Signature_Fit_Errors(target_loc, target_loc_sig_bag, search_area, search_criteria, output_criteria)

/* Input: target_loc: An MS location or a location hypothesis for an MS. Note, this can be any of the following:

(a) An MS location hypothesis, in which case, if the hypothesis is inaccurate, then the loc sigs in "target_loc_sig_bag" are the location signature cluster from which this location hypothesis was derived. Note that if this location is inaccurate, then "target_loc_sig_bag" is unlikely to be similar to the comparable loc sigs derived from the loc sigs of the location signature data base close "target_loc"; or

(b) A previously verified MS location, in which case, the loc sigs of "target_loc_sig_bag" were the loc sigs measurements at the time they were verified. However, these loc sigs may or may not be accurate now.

target_loc_sig_bag: Measured location signatures ("loc sigs" for short) obtained from the MS (the data structure here, bag, is an aggregation such as array or list). It is assumed that there is at least one loc sig in the bag. Further, it is assumed that there is at most one loc sig per Base Station;

search_area: The representation of the geographic area surrounding "target_loc". This parameter is used for searching the Location Signature data base for verified loc sigs that correspond geographically to the location of an MS in "search_area;

search_criteria: The criteria used in searching the location signature data base. The criteria may include the following:

(a) "USE ALL LOC SIGS IN DB",

(b) "USE ONLY REPEATABLE LOC SIGS",

(c) "USE ONLY LOC SIGS WITH SIMILAR TIME OF DAY".

However, environmental characteristics such as: weather, traffic, season are also contemplated.

output_criteria: The criteria used in determining the error records to output in "error_rec_bag". The criteria here may include one of:

(a) "OUTPUT ALL POSSIBLE ERROR_RECS";

(b) "OUTPUT ERROR_RECS FOR INPUT LOC SIGS ONLY".

Returns: error_rec_bag: A bag of error records or objects providing an indication of the similarity between each loc sig in "target_loc_sig_bag" and an estimated loc sig computed for "target_loc" from stored loc sigs in a surrounding area of "target_loc". Thus, each error record/object in "error_rec_bag" provides a measurement of how well a loc sig (i.e., wireless signal characteristics) in "target_loc_sig_bag" (for an associated BS and the MS at "target_loc") correlates with an estimated loc sig between this BS and MS. Note that the estimated loc sigs are determined using verified location signatures in the Location Signature data base. Note, each error record in "error_rec_bag" includes: (a) a BS ID indicating the base station to which the error record corresponds; and (b) a error measurement (>=0), and (c) a confidence value (in [0, 1]) indicating the confidence to be placed in the error measurement.

Computed Location Signature Program

The following program receives a collection of loc sigs and computes a loc sig that is representative of the loc sigs in the collection. That is, given a collection of loc sigs, "loc_sig_bag", wherein each loc sig is associated with the same predetermined Base Station, this program uses these loc sigs to compute a representative or estimated loc sig associated with the predetermined Base Station and associated with a predetermined MS location, "loc_for_estimation". Thus, if the loc sigs in "loc_sig_bag" are from the verified loc sigs of the location signature data base such that each of these loc sigs also has its associated MS location relatively close to "loc_for_estimation", then this program can compute and return a reasonable approximation of what a measured loc sig between an MS at "loc_for_estimation" and the predetermined Base Station ought to be. This program is invoked by "Determine_Location_Signature_Fit_Errors".

estimate_loc_sig_from_DB(loc_for_estimation, loc_sig_bag)

Geographic Area Representation Program

The following program determines and returns a representation of a geographic area about a location, "loc", wherein: (a) the geographic area has associated MS locations for an acceptable number (i.e., at least a determined minimal number) of verified loc sigs from the location signature data base, and (b) the geographical area is not too big. However, if there are not enough loc sigs in even a largest acceptable search area about "loc", then this largest search area is returned. "DB_Loc_Sig_Error_Fit"

get_area_to_search(loc)

Location signature Comparison Program

This program compares two location signatures, "target_loc_sig" and "comparison_loc_sig", both associated with the same predetermined Base Station and the same predetermined MS location (or hypothesized location). This program determines a measure of the difference or error between the two loc sigs relative to the variability of the verified location signatures in a collection of loc sigs denoted the "comparison_loc_sig_bag" obtained from the location signature data base. It is assumed that "target_loc_sig", "comparison_loc_sig" and the loc sigs in "comparison_loc_sig_bag" are all associated with the same base station. This program returns an error record (object), "error_rec", having an error or difference value and a confidence value for the error value. Note, the signal characteristics of "target_loc_sig" and those of "comparison_loc_sig" are not assumed to be similarly normalized (e.g., via filters as per the filters of the Signal Processing Subsystem) prior to entering this function. It is further assumed that typically the input loc sigs satisfy the "search_criteria". This program is invoked by: the program, "Determine_Location_Signature_Fit_Errors", described above.

get_difference_measurement(target_loc_sig, comparison_loc_sig, comparison_loc_sig_bag, search_area, search_criteria)

Input:

target_loc_sig: The loc sig to which the "error_rec" determined here is to be associated.

comparison_loc_sig: The loc sig to compare with the "target_loc_sig". Note, if "comparison_loc_sig" is NIL, then this parameter has a value that corresponds to a noise level of "target_loc_sig".

comparison_loc_sig_bag: The universe of loc sigs to use in determining an error measurement between "target_loc_sig" and "comparison_loc_sig". Note, the loc sigs in this aggregation include all loc sigs for the associated BS that are in the "search_area".

search_area: A representation of the geographical area surrounding the location for all input loc sigs. This input is used for determining extra information about the search area in problematic circumstances.

search_criteria: The criteria used in searching the location signature data base. The criteria may include the following:

(a) "USE ALL LOC SIGS IN DB",

(b) "USE ONLY REPEATABLE LOC SIGS",

(c) "USE ONLY LOC SIGS WITH SIMILAR TIME OF DAY

However, environmental characteristics such as: weather, traffic, season are also contemplated.

Detailed Description of the Hypothesis Evaluator Modules

Context Adjuster Embodiments

The context adjuster 1326 performs the first set of potentially many adjustments to at least the confidences of location hypotheses, and in some important embodiments, both the confidences and the target MS location estimates provided by FOMs 1224 may be adjusted according to previous performances of the FOMs. More particularly, as mentioned above, the context adjuster adjusts confidences so that, assuming there is a sufficient density verified location signature clusters captured in the location signature data base 1320, the resulting location hypotheses output by the context adjuster 1326 may be further processed uniformly and substantially without concern as to differences in accuracy between the first order models from which location hypotheses originate. Accordingly, the context adjuster adjusts location hypotheses both to environmental factors (e.g., terrain, traffic, time of day, etc., as described in 30.1 above), and to how predictable or consistent each first order model (FOM) has been at locating previous target MS's whose locations were subsequently verified.

Of particular importance is the novel computational paradigm utilized herein. That is, if there is a sufficient density of previous verified MS location data stored in the location signature data base 1320, then the FOM location hypotheses are used as an "index" into this data base (i.e., the location signature data base) for constructing new target MS 140 location estimates. A more detailed discussion of this aspect of the present invention is given hereinbelow. Accordingly, only a brief overview is provided here. Thus, since the location signature data base 1320 stores previously captured MS location data including:

(a) clusters of MS location signature signals (see the location signature data base section for a discussion of these signals) and

(b) a corresponding verified MS location, for each such cluster, from where the MS signals originated, the context adjuster 1326 uses newly created target MS location hypotheses output by the FOM's as indexes or pointers into the location signature data base for identifying other geographical areas where the target MS 140 is likely to be located based on the verified MS location data in the location signature data base.

In particular, at least the following two criteria are addressed by the context adjuster 1326:

(32.1) Confidence values for location hypotheses are to be comparable regardless of first order models from which the location hypotheses originate. That is, the context adjuster moderates or dampens confidence value assignment distinctions or variations between first order models so that the higher the confidence of a location hypothesis, the more likely (or unlikely, if the location hypothesis indicates an area estimate where the target MS is NOT) the target MS is perceived to be in the estimated area of the location hypothesis regardless of the First Order Model from which the location hypothesis was output;

(32.2) Confidence values for location hypotheses may be adjusted to account for current environmental characteristics such as month, day (weekday or weekend), time of day, area type (urban, rural, etc.), traffic and/or weather when comparing how accurate the first order models have previously been in determining an MS location according to such environmental characteristics. For example, in one embodiment of the present invention, such environmental characteristics are accounted for by utilizing a transmission area type scheme (as discussed in section 5.9 above) when adjusting confidence values of location hypotheses. Details regarding the use of area types for adjusting the confidences of location hypotheses and provided hereinbelow, and in particular, in APPENDIX D.

Note that in satisfying the above two criteria, the context adjuster 1326, at least in one embodiment, may use heuristic (fuzzy logic) rules to adjust the confidence values of location hypotheses from the first order models. Additionally, the context adjuster may also satisfy the following criteria:

(33.1) The context adjuster may adjust location hypothesis confidences due to BS failure(s),

(33.2) Additionally in one embodiment, the context adjuster may have a calibration mode for at least one of:

(a) calibrating the confidence values assigned by first order models to their location hypotheses outputs;

(b) calibrating itself.

A first embodiment of the context adjuster is discussed immediately hereinbelow and in APPENDIX D. However, the present invention also includes other embodiments of the context adjuster. A second embodiment is also described in Appendix D so as to not overburden the reader and thereby chance losing perspective of the overall invention.

A description of the high level functions in an embodiment of the context adjuster 1326 follows. Details regarding the implementation of these functions are provided in APPENDIX D. Also, many of the terms used hereinbelow are defined in APPENDIX D. Accordingly, the program descriptions in this section provide the reader with an overview of this first embodiment of the context adjuster 1326.

Context_adjuster(loc_hyp_list)

This function adjusts the location hypotheses on the list, "loc_hyp_list", so that the confidences of the location hypotheses are determined more by empirical data than default values from the First Order Models 1224. That is, for each input location hypothesis, its confidence (and an MS location area estimate) may be exclusively determined here if there are enough verified location signatures available within and/or surrounding the location hypothesis estimate.

This function creates a new list of location hypotheses from the input list, "loc_hyp_list", wherein the location hypotheses on the new list are modified versions of those on the input list. For each location hypothesis on the input list, one or more corresponding location hypotheses will be on the output list. Such corresponding output location hypotheses will differ from their associated input location hypothesis by one or more of the following: (a) the "image_area" field (see Fig. 9) may be assigned an area indicative of where the target MS is estimated to be, (b) if "image_area" is assigned, then the "confidence" field will be the confidence that the target MS is located in the area for "image_area", (c) if there are not sufficient "nearby" verified location signature clusters in the location signature data base 1320 to entirely rely on a computed confidence using such verified location signature clusters, then two location hypotheses (having reduced confidences) will be returned, one having a reduced computed confidence (for "image_area") using the verified clusters in the Location Signature data base, and one being substantially the same as the associated input location hypothesis except that the confidence (for the field "area_est") is reduced to reflect the confidence in its paired location hypothesis having a computed confidence for "image_area". Note also, in some cases, the location hypotheses on the input list, may have no change to its confidence or the area to which the confidence applies.

Get_adjusted_loc_hyp_list_for(loc_hyp)

This function returns a list (or more generally, an aggregation object) of one or more location hypotheses related to the input location hypothesis, "loc_hyp". In particular, the returned location hypotheses on the list are "adjusted" versions of "loc_hyp" in that both their target MS 140 location estimates, and confidence placed in such estimates may be adjusted according to archival MS location information in the location signature data base 1320. Note that the steps herein are also provided in flowchart form in Figs. 26a through 26c.

RETURNS: loc_hyp_list This is a list of one or more location hypotheses related to the input "loc_hyp". Each location hypothesis on "loc_hyp_list" will typically be substantially the same as the input "loc_hyp" except that there may now be a new target MS estimate in the field, "image_area", and/or the confidence value may be changed to reflect information of verified location signature clusters in the location signature data base.

The function, "get_adjusted_loc_hyp_list_for," and functions called by this function presuppose a framework or paradigm that requires some discussion as well as the defining of some terms. Note that some of the terms defined hereinbelow are illustrated in Fig. 243.

Define the term the "the cluster set" to be the set of all MS location point estimates (e.g., the values of the "pt_est" field of the location hypothesis data type), for the present FOM, such that:

(a) these estimates are within a predetermined corresponding area (e.g., the "loc_hyp.pt_covering" being such a predetermined corresponding area, or more generally, this predetermined corresponding area is determined as a function of the distance from an initial location estimate, e.g., "loc_hyp.pt_est", from the FOM), and

(b) these point estimates have verified location signature clusters in the location signature data base.

Note that the predetermined corresponding area above will be denoted as the "cluster set area".

Define the term "image cluster set" (for a given First Order Model identified by "loc_hyp.FOM_ID") to mean the set of <u>verified</u> location signature clusters whose MS location point estimates are in "the cluster set".

Note that an area containing the "image cluster set" will be denoted as the "image cluster set area" or simply the "image area" in some contexts. Further note that the "image cluster set area" will be a "small" area encompassing the "image cluster set". In one embodiment, the image cluster set area will be the smallest covering of cells from the mesh for the present FOM that covers the convex hull of the image cluster set. Note that preferably, each cell of each mesh for each FOM is substantially contained within a single (transmission) area type.

Thus, the present FOM provides the correspondences or mapping between elements of the cluster set and elements of the image cluster set.

confidence_adjuster(FOM_ID, image_area, image_cluster_set)

This function returns a confidence value indicative of the target MS 140 being in the area for "image_area". Note that the steps for this function are provided in flowchart form in Figs. 27a and 27b.

RETURNS: A confidence value. This is a value indicative of the target MS being located in the area represented by "image_area" (when it is assumed that for the related "loc_hyp," the "cluster set area" is the "loc_hyp.pt_covering" and "loc_hyp.FOM_ID" is "FOM_ID").

The function, "confidence_adjuster," (and functions called by this function) presuppose a framework or paradigm that requires some discussion as well as the defining of terms.

Define the term "mapped cluster density" to be the number of the verified location signature clusters in an "image cluster set" <u>per unit of area</u> in the "image cluster set area".

It is believed that the higher the "mapped cluster density", the greater the confidence can be had that a target MS actually resides in the "image cluster set area" when an estimate for the target MS (by the present FOM) is in the corresponding "the cluster set".

Thus, the mapped cluster density becomes an important factor in determining a confidence value for an estimated area of a target MS such as, for example, the area represented by "image_area". However, the mapped cluster density value requires modification before it can be utilized in the confidence calculation. In particular, confidence values must be in the range [-1, 1] and a mapped cluster density does not have this constraint. Thus, a "relativized mapped cluster density" for an estimated MS area is desired, wherein this relativized measurement is in the range [-1, +1], and in particular, for positive confidences in the range [0, 1]. Accordingly, to alleviate this difficulty, for the FOM define the term "prediction mapped cluster density" as a mapped cluster density value, MCD, for the FOM and image cluster set area wherein:

(i) MCD is sufficiently high so that it correlates (at least at a predetermined likelihood threshold level) with the actual target MS location being in the "image cluster set area" when a FOM target MS location estimate is in the corresponding "cluster set area";

That is, for a cluster set area (e.g., "loc_hyp.pt_covering") for the present FOM, if the image cluster set area: has a mapped cluster density greater than the "prediction mapped cluster density", then there is a high likelihood of the target MS being in the image cluster set area.

It is believed that the prediction mapped cluster density will typically be dependent on one or more area types. In particular, it is assumed that for each area type, there is a likely range of prediction mapped cluster density values that is substantially uniform across the area type. Accordingly, as discussed in detail hereinbelow, to calculate a prediction mapped cluster density for a particular area type, an estimate is made of the correlation between the mapped cluster densities of image areas (from cluster set areas) and the likelihood that if a verified MS location: (a) has a corresponding FOM MS estimate in the cluster set, and (b) is also in the particular area type, then the verified MS location is also in the image area.

Thus, if an area is within a single area type, then such a "relativized mapped cluster density" measurement for the area may be obtained by dividing the mapped cluster density by the prediction mapped cluster density and taking the smaller of: the resulting ratio and 1.0 as the value for the relativized mapped cluster density.

In some (perhaps most) cases, however, an area (e.g., an image cluster set area) may have portions in a number of area types. Accordingly, a "composite prediction mapped cluster density" may be computed, wherein, a weighted sum is computed of the prediction mapped cluster densities for the portions of the area that is in each of the area types. That is, the weighting, for each of the single area type prediction mapped cluster densities, is the fraction of the total area that this area type is. Thus, a "relativized composite mapped cluster density" for the area here may also be computed by dividing the mapped cluster density by the composite prediction mapped cluster density and taking the smaller of: the resulting ratio and 1.0 as the value for the relativized composite mapped cluster density.

Accordingly, note that as such a relativized (composite) mapped cluster density for an image cluster set area increases/decreases, it is assumed that the confidence of the target MS being in the image cluster set area should increase/decrease, respectively.

get_composite_prediction_mapped_cluster_density_for_high_certainty(FOM_ID, image_area);

The present function determines a composite prediction mapped cluster density by determining a composite prediction mapped cluster density for the area represented by "image_area" and for the First Order Model identified by "FOM_ID".

OUTPUT: composite_mapped_density This is a record for the composite prediction mapped cluster density. In particular, there are with two fields:

(i) a "value" field giving an approximation to the prediction mapped cluster density for the First Order Model having id, FOM_ID;

(ii) a "reliability" field giving an indication as to the reliability of the "value" field. The reliability field is in the range [0, 1] with 0 indicating that the "value" field is worthless and the larger the value the more assurance can be put in "value" with maximal assurance indicated when "reliability" is 1.

get_prediction_mapped_cluster_density_for(FOM_ID, area_type)

The present function determines an approximation to a prediction mapped cluster density, D, for an area type such that if an image cluster set area has a mapped cluster density $>=$ D, then there is a high expectation that the target MS 140 is in the image cluster set area. Note that there are a number of embodiments that may be utilized for this function. The steps herein are also provided in flowchart form in Figs. 29a through 29h.

OUTPUT: prediction_mapped_cluster_density This is a value giving an approximation to the prediction mapped cluster density for the First Order Model having identity, "FOM_ID", and for the area type represented by "area_type" */

It is important to note that the computation here for the prediction mapped cluster density may be more intense than some other computations but the cluster densities computed here need not be performed in real time target MS location processing. That is, the steps of this function may be performed only periodically (e.g., once a week), for each FOM and each area type thereby precomputing the output for this function. Accordingly, the values obtained here may be stored in a table that is accessed during real time target MS location processing. However, for simplicity, only the periodically performed steps are presented here. However, one skilled in the art will understand that with sufficiently fast computational devices, some related variations of this function may be performed in real-time. In particular, instead of supplying area type as an input to this function, a particular area, A, may be provided such as the image area for a cluster set area, or, the portion of such an image area in a particular area type. Accordingly, wherever "area_type" is used in a statement of the embodiment of this function below, a comparable statement with "A" can be provided.

Location Hypothesis Analyzer Embodiment

Referring now to Fig. 7, an embodiment of the Hypothesis Analyzer is illustrated. The control component is denoted the control module 1400. Thus, this control module manages or controls access to the run time location hypothesis storage area 1410. The control module 1400 and the run time location hypothesis storage area 1410 may be implemented as a blackboard system and/or an expert system. Accordingly, in the blackboard embodiment, , and the control module 1400 determines when new location hypotheses may be entered onto the blackboard from other processes such as the context adjuster 1326 as well as when location hypotheses may be output to the most likelihood estimator 1344.

The following is a brief description of each submodule included in the location hypothesis analyzer 1332.

(35.1) A control module 1400 for managing or controlling further processing of location hypotheses received from the context adjuster. This module controls all location hypothesis processing within the location hypothesis analyzer as well as providing the input interface with the context adjuster. There are numerous embodiments that may be utilized for this module, including, but not limited to, expert systems and blackboard managers.

(35.2) A run-time location hypothesis storage area 1410 for retaining location hypotheses during their processing by the location hypotheses analyzer. This can be, for example, an expert system fact base or a blackboard. Note that in some of the discussion hereinbelow, for simplicity, this module is referred to as a "blackboard". However, it is not intended that such notation be a limitation on the present invention; i.e., the term "blackboard" hereinafter will denote a run-time data repository for a data processing paradigm wherein the flow of control is substantially data-driven.

(35.3) An analytical reasoner module 1416 for determining if (or how well) location hypotheses are consistent with well known physical or heuristic constraints as, e.g., mentioned in (30.4) above. Note that this module may be a daemon or expert system rule base.

(35.4) An historical location reasoner module 1424 for adjusting location hypotheses' confidences according to how well the location signature characteristics (i.e., loc sigs) associated with a location hypothesis compare with "nearby" loc sigs in the location signature data base as indicated in (30.3) above. Note that this module may also be a daemon or expert system rule base.

(35.5) A location extrapolator module 1432 for use in updating previous location estimates for a target MS when a more recent location hypothesis is provided to the location hypothesis analyzer 1332. That is, assume that the control module 1400 receives a new location hypothesis for a target MS for which there are also one or more previous location hypotheses that either have been recently processed (i.e., they reside in the MS status repository 1338, as shown best in Fig. 6), or are currently being processed (i.e., they reside in the run-time location hypothesis storage area 1410). Accordingly, if the active_timestamp (see Fig. 9 regarding location hypothesis data fields) of the newly received location hypothesis is sufficiently more recent than the active_timestamp of one of these previous location hypotheses, then an extrapolation may be performed by the location extrapolator module 1432 on such previous location hypotheses so that all target MS location hypotheses being concurrently analyzed are presumed to include target MS location estimates for substantially the same point in time. Thus, initial location estimates generated by the FOMs using different wireless signal measurements, from different signal transmission time intervals, may have their corresponding dependent location hypotheses utilized simultaneously for determining a most likely target MS location estimate. Note that this module may also be daemon or expert system rule base.

(35.6) hypothesis generating module 1428 for generating additional location hypotheses according to, for example, MS location information not adequately utilized or modeled. Note, location hypotheses may also be decomposed here if, for example it is determined that a location hypothesis includes an MS area estimate that has subareas with radically different characteristics such as an MS area estimate that includes an uninhabited area and a densely populated area. Additionally, the hypothesis generating module 1428 may generate "poor reception" location hypotheses that specify MS location areas of known poor reception that are "near" or intersect currently active location hypotheses. Note, that these poor reception location hypotheses may be specially tagged (e.g., with a distinctive FOM_ID value or specific tag field) so that regardless of substantially any other location hypothesis confidence value overlapping such a poor reception area, such an area will maintain a confidence value of "unknown" (i.e., zero). Note that substantially the only exception to this constraint is location hypotheses generated from mobile base stations 148. Note that this module may also be daemon or expert system rule base.

In the blackboard system embodiment of the location hypothesis analyzer, a blackboard system is the mechanism by which the last adjustments are performed on location hypotheses and by which additional location hypotheses may be generated. Briefly, a blackboard system can be described as a particular class of software that typically includes at least three basic components. That is:

(36.1) a data base called the "blackboard," whose stored information is commonly available to a collection of programming elements known as "daemons", wherein, in the present invention, the blackboard includes information concerning the current status of the location hypotheses being evaluated to determine a "most likely" MS location estimate. Note that this data base is provided by the run time location hypothesis storage area 1410;

(36.2) one or more active (and typically opportunistic) knowledge sources, denoted conventionally as "daemons," that create and modify the contents of the blackboard. The blackboard system employed requires only that the daemons have application knowledge specific to the MS location problem addressed by the present invention. As shown in Fig. 7, the knowledge sources or daemons in the hypothesis analyzer include the analytical reasoner module 1416, the hypothesis generating module 1428, and the historical location reasoner module 1416;

(36.3) a control module that enables the realization of the behavior in a serial computing environment. The control element orchestrates the flow of control between the various daemons. This control module is provided by the control module 1400.

Note that this blackboard system may be commercial, however, the knowledge sources, i.e., daemons, have been developed specifically for the present invention. For further information regarding such blackboard systems, the following references are incorporated herein by reference: (a) Jagannathan, V., Dodhiawala, R., & Baum, L. S. (1989). Blackboard architectures and applications. Boston, MA: Harcourt Brace Jovanovich Publishers; (b) Engelmore, R., & Morgan, T. (1988). Blackboard systems. Reading, MA: Addison-Wesley Publishing Company.

Alternatively, the control module 1400 and the run-time location hypothesis storage area 1410 may be implemented as an expert system or as a fuzzy rule inferencing system, wherein the control module 1400 activates or "fires" rules related to the knowledge domain (in the present case, rules relating to the accuracy of MS location hypothesis estimates), and wherein the rules provide a computational embodiment of, for example, constraints and heuristics related to the accuracy of MS location estimates. Thus, the control module 1400 for the present embodiment is also used for orchestrating, coordinating and controlling the activity of the individual rule bases of the location hypothesis analyzer (e.g. as shown in Fig. 7, the analytical reasoner module 1416, the hypothesis generating module 1428 , the historical location reasoner module 1424, and the location extrapolator module 1432). For further information regarding such expert systems, the following reference is incorporated herein by reference: Waterman, D. A. (1970). A guide to expert systems. Reading, MA: Addison-Wesley Publishing Company.

MS Status Repository Embodiment

The MS status repository 1338 is a run-time storage manager for storing location hypotheses from previous activations of the location engine 139 (as well as the output target MS location estimate(s)) so that a target MS may be tracked using target MS location hypotheses from previous location engine 139 activations to determine, for example, a movement of the target MS between evaluations of the target MS location. Thus, by retaining a moving window of previous location hypotheses used in evaluating positions of a target MS, measurements of the target MS's velocity, acceleration, and likely next position may be determined by the location hypothesis analyzer 1332. Further, by providing accessibility to recent MS location hypotheses, these hypotheses may be used to resolve conflicts between hypotheses in a current activation for locating the target MS; e.g., MS paths may be stored here for use in extrapolating a new location

Most Likelihood Estimator Embodiment

The most likelihood estimator 1344 is a module for determining a "most likely" location estimate for a target MS 140 being located (e.g., as in (30.7) above). In one embodiment, the most likelihood estimator performs an integration or summing of all location hypothesis confidence values for any geographic region(s) of interest having at least one location hypothesis that has been provided to the most likelihood estimator, and wherein the location hypothesis has a relatively (or sufficiently) high confidence. That is, the most likelihood estimator 1344 determines the area(s) within each such region having high confidences (or confidences above a threshold) as the most likely target MS 140 location estimates.

In one embodiment of the most likelihood estimator 1344, this module utilizes an area mesh, M, over which to integrate, wherein the mesh cells of M are preferably smaller than the greatest location accuracy desired. That is, each cell, c, of M is assigned a confidence value indicating a likelihood that the target MS 140 is located in c, wherein the confidence value for c is determined by the confidence values of the target MS location estimates provided to the most likelihood estimator 1344. Thus, to obtain the most likely location determination(s) the following steps are performed:

(a) For each of the active location hypotheses output by, e.g., the hypothesis analyzer 1332 (alternatively, the context adjuster 1326), each corresponding MS location area estimate, LAE, is provided with a smallest covering, C_{LEA}, of cells c from M.

(b) Subsequently, each of the cells of C_{LEA} have their confidence values adjusted by adding to it the confidence value for LAE. Accordingly, if the confidence of LEA is positive, then the cells of C_{LEA} have their confidences increased. Alternatively, if the confidence of LEA is negative, then the cells of C_{LEA} have their confidences decreased.

(c) Given that the interval [-1.0, +1.0] represents the range in confidence values, and that this range has been partitioned into intervals, Int, having lengths of, e.g., 0.05, for each interval, Int, perform a cluster analysis function for clustering cells with confidences that are in Int. Thus, a topographical-type map may be constructed from the resulting cell clusters, wherein higher confidence areas are analogous to representations of areas having higher elevations.

(d) Output a representation of the resulting clusters for each Int to the output gateway 1356 for determining the location granularity and representation desired by each location application 146 requesting the location of the target MS 140.

Of course, variations in the above algorithm also within the scope of the present invention. For example, some embodiments of the most likelihood estimator 1344 may:

(e) Perform special processing for areas designated as "poor reception" areas. For example, the most likelihood estimator 1344 may be able to impose a confidence value of zero (i.e., meaning it is unknown as to whether the target MS is in the area) on each such poor reception area regardless of the location estimate confidence values unless there is a location hypothesis from a reliable and unanticipated source. That is, the mesh cells of a poor reception area may have their confidences set to zero unless, e.g., there is a location hypothesis derived from target MS location data provided by a mobile base station 148 that: (a) is near the poor reception area, (b) able to detect that the target MS 140 is in the poor reception area, and (c) can relay target MS location data to the location center 142. In such a case, the confidence of the target MS location estimate from the MBS location hypothesis may take precedence.

(f) Additionally, in some embodiments of the most likelihood estimator 1344, cells c of M that are "near" or adjacent to a covering C_{LEA} may also have their confidences adjusted according to how near the cells c are to the covering. That is, the assigning of confidences to cell meshes may be "fuzzified" in the terms of fuzzy logic so that the confidence value of each location hypothesis utilized by the most likelihood estimator 1344 is provided with a weighting factor depending on its proxity to the target MS location estimate of the location hypothesis. More precisely, it is believed that "nearness," in the present context, should be monotonic with the "wideness" of the covering; i.e., as the extent of the covering increases (decreases) in a particular direction, the cells c affected beyond the covering also increases (decreases). Furthermore, in some embodiments of the most likelihood estimator 1344, the greater (lesser) the confidence in the LEA, the more (fewer) cells c beyond the covering have their confidences affected. To describe this technique in further detail, reference is made to Fig. 10, wherein an area A is assumed to be a covering C_{LEA} having a confidence denoted "conf". Accordingly, to determine a confidence adjustment to add to a cell c not in A (and additionally, the centroid of A not being substantially identical with the centroid of c which could occur if A were donut shaped), the following steps may be performed:

(i) Determine the centroid of A, denoted Cent(A).

(ii) Determine the centroid of the cell c, denoted Q.

(iii) Determine the extent of A along the line between Cent(A) and Q, denoted L.

(iv) For a given type of probability density function, P(x), such as a Gaussian function, let T be the beginning portion of the function that lives on the x-axis interval [0, t], wherein P(t) = ABS(conf) = the absolute value of the confidence of C_{LEA}.

(v) Stretch T along the x-axis so that the stretched function, denoted sT(x), has an x-axis support of $[0, L/(1+e^{-[a(ABS(conf)-1)]})]$, where a is in range of 3.0 to 10.0; e.g., 5.0. Note that sT(x) is the function,

$$P(x * (1+e^{-[a(ABS(conf)-1)]})/L),$$

on this stretched extent. Further note that for confidences of +1 and -1, the support of sT(x) is [0, L] and for confidences at (or near) zero this support. Further, the term,

$$L/(1+e^{-[a(ABS(conf)-1)]})$$

is monotonically increasing with L and ABS(conf).

(vi) Determine D = the minimum distance that Q is outside of A along the line between Cent(A) and Q.

(vii) Determine the absolute value of the change in the confidence of c as sT(D).

(viii) Provide the value sT(D) with the same sign as conf, and provide the potentially sign changed value sT(D) as the confidence of the cell c.

Additionally, in some embodiments, the most likelihood estimator 1344, upon receiving one or more location hypotheses from the hypothesis analyzer 1332, also performs some or all of the following tasks:

(37.1) Filters out location hypotheses having confidence values near zero whenever such location hypotheses are deemed too unreliable to be utilized in determining a target MS location estimate. For example, location hypotheses having confidence values in the range [-0.02, 0.02] may be filtered here;

(37.2) Determines the area of interest over which to perform the integration. In one embodiment, this area is a convex hull including each of the MS area estimates from the received location hypotheses (wherein such location hypotheses have not been removed from consideration by the filtering process of (37.1));

(37.3) Determines, once the integration is performed, one or more collections of contiguous area mesh cells that may be deemed a "most likely" MS location estimate, wherein each such collection includes one or more area mesh cells having a high confidence value.

Detailed Description of the Location Hypothesis Analyzer Submodules

Analytical Reasoner Module

The analytical reasoner applies constraint or "sanity" checks to the target MS estimates of the location hypotheses residing in the Run-time Location Hypothesis Storage Area for adjusting the associated confidence values accordingly. In one embodiment, these sanity checks involve "path" information. That is, this module determines if (or how well) location hypotheses are consistent with well known physical constraints such as the laws of physics, in an area in which the MS (associated with the location hypothesis) is estimated to be located. For example, if the difference between a previous (most likely) location estimate of a target MS and an estimate by a current location hypothesis requires the MS to:

(a) move at an unreasonably high rate of speed (e.g., 200 mph), or

(b) move at an unreasonably high rate of speed for an area (e.g., 80 mph in a corn patch), or

(c) make unreasonably sharp velocity changes (e.g., from 60 mph in one direction to 60 mph in the opposite direction in 4 sec),

then the confidence in the current hypothesis is reduced. Such path information may be derived for each time series of location hypotheses resulting from the FOMs by maintaining a window of previous location hypotheses in the MS status repository 1338. Moreover, by additionally retaining the "most likely" target MS location estimates (output by the most likelihood estimator 1344), current location hypotheses may be compared against such most likely MS location estimates.

The following path sanity checks are incorporated into the computations of this module. That is:

(1) do the predicted MS paths generally follow a known transportation pathway (e.g., in the case of a calculated speed of greater than 50 miles per hour are the target MS location estimates within, for example, .2 miles of a pathway where such speed may be sustained); if so (not), then increase (decrease) the confidence of the location hypotheses not satisfying this criterion;

(2) are the speeds, velocities and accelerations, determined from the current and past target MS location estimates, reasonable for the region (e.g., speeds should be less than 60 miles per hour in a dense urban area at 9 am); if so (not), then increase (decrease) the confidence of those that are (un)reasonable;

(3) are the locations, speeds, velocities and/or accelerations similar between target MS tracks produced by different FOMs similar; decrease the confidence of the currently active location hypotheses that are indicated as "outliers" by this criterion;

(4) are the currently active location hypothesis target MS estimates consistent with previous predictions of where the target MS is predicted to be from a previous (most likely) target MS estimate; if not, then decrease the confidence of at least those location hypothesis estimates that are substantially different from the corresponding predictions. Note, however, that in some cases this may be over ruled. For example, if the prediction is for an area for which there is Location Base Station coverage, and no Location Base Station covering the area subsequently reports communicating with the target MS, then the predictions are incorrect and any current location hypothesis from the same FOM should not be decreased here if it is outside of this Location Base Station coverage area.

Notice from Fig. 7 that the analytical reasoner can access location hypotheses currently posted on the Run-time Location Hypothesis Storage Area. Additionally, it interacts with the Pathway Database which contains information concerning the location of natural transportation pathways in the region (highways, rivers, etc.) and the Area Characteristics Database which contains information concerning, for example, reasonable velocities that can be expected in various regions (for instance, speeds of 80 mph would not be reasonably expected in dense urban areas). Note that both speed and direction can be important constraints; e.g., even though a speed might be appropriate for an area, such as 20 mph in a dense urban area, if the direction indicated by a time series of related location hypotheses is directly through an extensive building complex having no through traffic routes, then a reduction in the confidence of one or more of the location hypotheses may be appropriate.

One embodiment of the Analytical Reasoner illustrating how such constraints may be implemented is provided in the following section. Note, however, that this embodiment analyzes only location hypotheses having a non-negative confidence value.

Modules of an embodiment of the analytical reasoner module 1416 are provided hereinbelow.

Path Comparison Module

The path comparison module 1454 implements the following strategy: the confidence of a particular location hypothesis is be increased (decreased) if it is (not) predicting a path that lies along a known transportation pathway (and the speed of the target MS is sufficiently high). For instance, if a time series of target MS location hypotheses for a given FOM is predicting a path of the target MS that lies along an interstate highway, the confidence of the currently active location hypothesis for this FOM should, in general, be increased. Thus, at a high level the following steps may be performed:

(a) For each FOM having a currently active location hypothesis in the Run-time Location Hypothesis Storage Area (also denoted "blackboard"), determine a recent "path" obtained from a time series of location hypotheses for the FOM. This computation for the "path" is performed by stringing together successive "center of area" (COA) or centroid values determined from the most pertinent target MS location estimate in each location hypothesis (recall that each location hypothesis may have a plurality of target MS area estimates with one being the most pertinent). The information is stored in, for example, a matrix of values wherein one dimension of the matrix identifies the FOM and the a second dimension of the matrix represents a series of COA path values. Of course, some entries in the matrix may be undefined.

(b) Compare each path obtained in (a) against known transportation pathways in an area containing the path. A value, path_match(i), representing to what extent the path matches any known transportation pathway is computed. Such values are used later in a computation for adjusting the confidence of each corresponding currently active location hypothesis.

Velocity/Acceleration Calculation Module

The velocity/acceleration calculation module 1458 computes velocity and/or acceleration estimates for the target MS 140 using currently active location hypotheses and previous location hypothesis estimates of the target MS. In one embodiment, for each FOM 1224 having a currently active location hypothesis (with positive confidences) and a sufficient number of previous (reasonably recent) target MS location hypotheses, a velocity and/or acceleration may be calculated. In an alternative embodiment, such a velocity and/or acceleration may be calculated using the currently active location hypotheses and one or more recent "most likely" locations of the target MS output by the location engine 139. If the estimated velocity and/or acceleration corresponding to a currently active location hypothesis is reasonable for the region, then its confidence value may be incremented; if not, then its confidence may be decremented. The algorithm may be summarized as follows:

(a) Approximate speed and/or acceleration estimates for currently active target MS location hypotheses may be provided using path information related to the currently active location hypotheses and previous target MS location estimates in a manner similar to the description of the path comparison module 1454. Accordingly, a single confidence adjustment value may be determined for each currently active location hypothesis for indicating the extent to which its corresponding velocity and/or acceleration calculations are reasonable for its particular target MS location estimate. This calculation is performed by retrieving information from the area characteristics data base 1450 (e.g., Figs. 6 and 7). Since each location hypothesis includes timestamp data indicating when the MS location signals were received from the target MS, the velocity and/or acceleration associated with a path for a currently active location hypothesis can be straightforwardly approximated. Accordingly, a confidence adjustment value, vel_ok(i), indicating a likelihood that the velocity calculated for the i^{th} currently active location hypothesis (having adequate corresponding path information) may be appropriate is calculated using for the environmental characteristics of the location hypothesis' target MS location estimate. For example, the area characteristics data base 1450 may include expected maximum velocities and/or accelerations for each area type and/or cell of a cell mesh of the coverage area 120. Thus, velocities and/or accelerations above such maximum values may be indicative of anomalies in the MS location estimating process. Accordingly, in one embodiment, the most recent location hypotheses yielding such extreme velocities and/or accelerations may have their confidence values decreased. For example, if the target MS location estimate includes a portion of an interstate highway, then an appropriate velocity might correspond to a speed of up to 100 miles per hour, whereas if the target MS location estimate includes only rural dirt roads and tomato patches, then a likely speed might be no more than 30 miles per hour with an maximum speed of 60 miles per hour (assuming favorable environmental characteristics such as weather). Note that a list of such environmental characteristics may include such factors as: area type, time of day, season. Further note that more unpredictable environmental characteristics such as traffic flow patterns, weather (e.g., clear, raining, snowing, etc.) may also be included, values for these latter characteristics coming from the environmental data base 1354 which receives and maintains information on such unpredictable characteristics (e.g., Figs. 6 and 7). Also note that a similar confidence adjustment value, acc_ok(i), may be provided for currently active location hypotheses, wherein the confidence adjustment is related to the appropriateness of the acceleration estimate of the target MS.

Attribute Comparison Module

The attribute comparison module 1462 compares attribute values for location hypotheses generated from different FOMs, and determines if the confidence of certain of the currently active location hypotheses should be increased due to a similarity in related values for the attribute. That is, for an attribute A, an attribute value for A derived from a set $S_{FOM[1]}$ of one or more location hypotheses generated by one FOM, FOM[1], is compared with another attribute value for A derived from a set $S_{FOM[2]}$ of one or more location hypotheses generated by a different FOM, FOM[2] for determining if these attribute values cluster (i.e., are sufficiently close to one another) so that a currently active location hypothesis in $S_{FOM[1]}$ and a currently active location hypothesis in $S_{FOM[2]}$ should have their confidences increased. For example, the attribute may be a "target MS path data" attribute, wherein a value for the attribute is an estimated target MS path derived from location hypotheses generated by a fixed FOM over some (recent) time period. Alternatively, the attribute might be, for example, one of a velocity and/or acceleration, wherein a value for the attribute is a velocity and/or acceleration derived from location hypotheses generated by a fixed FOM over some (recent) time period.

In a general context, the attribute comparison module 1462 operates according to the following premise:

(38.1) for each of two or more currently active location hypotheses (with, e.g., positive confidences) if:

(a) each of these currently active location hypotheses, H, was initially generated by a corresponding different FOM_H;

(b) for a given MS estimate attribute and each such currently active location hypothesis, H, there is a corresponding value for the attribute (e.g., the attribute value might be an MS path estimate, or alternatively an MS estimated velocity, or an MS estimated acceleration), wherein the attribute value is derived without using a FOM different from FOM_H, and;

(c) the derived attribute values cluster sufficiently well,

then each of these currently active location hypotheses, H, will have their corresponding confidences increased. That is, these confidences will be increased by a confidence adjustment value or delta.

Note that the phrase "cluster sufficiently well" above may have a number of technical embodiments, including performing various cluster analysis techniques wherein any clusters (according to some statistic) must satisfy a system set threshold for the members of the cluster being close enough to one another. Further, upon determining the (any) location hypotheses satisfying (38.1), there are various techniques that may be used in determining a change or delta in confidences to be applied. For example, in one embodiment, an initial default confidence delta that may be utilized is: if "cf" denotes the confidence of such a currently active location hypothesis satisfying (38.1), then an increased confidence that still remains in the interval [0, 1.0] may be: $cf + [(1 - cf)/(1 + cf)]^2$, or, $cf * [1.0 + cf^n]$, n => 2, or, cf * [a constant having a system tuned parameter as a factor]. That is, the confidence deltas for these examples are: $[(1 - cf)/(1 + cf)]^2$ (an additive delta), and, $[1.0 + cf^n]$ (a multiplicative delta), and a constant. Additionally, note that it is within the scope of the present invention to also provide such confidence deltas (additive deltas or multiplicative deltas) with factors related to the number of such location hypotheses in the cluster.

Moreover, note that it is an aspect of the present invention to provide an adaptive mechanism (i.e., the adaptation engine 1382 shown in Figs. 5, 6 and 8) for automatically determining performance enhancing changes in confidence adjustment values such as the confidence deltas for the present module. That is, such changes are determined by applying an adaptive mechanism, such as a genetic algorithm, to a collection of "system parameters" (including parameters specifying confidence adjustment values as well as system parameters of, for example, the context adjuster 1326) in order to enhance performance of the present invention. More particularly, such an adaptive mechanism may repeatedly perform the following steps:

(a) modify such system parameters;

(b) consequently activate an instantiation of the location engine 139 (having the modified system parameters) to process, as input, a series of MS signal location data that has been archived together with data corresponding to a verified MS location from which signal location data was transmitted (e.g., such data as is stored in the location signature data base 1320); and

(c) then determine if the modifications to the system parameters enhanced location engine 139 performance in comparison to previous performances.

Assuming this module adjusts confidences of currently active location hypotheses according to one or more of the attributes: target MS path data, target MS velocity, and target MS acceleration, the computation for this module may be summarized in the following steps:

(a) Determine if any of the currently active location hypotheses satisfy the premise (38.1) for the attribute. Note that in making this determination, average distances and average standard deviations for the paths (velocities and/or accelerations) corresponding to currently active location hypotheses may be computed.

(b) For each currently active location hypothesis (wherein "i" uniquely identifies the location hypothesis) selected to have its confidence increased, a confidence adjustment value, path_similar(i) (alternatively, velocity_similar(i) and/or acceleration_similar(i)), is computed indicating the extent to which the attribute value matches another attribute value being predicted by another FOM.

Note that such confidence adjustment values are used later in the calculation of an aggregate confidence adjustment to particular currently active location hypotheses.

Analytical Reasoner Controller

Given one or more currently active location hypotheses for the same target MS input to the analytical reasoner controller 1466, this controller activates, for each such input location hypothesis, the other submodules of the analytical reasoner module 1416 (denoted hereinafter as "adjustment submodules") with this location hypothesis. Subsequently, the analytical reasoner controller 1466 receives an output confidence adjustment value computed by each adjustment submodule for adjusting the confidence of this location hypothesis. Note that each adjustment submodule determines:

(a) whether the adjustment submodule may appropriately compute a confidence adjustment value for the location hypothesis supplied by the controller. (For example, in some cases there may not be a sufficient number of location hypotheses in a time series from a fixed FOM);

(b) if appropriate, then the adjustment submodule computes a non-zero confidence adjustment value that is returned to the analytical reasoner controller.

Subsequently, the controller uses the output from the adjustment submodules to compute an aggregate confidence adjustment for the corresponding location hypothesis. In one particular embodiment of the present invention, values for the eight types of confidence adjustment values (described in sections above) are output to the present controller for computing an aggregate confidence adjustment value for adjusting the confidence of the currently active location hypothesis presently being analyzed by the analytical reasoner module 1416. As an example of how such confidence adjustment values may be utilized, assuming a currently active location hypothesis is identified by "i", the outputs from the above described adjustment submodules may be more fully described as:

path_match(i)	1	if there are sufficient previous (and recent) location hypotheses for the same target MS as "i" that have been generated by the same FOM that generated "i", and, the target MS location estimates provided by the location hypothesis "i" and the previous location hypotheses follow a known transportation pathway.
	0	otherwise.
vel_ok(i)	1	if the velocity calculated for the i^{th} currently active location hypothesis (assuming adequate corresponding path information) is typical for the area (and the current environmental characteristics) of this location hypothesis' target MS location estimate;
	0.2	if the velocity calculated for the i^{th} currently active location hypothesis is near a maximum for the area (and the current environmental characteristics) of this location hypothesis' target MS location estimate;.
	0	if the velocity calculated is above the maximum.
acc_ok(i)	1	if the acceleration calculated for the i^{th} currently active location hypothesis (assuming adequate corresponding path information) is typical for the area (and the current environmental characteristics) of this location hypothesis' target MS location estimate;
	0.2	if the acceleration calculated for the i^{th} currently active location hypothesis is near a maximum for the area (and the current environmental characteristics) of this location hypothesis' target MS location estimate;.
	0	if the acceleration calculated is above the maximum.
similar_path(i)	1	if the location hypothesis "i" satisfies (38.1) for the target MS path data attribute; 0 otherwise.
velocity_similar(i)	1	if the location hypothesis "i" satisfies (38.1) for the target MS velocity attribute; 0 otherwise.

acceleration_similar(i)	1	if the location hypothesis "i" satisfies (38.1) for the target MS acceleration attribute; 0 otherwise.
extrapolation_chk(i)	1	if the location hypothesis "i" is "near" a previously predicted MS location for the target MS; 0 otherwise.

Additionally, for each of the above confidence adjustments, there is a corresponding location engine 139 system setable parameter whose value may be determined by repeated activation of the adaptation engine 1382. Accordingly, for each of the confidence adjustment types, T, above, there is a corresponding system setable parameter, "alpha_T", that is tunable by the adaptation engine 1382. Accordingly, the following high level program segment illustrates the aggregate confidence adjustment value computed by the Analytical Reasoner Controller.

```
target_MS_loc_hyps <--- get all currently active location hypotheses, H, identifying the present target;
for each currently active location hypothesis, hyp(i), from target_MS_loc_hyps do
{
   for each of the confidence adjustment submodules, CA, do
      activate CA with hyp(i) as input;
   /* now compute the aggregate confidence adjustment using the output from the confidence adjustment submodules. */
   aggregate_adjustment(i) <--- alpha_path_match * path_match(i)
                              + alpha_velocity * vel_ok(i)
                              + alpha_path_similar * path_similar(i)
                              + alpha_velocity_similar * velocity_similar(i)
                                + alpha_acceleration_similar* acceleration_similar(i)
                                + alpha_extrapolation * extrapolation_chk(i);
   hyp(i).confidence <--- hyp(i).confidence + aggregate_adjustment(i);
}
```

Historical Location Reasoner

The historical location reasoner module 1424 may be, for example, a daemon or expert system rule base. The module adjusts the confidences of currently active location hypotheses by using (from location signature data base 1320) historical signal data correlated with: (a) verified MS locations (e.g. locations verified when emergency personnel co-locate with a target MS location), and (b) various environmental factors to evaluate how consistent the location signature cluster for an input location hypothesis agrees with such historical signal data.

This reasoner will increase/decrease the confidence of a currently active location hypothesis depending on how well its associated loc sigs correlate with the loc sigs obtained from data in the location signature data base.

Note that the embodiment hereinbelow is but one of many embodiments that may adjust the confidence of currently active location hypotheses appropriately. Accordingly, it is important to note other embodiments of the historical location reasoner functionality are within the scope of the present invention as one skilled in the art will appreciate upon examining the techniques utilized within this specification. For example, calculations of a confidence adjustment factor may be determined using Monte Carlo techniques as in the context adjuster 1326. Each such embodiment generates a measurement of at least one of the similarity and the discrepancy between the signal characteristics of the verified location signature clusters in the location signature data base and the location signature cluster for an input currently active location hypothesis, "loc_hyp".

The embodiment hereinbelow provides one example of the functionality that can be provided by the historical location reasoner 1424 (either by activating the following programs as a daemon or by transforming various program segments into the consequents of expert system rules). The present embodiment generates such a confidence adjustment by the following steps:

(a) comparing, for each cell in a mesh covering of the most relevant MS location estimate in "loc_hyp", the location signature cluster of the "loc_hyp" with the verified location signature clusters in the cell so that the following are computed: (i) a discrepancy or error measurement is determined, and (ii) a corresponding measurement indicating a likelihood or confidence of the discrepancy measurement being relatively accurate in comparison to other such error measurements;

(b) computing an aggregate measurement of both the errors and the confidences determined in (a); and

(c) using the computed aggregate measurement of (b) to adjust the confidence of "loc_hyp".

The program illustrated in APPENDIX E provides a more detailed embodiment of the steps immediately above.

Location Extrapolator

The location extrapolator 1432 works on the following premise: if for a currently active location hypothesis there is sufficient previous related information regarding estimates of the target MS (e.g., from the same FOM or from using a "most likely" previous target MS estimate output by the location engine 139), then an extrapolation may be performed for predicting future target MS locations that can be compared with new location hypotheses provided to the blackboard. Note that interpolation routines (e.g., conventional algorithms such as Lagrange or Newton polynomials) may be used to determine an equation that approximates a target MS path corresponding to a currently active location hypothesis.

Subsequently, such an extrapolation equation may be used to compute a future target MS location. For further information regarding such interpolation schemes, the following reference is incorporated herein by reference: Mathews, 1992, Numerical methods for mathematics, science, and engineering. Englewood Cliffs, NJ: Prentice Hall.

Accordingly, if a new currently active location hypothesis (e.g., supplied by the context adjuster) is received by the blackboard, then the target MS location estimate of the new location hypothesis may be compared with the predicted location. Consequently, a confidence adjustment value can be determined according to how well if the location hypothesis "i" . That is, this confidence adjustment value will be larger as the new MS estimate and the predicted estimate become closer together.

Note that in one embodiment of the present invention, such predictions are based solely on previous target MS location estimates output by location engine 139. Thus, in such an embodiment, substantially every currently active location hypothesis can be provided with a confidence adjustment value by this module once a sufficient number of previous target MS location estimates have been output. Accordingly, a value, extrapolation_chk(i), that represents how accurately the new currently active location hypothesis (identified here by "i") matches the predicted location is determined.

Hypothesis Generating Module

The hypothesis generating module 1428 is used for generating additional location hypotheses according to, for example, MS location information not adequately utilized or modeled. Note, location hypotheses may also be decomposed here if, for example it is determined that a location hypothesis includes an MS area estimate that has subareas with radically different characteristics such as an area that includes an uninhabited area and a densely populated area. Additionally, the hypothesis generating module 1428 may generate "poor reception" location hypotheses that specify MS location areas of known poor reception that are "near" or intersect currently active location hypotheses. Note, that these poor reception location hypotheses may be specially tagged (e.g., with a distinctive FOM_ID value or specific tag field) so that regardless of substantially any other location hypothesis confidence value overlapping such a poor reception area, such an area will maintain a confidence value of "unknown" (i.e., zero). Note that substantially the only exception to this constraint is location hypotheses generated from mobile base stations 148.

Mobile Base Station Location Subsystem Description

Mobile Base Station Subsystem Introduction

Any collection of mobile electronics (denoted mobile location unit) that is able to both estimate a location of a target MS 140 and communicate with the base station network may be utilized by the present invention to more accurately locate the target MS. Such mobile location units may provide greater target MS location accuracy by, for example, homing in on the target MS and by transmitting additional MS location information to the location center 142. There are a number of embodiments for such a mobile location unit contemplated by the present invention. For example, in a minimal version, such the electronics of the mobile location unit may be little more than an onboard MS 140, a sectored/directional antenna and a controller for communicating between them. Thus, the onboard MS is used to communicate with the location center 142 and possibly the target MS 140, while the antenna monitors signals for homing in on the target MS 140. In an enhanced version of the mobile location unit, a GPS receiver may also be incorporated so that the location of the mobile location unit may be determined and consequently an estimate of the location of the target MS may also be determined. However, such a mobile location unit is unlikely to be able to determine substantially more than a direction of the target MS 140 via the sectored/directional antenna without further base station infrastructure cooperation in, for example, determining the transmission power level of the target MS or varying this power level. Thus, if the target MS or the mobile location unit leaves the coverage area 120 or resides in a poor communication area, it may be difficult to accurately determine where the target MS is located. None-the-less, such mobile location units may be sufficient for many situations, and in fact the present invention contemplates their use. However, in cases where direct communication with the target MS is desired without constant contact with the base station infrastructure, the present invention includes a mobile location unit that is also a scaled down version of a base station 122. Thus, given that such a mobile base station or MBS 148 includes at least an onboard MS 140, a sectored/directional antenna, a GPS receiver, a scaled down base station 122 and sufficient components (including a controller) for integrating the capabilities of these devices, an enhanced autonomous MS mobile location system can be provided that can be effectively used in, for example, emergency vehicles, air planes and boats. Accordingly, the description that follows below describes an embodiment of an MBS 148 having the above mentioned components and capabilities for use in a vehicle.

As a consequence of the MBS 148 being mobile, there are fundamental differences in the operation of an MBS in comparison to other types of BS's 122 (152). In particular, other types of base stations have fixed locations that are precisely determined and known by the location center, whereas a location of an MBS 148 may be known only approximately and thus may require repeated and frequent re-estimating. Secondly, other types of base stations have substantially fixed and stable communication with the location center (via possibly other BS's in the case of LBSs 152) and therefore although these BS's may be more reliable in their in their ability to communicate information related to the location of a target MS with the location center, accuracy can be problematic in poor reception areas. Thus, MBS's may be used in areas (such as wilderness areas) where there may be no other means for reliably and cost effectively locating a target MS 140 (i.e., there may be insufficient fixed location BS's coverage in an area).

Fig. 11 provides a high level block diagram architecture of one embodiment of the MBS location subsystem 1508., Accordingly, an MBS may include components for communicating with the fixed location BS network infrastructure and the location center 142 via an on-board transceiver 1512 that is effectively an MS 140 integrated into the location subsystem 1508. Thus, if the MBS 148 travels through an area having poor infrastructure signal coverage, then the MBS may not be able to communicate reliably with the location center 142 (e.g., in rural or mountainous areas having reduced wireless telephony coverage). So it is desirable that the MBS 148 must be capable of functioning substantially autonomously from the location center. In one embodiment, this implies that each MBS 148 must be capable of estimating both its own location as well as the location of a target MS 140.

Additionally, many commercial wireless telephony technologies require all BS's in a network to be very accurately time synchronized both for transmitting MS voice communication as well as for other services such as MS location. Accordingly, the MBS 148 will also require such time synchronization. However, since an MBS 148 may not be in constant communication with the fixed location BS network (and indeed may be off-line for substantial periods of time), on-board highly accurate timing device may be necessary. In one embodiment, such a device may be a commercially available ribidium oscillator 1520 as shown in Fig. 11.

Since the MBS 148 , includes a scaled down version of a BS 122 (denoted 1522 in Fig. 11), it is capable of performing most typical BS 122 tasks, albeit on a reduced scale. In particular, the base station portion of the MBS 148 can:

(a) raise/lower its pilot channel signal strength,

(b) be in a state of soft hand-off with an MS 140, and/or

(c) be the primary BS 122 for an MS 140, and consequently be in voice communication with the target MS (via the MBS operator telephony interface 1524) if the MS supports voice communication.

Further, the MBS 148 can, if it becomes the primary base station communicating with the MS 140, request the MS to raise/lower its power or, more generally, control the communication with the MS (via the base station components 1522). However, since the MBS 148 will likely have substantially reduced telephony traffic capacity in comparison to a standard infrastructure base station 122, note that the pilot channel for the MBS is preferably a nonstandard pilot channel in that it should not be identified as a conventional telephony traffic bearing BS 122 by MS's seeking normal telephony communication. Thus, a target MS 140 requesting to be located may, depending on its capabilities, either automatically configure itself to scan for certain predetermined MBS pilot channels, or be instructed via the fixed location base station network (equivalently BS infrastructure) to scan for a certain predetermined MBS pilot channel.

Moreover, the MBS 148 has an additional advantage in that it can substantially increase the reliability of communication with a target MS 140 in comparison to the base station infrastructure by being able to move toward or track the target MS 140 even if this MS is in (or moves into) a reduced infrastructure base station network coverage area. Furthermore, an MBS 148 may preferably use a directional or smart antenna 1526 to more accurately locate a direction of signals from a target MS 140. Thus, the sweeping of such a smart antenna 1526 (physically or electronically) provides directional information regarding signals received from the target MS 140. That is, such directional information is determined by the signal propagation delay of signals from the target MS 140 to the angular sectors of one of more directional antennas 1526 on-board the MBS 148.

Before proceeding to further details of the MBS location subsystem 1508, an example of the operation of an MBS 148 in the context of responding to a 911 emergency call is given. In particular, this example describes the high level computational states through which the MBS 148 transitions, these states also being illustrated in the state transition diagram of Fig. 12. Note that this figure illustrates the primary state transitions between these MBS 148 states, wherein the solid state transitions are indicative of a typical "ideal" progression when locating or tracking a target MS 140, and the dashed state transitions are the primary state reversions due, for example, to difficulties in locating the target MS 140.

Accordingly, initially the MBS 148 may be in an inactive state 1700, wherein the MBS location subsystem 1508 is effectively available for voice or data communication with the fixed location base station network, but the MS 140 locating capabilities of the MBS are not active. From the inactive state 1700 the MBS (e.g., a police or rescue vehicle) may enter an active state 1704 once an MBS operator has logged onto the MBS location subsystem of the MBS, such logging being for authentication, verification and journaling of MBS 148 events. In the active state 1704, the MBS may be listed by a 911 emergency center and/or the location center 142 as eligible for service in responding to a 911 request. From this state, the MBS 148 may transition to a ready state 1708 signifying that the MBS is ready for use in locating and/or intercepting a target MS 140. That is, the MBS 148 may transition to the ready state 1708 by performing the following steps:

(1a) Synchronizing the timing of the location subsystem 1508 with that of the base station network infrastructure. In one embodiment, when requesting such time synchronization from the base station infrastructure, the MBS 148 will be at a predetermined or well known location so that the MBS time synchronization may adjust for a known amount of signal propagation delay in the synchronization signal.

(1b) Establishing the location of the MBS 148. In one embodiment, this may be accomplished by, for example, an MBS operator identifying the predetermined or well known location at which the MBS 148 is located.

(1c) Communicating with, for example, the 911 emergency center via the fixed location base station infrastructure to identify the MBS 148 as in the ready state.

Thus, while in the ready state 1708, as the MBS 148 moves, it has its location repeatedly (re)-estimated via, for example, GPS signals, location center 142S location estimates from the base stations 122 (and 152), and an on-board deadreckoning subsystem 1527 having an MBS location estimator according to the programs described hereinbelow. However, note that the accuracy of the base station time synchronization (via the ribidium oscillator 1520) and the accuracy of the MBS 148 location may need to both be periodically recalibrated according to (1a) and (1b) above.

Assuming a 911 signal is transmitted by a target MS 140, this signal is transmitted, via the fixed location base station infrastructure, to the 911 emergency center and the location center 142, and assuming the MBS 148 is in the ready state 1708, if a corresponding 911 emergency request is transmitted to the MBS (via the base station infrastructure) from the 911 emergency center or the location center, then the MBS may transition to a seek state 1712 by performing the following steps:

(2a) Communicating with, for example, the 911 emergency response center via the fixed location base station network to receive the PN code for the target MS to be located (wherein this communication is performed using the MS-like transceiver 1512 and/or the MBS operator telephony interface 1524).

(2b) Obtaining a most recent target MS location estimate from either the 911 emergency center or the location center 142.

(2c) Inputting by the MBS operator an acknowledgment of the target MS to be located, and transmitting this acknowledgment to the 911 emergency response center via the transceiver 1512.

Subsequently, when the MBS 148 is in the seek state 1712, the MBS may commence toward the target MS location estimate provided. Note that it is likely that the MBS is not initially in direct signal contact with the target MS. Accordingly, in the seek state 1712 the following steps may be, for example, performed:

(3a) The location center 142 or the 911 emergency response center may inform the target MS, via the fixed location base station network, to lower its threshold for soft hand-off and at least periodically boost its location signal strength. Additionally, the target MS may be informed to scan for the pilot channel of the MBS 148. (Note the actions here are not, actions performed by the MBS 148 in the "seek state"; however, these actions are given here for clarity and completeness.)

(3b) Repeatedly, as sufficient new MS location information is available, the location center 142 provides new MS location estimates to the MBS 148 via the fixed location base station network.

(3c) The MBS repeatedly provides the MBS operator with new target MS location estimates provided substantially by the location center via the fixed location base station network.

(3d) The MBS 148 repeatedly attempts to detect a signal from the target MS using the PN code for the target MS.

(3e) The MBS 148 repeatedly estimates its own location (as in other states as well), and receives MBS location estimates from the location center.

Assuming that the MBS 148 and target MS 140 detect one another (which typically occurs when the two units are within .25 to 3 miles of one another), the MBS enters a contact state 1716 when the target MS 140 enters a soft hand-off state with the MBS. Accordingly, in the contact state 1716, the following steps are, for example, performed:

(4a) The MBS 148 repeatedly estimates its own location.

(4b) Repeatedly, the location center 142 provides new target MS 140 and MBS location estimates to the MBS 148 via the fixed location base infrastructure network.

(4c) Since the MBS 148 is at least in soft hand-off with the target MS 140, the MBS can estimate the direction and distance of the target MS itself using, for example, detected target MS signal strength and TOA as well as using any recent location center target MS location estimates.

(4d) The MBS 148 repeatedly provides the MBS operator with new target MS location estimates provided using MS location estimates provided by the MBS itself and by the location center via the fixed location base station network.

When the target MS 140 detects that the MBS pilot channel is sufficiently strong, the target MS may switch to using the MBS 148 as its primary base station. When this occurs, the MBS enters a control state 1720, wherein the following steps are, for example, performed:

(5a) The MBS 148 repeatedly estimates its own location.

(5b) Repeatedly, the location center 142 provides new target MS and MBS location estimates to the MBS 148 via the network of base stations 122 (152).

(5c) The MBS 148 estimates the direction and distance of the target MS 140 itself using, for example, detected target MS signal strength and TOA as well as using any recent location center target MS location estimates.

(5d) The MBS 148 repeatedly provides the MBS operator with new target MS location estimates provided using MS location estimates provided by the MBS itself and by the location center 142 via the fixed location base station network.

(5e) The MBS 148 becomes the primary base station for the target MS 140 and therefore controls at least the signal strength output by the target MS.

Note, there can be more than one MBS 148 tracking or locating an MS 140. There can also be more than one target MS 140 to be tracked concurrently and each target MS being tracked may be stationary or moving.

MBS Subsystem Architecture

An MBS 148 uses MS signal characteristic data for locating the MS 140. The MBS 148 may use such signal characteristic data to facilitate determining whether a given signal from the MS is a "direct shot" or an multipath signal. That is, in one embodiment, the MBS 148 attempts to determine or detect whether an MS signal transmission is received directly, or whether the transmission has been reflected or deflected. For example, the MBS may determine whether the expected signal strength, and TOA agree in distance estimates for the MS signal transmissions. Note, other signal characteristics may also be used, if there are sufficient electronics and processing available to the MBS 148; i.e., determining signal phase and/or polarity as other indications of receiving a "direct shot" from an MS 140.

In one embodiment, the MBS 148 (Fig. 11) includes an MBS controller 1533 for controlling the location capabilities of the MBS 148. In particular, the MBS controller 1533 initiates and controls the MBS state changes as described in Fig. 12 above. Additionally, the MBS controller 1533 also communicates with the location controller 1535, wherein this latter controller controls MBS activities related to MBS location and target MS location; e.g., this performs the program, "mobile_base_station_controller" described in APPENDIX A hereinbelow. The location controller 1535 receives data input from an event generator 1537 for generating event records to be provided to the location controller 1535. For example, records may be generated from data input received from: (a) the vehicle movement detector 1539 indicating that the MBS 148 has moved at least a predetermined amount and/or has changed direction by at least a predetermined angle, or (b) the MBS signal processing subsystem 1541 indicating that the additional signal measurement data has been received from either the location center 142 or the target MS 140. Note that the MBS signal processing subsystem 1541, in one embodiment, is similar to the signal processing subsystem 1220 of the location center 142. may have multiple command schedulers. In particular, a scheduler 1528 for commands related to communicating with the location center 142, a scheduler 1530 for commands related to GPS communication (via GPS receiver 1531), a scheduler 1529 for commands related to the frequency and granularity of the reporting of MBS changes in direction and/or position via the MBS dead reckoning subsystem 1527 (note that this scheduler is potentially optional and that such commands may be provided directly to the deadreckoning estimator 1544), and a scheduler 1532 for communicating with the target MS(s) 140 being located. Further, it is assumed that there is sufficient hardware and/or software to appear to perform commands in different schedulers substantially concurrently.

In order to display an MBS computed location of a target MS 140, a location of the MBS must be known or determined. Accordingly, each MBS 148 has a plurality of MBS location estimators (or hereinafter also simply referred to as location estimators) for determining the location of the MBS. Each such location estimator computes MBS location information such as MBS location estimates, changes to MBS location estimates, or, an MBS location estimator may be an interface for buffering and/or translating a previously computed MBS location estimate into an appropriate format. In particular, the MBS location module 1536, which determines the location of the MBS, may include the following MBS location estimators 1540 (also denoted baseline location estimators):

(a) a GPS location estimator 1540a (not individually shown) for computing an MBS location estimate using GPS signals,

(b) a location center location estimator 1540b (not individually shown) for buffering and/or translating an MBS estimate received from the location center 142,

(c) an MBS operator location estimator 1540c (not individually shown) for buffering and/or translating manual MBS location entries received from an MBS location operator, and

(d) in some MBS embodiments, an LBS location estimator 1540d (not individually shown) for the activating and deactivating of LBS's 152. Note that, in high multipath areas and/or stationary base station marginal coverage areas, such low cost location base stations 152 (LBS) may be provided whose locations are fixed and accurately predetermined and whose signals are substantially only receivable within a relatively small range (e.g., 2000 feet), the range potentially being variable. Thus, by communicating with the LBS's 152 directly, the MBS 148 may be able to quickly use the location information relating to the location base stations for determining its location by using signal characteristics obtained from the LBSs 152.

Note that each of the MBS baseline location estimators 1540, such as those above, provide an actual MBS location rather than, for example, a change in an MBS location. Further note that it is an aspect of the present invention that additional MBS baseline location estimators 1540 may be easily integrated into the MBS location subsystem 1508 as such baseline location estimators become available. For example, a baseline location estimator that receives MBS location estimates from reflective codes provided, for example, on streets or street signs can be straightforwardly incorporated into the MBS location subsystem 1508.

Additionally, note that a plurality of MBS location technologies and their corresponding MBS location estimators are utilized due to the fact that there is currently no single location technology available that is both sufficiently fast, accurate and accessible in substantially all terrains to meet the location needs of an MBS 148. For example, in many terrains GPS technologies may be sufficiently accurate; however, GPS technologies: (a) may require a relatively long time to provide an initial location estimate (e.g., greater than 2 minutes); (b) when GPS communication is disturbed, it may require an equally long time to provide a new location estimate; (c) clouds, buildings and/or mountains can prevent location estimates from being obtained; (d) in some cases signal reflections can substantially skew a location estimate. As another example, an MBS 148 may be able to use triangulation or trilateralization technologies to obtain a location estimate; however, this assumes that there is sufficient (fixed location) infrastructure BS coverage in the area the MBS is located. Further, it is well known that the multipath phenomenon can substantially distort such location estimates. Thus, for an MBS 148 to be highly effective in varied terrains, an MBS is provided with a plurality of location technologies, each supplying an MBS location estimate.

In fact, much of the architecture of the location engine 139 could be incorporated into an MBS 148. For example, in some embodiments of the MBS 148, the following FOMs 1224 may have similar location models incorporated into the MBS:

(a) a variation of the distance FOM 1224 wherein TOA signals from communicating fixed location BS's are received (via the MBS transceiver 1512) by the MBS and used for providing a location estimate;

(b) a variation of the artificial neural net based FOMs 1224 (or more generally a location learning or a classification model) may be used to provide MBS location estimates via, for example, learned associations between fixed location BS signal characteristics and geographic locations;

(c) an LBS location FOM 1224 for providing an MBS with the ability to activate and deactivate LBS's to provide (positive) MBS location estimates as well as negative MBS location regions (i.e., regions where the MBS is unlikely to be since one or more LBS's are not detected by the MBS transceiver);

(d) one or more MBS location reasoning agents and/or a location estimate heuristic agents for resolving MBS location estimate conflicts and providing greater MBS location estimate accuracy. For example, modules similar to the analytical reasoner module 1416 and the historical location reasoner module 1424.

However, for those MBS location models requiring communication with the base station infrastructure, an alternative embodiment is to rely on the location center 142 to perform the computations for at least some of these MBS FOM models. That is, since each of the MBS location models mentioned immediately above require communication with the network of fixed location BS's 122 (152), it may be advantageous to transmit MBS location estimating data to the location center 142 as if the MBS were another MS 140 for the location center to locate, and thereby rely on the location estimation capabilities at the location center rather than duplicate such models in the MBS 148. The advantages of this approach are that:

(a) an MBS is likely to be able to use less expensive processing power and software than that of the location center;

(b) an MBS is likely to require substantially less memory, particularly for data bases, than that of the location center.

As will be discussed further below, in one embodiment of the MBS 148, there are confidence values assigned to the locations output by the various location estimators 1540. Thus, the confidence for a manual entry of location data by an MBS operator may be rated the highest and followed by the confidence for (any) GPS location data, followed by the confidence for (any) location center location 142 estimates, followed by the confidence for (any) location estimates using signal characteristic data from LBSs. However, such prioritization may vary depending on, for instance, the radio coverage area 120. In an one embodiment of the present invention, it is an aspect of the present invention that for MBS location data received from the GPS and location center, their confidences may vary according to the area in which the MBS 148 resides. That is, if it is known that for a given area, there is a reasonable probability that a GPS signal may suffer multipath distortions and that the location center has in the past provided reliable location estimates, then the confidences for these two location sources may be reversed.

In one embodiment of the present invention, MBS operators may be requested to occasionally manually enter the location of the MBS 148 when the MBS is stationary for determining and/or calibrating the accuracy of various MBS location estimators.

There is an additional important source of location information for the MBS 148 that is incorporated into an MBS vehicle (such as a police vehicle) that has no comparable functionality in the network of fixed location BS's. That is, the MBS 148 may use deadreckoning information provided by a deadreckoning MBS location estimator 1544 whereby the MBS may obtain MBS deadreckoning location change estimates. Accordingly, the deadreckoning MBS location estimator 1544 may use, for example, an on-board gyroscope 1550, a wheel rotation measurement device (e.g., odometer) 1554, and optionally an accelerometer (not shown). Thus, such a deadreckoning MBS location estimator 1544 periodically provides at least MBS distance and directional data related to MBS movements from a most recent MBS location estimate. More precisely, in the absence of any other new MBS location information, the deadreckoning MBS location estimator 1544 outputs a series of measurements, wherein each such measurement is an estimated change (or delta) in the position of the MBS 148 between a request input timestamp and a closest time prior to the timestamp, wherein a previous deadreckoning terminated. Thus, each deadreckoning location change estimate includes the following fields:

(a) an "earliest timestamp" field for designating the start time when the deadreckoning location change estimate commences measuring a change in the location of the MBS;

(b) a "latest timestamp" field for designating the end time when the deadreckoning location change estimate stops measuring a change in the location of the MBS; and

(c) an MBS location change vector.

That is, the "latest timestamp" is the timestamp input with a request for deadreckoning location data, and the "earliest timestamp" is the timestamp of the closest time, T, prior to the latest timestamp, wherein a previous deadreckoning output has its a timestamp at a time equal to T.

Further, the frequency of such measurements provided by the deadreckoning subsystem 1527 may be adaptively provided depending on the velocity of the MBS 148 and/or the elapsed time since the most recent MBS location update. Accordingly, the architecture of at least some embodiments of the MBS location subsystem 1508 must be such that it can utilize such deadreckoning information for estimating the location of the MBS 148.

In one embodiment of the MBS location subsystem 1508 described in further detail hereinbelow, the outputs from the deadreckoning MBS location estimator 1544 are used to synchronize MBS location estimates from different MBS baseline location estimators. That is, since such a deadreckoning output may be requested for substantially any time from the deadreckoning MBS location estimator, such an output can be requested for substantially the same point in time as the occurrence of the signals from which a new MBS baseline location estimate is derived. Accordingly, such a deadreckoning output can be used to update other MBS location estimates not using the new MBS baseline location estimate.

It is assumed that the error with dead reckoning increases with deadreckoning distance. Accordingly, it is an aspect of the embodiment of the MBS location subsystem 1508 that when incrementally updating the location of the MBS 148 using deadreckoning and applying deadreckoning location change estimates to a "most likely area" in which the MBS 148 is believed to be, this area is incrementally enlarged as well as shifted. The enlargement of the area is used to account for the inaccuracy in the deadreckoning capability. Note, however, that the deadreckoning MBS location estimator is periodically reset so that the error accumulation in its outputs can be decreased. In particular, such resetting occurs when there is a high probability that the location of the MBS is known. For example, the deadreckoning MBS location estimator may be reset when an MBS operator manually enters an MBS location or verifies an MBS location, or a computed MBS location has sufficiently high confidence.

Thus, due to the MBS 148 having less accurate location information (both about itself and a target MS 140), and further that deadreckoning information must be utilized in maintaining MBS location estimates, a first embodiment of the MBS location subsystem architecture is somewhat different from the location engine 139 architecture. That is, the architecture of this first embodiment is simpler than that of the architecture of the location engine 139. However, it important to note that, at a high level, the architecture of the location engine 139 may also be applied for providing a second embodiment of the MBS location subsystem 1508, as one skilled in the art will appreciate after reflecting on the architectures and processing provided at an MBS 148. For example, an MBS location subsystem 1508 architecture may be provided that has one or more first order models 1224 whose output is supplied to, for example, a blackboard or expert system for resolving MBS location estimate conflicts, such an architecture being analogous to one embodiment of the location engine 139 architecture.

Furthermore, it is also an important aspect of the present invention that, at a high level, the MBS location subsystem architecture may also be applied as an alternative architecture for the location engine 139. For example, in one embodiment of the location engine 139, each of the first order models 1224 may provide its MS location hypothesis outputs to a corresponding "location track," analogous to the MBS location tracks described hereinbelow, and subsequently, a most likely MS current location estimate may be developed in a "current location track" (also described hereinbelow) using the most recent location estimates in other location tracks.

Further, note that the ideas and methods discussed here relating to MBS location estimators 1540 and MBS location tracks, and, the related programs hereinbelow are sufficiently general so that these ideas and methods may be applied in a number of contexts related to determining the location of a device capable of movement and wherein the location of the device must be maintained in real time. For example, the present ideas and methods may be used by a robot in a very cluttered environment (e.g., a warehouse), wherein the robot has access: (a) to a plurality of "robot location estimators" that may provide the robot with sporadic location information, and (b) to a deadreckoning location estimator.

Each MBS 148, additionally, has a location display (denoted the MBS operator visual user interface 1558 in Fig. 11) where area maps that may be displayed together with location data. In particular, MS location data may be displayed on this display as a nested collection of areas, each smaller nested area being the most likely area within (any) encompassing area for locating a target MS 140. Note that the MBS controller algorithm below may be adapted to receive location center 142 data for displaying the locations of other MBSs 148 as well as target MSs 140.

Further, the MBS 148 may constrain any location estimates to streets on a street map using the MBS location snap to street module 1562. For example, an estimated MBS location not on a street may be "snapped to" a nearest street location. Note that a nearest street location determiner may use "normal" orientations of vehicles on streets as a constraint on the nearest street location.

Particularly, if an MBS 148 is moving at typical rates of speed and acceleration, and without abrupt changes direction. For example, if the deadreckoning MBS location estimator 1544 indicates that the MBS 148 is moving in a northerly direction, then the street snapped to should be a north-south running street. Moreover, the MBS location snap to street module 1562 may also be used to enhance target MS location estimates when, for example, it is known or suspected that the target MS 140 is in a vehicle and the vehicle is moving at typical rates of speed. Furthermore, the snap to street location module 1562 may also be used in enhancing the location of a target MS 140 by either the MBS 148 or by the location engine 139. In particular, the location estimator 1344 or an additional module between the location estimator 1344 and the output gateway 1356 may utilize an embodiment of the snap to street location module 1562 to enhance the accuracy of target MS 140 location estimates that are known to be in vehicles. Note that this may be especially useful in locating stolen vehicles that have embedded wireless location transceivers (MSs 140), wherein appropriate wireless signal measurements can be provided to the location center 142.

MBS Data Structure Remarks

Assuming the existence of at least some of the location estimators 1540 that were mentioned above, the discussion here refers substantially to the data structures and their organization as illustrated in Fig. 13.

The location estimates (or hypotheses) for an MBS 148 determining its own location each have an error or range estimate associated with the MBS location estimate. That is, each such MBS location estimate includes a "most likely MBS point location" within a "most likely area". The "most likely MBS point location" is assumed herein to be the centroid of the "most likely area." In one embodiment of the MBS location subsystem 1508, a nested series of "most likely areas" may be provided about a most likely MBS point location. However, to simplify the discussion herein each MBS location estimate is assumed to have a single "most likely area". One skilled in the art will understand how to provide such nested "most likely areas" from the description herein. Additionally, it is assumed that such "most likely areas" are not grossly oblong; i.e., area cross sectioning lines through the centroid of the area do not have large differences in their lengths. For example, for any such "most likely area", A, no two such cross sectioning lines of A may have lengths that vary by more than a factor of two.

Each MBS location estimate also has a confidence associated therewith providing a measurement of the perceived accuracy of the MBS being in the "most likely area" of the location estimate.

A (MBS) "location track" is an data structure (or object) having a queue of a predetermined length for maintaining a temporal (timestamp) ordering of "location track entries" such as the location track entries 1770a, 1770b, 1774a, 1774b, 1778a, 1778b, 1782a, 1782b, and 1786a (Fig. 13), wherein each such MBS location track entry is an estimate of the location of the MBS at a particular corresponding time.

There is an MBS location track for storing MBS location entries obtained from MBS location estimation information from each of the MBS baseline location estimators described above (i.e., a GPS location track 1750 for storing MBS location estimations obtained from the GPS location estimator 1540, a location center location track 1754 for storing MBS location estimations obtained from the location estimator 1540 deriving its MBS location estimates from the location center 142, an LBS location track 1758 for storing MBS location estimations obtained from the location estimator 1540 deriving its MBS location estimates from base stations 122 and/or 152, and a manual location track 1762 for MBS operator entered MBS locations). Additionally, there is one further location track, denoted the "current location track" 1766 whose location track entries may be derived from the entries in the other location tracks (described further hereinbelow). Further, for each location track, there is a location track head that is the head of the queue for the location track. The location track head is the most recent (and presumably the most accurate) MBS location estimate residing in the location track. Thus, for the GPS location track 1750 has location track head 1770; the location center location track 1754 has location track head 1774; the LBS location track 1758 has location track head 1778; the manual location track 1762 has location track head 1782; and the current location track 1766 has location track head 1786. Additionally, for notational convenience, for each location track, the time series of previous MBS location estimations (i.e., location track entries) in the location track will herein be denoted the "path for the location track." Such paths are typically the length of the location track queue containing the path. Note that the length of each such queue may be determined using at least the following considerations:

(i) In certain circumstances (described hereinbelow), the location track entries are removed from the head of the location track queues so that location adjustments may be made. In such a case, it may be advantageous for the length of such queues to be greater than the number of entries that are expected to be removed;

(ii) In determining an MBS location estimate, it may be desirable in some embodiments to provide new location estimates based on paths associated with previous MBS location estimates provided in the corresponding location track queue.

Also note that it is within the scope of the present invention that the location track queue lengths may be a length of one.

Regarding location track entries, each location track entry includes:

(a) a "derived location estimate" for the MBS that is derived using at least one of:

(i) at least a most recent previous output from an MBS baseline location estimator 1540 (i.e., the output being an MBS location estimate);

(ii) deadreckoning output information from the deadreckoning subsystem 1527.

Further note that each output from an MBS location estimator has a "type" field that is used for identifying the MBS location estimator of the output.

(b) an "earliest timestamp" providing the time/date when the earliest MBS location information upon which the derived location estimate for the MBS depends. Note this will typically be the timestamp of the earliest MBS location estimate (from an MBS baseline location estimator) that supplied MBS location information used in deriving the derived location estimate for the MBS 148.

(c) a "latest timestamp" providing the time/date when the latest MBS location information upon which the derived location estimate for the MBS depends. Note that earliest timestamp = latest timestamp only for so called "baseline entries" as defined hereinbelow. Further note that this attribute is the one used for maintaining the "temporal (timestamp) ordering" of location track entries.

(d) A "deadreckoning distance" indicating the total distance (e.g., wheel turns or odometer difference) since the most recently previous baseline entry for the corresponding MBS location estimator for the location track to which the location track entry is assigned.

For each MBS location track, there are two categories of MBS location track entries that may be inserted into a MBS location track:

(a) "baseline" entries, wherein each such baseline entry includes (depending on the location track) a location estimate for the MBS 148 derived from: (i) a most recent previous output either from a corresponding MBS baseline location estimator, or (ii) from the baseline entries of other location tracks (this latter case being the for the "current" location track);

(b) "extrapolation" entries, wherein each such entry includes an MBS location estimate that has been extrapolated from the (most recent) location track head for the location track (i.e., based on the track head whose "latest timestamp" immediately precedes the latest timestamp of the extrapolation entry). Each such extrapolation entry is computed by using data from a related deadreckoning location change estimate output from the deadreckoning MBS location estimator 1544. Each such deadreckoning location change estimate includes measurements related to changes or deltas in the location of the MBS 148. More precisely, for each location track, each extrapolation entry is determined using: (i) a baseline entry, and (ii) a set of one or more (i.e., all later occurring) deadreckoning location change estimates in increasing "latest timestamp" order. Note that for notational convenience this set of one or more deadreckoning location change estimates will be denoted the "deadreckoning location change estimate set" associated with the extrapolation entry resulting from this set.

(c) Note that for each location track head, it is either a baseline entry or an extrapolation entry. Further, for each extrapolation entry, there is a most recent baseline entry, B, that is earlier than the extrapolation entry and it is this B from which the extrapolation entry was extrapolated. This earlier baseline entry, B, is hereinafter denoted the "baseline entry associated with the extrapolation entry." More generally, for each location track entry, T, there is a most recent previous baseline entry, B, associated with T, wherein if T is an extrapolation entry, then B is as defined above, else if T is a baseline entry itself, then T=B. Accordingly, note that for each extrapolation entry that is the head of a location track, there is a most recent baseline entry associated with the extrapolation entry.

Further, there are two categories of location tracks:

(a) "baseline location tracks," each having baseline entries exclusively from a single predetermined MBS baseline location estimator; and

(b) a "current" MBS location track having entries that are computed or determined as "most likely" MBS location estimates from entries in the other MBS location tracks.

MBS Location Estimating Strategy

In order to be able to properly compare the track heads to determine the most likely MBS location estimate it is an aspect of the present invention that the track heads of all location tracks include MBS location estimates that are for substantially the same (latest) timestamp. However, the MBS location information from each MBS baseline location estimator is inherently substantially unpredictable and unsynchronized. In fact, the only MBS location information that may be considered predicable and controllable is the deadreckoning location change estimates from the deadreckoning MBS location estimator 1544 in that these estimates may reliably be obtained whenever there is a query from the location controller 1535 for the most recent estimate in the change of the location for the MBS 148. Consequently (referring to Fig. 13), synchronization records 1790 (having at least a 1790b portion, and in some cases also having a 1790a portion) may be provided for updating each location track with a new MBS location estimate as a new track head. In particular, each synchronization record includes a deadreckoning location change estimate to be used in updating all but at most one of the location track heads with a new MBS location estimate by using a deadreckoning location change estimate in conjunction with each MBS location estimate from an MBS baseline location estimator, the location track heads may be synchronized according to timestamp. More precisely, for each MBS location estimate, E, from an MBS baseline location estimator, the present invention also substantially simultaneously queries the deadreckoning MBS location estimator for a corresponding most recent change in the location of the MBS 148. Accordingly, E and the retrieved MBS deadreckoning location change estimate, C, have substantially the same "latest timestamp". Thus, the location estimate E may be used to create a new baseline track head for the location track having the corresponding type for E, and C may be used to create a corresponding extrapolation entry as the head of each of the other location tracks. Accordingly, since for each MBS location estimate, E, there is a MBS deadreckoning location change estimate, C, having substantially the same "latest timestamp", E and C will be hereinafter referred as "paired."

High level descriptions of an embodiment of the location functions performed by an MBS 148 are provided in APPENDIX A hereinbelow.

APPENDIX A: MBS Function Embodiments

Mobile Base Station Controller Program

```
mobile_base_station_controller()
{
wait_for_input_of_first_MBS_location(event); /* "event" is a record (object) with MBS location data */
WHILE (no MBS operator input to exit) DO
    CASE OF (event): /* determine the type of "event" and process it. */
        MBS LOCATION DATA RECEIVED FROM GPS:
        MBS LOCATION DATA RECEIVED FROM LBS:
        MBS LOCATION DATA RECEIVED FROM ANY OTHER HIGHLY RELIABLE MBS LOCATION
                SOURCES (EXCEPT LOCATION CENTER):
        {
            MBS_new_est <--- get_new_MBS_location_using_estimate(event);
              /* Note, whenever a new MBS location estimate is entered as a baseline estimate into the location tracks, the other
              location tracks must be immediately updated with any deadreckoning location change estimates so that all
              location tracks are substantially updated at the same time. */
            deadreck_est <--- get_deadreckoning_location_change_estimate(event);
            MBS_curr_est <--- DETERMINE_MBS_LOCATION_ESTIMATE(MBS_new_est, deadreck_est);
            if (MBS_curr_est.confidence > a predetermined high confidence threshold) then
              reset_deadreckoning_MBS_location_estimator(event);
                                        /* deadreckoning starts over from here. */

            /* Send MBS location information to the Location Center. */
            if ( MBS has not moved since the last MBS location estimate of this type and is not now moving) then
            {
              configure the MBS on-board transceiver (e.g., MBS-MS) to immediately transmit location signals to the fixed
              location BS network as if the MBS were an ordinary location device (MS);

              communicate with the Location Center via the fixed location BS infrastructure the following:
                  (a) a "locate me" signal,
```

(b) MBS_curr_est,

(c) MBS_new_est and

(d) the timestamp for the present event.

Additionally, any location signal information between the MBS and the present target MS may be transmitted to the Location Center so that this information may also be used by the Location Center to provide better estimates of where the MBS is. Further, if the MBS determines that it is immediately adjacent to the target MS and also that its own location estimate is highly reliable (e.g., a GPS estimate), then the MBS may also communicate this information to the Location Center so that the Location Center can: (a) associate any target MS location signature cluster data with the fixed base station infrastructure with the location provided by the MBS, and (b) insert this associated data into the location signature data base of the Location Center as a verified cluster of "random loc sigs";

/* note, this transmission preferably continues (i.e., repeats) for at least a predetermined length of time of sufficient length for the Signal Processing Subsystem to collect a sufficient signal characteristic sample size. */

}

else SCHEDULE an event (if none scheduled) to transmit to the Location Center the following: (a) MBS_curr_est, and (b) the GPS location of the MBS and the time of the GPS location estimate;

/* Now update MBS display with new MBS location; note, MBS operator must request MBS locations on the MBS display; if not requested, then the following call does not do an update. */

update_MBS_operator_display_with_MBS_est(MBS_curr_est);

}

SINCE LAST MBS LOCATION UPDATE

***MBS HAS MOVED A THRESHOLD DISTANCE:* {**

deadreck_est <--- *get_deadreckoning_location_change_estimate*(event);

/* Obtain from MBS Dead Reckoning Location Estimator a new dead reckoning MBS location estimate having an estimate as to the MBS location change from the location of the last MBS location provided to the MBS. */

MBS_curr_est <---- **DETERMINE_MBS_LOCATION_ESTIMATE**(NULL, deadreck_est);

/* this new MBS estimate will be used in new target MS estimates*/

update_MBS_display_with_updated_MBS_location(MBS_curr_est);

SCHEDULE an event (if none scheduled) to request new GPS location data for MBS;

SCHEDULE an event (if none scheduled) to request communication with Location Center (LC) related to new MBS location data;

SCHEDULE an event (if none scheduled) to request new LBS location communication between the MBS and any LBS's that can detect the MBS;

/* Note, in some embodiments the processing of MBS location data from LBS's may be performed automatically by the Location Center, wherein the Location Center uses signal characteristic data from the LBS's in determining an estimated location of the MBS. */

SCHEDULE an event (if none scheduled) to obtain new target MS signal characteristics from MS; /* i.e., may get a better target MS location estimate now. */

}

TIMER HAS EXPIRED SINCE LAST RELIABLE TARGET MS LOCATION INFORMATION OBTAINED: {

SCHEDULE an event (if none scheduled) to request location communication with the target MS, the event is at a very high priority;

RESET timer for target MS location communication; /* Try to get target MS location communication again within a predetermined time. Note, timer may dynamically determined according to the perceived velocity of the target MS. */

}

LOCATION COMMUNICATION FROM TARGET MS RECEIVED: {

MS_raw_signal_data <--- *get_MS_signal_characteristic_raw_data*(event);

/* Note, "MS_raw_signal_data" is an object having substantially the unfiltered signal characteristic values for communications between the MBS and the target MS as well as timestamp information. */

Construct a message for sending to the Location Center, wherein the message includes at least "MS_raw_signal_data" and "MBS_curr_est" so that the Location Center can also compute an estimated location for the target MS;

SCHEDULE an event (if none scheduled) to request communication with Location Center (LC) for sending the constructed message;

/* Note, this data does not overwrite any previous data waiting to be sent to the LC. */

MS_signal_data <--- *get_MS_signal_characteristic_data*(event);

/* Note, the MS signal data obtained above is, in one embodiment, "raw" signal data. However, in a second embodiment, this data is filtered substantially as in the Location Center by the Signal

```
            Processing Subsystem. For simplicity of discussion here, it is assumed that each MBS includes at least
            a scaled down version of the Signal Processing Subsystem (see FIG. 11). */
MS_new_est <---- DETERMINE_MS_MOST_RECENT_ESTIMATE(MBS_curr_est, MS_curr_est,
                                    MS_signal_data);
            /* May use forward and reverse TOA, TDOA, signal power, signal strength, and signal quality
            indicators. Note, "MS_curr_est" includes a timestamp of when the target MS signals were received.
            */
if (MS_new_est.confidence > min_MS_confidence ) then
{
    mark_MS_est_as_temporary(MS_new_est);
            /* Note, it is assumed that this MS location estimate is "temporary" in the sense that it will be
            replaced by a corresponding MS location estimate received from the Location Center that is based on
            the same target MS raw signal data. That is, if the Location Center responds with a corresponding
            target MS location estimate, E, while "MS_new_est" is a value in a "moving window" of target MS
            location estimates (as described hereinbelow), then E will replace the value of "MS_new_est". Note,
            the moving window may dynamically vary in size according to, for example, a perceived velocity of
            the target MS and/or the MBS. */
    MS_moving_window <--- get_MS_moving_window(event);
                    /* get moving window of location estimates for this target MS. */

    add_MS_estimate_to_MS_location_window(MS_new_est, MS_moving_window);
            /* Since any given single collection of measurements related to locating the target MS may be
            potentially misleading, a "moving window" of location estimates are used to form a "composite
            location estimate" of the target MS. This composite location estimate is based on some number of the
            most recent location estimates determined. Such a composite location estimate may be, for example,
            analogous to a moving average or some other weighting of target MS location estimates. Thus, for
            example, for each location estimate (i.e., at least one MS location area, a most likely single location,
            and, a confidence estimate) a centroid type calculation may be performed to provide the composite
            location estimate.*/
    MS_curr_est <---- DETERMINE_MS_LOCATION_ESTIMATE(MS_moving_window);
            /* DETERMINE new target MS location estimate. Note this may an average location or a weighted
              average location. */
    remove_scheduled_events("TARGET_MS_SCHEDULE", event.MS_ID);
```

```
            /* REMOVE ANY OTHER EVENTS SCHEDULED FOR REQUESTING LOCATION COMMUNICATION FROM
            TARGET MS */
        }
        else /* target MS location data received but it is not deemed to be reliable (e.g., too much multipath and/or
                inconsistent measurements, so SCHEDULE an event (if none scheduled) to request new location
                communication with the target MS, the event is at a high priority*/
            add_to_scheduled_events("TARGET_MS_SCHEDULE", event.MS_ID);
        update_MBS_operator_display_with_MS_est(MS_curr_est);
            /* The MBS display may use various colors to represent nested location areas overlayed on an area map
                wherein, for example, 3 nested areas may be displayed on the map overlay: (a) a largest area having a
                relatively high probability that the target MS is in the area (e.g., >95%); (b) a smaller nested area having
                a lower probability that the target MS is in this area (e.g., >80%); and (c) a smallest area having the
                lowest probability that the target MS is in this area (e.g., >70%). Further, a relatively precise specific
                location is provided in the smallest area as the most likely single location of the target MS. Note that in one
                embodiment, the colors for each region may dynamically change to provide an indication as to how high
                their reliability is; e.g., no colored areas shown for reliabilities below, say, 40%; 40-50% is purple; 50-60%
                is blue; 60-70% is green; 70-80% is amber; 80-90% is white; and red denotes the most likely single
                location of the target MS. Further note the three nested areas may collapse into one or two as the MBS gets
                closer to the target MS. Moreover, note that the collapsing of these different areas may provide operators in
                the MBS with additional visual reassurance that the location of the target MS is being determined with better
                accuracy.*/

        /* Now RESET timer for target MS location communication to try to get target MS
          location communication again within a predetermined time. */
        reset_timer("TARGET_MS_SCHEDULE", event.MS_ID);
    }
    COMMUNICATION OF LOCATION DATA TO MBS FROM LOCATION CENTER: {
        /* Note, target MS location data may be received from the Location Center in the seek state, contact state and the
            control state. Such data may be received in response to the MBS sending target MS location signal data to the
            Location Center (as may be the case in the contact and control states), or such data may be received from the
            Location Center regardless of any previously received target MS location sent by the MBS (as may be the case in
            the seek, contact and control states). */
```

```
if ( (the timestamp of the latest MBS location data sent to the Location Center)    <=         (the timestamp
     returned by this Location Center communication identifying the MBS location data used by the Location Center
     for generating the MBS location data of the present event) )
  then /* use the LC location data since it is more recent than what is currently being used. */
{
       MBS_new_est <--- get_Location_Center_MBS_est(event);
       deadreck_est <--- get_deadreckoning_location_change_estimate(event);
       MBS_curr_est <----DETERMINE_MBS_LOCATION_ESTIMATE(MBS_new_est, deadreck_est);
       if (MBS_curr_est.confidence > a predetermined high confidence threshold) then
          reset_deadreckoning_MBS_location_estimator(event);
       update_MBS_operator_display_with_MBS_est(MBS_curr_est);
}
if ( (the timestamp of the latest target MS location data sent to the Location Center)    <=         (the
     timestamp returned by this Location Center communication identifying the MS location data used by the
     Location Center for generating the target MS location estimate of the present event))
  then /* use the MS location estimate from the LC since it is more recent than what is currently being used. */
{
       MS_new_est <--- get_Location_Center_MS_est(event);
           /* This information includes error or reliability estimates that may be used in subsequent attempts to
           determine an MBS location estimate when there is no communication with the LC and no exact (GPS)
           location can be obtained. That is, if the reliability of the target MS's location is deemed highly reliable,
           then subsequent less reliable location estimates should be used only to the degree that more highly
           reliable estimates become less relevant due to the MBS moving to other locations. */
       MS_moving_window <--- get_MS_moving_window(event);
                          /* get moving window of location estimates for this target MS. */

       if ( (the Location Center target MS estimate utilized the MS location signature data supplied by the MBS) then
              if (a corresponding target MS location estimate marked as "temporary" is still in the moving
                   window)
                then /* It is assumed that this new target MS location data is still timely (note the target MS
                        may be moving); so replace the temporary estimate with the Location Center estimate.
                        */
                  replace the temporary target MS location estimate in the moving window with
                        "MS_new_est";
```

```
                else        /* there is no corresponding "temporary" target MS location in the moving window; so
                                this MS estimate must be too old; so don't use it. */
            else   /* the Location Center did not use the MS location data from the MBS even though the timestamp of
                        the latest MS location data sent to the Location Center is older that the MS location data used by
                        the Location Center to generate the present target MS location estimate.  Use the new MS location
                        data anyway.  Note there isn't a corresponding "temporary" target MS location in the moving
                        window. */
                    add_MS_estimate_to_MS_location_window(MS_new_est);
    }
    else /* the MS location estimate from the LC is not more recent than the latest MS location data sent to the LC from
            the MBS. */
            if (a corresponding target MS location estimate marked as "temporary" is still in the moving window)
                then /* It is assumed that this new target MS location data is still timely (note the target MS may be
                            moving); so replace the temporary estimate with the Location Center estimate. */
                        replace the temporary target MS location estimate in the moving window with "MS_new_est";
            else        /* there is no corresponding "temporary" target MS location in the moving window; so this MS
                                estimate must be too old; so don't use it. */
    MS_curr_est <---- DETERMINE_MS_LOCATION_ESTIMATE(MS_moving_window);
    update_MBS_operator_display_with_MS_est(MS_curr_est);
    reset_timer("LC_COMMUNICATION", event.MS_ID);
}
NO COMMUNICATION FROM LC: {
        /* i.e., too long a time has elapsed since last communication from LC. */
    SCHEDULE an event (if none scheduled) to request location data (MBS and/or target MS) from the Location Center,
            the event is at a high priority;
    reset_timer("LC_COMMUNICATION", event.MS_ID);
}
REQUEST TO NO LONGER CONTINUE LOCATING THE PRESENT TARGET MS: {
    if (event not from operator) then
            request MBS operator verification;
    else {
        REMOVE the current target MS from the list of MSs  currently being located and/or tracked;
        SCHEDULE an event (if none scheduled) to send communication to the Location Center that the current target MS
            is no longer being tracked;
```

PURGE MBS of all data related to current target MS except any exact location data for the target MS that has not been sent to the Location Center for archival purposes;

}

}

REQUEST FROM LOCATION CENTER TO ADD ANOTHER TARGET MS TO THE LIST OF MSs BEING TRACKED: {

/* assuming the Location Center sends MBS location data for a new target MS to locate and/or track (e.g., at least a new MS ID and an initial MS location estimate), add this new target MS to the list of MSs to track. Note the MBS will typically be or transitioning to in the seek state.*/

if (event not from operator) then

request MBS operator verification;

else {

INITIALIZE MBS with data received from the Location Center related to the estimated location of the new target MS; /* e.g., initialize a new moving window for this new target MS; initialize MBS operator interface by graphically indicating where the new target MS is estimated to be. */

CONFIGURE MBS to respond to any signals received from the new target MS by requesting location data from the new target MS;

INITIALIZE timer for communication from LC; /* A timer may be set per target MS on list. */

}

}

REQUEST TO MANUALLY ENTER A LOCATION ESTIMATE FOR MBS (FROM AN MBS OPERATOR): {

/* Note, MBS could be moving or stationary. If stationary, then the estimate for the location of the MBS is given high reliability and a small range (e.g., 20 feet). If the MBS is moving, then the estimate for the location of the MBS is given high reliability but a wider range that may be dependent on the speed of the MBS. In both cases, if the MBS operator indicates a low confidence in the estimate, then the range is widened, or the operator can manually enter a range.*/

MS_new_est <--- *get_new_MBS_location_est_from_operator*(event; /* The estimate may be obtained, for example, using a light pen on a displayed map */

if (operator supplies a confidence indication for the input MBS location estimate) then

MBS_new_est.confidence <--- *get_MBS_operator_confidence_of_estimate*(event);

else MBS_new_est.confidence <--- 1; /* This is the highest value for a confidence. */

deadreck_est <--- *get_deadreckoning_location_change_estimate*(event);

```
MBS_curr_est <--- DETERMINE_MBS_LOCATION_ESTIMATE(MBS_new_est, deadreck_est );
if (MBS_curr_est.confidence > a predetermined high confidence threshold) then
    reset_deadreckoning_MBS_location_estimator(event);
update_MBS_operator_display_with_MBS_est(MBS_curr_est);

/* Note, one reason an MBS operator might provide a manual MBS input is that the MBS might be too inaccurate in
   its location. Moreover, such inaccuracies in the MBS location estimates can cause the target MS to be estimated
   inaccurately, since target MS signal characteristic values may be utilized by the MBS to estimate the location of the
   target MS as an offset from where the MBS is. Thus, if there are target MS estimates in the moving window of
   target MS location estimates that are relatively close to the location represented by "MBS_curr_est", then these
   select few MS location estimates may be updated to reflect a more accurate MBS location estimate. */
MS_moving_window <--- get_MS_moving_window(event);
if (MBS has not moved much since the receipt of some previous target MS location that is still being used to location
      the target MS)
      then
{
      UPDATE those target MS location estimates in the moving window according to the new MBS location estimate
              here;
      MS_curr_est <---- DETERMINE_MS_LOCATION_ESTIMATE(MS_moving_window);
      update_MBS_operator_display_with_MS_est(MS_curr_est);
}
    }
} /* end case statement */
```

Lower Level MBS Function Descriptions

/* PROCEDURE: DETERMINE_MBS_LOCATION_ESTIMATE REMARKS:

It is assumed that with increasing continuous **dead reckoning** without additional MBS location verification, the potential **error** in the MBS location **increases**.

It is assumed that each MBS location estimate includes: (a) a most likely area estimate surrounding a central location and (b) a confidence value of the MBS being in the location estimate.

The **confidence value** for each MBS location estimate is a measurement of the likelihood of the MBS location estimate being correct. More precisely, a confidence value for a new MBS location estimate is a measurement that is adjusted according to the following criteria:

(a) the confidence value increases with the perceived accuracy of the new MBS location estimate (independent of any current MBS location estimate used by the MBS),

(b) the confidence value decreases as the location discrepancy with the current MBS location increases,

(c) the confidence value for the current MBS location increases when the new location estimate is contained in the current location estimate,

(d) the confidence value for the current MBS location decrease when the new location estimate is not contained in the current location estimate, and

Therefore, **the confidence value is an MBS location likelihood measurement which takes into account the history of previous MBS location estimates.**

It is assumed that with each MBS location estimate supplied by the Location Center there is a default confidence value supplied which the MBS may change.

*/

DETERMINE_MBS_LOCATION_ESTIMATE(MBS_new_est, deadreck_est)

/* Add the pair, "MBS_new_est" and "deadreck_est" to the location tracks and determine a new current MBS location estimate.

Input:	**MBS_new_est**	**A new MBS baseline location estimate to use in determining the location of the MBS, but not a (deadreckoning) location change estimate**
	deadreck_est	**The deadreckoning location change estimate paired with "MBS_new_est". */**

```
{
    if (MBS_new_est is not NULL) then /* the "deadreck_est" is paired with "MBS_new_est" */
    {
        if (all MBS location tracks are empty) then
        {
            insert "MBS_new_est" as the head of the location track of type, "MBS_new_est.type";
            insert "MBS_new_est" as the head of the current track; /* so now there is a "MBS_curr_est" MBS location
                estimate to use */
            MBS_curr_est <--- get_curr_est(MBS_new_est.MS_ID); /* from current location track */
        }
```

```
else /* there is at least one non-empty location track in addition to the current location track being non-
        empty*/
{
    if (MBS_new_est is of type MANUAL_ENTRY) then
    {   /* MBS operator entered an MBS location estimate for the MBS; so must use
            it */
        MBS_curr_est <--- add_location_entry(MBS_new_est, deadreck_est);
    }
    else /* "MBS_new_est" is not of type MANUAL_ENTRY */
        if (the MBS location track of type, "MBS_new_est.type", is empty) then
        {   /* some other location track is non-empty */
            MBS_curr_est <--- add_location_entry(MBS_new_est, deadreck_est);
        }
        else /* "MBS_new_est.type" location track is non-empty and "MBS_new_est"
                is not of type MANUAL_ENTRY */
        {   /* In the next statement determine if "MBS_new_est" is of at least
                minimal useful quality in comparison to any previous estimates of the
                same type; see program def'n below */
            continue_to_process_new_est <-- FILTER(MBS_new_est);
            if (continue_to_process_new_est) then /* "MBS_new_est" is of sufficient quality to
                                                      continue processing. */
            {
                MBS_curr_est <--- add_location_entry(MBS_new_est, deadreck_est);
            }/* end "MBS_new_est" not filtered out */
            else /* "MBS_new_est" is filtered out; do nothing */;
        }/* end else */
}/* end else at least one non-empty location track */
}
else /* MBS_new_est is NULL; thus only a deadreckoning output is to be added to location tracks */
{
    extrapolation_entry <--- create_an_extrapolation_entry_from(deadreck_est);
    insert_into_every_location_track(extrapolation_entry); /* including the "current location track" */
    MBS_curr_est <--- get_curr_est(MBS_new_est.MS_ID); /* from current location track */
```

}

RETURN(MBS_curr_est);

} **END /* DETERMINE_MBS_LOCATION_ESTIMATE */**

add_location_entry(MBS_new_est, deadreck_est);

/* This function adds the baseline entry, "MBS_new_est" and its paired deadreckoning location change estimate, "deadreck_est" to the location tracks, including the "current location track". Note, however, that this function will roll back and rearrange location entries, if necessary, so that the entries are in latest timestamp order.

Returns: MBS_curr_est */

```
{
    if (there is a time series of one or more dead reckoning extrapolation entries in the location track of type "MBS_new_est.type"
        wherein the extrapolation entries have a "latest timestamp" more recent than the timestamp of "MBS_new_est") then
    {   /* Note, this condition may occur in a number of ways; e.g., (a) an MBS location estimate received from the Location
            Center could be delayed long enough (e.g., 1-4 sec) because of transmission and processing time; (b) the estimation
            records output from the MBS baseline location estimators are not guaranteed to be always presented to the location
            tracks in the temporal order they are created. */
        roll back all (any) entries on all location tracks, including the "current" track, in "latest timestamp" descending order,
            until a baseline entry, B, is at the head of a location track wherein B is a most recent entry having a "latest
            timestamp" prior to "MBS_new_est"; let "stack" be the stack of a location track entries rolled off the location
            tracks, wherein an entry in the stack is either a baseline location entry and a paired deadreckoning location change
            estimate, or, an unpaired deadreckoning location change estimate associated with a NULL for the baseline location
            entry;
        insert "MBS_new_est" at the head of the location track of type "MBS_new_est.type" as a new baseline entry;
        insert the extrapolation entry derived from "deadreck_est" in each of the other baseline location tracks except
            the current track;
        /* It is important to note that "deadreck_est" includes the values for the change in the MBS location substantially for the
           time period between the timestamp, T, of "MS_new_est" and the timestamp of the closest deadreckoning output just
           before T. Further note that if there are any extrapolation entries that were rolled back above, then there is an
           extrapolation entry, E, previously in the location tracks and wherein E has an earliest timestamp equal to the latest
           timestamp of B above. Thus, all the previous extrapolation entries removed can be put back if E is modified as follows:
           the MBS location change vector of E (denoted herein as E.delta) becomes E.delta - [location change vector of
           "deadreck_est"]. */
        MBS_curr_est <--- UPDATE_CURR_EST(MBS_new_est, deadreck_est);
        if (the extrapolation entry E exists) then /* i.e., "stack" is not empty */
```

```
            {
                modify the extrapolation entry E as per the comment above;
                /* now fix things up by putting all the rolled off location entries back, including
                   the "current location track" */
                do until "stack" is empty
                {
                    stack_top <--- pop_stack(stack);
                        /* "stack_top" is either a baseline location entry and a paired deadreckoning location change
                           estimate, or, an unpaired deadreckoning location change estimate associated with a NULL for the
                           baseline location entry */
                    MBS_nxt_est <--- get_baseline_entry(stack_top);
                    deadreck_est <--- get_deadreckoning_entry(stack_top);
                    MBS_curr_est <--- DETERMINE_MBS_LOCATION_ESTIMATE(MBS_nxt_est,
                                                                      deadreck_est);
                }
            }
        }
        else /* there is no deadreckoning extrapolation entries in the location track of type "MBS_new_est.type" wherein the
                extrapolation entries have a "latest timestamp" more recent than the timestamp of "MBS_new_est". So just insert
                "MBS_new_est" and "deadreck_est".*/
        {
            insert "MBS_new_est" at the head of the location track of type "MBS_new_est.type" as a new baseline entry;
            insert the extrapolation entry derived from "deadreck_est" in each of the other location tracks except the current track;
            MBS_curr_est <--- UPDATE_CURR_EST(MBS_new_est, deadreck_est); /* see prog def'n below */
        }
        RETURN(MBS_curr_est);
    } /* end add_location_entry */
```

FILTER(MBS_new_est)

/* This function determines whether "MBS_new_est" is of sufficient quality to insert into it's corresponding MBS location track. It is assumed that the location track of "MBS_new_est.type" is non-empty.

Input: MBS_new_est A new MBS location estimate to use in determining the location of the MBS.

Returns: FALSE if "MBS_new_est" was processed here (i.e., filtered out),

TRUE if processing with "MBS_new_est" may be continued . */

```
{
continue_to_process_new_est <--TRUE; /* assume "MBS_new_est" will be good enough to use as an MBS location estimate */
/* see if "MBS_new_est" can be filtered out. */
if (the confidence in MBS_new_est < a predetermined function of the confidence(s) of previous MBS location estimates of
        type "MBS_new_est.type")
            /* e.g., the predetermined function here could be any of a number of functions that provide a minimum threshold on
              what constitutes an acceptable confidence value for continued processing of "MBS_new_est". The following is an
              example of one such predetermined function: K*(confidence of "MBS_new_est.type" location track head) for
              some K,    0<K<= 1.0, wherein K varies with a relative frequency of estimates of type
              "MBS_new_est.type" not filtered; e.g.., for a given window of previous MBS location estimates of this type, K=
              (number of MBS location estimates of "MBS_new_est.type" not filtered)/(the total number of estimates of this
              type in the window). Note, such filtering here may be important for known areas where, for example, GPS signals
              may be potentially reflected from an object (i.e., multipath), or, the Location Center provides an MBS location
              estimate of very low confidence. For simplicity, the embodiment here discards any filtered location estimates.
              However, in an alternative embodiment, any such discarded location estimates may be stored separately so that,
              for example, if no additional better MBS location estimates are received, then the filtered or discarded location
              estimates may be reexamined for possible use in providing a better subsequent MBS location estimate.*/
        then continue_to_process_new_est <-- FALSE;
else if (an area for "MBS_new_est" > a predetermined function of the corresponding area(s) of entries in the location
        track of type "MBS_new_est.type")
            /* e.g., the predetermined function here could be any of a number of functions that provide a maximum threshold
              on what constitutes an acceptable area size for continued processing of "MBS_new_est". The following are
              examples of such predetermined functions: (a) the identity function on the area of the head of the location track
              of type "MBS_new_est.type"; or, (b) K*(the area of the head of the location track of type
              "MBS_new_est.type"), for some K, K> =1.0, wherein for a given window of previous MBS location estimates of
              this type, K= (the total number of estimates in the window)/ (number of these location estimates not filtered);
              note, each extrapolation entry increases the area of the head; so areas of entries at the head of each location
              track type grow in area as extrapolation entries are applied. */
        then continue_to_process_new_est <-- FALSE;
```

```
RETURN(continue_to_process_new_est)
}

UPDATE_CURR_EST(MBS_new_est, deadreck_est)
  /* This function updates the head of the "current" MBS location track whenever
     "MBS_new_est" is perceived as being a more accurate estimate of the location of the
     MBS.
      Input:  MBS_new_est  A new MBS location estimate to use in determining the location
                           of the                                   MBS
              deadreck_est The deadreckoning MBS location change estimate paired with
                           "MBS_new_est".
              Returns a potentially updated "MBS_curr_est" */
{
  if (MBS_new_est is of type MANUAL_ENTRY) then
  {  /* MBS operator  entered an MBS location estimate for the MBS; so must use it */
     insert "MBS_new_est" as the head of the "current MBS location  track" which is the location track indicating the best
          current approximation of the location of the MBS;
  }
  else /* "MBS_new_est" is not a manual entry */
  {
     MBS_curr_est <--- get_curr_est(MBS_new_est.MS_ID); /* get the head of the "current location track" */
     adjusted_curr_est <--- apply_deadreckoning_to(MBS_curr_est, deadreck_est);
               /* The above function returns an object of the same type as "MBS_curr_est", but with the most likely MBS
                  point and area locations adjusted by "deadreck_est". Accordingly, this function performs the following
                  computations:
                    (a) selects, A_MBS, the MBS location area estimate of "MBS_curr_est" (e.g., one of the "most likely"
                        nested area(s) provided by "MBS_curr_est" in one embodiment of the present invention);
                    (b) applies the deadreckoning translation corresponding to "deadreck_est" to A_MBS to thereby
                        translate it (and expand it to at least account for deadreckoning inaccuracies). */
     if (reasonably_close(MBS_new_est, adjusted_curr_est, MBS_curr_est))
          /* In one embodiment, the function "reasonably_close" here determines whether a most likely MBS point
             location (i.e., centroid) of "MBS_new_est" is contained in the MBS estimated area of
             "adjusted_curr_est"
```

Note that the reasoning for this constraint is that if "MBS_curr_est" ***was*** accurate, then any "most likely MBS point location" of a new MBS baseline estimate that is also accurate ought to be in the MBS estimated area of "adjusted_curr_est".

In a second embodiment, the function "reasonably_close" determines whether the centroid (or most likely MBS point location) of "MBS_new_est" is **close enough** to "MBS_curr_est" **so that no MBS movement constraints** are (grossly) **violated between the most likely point locations of "MBS_new_est" and "MBS_curr_est"**; i.e., constraints on (de)acceleration, abruptness of direction change, velocity change, max velocity for the terrain. Note, such constraints are discussed in more detail in the section herein describing the "Analytical Reasoner". Accordingly, it is an aspect of the present invention to provide similar capabilities to that of the Analytical Reasoner as part of the MBS, and in particular, as the functionality of the "MBS LOCATION CONSTRAINT CHECKER" illustrated in Fig. 11. It is assumed hereinafter that the embodiment of the function, "reasonably_close", performed here is a combination of both the first and second embodiments, wherein the constraints of both the first and second embodiments must be satisfied for the function to return TRUE. */

then

if (the **confidence in MBS_new_est >= the confidence in MBS_curr_est**) then

{

if (the most likely MBS area of MBS_new_est contains the most likely MBS area of "adjusted_curr_est" as computed above) then

shrink MBS_new_est uniformly about its centroid (i.e., "most likely MBS point location") until it is as small as possible and still contain the MBS estimated area of "adjusted_curr_est".

insert_into_location_track("current", MBS_new_est);

/* The program invoked here inserts a location track entry corresponding to the second parameter into the location track identified by the first parameter (e.g., "current"). It is important to note that the second parameter for this program may be *either* of the following data structures: a "location track entry", or an "MBS location estimate" and the appropriate location track entry or entries will be put on the location track corresponding to the first parameter. The insertion is performed so that a "latest timestamp" order is maintained; i.e.,

(a) any extrapolation entries in the location track, wherein these entries have a more recent "latest timestamp" than the ("earliest" or only) timestamp (depending on the data structure) of the second parameter are removed, and

(b) conceptually at least, the location change estimates output from the deadreckoning MBS location estimator that correspond with the removed extrapolation entries are then reapplied in timestamp order to the head of the target location track. */

}

else /* the centroid of "MBS_new_est", is contained in an area of "MBS_curr_est", but the **confidence in "MBS_new_est" < confidence in "MBS_curr_est"** */

{

most_likely_est <-- determine a "most likely MBS location estimate" using the set S = {the MBS location estimate centroid(s) of any MBS location track heads contained in the MBS estimated area of "adjusted_curr_est", plus, the centroid of "MBS_new_est"};

/* Note, in the above statement, the "most likely MBS location estimate" may be determined using a number of different techniques depending on what function(s) is used to embody the meaning of "most likely". In one embodiment, such a "most likely" function is a function of the confidence values of a predetermined population of measurements (e.g., the selected location track heads in this case) from which a "most likely" measurement is determined (e.g., computed or selected). For example, in one embodiment, a "most likely" function may include selecting a measurement having the maximum confidence value from among the population of measurements. In a second embodiment, a "most likely" function may include a weighting of measurements (e.g., location track heads) according to corresponding confidence values of the measurements. For example, in the present context (of MBS location track heads) the following steps provide an embodiment of a "most likely" function:

(a) determine a centroid of area for each of the selected track heads (i.e., the location track heads having a point location estimate contained in the MBS estimated area of "adjusted_curr_est");

(b) determine the "most likely location MBS ***position***" P as a weighted centroid of the centroids from step (a), wherein the weighting of each of the centroids from (a) is provided by their corresponding confidence values;

(c) output an area, A_l, as the "most likely MBS location ***area***", wherein the centroid of A_l is P and A_l is the largest area within the MBS estimated area of "adjusted_curr_est" satisfying this condition; and

(d) set a confidence value for A_l as the average confidence value of "MBS_new_est", "MBS_curr_est" and the selected location track head used. */

insert_into_location_track("current", most_likely_est);

}

```
else /* "MBS_new_est" is not reasonably close to "adjusted_curr_est" (i.e.,
        "MBS_curr_est" with "deadreck_est" applied to it), so a conflict exists here; e.g.,
        (i) "MBS_new_est" is not a manual entry, and (ii) "MBS_new_est" does not have its centroid contained in the
        MBS estimated area of "adjusted_curr_est", or, there has been a movement constraint violation. Note that it is
        not advisable to just replace "MBS_curr_est" with "new_est_head" because:
            (a) "MBS_new_est" may be the MBS location estimate that is least accurate, while the previous entries
                of the current location track have been accurate;
            (b) the "MBS_curr_est" may be based on a recent MBS operator manual entry which should not be
                overridden. */
    {
        MBS_curr_est <--- resolve_conflicts(MBS_new_est, adjusted_curr_est, MBS_curr_est);
    }
  } /* end else "MBS_new_est" not a manual entry */
  if (MBS is a vehicle) and (not off road) then
        /* it is assumed that a vehicular MBS is on-road unless explicitly indicated otherwise by MBS operator. */
    MBS_curr_est <--- snap_to_best_fit_street(MBS_curr_est); /* snap to best street location according to location
        estimate, velocity, and/or direction of travel. Note, this is a translation of "MBS_curr_est". */
  RETURN(MBS_curr_est)
} /* END UPDATE(MBS_CURR_EST) */

resolve_conflicts(MBS_new_est, adjusted_curr_est, MBS_curr_est)
/* There is a basic conflict here,
        (i) "MBS_new_est" is not a manual entry, and
        (ii) one of the following is true: "MBS_new_est" does not have its centroid contained
            in the area "adjusted_curr_est", or, using "MBS_new_est" implies an MBS
            movement constraint violation.
    Input:  MBS_new_est    The newest MBS location estimate record.
            adjusted_curr_est    The version of "MBS_curr_est" adjusted by the deadreckoning
                                 location change estimate paired with "MBS_new_est".
            MBS_curr_est         The location track entry that is the head of the "current" location track. Note
                                 that "MBS_new_est.confidence" > "MBS_curr_est.cofidence".
    Output: An updated "MBS_curr_est". */
{
```

mark that a conflict has arisen between "MBS_curr_est" and "MBS_new_est";
if (the MBS operator desires notification of MBS location estimate conflicts) then
notify the MBS operator of an MBS location estimate conflict;
if (the MBS operator has configured the MBS location system to **ignore new estimates** that are **not "reasonably close" to adjusted_curr_est) or**
(MBS_curr_est is based on a manual MBS operator location estimate, and the MBS has moved less than a predetermined distance (wheel turns) from where the manual estimate was provided) then
RETURN(adjusted_curr_est);
else **/* not required to ignore "MBS_new_est", and there has been no recent manual estimate input*/**
{ /* try to use "MBS_new_est" */
if **((MBS_new_est.confidence - adjusted_curr_est.confidence) > a large predetermined threshold) then**
/* Note, the confidence discrepancy is great enough so that "MBS_new_est" should be the most recent baseline estimate on current MBS location track. Note that the threshold here may be approximately 0.3, wherein confidences are in the range [0, 1].*/
insert_into_location_track("current", MBS_new_est);
/* insert "MBS_new_est" into "current" location track (as a baseline entry) in "latest timestamp" order; i.e., remove any extrapolation entries with a more recent "latest timestamp" in this track, and reapply, in timestamp order, the location change estimates output from the deadreckoning MBS location estimator that correspond with the removed extrapolation entries removed; */
else **/* "MBS_new_est.confidence" is not substantially bigger than "adjusted_curr_est.confidence"; so check to see if there are potentially MBS location system instabilities */**
{ /* check for instabilities */
if **[** (there has been more than a determined fraction of conflicts between the "MBS_curr_est" and "MBS_new_est" within a predetermined number of most recent "MBS_new_est" instantiations) **or**
(the path corresponding to the entries of the "current location track" of the MBS has recently violated MBS movement constraints more than a predetermined fraction of the number of times there has been new instantiation of "MBS_curr_est", wherein such movement constraints may be (de)acceleration constraints, abrupt change in direction constraints, constraints relating to too high a velocity for a terrain) **or**
(there has been an MBS operator indication of lack of confidence in the recently displayed MBS location estimates)**]**

then /* the **MBS location system is likely unstable and/or inaccurate; check to see if this condition has been addressed in the recent past.** */

{ /* fix instability */

if (fix_instability_counter equal to 0) then /* **no instabilities have been addressed here within the recent past**; i.e., "fix_instability_counter" has the following semantics: if it is 0, then no instabilities have been addressed here within the recent past; else if not 0, then a recent instability has been attempted to be fixed here. Note, "fix_instability_counter" is decremented, if not zero, each time a new baseline location entry is inserted into its corresponding **baseline location track**. Thus, this counter provides a "wait and see" strategy to determine if a previous performance of the statements below mitigated the (any) MBS location system instability. */

{

most_likely_est <-- determine a new "most likely MBS location estimate"; **[30.1]**

/* Note, a number of MBS location estimates may be generated and compared here for determining the "most_likely_est". For example, various weighted centroid MBS location estimates may be determined by a **clustering** of location track head entries in various ways.

In a first embodiment for determining a value (object) for "most_likely_est", a "most likely" function may be performed, wherein a weighting of location track heads according to their corresponding confidence values is performed. For example, the following steps provide an embodiment of a "most likely" function:

(a) obtain a set S having: (i) a centroid of area for each of the track heads having a corresponding area contained in a determined area surrounding the point location of "adjusted_curr_est" (e.g., the MBS estimated area of "adjusted_curr_est"), plus (ii) the centroid of "MBS_new_est";

(b) determine the "most likely location MBS ***position***" P as a weighted centroid of the centroids of the set S from step (a), wherein the weighting of each of the centroids from (a) is provided by their corresponding confidence values;

(c) output an area, A, as the "most likely MBS location ***area***" wherein A has P as a centroid and A is a "small" area (e.g., a convex hull) containing the corresponding the centroids of the set S; and

(d) set a **confidence value** for A as the average confidence value of the centroids of the set S.

In a second embodiment, "most_likely_est" may be determined by expanding (e.g., substantially uniformly in all directions) the MBS location estimate area of "MBS_new_est" until the resulting expanded area contains at least the most likely point location of "adjusted_curr_est" as its most likely MBS location area. */

insert_into_location_track("current", most_likely_est);

fix_instability_counter <--- a predetermined number, C, corresponding to a number of baseline entries to be put on the baseline location tracks until MBS location system instabilities are to be addressed again here; /* when this counter goes to zero and the MBS location system is unstable, then the above statements above will be performed again. Note, this counter must be reset to C (or higher) if a manual MBS estimate is entered. */

}

} /* fix instability */

else /* **The MBS location system has been reasonably stable, and "MBS_curr_est.confidence" is not substantially bigger than "adjusted_new_est.confidence" . */**

{

most_likely_est <-- determine a most likely MBS location estimate;

/* The determination in the statement above may be similar or substantially the same as the computation discussed in relation to statement [30.1] above. However, since there is both more stability in this case than in [30.1] and less confidence in "MBS_new_est", certain MBS movement constraints may be more applicable here than in [30.1].

Accordingly, note that in any embodiment for determining "most_likely_est" here, reasonable movement constraints may also be used such as: (a) unless indicated otherwise, an MBS vehicle will be assumed to be on a road, (b) a new MBS location estimate should not imply that the MBS had to travel faster than, for example, 120 mph or change direction too abruptly or change velocity too abruptly or traverse a roadless region (e.g., corn field or river) at an inappropriate rate of speed.

Thus, once a tentative MBS location estimate (e.g., such as in the steps of the first embodiment of [30.1]) for "most_likely_est" has been determined, such constraints may be applied to the tentative estimate for determining whether it should be pulled back toward the centroid of the "MBS_curr_est" in order to satisfy the movement constraints*/

insert_into_location_track("current", most_likely_est); /* note, the second parameter for this function may be either of the following data structures: a "location track entry", or a "MBS location estimate" and the appropriate location track entry or entries will be put on the location track corresponding to the first parameter. */

}

```
        } /* check for instabilities */
        MBS_curr_est <--- get_curr_est(MBS_new_est.MS_ID); /* from current location track */
    } /* try to use "MBS_new_est" */
    RETURN(MBS_curr_est)
} /* END resolve_conflicts */
```

APPENDIX B: Pseudo code for a genetic algorithm

Pseudo code for a genetic algorithm

```
Genetic_Algorithm (*decode, *fitness_function, parms)
/* This program implements a genetic algorithm for determining efficient
  values of parameters for a search problem. The current best values of the parameters are received by the genetic algorithm in a data
structure such as an array. If no such information is available, then the genetic algorithm receives random guesses of the parameter values.
This program also receives as input a pointer to a decode function that provides the genetic algorithm with information about how the
parameters are represented by bit strings (see genetic algorithm references). The program also receives a pointer to a fitness function,
"fitness_functions", that provides the genetic algorithm with information about how the quality of potential solutions should be determined.
The program computes new, improved values of parameters and replaces the old values in the array "parms."
*/
// assume that each particular application will have a specific fitness function and decoding
// scheme; otherwise, the procedure is the same every time
// generate the initial population
// generate a random population of binary strings containing popsize strings
for i = 1 to popsize
 for j = 1 to string_length
  string(i,j) = random(0,1)
 end loop on j
end loop on i
// keep generating new populations until finished
do until finished
 for i = 1 to popsize
  // transform the binary strings into parametersfrom the problem at hand; requires problem
   // specific function
  decode (string(i))
  // evaluate each string
  evaluate (string(i))
 end loop on i
 // perform reproduction
 reproduce (population_of_strings)
```

```
//perform crossover
crossover (population_of_strings)
//perform mutation
mutate (population_of_strings)
// evaluate the new population
for i = 1 to popsize
 //transform the binary strings into parameters
  //from the problem at hand; requires problem
  //specific function
 decode (string(i))
 //evaluate the fitness of each string
 evaluate (string(i,j))
end loop on i
if finished then report new results to the calling routine
else go back to tip of do-until loop
```

APPENDIX C: Location Database Maintenance Programs

DATA BASE PROGRAMS FOR MAINTAINING THE LOCATION SIGNATURE DATA BASE

In the algorithms below, external parameter values needed are underlined. Note that in one embodiment of the present invention, such parameters may be adaptively tuned using, for example, a genetic algorithm.

EXTERNALLY INVOCABLE PROGRAMS:

Update_Loc_Sig_DB(new_loc_obj, selection_criteria, loc_sig_pop)

/* This program updates loc sigs in the Location Signature data base. That is, this program updates, for example, at least the location information for verified random loc sigs residing in this data base. Note that the steps herein are also provided in flowchart form in Fig. 17a through FIG. 17C.

Introductory Information Related to the Function, "Update_Loc_Sig_DB"

The general strategy here is to use information (i.e., "new_loc_obj") received from a newly verified location (that may not yet be entered into the Location Signature data base) to assist in determining if the previously stored random verified loc sigs are still reasonably valid to use for:

(29.1) estimating a location for a given collection (i.e., "bag") of wireless (e.g., CDMA) location related signal characteristics received from an MS,

(29.2) training (for example) adaptive location estimators (and location hypothesizing models), and

(29.3) comparing with wireless signal characteristics used in generating an MS location hypothesis by one of the MS location hypothesizing models (denoted First Order Models, or, FOMs).

More precisely, since it is assumed that it is more likely that the newest location information obtained is more indicative of the wireless (CDMA) signal characteristics within some area surrounding a newly verified location than the verified loc sigs (location signatures) previously entered into the Location Signature DB, such verified loc sigs are compared for signal characteristic consistency with the newly verified location information (object) input here for determining whether some of these "older" data base verified loc sigs still appropriately characterize their associated location.

In particular, comparisons are iteratively made here between each (target) loc sig "near" "new_loc_obj" and a population of loc sigs in the location signature data base (such population typically including the loc sig for "new_loc_obj) for:

(29.4) adjusting a confidence factor of the target loc sig. Note that each such confidence factor is in the range [0, 1] with 0 being the lowest and 1 being the highest. Further note that a confidence factor here can be raised as well as lowered depending on how well the target loc sig matches or is consistent with the population of loc sigs to which it is compared. Thus, the confidence in any particular verified loc sig, LS, can fluctuate with successive invocations of this program if the input to the successive invocations are with location information geographically "near" LS.

(29.5) remove older verified loc sigs from use whose confidence value is below a predetermined threshold. Note, it is intended that such predetermined thresholds be substantially automatically adjustable by periodically testing various confidence factor thresholds in a specified geographic area to determine how well the eligible data base loc sigs (for different thresholds) perform in agreeing with a number of verified loc sigs in a "loc sig test-bed", wherein the test bed may be composed of, for example, repeatable loc sigs and recent random verified loc sigs.

Note that this program may be invoked with a (verified/known) random and/or repeatable loc sig as input. Furthermore, the target loc sigs to be updated may be selected from a particular group of loc sigs such as the random loc sigs or the repeatable loc sigs, such selection being determined according to the input parameter, "selection_criteria" while the comparison population may be designated with the input parameter, "loc_sig_pop". For example, to update confidence factors of certain random loc sigs near "new_loc_obj", "selection_criteria" may be given a value indicating, "USE_RANDOM_LOC_SIGS", and "loc_sig_pop" may be given a value indicating, "USE_REPEATABLE_LOC_SIGS". Thus, if in a given geographic area, the repeatable loc sigs (from, e.g., stationary transceivers) in the area have recently been updated, then by successively providing "new_loc_obj" with a loc sig for each of these repeatable loc sigs, the stored random loc sigs can have their confidences adjusted.

Alternatively, in one embodiment of the present invention, the present function may be used for determining when it is desirable to update repeatable loc sigs in a particular area (instead of automatically and periodically updating such repeatable loc sigs). For example, by adjusting the confidence factors on repeatable loc sigs here provides a method for determining when repeatable loc sigs for a given area should be updated. That is, for example, when the area's average confidence factor for the repeatable loc sigs drops below a given (potentially high) threshold, then the MSs that provide the repeatable loc sigs can be requested to respond with new loc sigs for updating the DB. Note, however, that the approach presented in this function assumes that the repeatable location information in the DB is maintained with high confidence by, for example, frequent DB updating. Thus, the random verified DB location information may be effectively compared against the repeatable loc sigs in an area.

INPUT:

new_loc_obj: a data representation at least including a loc sig for an associated location about which Location Signature loc sigs are to have their confidences updated.

selection_criteria: a data representation designating the loc sigs to be selected to have their confidences updated (may be defaulted). The following groups of loc sigs may be selected: "USE_RANDOM_LOC_SIGS" (this is the default), USE_REPEATABLE_LOC_SIGS", "USE_ALL_LOC_SIGS". Note that each of these selections has values for the following values associated with it (although the values may be defaulted):

(a) a <u>confidence reduction factor</u> for reducing loc sig confidences,

(b) a <u>big_error_threshold</u> for determining the errors above which are considered too big to ignore,

(c) a <u>confidence_increase_factor</u> for increasing loc sig confidences,

(d) a <u>small_error_threshold</u> for determining the errors below which are considered too small (i.e., good) to ignore.

(e) a <u>recent_time</u> for specifying a time period for indicating the loc sigs here considered to be "recent".

loc_sig_pop: a data representation of the type of loc sig population to which the loc sigs to be updated are compared. The following values may be provided:

(a) "USE ALL LOC SIGS IN DB",

(b) "USE ONLY REPEATABLE LOC SIGS" (this is the default),

(c) "USE ONLY LOC SIGS WITH SIMILAR TIME OF DAY"

However, environmental characteristics such as: weather, traffic, season are also contemplated. */

/* Make sure "new_loc_obj" is in Location DB. */

if (NOT new_loc_obj.in_DB) then /* this location object is not in the Location Signature DB; note this can be determined by comparing the location and times/datestamp with DB entries */

DB_insert_new_loc_sig_entries(new_loc_obj); // stores loc sigs in Location Signature DB

/* Determine a geographical area surrounding the location associated with "new_loc_obj" for adjusting the confidence factors of loc sigs having associated locations in this area. */

DB_search_areal <--- *get_confidence_adjust_search_area_for_DB_random_loc_sigs*(new_loc_obj.location);

/* get the loc sigs to have their confidence factors adjusted. */

DB_loc_sigs <--- *get_all_DB_loc_sigs_for*(DB_search_areal, selection_criteria);

nearby_loc_sig_bag <--- get loc sigs from "DB_loc_sigs" wherein for each loc sig the distance between the location associated with "new_loc_obj.location" and the verified location for the loc sig is closer than, for example, some standard deviation (such as the second standard deviation) of these distances for all loc sigs in "DB_loc_sigs";

/* For each "loc sig" having its confidence factor adjusted do */

for each loc_sig[i] in nearby_loc_sig_bag do // determine a confidence for these random loc sigs

```
{
    /* Determine a search area surrounding the location associated with "loc
    sig" */
    loc <--- get_verified_location(loc_sig[i]);
    /* Determine the error corresponding to how well "loc sig" fits with the
    portion of the inputted type of loc sig population that is also in the search
    area. */
    BS <--- get_BS(loc_sig[i]);
    mark_as_unaccessable(loc_sig[i]); /* mark "loc_sig[i]" in the Location Signature DB so that it isn't retrieved. */
    DB_search_area2 <--- get_confidence_adjust_search_area_for_DB_loc_sigs(loc.location);
      /* Get search area about "rand_loc". Typically, the "new_loc_obj" would be in this search area */
    loc_sig_bag <--- create_loc_sig_bag(loc_sig[i]); /* create a loc sig bag having a single loc sig, "loc_sig[i]"*/
    output_criteria <--- get criteria to input to "Determine_Location_Signature_Fit_Errors" indicating that the function
                    should generate error records in the returned "error_rec_bag" only for the single loc sig in
                    "loc_sig_bag". That is, the output criteria is: "OUTPUT ERROR_RECS FOR INPUT LOC SIGS
                    ONLY".
    error_rec_bag[i] <--- Determine_Location_Signature_Fit_Errors(loc.location, loc_sig_bag,
                    DB_search_area2, loc_sig_pop, output_criteria);
    unmark_making_accessable(loc_sig[i]); /* unmark "loc_sig[i]" in the Location Signature DB so that it can now be
                    retrieved. */
}
/* Reduce confidence factors of loc sigs: (a) that are nearby to the location
associated with "new_loc_obj", (b) that have big errors, and (c) that have not
been recently updated/acquired. */
error_rec_set <--- make_set_union_of(error_rec_bag[i] for all i);
    /* Now modify confidences of loc sigs in DB and delete loc sigs with very low confidences */
reduce_bad_DB_loc_sigs(nearby_loc_sig_bag, error_rec_set, selection_criteria.big_error_threshold,
                    selection_criteria.confidence_reduction_factor, selection_criteria.recent_time);
/* Increase confidence factors of loc sigs: (a) that are nearby to the location
associated with "new_loc_obj", (b) that have small errors, and (c) that have not
been recently updated/acquired. */
```

increase_confidence_of_good_DB_loc_sigs(nearby_loc_sig_bag, error_rec_set,
selection_criteria.small_error_threshold,
selection_criteria.confidence_increase_factor,
selection_criteria.recent_time);

END OF Update_Loc_Sig_DB

DB_Loc_Sig_Error_Fit(MS_loc_est, DB_search_area, measured_loc_sig_bag, search_criteria)

/* This function determines how well the collection of loc sigs in "measured_loc_sig_bag" fit with the loc sigs in the location signature data base wherein the data base loc sigs must satisfy the criteria of the input parameter "search_criteria" and are relatively close to the MS location estimate of the location hypothesis, "hypothesis". Thus, in one embodiment of the present invention, the present function may be invoked by, for example, the confidence adjuster module to adjust the confidence of a location hypothesis.

Input: **hypothesis**: MS location hypothesis;

measured_loc_sig_bag: A collection of measured location signatures ("loc sigs" for short) obtained from the MS (the data structure here is an aggregation such as an array or list). Note, it is assumed that there is at most one loc sig here per Base Station in this collection. Additionally, note that the input data structure here may be a location signature cluster such as the "loc_sig_cluster" field of a location hypothesis (cf. Fig. 9). Note that variations in input data structures may be accepted here by utilization of flag or tag bits as one skilled in the art will appreciate;

search_criteria: The criteria for searching the verified location signature data base for various categories of loc sigs. The only limitation on the types of categories that may be provided here is that, to be useful, each category should have meaningful number of loc sigs in the location signature data base. The following categories included here are illustrative, but others are contemplated:

(a) "USE ALL LOC SIGS IN DB" (the default),

(b) "USE ONLY REPEATABLE LOC SIGS",

(c) "USE ONLY LOC SIGS WITH SIMILAR TIME OF DAY".

Further categories of loc sigs close to the MS estimate of "hypothesis" contemplated are: all loc sigs for the same season and same time of day, all loc sigs during a specific weather condition (e.g., snowing) and at the same time of day, as well as other limitations for other environmental conditions such as traffic patterns. Note, if this parameter is NIL, then (a) is assumed.

Returns: An error object (data type: "error_object") having: (a) an "error" field with a measurement of the error in the fit of the location signatures from the MS with verified location signatures in the Location Signature data base; and

(b) a "confidence" field with a value indicating the perceived confidence that is to be given to the "error" value. */

if ("search_criteria" is NIL) then

search_criteria <--- "USE ALL LOC SIGS IN DB";

/* determine a collection of error records wherein there is an error record for each BS that is associated with a loc sig in "measure_loc_sig_bag" and for each BS associated with a loc sig in a geographical area surrounding the hypothesis's location. */

output_criteria <--- "OUTPUT ALL POSSIBLE ERROR_RECS";

/* The program invoked in the following statement is described in the location signature data base section. */

error_rec_bag <--- **Determine_Location_Signature_Fit_Errors**(MS_loc_est, measured_loc_sig_bag, DB_search_area, search_criteria, output_criteria);

/* Note, "error_rec_bag" has "error_rec's" for each BS having a loc sig in "DB_search_area" as well as each BS having a loc sig in "measured_loc_sig_bag". */

/* determine which error records to ignore */

BS_errors_to_ignore_bag <--- *get_BS_error_recs_to_ignore*(DB_search_area, error_rec_bag,);

/* Our general strategy is that with enough BSs having: (a) loc sigs with the target MS, and (b) also having verified locations within an area about the MS location "MS_loc_est", some relatively large errors can be tolerated or ignored. For example, if the MS location estimate, "MS_loc_est", here is indeed an accurate estimate of the MS's location and if an area surrounding "MS_loc_est" has relatively homogeneous environmental characteristics and the area has an adequate number of verified location signature clusters in the location signature data base, then there will be presumably enough comparisons between the measured MS loc sigs of "measured_loc_sig_bag" and the estimated loc sigs, based on verified MS locations in the DB (as determined in "Determine_Location_Signature_Fit_Errors"), for providing "error_rec_bag" with enough small errors that these small errors provide adequate evidence for "MS_loc_est" being accurate.

Accordingly, it is believed that, in most implementations of the present invention, only a relatively small number of loc_sig comparisons need have small errors for there to be consistency between the loc sigs of "measured_loc_sig_bag" and the verified loc sigs in the location signature data base. That is, a few large errors are assumed, in general, to be less indicative of the MS location hypothesis being incorrect than small errors are indicative of accurate MS locations. Thus, if there were ten measured and estimated loc sig pairs, each associated with a different BS, then if four pairs have small errors, then that might be enough to have high confidence in the MS location hypothesis. However, note that this determination could depend on the types of base stations; e.g., if five full-service base stations had measured and verified loc sigs that match reasonably well but five location BSs in the search area are not detected by the MS (i.e., the measured_loc_sig_bag has no loc sigs for these location BSs), then the confidence is lowered by the mismatches.

Thus, for example, the largest x% of the errors in "error_rec_bag" may be ignored. Note, that "x" may be: (a) a system parameter that is tunable using, for example, a genetic algorithm; and (b) "x" may be tuned separately for each different set of environmental characteristics that appear most important to accurately accessing discrepancies or errors between loc sigs. Thus, for a first set of environmental characteristics corresponding to: rural, flat terrain, summer, 8 PM and clear weather, it may be the case that no loc sig errors are ignored. Whereas, for a second set of environmental characteristics corresponding to: dense urban, hilly, fall, 8 PM, heavy traffic, and snowing, all but the three smallest errors may be ignored. */

/* determine (and return) error object based on the remaining error records */

```
error_obj.measmt <--- 0; // initializations
error_obj.confidence <--- 0;
for each error_rec[i] in (error_rec_bag - BS_errors_to_ignore_bag) do
{
    error_obj.measmt <--- error_obj.measmt + (error_rec[i].error);
    error_obj.confidence <--- error_obj.confidence + (error_rec[i].confidence);
}
error_obj.measmt <--- error_obj.measmt / SIZEOF(error_rec_bag - BS_errors_to_ignore_bag);
error_obj.confidence <--- error_obj.confidence / SIZEOF(error_rec_bag - BS_errors_to_ignore_bag);
RETURN(error_obj);
```

ENDOF DB_Loc_Sig_Error_Fit

<u>INTERNAL PROGRAMS:</u>

reduce_bad_DB_loc_sigs(loc_sig_bag , error_rec_set, big_error_threshold confidence_reduction_factor, recent_time)

/* This program reduces the confidence of verified DB loc sigs that are (seemingly) no longer accurate (i.e., in agreement with comparable loc sigs in the DB). If the confidence is reduced low enough, then such loc sigs are removed from the DB. Further, if for a DB verified location entity (referencing a collection of loc sigs for the same location and time), this entity no longer references any valid loc sigs, then it is also removed from the location signature data base 1320. .Note that the steps herein are also provided in flowchart form in Figs. 18a through 18b.

Inputs:

loc_sig_bag: The loc sigs to be tested for determining if their confidences should be lowered and/or these loc sigs removed.

error_rec_set: The set of "error_recs" providing information as to how much each loc sig in "loc_sig_bag" disagrees with comparable loc sigs in the DB. That is, *there is an "error_rec" here for each loc sig in "loc_sig_bag".*

big_error_threshold: The error threshold above which the errors are considered too big to ignore.

confidence_reduction_factor: The factor by which to reduce the confidence of loc sigs.

recent_time: Time period beyond which loc sigs are no longer considered recent.

{ /* get loc sigs from the Location DB having both big absolute and relative errors (in comparison to other DB nearby loc sigs) */

relatively_big_errors_bag <--- get "error_recs" in "error_rec_set" wherein each "error_rec.error" has a size larger than, for example, the second standard deviation from the mean (average) of such errors;

big_errors_bag <--- get "error_recs" in "relatively_big_errors_bag" wherein each "error_rec.error" has a value larger than "big_error_threshold";

DB_loc_sigs_w_big_errors <--- get the loc sigs for "error_recs" in "big_errors_bag" wherein each loc sig gotten here is identified by "error_rec.loc_sig_id";

/* get loc sigs from the Location DB that have been recently added or updated */

recent_loc_sigs <--- *get_recent_loc_sigs*(loc_sig_bag, recent_time); /* Note, the function, "get_recent_loc_sigs" can have various embodiments, including determining the recent location signatures by comparing their time stamps (or other time related measurements) with one or more threshold values for classifying location signatures into a "recent" category returned here and an a category for "old" or updatable location signatures. Note that these categories can be determined by a (tunable) system time threshold parameter(s) for determining a value for the variable, "recent_time", and/or, by data driving this categorization by, e.g., classifying the location signatures according to a standard deviation, such as defining the "recent" category as those location signatures more recent than a second standard deviation of the timestamps of the location signatures in "loc_sig_bag". */

/* subtract the recent loc sigs from the loc sigs with big errors to get the bad ones */

bad_DB_loc_sigs <--- (big_error_DB_loc_sigs) - (recent_loc_sigs);

/* lower the confidence of the bad loc sigs */

for each loc_sig[i] in bad_DB_loc_sigs do

loc_sig[i].confidence <--- (loc_sig[i].confidence) * (confidence_reduction_factor);

/* for each bad loc sig, update it in the DB or remove it from use if its confidence is too low */

```
/* Now delete any loc sigs from the DB whose confidences have become too low. */
for each loc_sig[i] in bad_DB_loc_sigs do
    if (loc_sig[i].confidence < min_loc_sig_confidence) then
    {
        REMOVE_FROM_USE(loc_sig[i]);
        /* update composite location objects to reflect a removal of a referenced loc sig*/
        verified_loc_entity <--- retrieve_composite_location_entity_having(loc_sig[i]);
            /* This gets all other (if any) loc sigs for the composite location object that were verified at the same time as
            "loc_sig[i]". Note, these other loc sigs may not need to be deleted (i.e., their signal characteristics may have a
            high confidence); however, it must be noted in the DB, that for the DB composite location entity having
            "loc_sig[i]", this entity is no longer complete. Thus, this entity may not be useful as, e.g., neural net training
            data. */
        mark "verified_loc_entity" as incomplete but keep track that a loc sig did exist for the BS associated with "loc_sig[i]";
        if ("verified_loc_entity" now references no loc sigs) then REMOVE_FROM_USE(verified_loc_entity);
    }
    else DB_update_entry(loc_sig[i]); // with its new confidence
} ENDOF reduce_bad_DB_loc_sigs
```

increase_confidence_of_good_DB_loc_sigs(nearby_loc_sig_bag, error_rec_set, small_error_threshold, confidence_increase_factor, recent_time);

/* This program increases the confidence of verified DB loc sigs that are (seemingly) of higher accuracy (i.e., in agreement with comparable loc sigs in the DB). Note that the steps herein are also provided in flowchart form in Figs. 19a through 19b.

Inputs:

loc_sig_bag: The loc sigs to be tested for determining if their confidences should be increased.

error_rec_set: The set of "error_recs" providing information as to how much each loc sig in "loc_sig_bag" disagrees with comparable loc sigs in the DB. That is, *there is an "error_rec" here for each loc sig in "loc_sig_bag".*

small_error_threshold: The error threshold below which the errors are considered too small to ignore.

confidence_increase_factor: The factor by which to increase the confidence of loc sigs.

recent_time: Time period beyond which loc sigs are no longer considered recent.

/* get loc sigs from the Location DB having both small absolute and relative errors (in comparison to other DB nearby loc sigs) */

relatively_small_errors_bag <--- get "error_recs" in "error_rec_set" wherein each "error_rec.error" has a size smaller than, for example, the second standard deviation from the mean (average) of such errors;

small_errors_bag <--- get "error_recs" in "relatively_small_errors_bag" wherein each "error_rec.error" has a size smaller than "small_error_threshold";

DB_loc_sigs_w_small_errors <--- get the loc sigs for "error_recs" in "small_errors_bag" wherein each loc sig gotten here is identified by "error_rec.loc_sig_id";

/* get loc sigs from the Location DB that have been recently added or updated */

recent_loc_sigs <--- *get_recent_loc_sigs*(loc_sig_bag, recent_time);

/* subtract the recent loc sigs from the loc sigs with small errors to get the good ones */

good_DB_loc_sigs <--- (small_error_DB_loc_sigs) - (recent_loc_sigs);

/* for each good loc sig, update its confidence */

```
for each loc_sig[i] in good_DB_loc_sigs do
{
    loc_sig[i].confidence <--- (loc_sig[i].confidence) * (confidence_increase_factor);
    if (loc_sig[i].confidence > 1.0) then loc_sig[i] <--- 1.0;
}
```

ENDOF increase_good_DB_loc_sigs

DATA BASE PROGRAMS FOR DETERMINING THE CONSISTENCY OF LOCATION HYPOTHESES WITH VERIFIED LOCATION INFORMATION IN THE LOCATION SIGNATURE DATA BASE

LOW LEVEL DATA BASE PROGRAMS FOR LOCATION SIGNATURE DATA BASE

/* The following program compares: (a1) loc sigs that are contained in (or derived from) the loc sigs in "target_loc_sig_bag" with (b1) loc sigs computed from verified loc sigs in the location signature data base. That is, each loc sig from (a1) is compared with a corresponding loc sig from (b1) to obtain a measurement of the discrepancy between the two loc sigs. In particular, assuming each of the loc sigs for "target_loc_sig_bag" correspond to the same target MS location, wherein this location is "target_loc", this program determines how well the loc sigs in "target_loc_sig_bag" fit with a computed or estimated loc sig for the location, "target_loc" that is derived from the verified loc sigs in the location signature data base. Thus, this program may be used: (a2) for determining how well the loc sigs in the location signature cluster for a target MS ("target_loc_sig_bag") compares with loc sigs derived from verified location signatures in the location signature data base, and (b2) for determining how consistent a given collection of loc sigs ("target_loc_sig_bag") from the location signature data base is with other loc sigs in the location signature data base. Note that in (b2) each of the one or more loc sigs in "target_loc_sig_bag" have an error computed here that can be used in determining if the loc sig is becoming inapplicable for predicting target MS locations Note that the steps herein are also provided in flowchart form in Figs. 20a through 20d.*/

Determine_Location_Signature_Fit_Errors(target_loc, target_loc_sig_bag, search_area, search_criteria, output_criteria)

/* Input: **target_loc**: An MS location or a location hypothesis for a particular MS. Note, this can be any of the following:

(a) An ***MS location hypothesis***, in which case, the loc sigs in "target_loc_sig_bag" are included in a location signature cluster from which this location hypothesis was derived. Note that if this location is inaccurate, then "target_loc_sig_bag" is unlikely to be similar to the comparable loc sigs derived from the loc sigs of the location signature data base close "target_loc"; or

(b) A ***previously verified MS location***, in which case, the loc sigs of "target_loc_sig_bag" are previously verified loc sigs. However, these loc sigs may or may not be accurate now.

target_loc_sig_bag: Measured location signatures ("loc sigs" for short) obtained from the particular MS (the data structure here, bag, is an aggregation such as array or list). The location signatures here may be verified or unverified. However, ***it is assumed that there is at least one loc sig in the bag. Further, it is assumed that there is at most one loc sig per Base Station. It is also assumed that the present parameter includes a "type" field indicating whether the loc sigs here have been individually selected, or, whether this parameter references an entire (verified) loc sig cluster; i.e., the type field may have a value of: "UNVERIFIED LOC SIG CLUSTER" or "VERIFIED LOC SIG CLUSTER";***

search_area: The representation of the geographic area surrounding "target_loc". This parameter is used for searching the Location Signature data base for verified loc sigs that correspond geographically to the location of an MS in "search_area";

search_criteria: The criteria used in searching the location signature data base. The criteria may include the following:

(a) "USE ALL LOC SIGS IN DB",

(b) "USE ONLY REPEATABLE LOC SIGS",

(c) "USE ONLY LOC SIGS WITH SIMILAR TIME OF DAY".

However, environmental characteristics such as: weather, traffic, season are also contemplated.

output_criteria: The criteria used in determining the error records to output in "error_rec". The criteria here may include one of:

(a) "OUTPUT ALL POSSIBLE ERROR_RECS";

(b) "OUTPUT ERROR_RECS FOR INPUT LOC SIGS ONLY".

Returns: **error_rec**: A bag of error records or objects providing an indication of the similarity between each loc sig in "target_loc_sig_bag" and an estimated loc sig computed for "target_loc" from stored loc sigs in a surrounding area of "target_loc". Thus, each error record/object in "error_rec" provides a measurement of how well a loc sig (i.e., wireless signal characteristics) in "target_loc_sig_bag" (for an associated BS and the MS at "target_loc") correlates with an estimated loc sig between this BS and MS. Note that the estimated loc sigs are determined using verified location signatures in the Location Signature DB. Note, each error record in "error_rec" includes: (a) a BS ID indicating the base station to which the error record corresponds; and (b) an error measurement (>=0), and (c) a confidence value (in [0, 1]) indicating the confidence to be placed in the error measurement. Also note that since "error_rec" is an aggregate data type (which for many aggregate identifiers in this specification are denoted by the suffix "_bag" on the identifier), it can be any one of a number data types even though it's members are accessed hereinbelow using array notation. */

/* get BS's associated with DB loc sigs in "search_area" that satisfy "search_criteria" */

```
DB_loc_sig_bag <--- retrieve_verified_loc_sigs(search_area, search_criteria);
        // get all verified appropriate location signatures residing in the Location Signature data base.
        // Note, some loc sigs may be blocked from being retrieved.
DB_BS_bag <--- get_BSs(DB_loc_sig_bag); // get all base stations associated with at least one location
        // signature in DB_loc_sig_bag. Note, some of these BSs may be low power "location
        // BSs".
```

/* get BS's associated with loc sigs in "target_loc_sig_bag" */

```
target_BS_bag <--- get_BSs(target_loc_sig_bag); // get all base stations associated with at least one
        // location signature in "target_loc_sig_bag".
```

/* determine the BS's for which error records are to be computed */

```
case of "output_criteria" including:
    "OUTPUT ALL POSSIBLE ERROR_RECS": /* In this case, it is desired to determine a collection or error records wherein there is
            an error record for each BS that is associated with a loc sig in "target_loc_sig_bag" and for each BS associated
            with a loc in the "search_area" satisfying "search_criteria". */
                BS_bag <--- (DB_BS_bag) union (target_BS_bag);

    "OUTPUT ERROR_RECS FOR INPUT LOC SIGS ONLY":
                BS_bag <--- target_BS_bag;
endcase;"
/* for each BS to have an error record computed, make sure there are two loc sigs
to compare: one loc sig derived from the "BS_bag" loc sig data, and one from
derived from the loc sigs in the Location Signature DB, wherein both loc sigs are
associated with the location, "target_loc". */
for each BS[i] in "BS_bag" do
{   /* determine two (estimated) loc sigs at "target_loc", one derived from "target_loc_sig_bag" (if possible) and one derived
        from Location Signature DB loc sigs (if possible) */
      comparison_loc_sig_bag[i] <--- retrieve_verified_loc_sigs_for(BS[i], search_area, search_criteria);
            /* get all loc sigs for which BS[i] is associated and wherein the verified MS location is in
            "search_area" (which surrounds the location "target_loc") and wherein the loc
            sigs satisfy "search_criteria". */
      /* now determine if there are enough loc sigs in the "comparison_loc_sig_bag" to make
      it worthwhile to try to do a comparison. */
      if ( (SIZEOF(comparison_loc_sig_bag[i])/(SIZEOF(search_area)) ) < min_threshold_ratio(area_type(search_area)) )
          then
                /* it is believed that there is not a dense enough number of verified loc sigs to compute a composite
                    loc sig associated with a hypothetical MS at "target_loc". */
              error_rec[i].error <--- invalid;
      else /* there are enough loc sigs in "comparison_loc_sig_bag" to continue, and in
          particular, an estimated loc sig can be derived from the loc sigs in
          "comparison_loc_sig_bag"; however, first see if a target loc sig can be
          determined; if so, then make the estimated loc sig (denoted
          "estimated_loc_sig[i]"). */
      {
```

```
if (BS[i] is in target_BS_bag) then
        /* get a loc sig in "target_BS_bag" for BS[i]; assume at most one loc sig per BS in
        "target_loc_sig_bag" */
    target_loc_sig[i] <--- get_loc_sig(BS[i], target_loc_sig_bag);
else /* BS[i] is not in "target_BS_bag", accordingly this implies that we are in the
        process of attempting to output all possible error records for all BS's: (a)
        that have previously been detected in the area of "search_area" (satisfying "search_criteria"), union,
        (b) that are associated with a loc sig in "target_loc_sig_bag". Note, the path here is performed when
        the MS at the location for "target_loc" did not detect the BS[i], but BS[i] has previously been detected
        in this area. */
    if (target_loc_sig_bag.type = = "UNVERIFIED LOC SIG CLUSTER") then
            /* can at least determine if the MS for the cluster detected the BS[i]; i.e., whether BS[i]
            was in the set of BS's detected by the MS even though no loc sig was obtained for BS[i]. */
        if (BS_only_detected(target_loc_sig_bag, BS[i]) ) then /* detected but no loc sig */
            error_rec[i].error <--- invalid; /* can't determine an error if this is all the information
              we have */
        else /* BS[i] was not detected by the MS at "target_loc.location", so the pilot channel for BS[i] was
            in the noise; make an artificial loc sig at the noise ceiling (alternatively, e.g., a mean noise
            value) for the MS location at "target_loc" */
          target_loc_sig[i] <--- get_noise_ceiling_loc_sig(target_loc);
    else; /* do nothing; there are no other types for "target_loc_sig_bag.type" that are currently used when
          outputting all possible error records for BS's */
if (error_rec[i].error NOT invalid) then
        /* we have a "target_loc_sig" for comparing, so get the derived loc sig estimate obtained from the
          verified loc sigs in the location signature data base. */
        estimated_loc_sig[i] <--- estimate_loc_sig_from_DB(target_loc.location,
                                        comparison_loc_sig_bag[i]);
        /* The above call function provides an estimated loc sig for the location of "target_loc" and BS[i]
        using the verified loc sigs of "comparison_loc_sig_bag[i]" */
}
```

/* for each BS whose error record has not been marked "invalid", both "target_loc_sig" and "estimated_loc_sig" are now well-defined; so compute an

error record related to the difference between "target_loc_sig" and "estimated_loc_sig". */

```
for each BS[i] in "BS_bag " with error_rec[i].error not invalid do /* determine the error records for these base stations */
{
    /* Note, the "target_loc_sig" here is for an MS at or near the location for the center of area for "target_loc". */
    error_rec[i] <--- get_difference_measurement(target_loc_sig[i], estimated_loc_sig[i],
                        comparison_loc_sig_bag[i], search_area, search_criteria);/* get a measurement of the difference
                        between these two loc sigs. */
    error_rec.loc_sig_id <--- target_loc_sig[i].id; /* this is the loc sig with which this error_rec is associated */
    error_rec.comparison_loc_sig_id_bag <--- comparison_loc_sig_bag[i];
}
RETURN(error_rec);
```

ENDOF Determine_Location_Signature_Fit_Errors

estimate_loc_sig_from_DB(loc_for_estimation, loc_sig_bag)

/* This function uses the verified loc sigs in "loc_sig_bag" to determine a single estimated (or "typical") loc sig derived from the loc sigs in the bag. Note, it is assumed that all loc sigs in the "loc_sig_bag" are associated with the same BS 122 (denoted the BS associated with the "loc_sig_bag") and that the locations associated with these loc sigs are near "loc_for_estimation". Further, note ***that since the loc sigs are verified, the associated base station was the primary base station when the loc sig signal measurements were sampled.*** Thus, the measurements are as precise as the infrastructure allows. Note that the steps herein are also provided in flowchart form in Fig. 21.

Input: loc_for_estimation A representation of a service area location.

loc_sig_bag A collection of verified loc sigs, each associated with the same base station and each associated with a service area location presumably relatively near to the location represented by "loc_for_estimation". */

est_loc_sig <--- extrapolate/interpolate a location signature for the location at "loc_for_estimation" based on loc sigs in "loc_sig_bag";

/* Note, "est_loc_sig" includes a location signature and a confidence measure.

The confidence measure (in the range: [0, 1]) is based on: (a) the number of verified loc sigs in the search area; (b) how well they surround the center location of the new_loc, and (c) the confidence factors of the loc sigs in "loc_sig_bag" (e.g., use average confidence value).

Note, for the extrapolation/interpolation computation here, there are many such extrapolation/interpolation methods available as one skilled in the art will appreciate. For example, in one embodiment of an extrapolation/interpolation method, the following steps are contemplated:

(39.1) Apply any pre-processing constraints that may alter any subsequently computed "est_loc_sig" values derived below). For example, if the BS associated with "loc_sig_bag" is currently inactive "location BS" (i.e., "active" meaning the BS is on-line to process location information with an MS, "inactive" meaning the not on-line), then, regardless of any values that may be determined hereinbelow, a value or flag is set (for the signal topography characteristics) indicating "no signal" with a confidence value of 1 is provided. Further, additional pre-processing may be performed when the BS associated with "loc_sig_bag" is a location BS (LBS) since the constraint that a pilot channel from such an LBS is likely to be only detectable within a relatively small distance from the BS (e.g., 1000 ft). For example, if the MS location, "loc_for_estimation", does not intersect the radius (or area contour) of such a location BS, then, again , a value or flag is set (for the signal topography characteristics) indicating "outside of LBS area" with a confidence value of 1 is provided. Alternatively, if (a) a determined area, A, including the MS location, "loc_for_estimation" (which may itself be, and likely is, an area), intersects (b) the signal detectable area about the location BS, then (c) the confidence factor value may be dependent on the ratio of the area of the intersection to the minimum of the size of the area in which the LBS is detectable and the size of the area of "loc_for_estimation", as one skilled in the art will appreciate.

Further, it is noteworthy that such pre-processing constraints as performed in this step may be provided by a constraint processing expert system, wherein system parameters used by such an expert system are tuned using the adaptation engine 1382.

(39.2) Assuming a value of "no signal" or "outside of LBS area" was not set above (since otherwise no further steps are performed here), for each of the coordinates (records), C, of the signal topography characteristics in the loc sig data structure, generate a smooth surface, S(C), of minimal contour variation for the set of points { (x,y,z) such that (x,y) is a representation of a service area location , and z is a value of C at the location (x,y) for some loc sig in "loc_sig_bag" wherein (x,y) is a point estimate (likely centroid) of the loc sig}. Note that a least squares technique, a partial least squares technique, or averaging on "nearby" (x,y,z) points may be used with points from the above set to generate other points on the surface S(C). Additionally, note that for at least some surfaces characterizing signal energy, the generation process for such a surface may use the radio signal attenuation formulas for urban, suburban, and rural developed by M. Hata in IEEE Trans, VT-29, pgs. 317-325, Aug. 1980, "Empirical Formula For Propagation Loss In Land Mobile Radio" (herein incorporated by reference). For example, Hata's formulas may be used in:

(39.2.1) Determining portions of the surfaces S(C) where there is a low density of verified loc sigs in "loc_sig_bag". In particular, if there is a very low density of verified loc sigs in "loc_sig_bag" for the service area surrounding the location of "loc_for_estimation", then by determining the area type(s) (e.g., transmission area type as described hereinabove, assuming a .correspondence between the transmission area types and the more coarse grained categorization of : urban, suburban, and rural) between this location and the base station associated with "loc_sig_bag", and applying Hata's corresponding formula(s), a signal value z may be estimated according to these type(s) and their corresponding area extents between the MS and the BS. Note, however, that this option is considered less optimal to using the verified loc sigs of "loc_sig_bag" for determining the values of a surface S(C). Accordingly, a lower confidence value may be assigned the resulting composite loc sig (i.e., "est_loc_sig") determined in this manner; and relatedly,

(39.2.2) Determining a surface coordinate (x_0,y_0,z_0) of S(C) when there are nearby verified loc sigs in "loc_sig_bag". For example, by using Hata's formulas, an estimated surface value z_i at the location (x_0,y_0) may be derived from estimating a value z_i at (x_0,y_0) by adapting Hata's formula's to extrapolate/interpolate the value z_i from a nearby location (x_i,y_i) having a verified loc sig in "loc_sig_bag". Thus, one or more estimates z_i may be obtained used in deriving z_0 as one skilled in statistics will appreciate. Note, this technique may be used when there is a moderately low density of verified loc sigs in "loc_sig_bag" for the service area surrounding the location of "loc_for_estimation". However, since such techniques may be also considered less than optimal to using a higher density of verified loc sigs of "loc_sig_bag" for determining the values of a surface S(C) via a least squares or partial least square technique, a lower confidence value may be assigned the resulting composite loc sig (i.e., "est_loc_sig") determined in this manner.

Further, recall that the values, z, for each loc sig are obtained from a composite of a plurality of signal measurements with an MS, and, that each value z is the most distinct value that stands out above the noise in measurements for this coordinate, C. So, for example in the CDMA case, for each of the coordinates C representing a finger of signal energy from or to some MS at a verified location, it is believed that S(C) will be a smooth surface without undulations that are not intrinsic to the service area near "loc_for_estimation".

(39.3) For each of the coordinates, C, of the signal topography characteristics, extrapolate/interpolate a C-coordinate value on S(C) for an estimated point location of "loc_for_estimation".

Further note that to provide more accurate estimates, it is contemplated that Hata's three geographic categories and corresponding formulas may be used in a fuzzy logic framework with adaptive mechanisms such as the adaptation engine 1382 (for adaptively determining the fuzzy logic classifications).

Additionally, it is also within the scope of the present invention to use the techniques of L. E. Vogler as presented in "The Attenuation of Electromagnetic Waves by Multiple Knife Edge Diffraction", US Dept of Commerce, NTIA nos, 81-86 (herein incorporated by reference) in the present context for estimating a loc sig between the base station associated with "loc_sig_bag" and the location of "loc_for_estimation". */

RETURN(est_loc_sig)

ENDOF estimate_loc_sig_from_DB

get_area_to_search(loc)

```
/* This function determines and returns a representation of a geographic area about a location, "loc", wherein: (a) the geographic area has associated MS locations for an acceptable number (i.e., at least a determined minimal number) of verified loc sigs from the location signature data base, and (b) the geographical area is not too big. However, if there are not enough loc sigs in even a largest acceptable search area about "loc", then this largest search area is returned. Note that the steps herein are also provided in flowchart form in Figs. 22a through 22b. */
{
        loc_area_type <--- get_area_type(loc); /*get the area type surrounding "loc"; note this may be
                a vector of fuzzy values associated with a central location of "loc", or, associated with an area having "loc".
                */
        search_area <--- get_default_area_about(loc); /* this is the largest area that will be used */
        saved_search_area <--- search_area; // may need it after "search_area" has been changed
        search_area_types <--- get_area_types(search_area); // e.g., urban, rural, suburban, mountain, etc.
        loop until RETURN performed:
        {
            min_acceptable_nbr_loc_sigs <--- 0; // initialization
            for each area_type in "search_area_types" do
            {
                area_percent <--- get_percent_of_area_of(area_type, search_area);
                        /* get percentage of area having "area_type" */
                min_acceptable_nbr_loc_sigs <--- min_acceptable_nbr_loc_sigs +
                                [(get_min_acceptable_verifed_loc_sig_density_for(area_type)) *
                                (SIZEOF(search_area) * area_percentt / 100)];
            }
            /* Now get all verified loc sigs from the location signature data base whose associated MS location is in
               "search_area". */
            total_nbr_loc_sigs <--- get_all_verified_DB_loc_sigs(search_area);
            if (min_acceptable_nbr_loc_sigs > total_nbr_loc_sigs)
                then /* not enough loc sigs in "search_area"; so return "saved_search_area" */
                RETURN(saved_search_area);
            else /* there is at least enough loc sigs, so see if "search_area" can be decreased */
            {   saved_search_area <--- search_area;
```

```
search_area <--- decrease_search_area_about(loc, search_area);
            }
        }
    }
ENDOF get_area_to_search
```

/* For processing various types of loc sigs, particular signal processing filters may be required. Accordingly, in one embodiment of the present invention, a "filter_bag" object class is provided wherein various filters may be methods of this object (in object-oriented terminology) for transforming loc sig signal data so that it is comparable with other loc sig signal data from, for example, an MS of a different classification (e.g., different power classification). It is assumed here that such a "filter_bag" object includes (or references) one or more filter objects that correspond to an input filter (from the Signal Filtering Subsystem 1220) so that, given a location signature data object as input to the filter_bag object,, each such filter object can output loc sig filtered data corresponding to the filter object's filter. Note, such a filter_bag object may accept raw loc sig data and invoke a corresponding filter on the data. Further, a filter_bag object may reference filter objects having a wide range of filtering capabilities. For example, adjustments to loc sig data according to signal strength may be desired for a particular loc sig comparison operator so that the operator can properly compare MS's of different power classes against one another. Thus, a filter may be provided that utilizes, for each BS, a corresponding signal strength change topography map (automatically generated and updated from the verified loc sigs in the location signature data base 1320) yielding signal strength changes detected by the BS for verified MS location's at various distances from the BS, in the radio coverage area. Additionally, there may also be filters on raw signal loc sig data such as quality characteristics so that loc sigs having different signal quality characteristics may be compared. */

get_difference_measurement(target_loc_sig, estimated_loc_sig, comparison_loc_sig_bag, search_area, search_criteria)

/* Compare two location signatures between a BS and a particular MS location (either a verified or hypothesized location) for determining a measure of their difference relative to the variability of the verified location signatures in the "comparison_loc_sig_bag" from the location signature data base 1320. ***Note, it is assumed that "target_loc_sig", "estimated_loc_sig" and the loc sigs in "comparison_loc_sig_bag" are all associated with the same BS 122.*** Moreover, it is assumed that "target_loc_sig"and "estimated_loc_sig" are well-defined non-NIL loc sigs, and additionally, that "comparison_loc_sig_bag" is non-NIL. This function returns an error record, "error_rec", having an error or difference value and a confidence value for the error value. Note, the signal characteristics of "target_loc_sig" and those of "estimated_loc_sig" are not assumed to be normalized as described in section (26.1) prior to entering this function so that variations in signal characteristics resulting from variations in (for example) MS signal processing and generating characteristics of different types of MS's may be reduced, as described in the discussion of the loc sig data type hereinabove. It is further assumed that typically the input loc sigs satisfy the "search_criteria". Note that the steps herein are also provided in flowchart form in Figs. 23a through 23c.

target_loc_sig: The loc sig to which the "error_rec" determined here is to be associated. Note that this loc sig is associated with a location denoted hereinbelow as the "particular location".

estimated_loc_sig: The loc sig to compare with the "target_loc_sig", this loc sig: (a) being for the same MS location as "target_loc_sig", and (b) derived from verified loc sigs in the location signature data base whenever possible. However, note that if this loc sig is not derived from the signal characteristics of loc sigs in the location signature data base, then this parameter provides a loc sig that corresponds to a noise level at the particular MS location.

comparison_loc_sig_bag: The universe of loc sigs to use in determining an error measurement between "target_loc_sig" and "estimated_loc_sig". Note, the loc sigs in this aggregation include all loc sigs for the associated Base Station 122 that are in the "search_area" (which surrounds the particular MS location for "target_loc_sig") and satisfy the constraints of "search_criteria". It is assumed that there are sufficient loc sigs in this aggregation to perform at least a minimally effective variability measurement in the loc sigs here.

search_area: A representation of the geographical area surrounding the particular MS location for all input loc sigs. This input is used for determining extra information about the search area in problematic circumstances.

search_criteria: The criteria used in searching the location signature data base 1320. The criteria may include the following:

(a) "USE ALL LOC SIGS IN DB",

(b) "USE ONLY REPEATABLE LOC SIGS",

(c) "USE ONLY LOC SIGS WITH SIMILAR TIME OF DAY

However, environmental characteristics such as: weather, traffic, season are also contemplated. */

error <--- 0; // initialization

/* get identifiers for the filters to be used on the input loc sigs */

filter_bag <--- *get_filter_objects_for_difference_measurement*(target_loc_sig, estimated_loc_sig, comparison_loc_sig_bag);

/* It is assumed here that each entry in "filter_bag" identifies an input filter to be used in the context of determining a difference measurement between loc sigs. Note, if all loc sigs to be used here are of the same type, then it may be that there is no need for filtering here. Accordingly, "filter_bag" can be empty. Alternatively, there may be one or more filter objects in "filter_bag".*/

```
/* initializations */

/* for each filter, determine a difference measurement and confidence */
for each filter_obj indicated in filter_bag do
{
    /* filter "target_loc_sig", "estimated_loc_sig" and loc sigs in "comparison_loc_sig_bag";
    note, each filter_obj can determine when it needs to be applied since each loc sig includes:
    (a) a description of the type (e.g., make and model) of the loc sig's associated MS, and (b) a
    filter flag(s) indicating filter(s) that have been applied to the loc sig.*/
    target_loc_sig <--- filter_obj(target_loc_sig); /* filter at least the signal topography characteristics */
    estimated_loc_sig <--- filter_obj(estimated_loc_sig); /* filter at least the signal topography characteristics */
    comparison_loc_sig_bag <--- filter_obj(comparison_loc_sig_bag); /* filter loc sigs here too */
}

/* determine a difference measurement and confidence for each signal topography
characteristic coordinate */
for each signal topography characteristic coordinate, C, of the loc sig data type do
{
        variability_measmt.val <--- get_variability_range(C, comparison_loc_sig_bag);
            /* This function provides a range of the variability of the C-coordinate. In one embodiment this measurement is a
            range corresponding to a standard deviation. However, other variability measurement definitions are contemplated
            such as second, third or fourth standard deviations. */
        /* make sure there are enough variability measurements to determine the
        variability of values for this coordinate. */
        if (SIZEOF(comparison_loc_sig_bag) < expected_BS_loc_sig_threshold(search_area, search_criteria))
                then /* use the data here, but reduce the confidence in the variability measurement. Note that it is expected
                that this branch is performed only when "comparison_loc_sig_bag" is minimally big enough to use (since this
                is an assumption for performing this function), but not of sufficient size to have full confidence in the values
                obtained. Note, a tunable system parameter may also be incorporated as a coefficient in the computation in the
                statement immediately below. In particular, such a tunable system parameter may be based on "search_area"
                or more particularly, area types intersecting "search_area".*/
                {
```

```
                    variability_measmt_conf_reduction_factor <--- SIZEOF(comparison_loc_sig_bag)/
                                          expected_BS_loc_sig_threshold(search_area, search_criteria);
                }
        else /* There is a sufficient number of loc sigs in "comparison_loc_sig_bag" so continue */
        {
            variability_measmt_conf_reduction_factor <--- 1.0; //i.e., don't reduce confidence
        }
        /* Now determine the C-coord difference measurement between the
           "target_loc_sig" and the "estimated_loc_sig" */
        delta <--- ABS(target_loc_sig[C] - estimated_loc_sig[C]); // get absolute value of the difference
        if (delta > variability_measmt.val) then
        {
            error <--- error + (delta/variability_measmt.val);
        }
    }/* end C-coord processing */
    /* construct the error record and return it */
    error_rec.error <--- error;
    /* Get an average confidence value for the loc sigs in "comparison_loc_sig_bag" Note, we use
       this as the confidence of each loc sig coordinate below. */
    average_confidence <--- AVERAGE(loc_sig.confidence for loc_sig in "comparison_loc_sig_bag");
    error_rec.confidence <--- MIN(target_loc_sig.confidence, estimated_loc_sig.confidence, (average_confidence *
                              variability_measmt_conf_reduction_factor)); // presently not used
    RETURN(error_rec);
    ENDOF get_difference_measurement
```

APPENDIX D: Context Adjuster Embodiments

A description of the high level functions in a first embodiment of the Context Adjuster

context_adjuster(loc_hyp_list)

/* This function adjusts the location hypotheses on the list, "loc_hyp_list", so that the confidences of the location hypotheses are determined more by empirical data than default values from the First Order Models 1224. That is, for each input location hypothesis, its confidence (and an MS location area estimate) may be exclusively determined here if there are enough verified location signatures available within and/or surrounding the location hypothesis estimate.

This function creates a new list of location hypotheses from the input list, "loc_hyp_list", wherein the location hypotheses on the new list are modified versions of those on the input list. For each location hypothesis on the input list, one or more corresponding location hypotheses will be on the output list. Such corresponding output location hypotheses will differ from their associated input location hypothesis by one or more of the following: (a) the "image_area" field (see Fig. 9) may be assigned an area indicative of where the target MS is estimated to be, (b) if "image_area" is assigned, then the "confidence" field will be the confidence that the target MS is located in the area for "image_area", (c) if there are not sufficient "nearby" verified location signature clusters in the location signature data base to entirely rely on a computed confidence using such verified location signature clusters, then two location hypotheses (having reduced confidences) will be returned, one having a reduced computed confidence (for "image_area") using the verified clusters in the Location Signature DB, and one being substantially the same as the associated input location hypothesis except that the confidence (for the field "area_est") is reduced to reflect the confidence in its paired location hypothesis having a computed confidence for "image_area". Note also, in some cases, the location hypotheses on the input list, may have no change to its confidence or the area to which the confidence applies. Note that the steps herein are also provided in flowchart form in Figs. 25a and 25b.

```
*/
{
  new_loc_hyp_list <--- create_new_empty_list();
  for each loc_hyp[i] in loc_hyp_list do /* Note, "i" is a First Order Model 1224 indicator, indicating the model that output
                    "hyp_loc[i]" */
  {
     remove_from_list(loc_hyp[i], loc_hyp_list);
     if (NOT loc_hyp[i].adjust) then /* no adjustments will be made to the "area_est" or the "confidence" fields since the
              "adjust" field indicates that there is assurance that these other fields are correct; note that such designations
              indicating that no adjustment are presently contemplated are only for the location hypotheses generated by
              the Home Base Station First Order Model, the Location Base Station First Order Model and the Mobil Base
```

Station First Order Model. In particular, location hypotheses from the Home Base Station model will have confidences of 1.0 indicating with highest confidence that the target MS is within the area estimate for the location hypothesis. Alternatively, in the Location Base Station model, generated location hypotheses may have confidences of (substantially) +1.0 (indicating that the target MS is absolutely in the area for "area_est"), or, -1.0 (indicating that the target MS is NOT in the area estimate for the generated location hypothesis).*/

```
    {       loc_hyp[i].image_area <--- NULL; // no adjustment, then no "image_area"
            add_to_list(new_loc_hyp_list, loc_hyp[i]); // add "loc_hyp[i]" to the new list
    }
    else /* the location hypothesis can (and will) be modified; in particular, an "image_area" may be assigned, the
            "confidence" changed to reflect a confidence in the target MS being in the "image_area". Additionally, in some
            cases, more than one location hypothesis may be generated from "loc_hyp[i]". See the comments on FIG. 9 and
            the comments for "get_adjusted_loc_hyp_list_for" for a description of the terms here. */
    {
        temp_list <--- get_adjusted_loc_hyp_list_for(loc_hyp[i]);
        new_loc_hyp_list <--- combine_lists(new_loc_hyp_list, temp_list);
    }
    RETURN(new_loc_hyp_list);
}ENDOF
```

get_adjusted_loc_hyp_list_for(loc_hyp)

/* This function returns a list (or more generally, an aggregation object) of one or more location hypotheses related to the input location hypothesis, "loc_hyp". In particular, the returned location hypotheses on the list are "adjusted" versions of "loc_hyp" in that both their target MS 140 location estimates, and confidence placed in such estimates may be adjusted according to archival MS location information in the location signature data base 1320. Note that the steps herein are also provided in flowchart form in Figs. 26a through 26c.

RETURNS: loc_hyp_list — This is a list of one or more location hypotheses related to the input "loc_hyp". Each location hypothesis on "loc_hyp_list" will typically be substantially the same as the input "loc_hyp" except that there may now be a new target MS estimate in the field, "image_area", and/or the confidence value may be changed to reflect information of verified location signature clusters in the location signature data base.

Introductory Information Related to the Function, "get_adjusted_loc_hyp_list_for"

This function and functions called by this function presuppose a framework or paradigm that requires some discussion as well as the defining of some terms. Note that some of the terms defined hereinbelow are illustrated in Fig. 24.

Define the term the **"the cluster set"** to be the set of all MS location point estimates (e.g., the values of the "pt_est" field of the location hypothesis data type), for the present FOM, such that these estimates are within a predetermined corresponding area (e.g., "loc_hyp.pt_covering" being this predetermined corresponding area) and these point estimates have verified location signature clusters in the location signature data base.

Note that the predetermined corresponding area above will be denoted as the **"cluster set area"**.

Define the term **"image cluster set"** (for a given First Order Model identified by "loc_hyp.FOM_ID") to mean the set of verified location signature clusters whose MS location point estimates are in "the cluster set".

Note that an area containing the "image cluster set" will be denoted as the **"image cluster set area"** or simply the "image area" in some contexts. Further note that the "image cluster set area" will be a "small" area encompassing the "image cluster set". In one embodiment, the image cluster set area will be the smallest covering of cells from the mesh for the present FOM that covers the convex hull of the image cluster set. Note that preferably, each cell of each mesh for each FOM is substantially contained within a single (transmission) area type.

Thus, the present FOM provides the correspondences or mapping between elements of the cluster set and elements of the image cluster set. */

```
{
    add_to_list(loc_hyp_list, loc_hyp); /* note the fields of "loc_hyp" may be changed below, but add "loc_hyp" to the list,
                                    "loc_hyp_list here */
    mesh <--- get_cell_mesh_for_model(loc_hyp.FOM_ID); /* get the mesh of geographic cells for the First Order Model for this
                                    location hypothesis.*/
    pt_min_area <--- get_min_area_surrounding_pt(loc_hyp, mesh); /* Get a minimal area about the MS location point,
            "pt_est" of "loc_hyp[i]" indicating a point location of the target MS. Note that either the "pt_est" field must be
            valid or the "area_est" field of "loc_hyp[i]" must be valid. If only the latter field is valid, then the centroid of the
            "area_est" field is determined and assigned to the "pt_est" field in the function called here. Note that the mesh of
            the model may be useful in determining an appropriately sized area. In particular, in one embodiment, if
            "loc_hyp.pt_est" is interior to a cell, C, of the mesh, then "pt_min_area" may correspond to C. Further note that
            in at least one embodiment, "pt_min_area" may be dependent on the area type within which "loc_hyp.pt_est"
            resides, since sparsely populated flat areas may be provided with larger values for this identifier. Further, this
            function may provide values according to an algorithm allowing periodic tuning or adjusting of the values output,
            via, e.g., a Monte Carlo simulation (more generally, a statistical simulation), a regression or a Genetic Algorithm.
                For the present discussion, assume: (i) a cell mesh per FOM 1224; (ii) each cell is contained in substantially a
            single (transmission) area type; and (iii) "pt_min_area" represents an area of at least one cell. */
    area <--- pt_min_area; // initialization
```

pt_max_area <--- *get_max_area_surrounding_pt*(loc_hyp, mesh); /* Get the maximum area about "pt_est" that is deemed worthwhile for examining the behavior of the "loc_hyp.FOM_ID" First Order Model (FOM) about "pt_est". Note that in at least one embodiment, this value of this identifier may also be dependent on the area type within which "loc_hyp.pt_est" resides. Further, this function may provide values according to an algorithm allowing periodic tuning or adjusting of the values output, via, e.g., a Monte Carlo simulation (more generally, a statistical simulation or regression) or a Genetic Algorithm. In some embodiments of the present invention, the value determined here may be a relatively large proportion of the entire radio coverage area region. However, the tuning process may be used to shrink this value for (for example) various area types as location signature clusters for verified MS location estimates are accumulated in the location signature data base. */

min_clusters <--- *get_min_nbr_of_clusters*(loc_hyp.FOM_ID, area); /* For the area, "area", get the minimum number ("min_clusters") of archived MS estimates, L, desired in generating a new target MS location estimate and a related confidence, wherein this minimum number is likely to provide a high probability that this new target MS location estimate and a related confidence are meaningful enough to use in subsequent Location Center processing for outputting a target MS location estimate. More precisely, this minimum number, "min_clusters," is an estimate of the archived MS location estimates, L, required to provide the above mentioned high probability wherein each L satisfies the following conditions: (a) L is in the area for "area"; (b) L is archived in the location signature data base; (c) L has a corresponding verified location signature cluster in the location signature data base; and (d) L is generated by the FOM identified by "loc_hyp.FOM_ID"). In one embodiment, "min_clusters" may be a constant; however, in another it may vary according to area type and/or area size (of "area"), in some it may also vary according to the FOM indicated by "loc_hyp.FOM_ID". */

pt_est_bag <--- *get_pt_ests_for_image_cluster_set*(loc_hyp.FOM_ID, loc_hyp.pt_est, area); /* Get the MS location point estimates for this FOM wherein for each such estimate: (a) it corresponds to a verified location signature cluster (that may or may not be near its corresponding estimate), and (b) each such MS estimate is in "pt_min_area". */

/* Now, if necessary, expand an area initially starting with "pt_min_area" until at least "min_clusters" are obtained, or, until the expanded area gets too big. */

while ((sizeof(pt_est_bag) < min_clusters) and (sizeof(area) <= pt_max_area) do

{ area <--- *increase*(area);

min_clusters <--- *get_min_nbr_of_clusters*(loc_hyp.FOM_ID, area); // update for new "area"

pt_est_bag <--- *get_pt_ests_for_image_cluster_set*(loc_hyp.FOM_ID, loc_hyp.pt_est, area);

}

attach_to(loc_hyp.pt_covering, area); // Make "area" the "pt_covering" field

if (sizeof(pt_est_bag) == 0) then /* there aren't any other FOM MS estimates having corresponding verified location signature clusters; so designate "loc_hyp" as part of the second set as described above and return. */

```
{
    loc_hyp.image_area <--- NULL; // no image area for this loc_hyp; this indicates second set
    RETURN(loc_hyp_list);
}
```

/* It is now assured that "pt_est_bag" is non-empty and "area" is at least the size of a mesh cell. */

/* Now determine "image_area" field for "loc_hyp" and a corresponding confidence value using the verified location signature clusters corresponding to the MS point estimates of "area" (equivalently, in "pt_est_bag"). */

/* There are various strategies that may be used in determining confidences of the "image_area" of a location hypothesis. In particular, for the MS location estimates (generated by the FOM of loc_hyp.FOM_ID) having corresponding verified location signature clusters (that may or may not be in "area"), if the number of such MS location estimates in "area" is deemed sufficiently high (i.e., >= "min_clusters" for "area"), then a confidence value can be computed for the "image_area" that is predictive of the target MS being in "image_area". Accordingly, such a new confidence is used to overwrite any previous confidence value corresponding with the target MS estimate generated by the FOM. Thus, the initial estimate generated by the FOM is, in a sense, an index or pointer into the archived location data of the location signature data base for obtaining a new target MS location estimate (i.e., "image_area") based on previous verified MS locations and a new confidence value for this new estimate.

Alternatively, if the number of archived FOM MS estimates that are in "area," wherein each such MS estimate has a corresponding verified location signature clusters (in "image_area"), is deemed too small to reliably use for computing a new confidence value and consequently ignoring the original target MS location estimate and confidence generated by the FOM, then strategies such as the following may be implemented.

(a) In one embodiment, a determination may be made as to whether there is an alternative area and corresponding "image_area" that is similar to "area" and its corresponding "image_area" (e.g., in area size and type), wherein a confidence value for the "image_area" of this alternative area can be reliably computed due to there being a sufficient number of previous FOM MS estimates in the alternative area that have corresponding verified location signature clusters (in the location signature data base). Thus, in this embodiment, the confidence of the alternative "image_area" is assigned as the confidence for the "image_area" for of "area".

(b) In another embodiment, the area represented by "pt_max_area" may be made substantially identical with the MS location service region. So that in many cases, there will be, as "area" increases, eventually be enough MS location estimates in the cluster set so that at least "min_clusters" will be obtained. Note, a drawback here is that "image_area" may be in become inordinately large and thus be of little use in determining a meaningful target MS location estimate.

(c) In another embodiment, denoted herein as the two tier strategy, both the original FOM MS location estimate and confidence as well as the "image_area" MS location estimate and a confidence are used. That is, two location hypotheses are provided for the target MS location, one having the FOM MS location estimate and one having the MS location estimate for "image_area". However, the confidences of each of these location hypotheses maybe reduced to reflect the resulting ambiguity of providing two different location hypotheses derived from the same FOM MS estimate. Thus, the computations for determining the confidence of "image_area may be performed even though there are less than the minimally required archived FOM estimates nearby to the original FOM target MS estimate. In this embodiment, a weighting(s) may be used to weight the confidence values as, for example, by a function of the size of the "image_cluster_set". For example, if an original confidence value from the FOM was 0.76 and "area" contained only two-thirds of the minimally acceptable number, "min_clusters", then if the computation for a confidence of the corresponding "image_area" yielded a new confidence of 0.43, then a confidence for the original FOM target MS estimate may be computed as [0.76 * (1/3)] whereas a confidence for the corresponding "image_area" may be computed as [0.43 * (2/3)]. However, it is within the scope of the present invention to use other computations for modifying the confidences used here. For example, tunable system coefficients may also be applied to the above computed confidences. Additionally, note that some embodiments may require at least a minimal number of relevant verified location signature clusters in the location signature data base before a location hypothesis utilizes the "image_area" as a target MS location estimate.

Although an important aspect of the present invention is that it provides increasingly more accurate MS location estimates as additional verified location signatures are obtained (i.e., added to the location signature data base), it may be the case that for some areas there is substantially no pertinent verified location signature clusters in the location signature data base (e.g., "image_area" may be undefined). Accordingly, instead of using the original FOM generated location hypotheses in the same manner as the location hypotheses having target MS location estimates corresponding to "image_areas" in subsequent MS location estimation processing, these two types of location hypotheses may be processed separately. Thus, a strategy is provided, wherein two sets of (one or more) MS location estimates may result:

(i) one set having the location hypotheses with meaningful "image_areas" as their target MS location estimates and

(ii) a second set having the location hypotheses with their confidence values corresponding to the original FOM target MS estimates.

Since the first of these sets is considered, in general, more reliable, the second set may used as a "tie breaker" for determining which of a number of possible MS location estimates determined using the first set to output by the Location Center. Note, however, if there are no location hypotheses in the first set, then the second set may be used to output a Location Center target MS location estimate. Further note that in determining confidences of this second set, the weighting of confidence values as described above is contemplated. .

The steps provided hereinafter reflect a "two tier" strategy as discussed in (c) above.

*/

```
/* The following factor is analogous to the 2/3's factor discussed in (c) above. */
cluster_ratio_factor <--- min{(sizeof(pt_est_bag) / min_clusters), 1.0};

/* Now use "area" to obtain a new target MS location estimate and confidence based on
archived verified loc sigs, but first determine whether "area" is too big to ignore the original
target MS location estimate and confidence generated by the FOM . */
if (sizeof(area) > pt_max_area) then /* create a loc_hyp that is essentially a duplicate of the originally input "loc_hyp"
    except the confidence is lowered by "(1.0 - cluster_ratio_factor)". Note that the original "loc_hyp" will have its
    confidence computed below. */
{  new_loc_hyp <--- duplicate(loc_hyp); // get a copy of the "loc_hyp"
   new_loc_hyp.image_area <--- NULL; // no image area for this new loc_hyp
   /* Now modify the confidence of "loc_hyp"; note, in the one embodiment, a system (i.e., tunable) parameter may also be
   used as a coefficient in modifying the confidence here. */
   new_loc_hyp.confidence <--- new_loc_hyp.confidence * (1.0 - cluster_ratio_factor);
   add_to_list(loc_hyp_list, new_loc_hyp);
}
/* Now compute the "image_area" field and a confidence that the target MS is in
"image_area" */
image_cluster_set <--- get_verified_loc_sig_clusters_for(pt_est_bag); /* Note, this statement gets the verified location
        signature clusters for which the target MS point location estimates (for the First Order Model identified by
        "loc_hyp.FOM_ID") in "pt_est_bag" are approximations. Note that the set of MS location point estimates
        represented in "pt_est_bag" is defined as a "cluster set" hereinabove.*/
image_area <--- get_area_containing(image_cluster_set); /* Note, in obtaining an area here that contains these verified
        location signature clusters, various embodiments are contemplated. In a first embodiment, a (minimal) convex hull
        containing these clusters may be provided here. In a second embodiment, a minimal covering of cells from the mesh
        for the FOM identified by "loc_hyp.FOM_ID" may be used. In a third embodiment, a minimal covering of mesh cells
        may be used to cover the convex hull containing the clusters. It is assumed hereinbelow that the first embodiment is
        used. Note, that this area is also denoted the "image cluster set area" as is described hereinabove. */
attach_to(loc_hyp.image_area, image_area); /* Make "image_area" the "image_area" field of "loc_hyp". */
/* In the following step, determine a confidence value for the target MS being in the area for "image_area". */
confidence <--- confidence_adjuster(loc_hyp.FOM_ID, image_area, image_cluster_set);
/* In the following step, reduce the value of confidence if and only if the number of MS point location estimates in
        "pt_est_bag" is smaller than "min_clusters" */
```

loc_hyp.confidence <--- confidence * cluster_ratio_factor;

RETURN(loc_hyp_list);

}ENDOF **get_adjusted_loc_hyp_list_for**

confidence_adjuster(FOM_ID, image_area, image_cluster_set)

/* This function returns a confidence value indicative of the target MS 140 being in the area for "image_area". Note that the steps herein are also provided in flowchart form in Figs. 27a and 27b.

RETURNS: A confidence value. This is a value indicative of the target MS being located in the area represented by "image_area" (when it is assumed that for the related "loc_hyp," the "cluster set area" is the "loc_hyp.pt_covering" and "loc_hyp.FOM_ID" is "FOM_ID");

Introductory Information Related to the Function, "confidence_adjuster"

This function (and functions called by this function) presuppose a framework or paradigm that requires some discussion as well as the defining of terms.

Define the term **"mapped cluster density"** to be the number of the verified location signature clusters in an "image cluster set" <u>per unit of area</u> in the "image cluster set area".

It is believed that the higher the "mapped cluster density", the greater the confidence can be had that a target MS actually resides in the "image cluster set area" when an estimate for the target MS (by the present FOM) is in the corresponding "the cluster set".

Thus, the mapped cluster density becomes an important factor in determining a confidence value for an estimated area of a target MS such as, for example, the area represented by "image_area". However, the mapped cluster density value requires modification before it can be utilized in the confidence calculation. In particular, confidence values must be in the range [-1, 1] and a mapped cluster density does not have this constraint. Thus, a **"relativized mapped cluster density"** for an estimated MS area is desired, wherein this relativized measurement is in the range [-1, +1], and in particular, for positive confidences in the range [0, 1]. Accordingly, to alleviate this difficulty, for the FOM define the term **"prediction mapped cluster density"** as a mapped cluster density value, MCD, for the FOM and image cluster set area wherein:

(i) MCD is sufficiently high so that it correlates (at least at a predetermined likelihood threshold level) with the actual target MS location being in the "image cluster set area" when a FOM target MS location estimate is in the corresponding "cluster set area";

That is, for a cluster set area (e.g., "loc_hyp.pt_covering") for the present FOM, if the image cluster set area: has a mapped cluster density greater than the "prediction mapped cluster density", then there is a high likelihood of the target MS being in the image cluster set area.

It is believed that the prediction mapped cluster density will typically be dependent on one or more area types. In particular, it is assumed that for each area type, there is a likely range of prediction mapped cluster density values that is substantially uniform across the area type. Accordingly, as discussed in detail hereinbelow, to calculate a prediction mapped cluster density for a particular area type, an estimate is made of the correlation between the mapped cluster densities of image areas (from cluster set areas) and the likelihood that if a verified MS location: (a) has a corresponding FOM MS estimate in the cluster set, and (b) is also in the particular area type, then the verified MS location is also in the image area.

Thus, if an area is within a single area type, then such a "relativized mapped cluster density" measurement for the area may be obtained by dividing the mapped cluster density by the prediction mapped cluster density and taking the smaller of: the resulting ratio and 1.0 as the value for the relativized mapped cluster density.

In some (perhaps most) cases, however, an area (e.g., an image cluster set area) may have portions in a number of area types. Accordingly, a **"composite prediction mapped cluster density"** may be computed, wherein, a weighted sum is computed of the prediction mapped cluster densities for the portions of the area that is in each of the area types. That is, the weighting, for each of the single area type prediction mapped cluster densities, is the fraction of the total area that this area type is. Thus, a **"relativized composite mapped cluster density"** for the area here may also be computed by dividing the mapped cluster density by the composite prediction mapped cluster density and taking the smaller of: the resulting ratio and 1.0 as the value for the relativized composite mapped cluster density.

Accordingly, note that as such a relativized (composite) mapped cluster density for an image cluster set area increases/decreases, it is assumed that the confidence of the target MS being in the image cluster set area should increase/decrease, respectively. */

{

prediction_mapped_cluster_density <---

get_composite_prediction_mapped_cluster_density_with_high_certainty

(FOM_ID, image_area);

/* The function invoked above provides a "composite prediction cluster density" (i.e., clusters per unit area) that is used in determining the confidence that the target MS is in "image_area". That is, the composite prediction mapped cluster density value provided here is: high enough so that for a computed mapped cluster density greater than or equal to the composite prediction cluster density , and the target MS FOM estimate is in the "cluster set area", there is a high expectation that the actual target MS location is in the "image cluster set area" . */

max_area <--- *get_max_area_for_high_certainty*(FOM_ID, image_area); /* Get an area size value wherein it is highly likely that for an area of size, "max_area", surrounding "image_area", the actual target MS is located therein. Note, that one skilled in the art will upon contemplation be able to derive various embodiments of this function, some embodiments being similar to the steps described for embodying the function, "get_composite_prediction_mapped_cluster_density_with_high_certainty" invoked above; i.e., performing a Monte Carlo simulation. */

/* Given the above two values, a *positive* confidence value for the area, "image_area", can be calculated based on empirical data.

There are various embodiments that may be used to determine a confidence for the "image_area". In general, such a confidence should vary monotonically with (a) and (b) below; that is, the confidence should increase (decrease) with:

(a) an increase (decrease) in the size of the area, *particularly* if the area is deemed close or relevant to the location of the target MS; and

(b) an increase (decrease) in the size of the image cluster set (i.e., the number of verified location signature clusters in the area that each have a location estimate, from the FOM identified by "FOM_ID", in the "cluster set" corresponding to the "image_cluster_set;" e.g., the "cluster set" being a "loc_hyp.pt_covering").

As one skilled in the art will understand, there are many functions for providing confidences that vary monotonically with (a) and(b) above. In particular, for the cluster set area being "loc_hyp.pt_covering", one might be inclined to use the (area) size of the image cluster area as the value for (a), and the (cardinality) size of the image cluster set as the value for (b). Then, the following term might be considered for computing the confidence:

(sizeof(image cluster set area) * (sizeof(image cluster set)) which, in the present context, is equal to

(sizeof("image_area") * (sizeof("image_cluster_set")).

However, since confidences are intended to be in the range [-1,1], a normalization is also desirable for the values corresponding to (a) and (b). Accordingly, in one embodiment, instead of using the above values for (a) and (b), ratios are used. That is, assuming for a "relevant" area, A (e.g., including an image cluster set area of "loc_hyp.pt_covering") that there is a very high confidence that the target MS is in A, the following term may be used in place of the term, sizeof("image_area"), above:

min { [sizeof("image_area") / sizeof(A)], 1.0 }. [CA1.1]

Additionally, for the condition (b) above, a similar normalization may be provided. Accordingly, to provide this normalization, note that the term,

(sizeof(image_area) * prediction_mapped_cluster_density) [CA1.1.1]

is analogous to sizeof(A) in [CA1.1]. That is, the expression of [CA1.1.1] gives a threshold for the number of verified location signature clusters that are likely to be needed in order to have a high confidence or likelihood that the target MS is in the area represented by "image_area". Thus, the following term may be used for the condition (b):

min {(sizeof(image_cluster_set) /

[(sizeof(image_area) * prediction_mapped_cluster_density], 1.0}

[CA1.2]

As an aside, note that

sizeof(image_cluster_set) / [sizeof(image_area) * prediction_mapped_cluster_density]

is equivalent to

[sizeof(image_cluster_set) / sizeof(image_area)] / (prediction_mapped_cluster_density) and this latter term may be interpreted as the ratio of: (i) the mapped cluster density for "image_area" to (ii) an approximation of a cluster density providing a high expectation that the target MS is contained in "image_area".

Note that the product of [CA1.1] and [CA1.2] provide the above desired characteristics for calculating the confidence. However, there is no guarantee that the range of resulting values from such products is consistent with the interpretation that has been placed on (positive) confidence values; e.g., that a confidence of near 1.0 has a very high likelihood that the target MS is in the corresponding area. For example, it can be that this product rarely is greater than 0.8, even in the areas of highest confidence. Accordingly, a "tuning" function is contemplated which provides an additional factor for adjusting of the confidence. This factor is, for example, a function of the area types and the size of each area type in "image_area". Moreover, such a tuning function may be dependent on a "tuning coefficient" per area type. Thus, one such tuning function may be:

$$\min\left(\sum_{i=1}^{\text{number of area types}} [tc_i * \text{sizeof(area type}_i \text{ in "image\_area")} / \text{sizeof ("image\_area")}],\ 1.0\right)$$

where tc_i is a tuning coefficient (determined in background or off-line processing; e.g., by a Genetic Algorithm or Monte Carlo simulation or regression) for the area type indexed by "i".

Note that it is within the scope of the present invention, that other tuning functions may also be used whose values may be dependent on, for example, Monte Carlo techniques or Genetic Algorithms.

It is interesting to note that in the product of [CA1.1] and [CA1.2], the "image_area" size cancels out. This appears to conflict with the description above of a desirable confidence calculation. However, the resulting (typical) computed value:

[sizeof(image_cluster_set)] / [max_area * prediction_mapped_cluster_density] [CA1.3]

is strongly dependent on "image_area" since "image_cluster_set" is derived from "image_area" and "prediction_mapped_cluster_density" also depends on "image_area". Accordingly, it can be said that the product [CA1.3] above for the confidence does not depend on "raw" area size, but rather depends on a "relevant" area for locating the target MS.

An embodiment of the confidence computation follows:

```
*/
area_ratio <--- min((sizeof(image_area) / max_area), 1.0);
cluster_density_ratio <---
    min( ((sizeof(image_cluster_set) / [sizeof(image_area) * (prediction_mapped_cluster_density)]), 1.0 );
tunable_constant <--- get_confidence_tuning_constant(image_area); // as discussed in the comment above
confidence <--- (tunable_constant) * (area_ratio) * (cluster_density_ratio); //This is in the range [0, 1]
RETURN(confidence);
```

} **ENDOF confidence_adjuster**

get_composite_prediction_mapped_cluster_density_with_high_certainty (FOM_ID, image_area);

/* The present function determines a composite prediction mapped cluster density by determining a composite prediction mapped cluster density for the area represented by "image_area" and for the First Order Model identified by "FOM_ID". The steps herein are also provided in flowchart form in Fig. 28.

OUTPUT: **composite_mapped_density** This is a record for the composite prediction mapped cluster density. In particular, there are with two fields:

(i) a "value" field giving an approximation to the prediction mapped cluster density for the First Order Model having id, FOM_ID;

(ii) a "reliability" field giving an indication as to the reliability of the "value" field. The reliability field is in the range [0, 1] with 0 indicating that the "value" field is worthless and the larger the value the more assurance can be put in "value" with maximal assurance indicated when "reliability" is 1.*/

{

/* Determine a fraction of the area of "image_area" contained in each area type (if there is only one, e.g., dense urban or a particular transmission area type as discussed in the detailed description hereinabove, then there would be a fraction having a value of 1 for this area type and a value of zero for all others). */

composite_mapped_density <--- 0; // initialization

for each area_type intersecting "image_area" do // "area_type" may be taken from a list of area types.

{ /* determine a weighting for "area_type" as a fraction of its area in "image_area" */

intersection <--- *intersect*(image_area, *area_for*(area_type));

weighting <--- sizeof(intersection) / sizeof(area_image);

/* Now compute a prediction cluster density that highly correlates with predicting a location of the target MS for this area type. Then provide this cluster density as a factor of a weighted sum of the prediction cluster densities of each of the area types, wherein the weight for a particular area type's prediction cluster density is the fraction of the total area of "image_area" that is designated this particular area type. Note that the following function call does not utilize information regarding the location of "image_area". Accordingly, this function may access a precomputed table giving predication mapped cluster densities for (FOM_ID, area_type) pairs. However, in alternative embodiments of the present invention, the prediction mapped cluster densities may be computed specifically for the area of "image_area" intersect "area_type". */

```
        prediction_mapped_density <--- get_prediction_mapped_cluster_density_for(FOM_ID, area_type);
        composite_mapped_density <--- composite_mapped_density +
                                  ( weighting * prediction_mapped_density);
    }
    RETURN(composite_mapped_density);
} ENDOF get_composite_prediction_mapped_cluster_density_with_high_certainty
```

get_prediction_mapped_cluster_density_for(FOM_ID, area_type)

/* The present function **determines an approximation to a prediction mapped cluster density, D, for an area type such that if an image cluster set area has a mapped cluster density >= D, then there is a high expectation that the target MS 140 is in the image cluster set area.** Note that there are a number of embodiments that may be utilized for this function. The steps herein are also provided in flowchart form in Figs. 29a through 29h.

OUTPUT: prediction_mapped_cluster_density This is a value giving an approximation to the prediction mapped cluster density for the First Order Model having identity, "FOM_ID", and for the area type represented by "area_type" */

Introductory Information Related to the Function, "get_predication_mapped_cluster_density_for"

It is important to note that the computation here for the prediction mapped cluster density may be more intense than some other computations but **the cluster densities computed here need not be performed in real time** target MS location processing. That is, the steps of this function may be performed only periodically (e.g., once a week), for each FOM and each area type thereby precomputing the output for this function. Accordingly, the values obtained here may be stored in a table that is accessed during real time target MS location processing. However, for simplicity, only the periodically performed steps are presented here. However, one skilled in the art will understand that with sufficiently fast computational devices, some related variations of this function may be performed in real-time. In particular, instead of supplying area type as an input to this function, a particular area, A, may be provided such as the image area for a cluster set area, or, the portion of such an image area in a particular area type. Accordingly, wherever "area_type" is used in a statement of the embodiment of this function below, a comparable statement with "A" can be provided.

```
{
    mesh <--- get_mesh_for(FOM_ID); /* get the mesh for this First Order Model; preferably each cell of "mesh" is substantially
                  in a single area type. */
```

max_nbr_simulations <--- *get_Monte_Carlo_simulation_nbr*(FOM_ID, area_type); /* This function outputs a value of the maximum number of simulations to perform for estimating the prediction mapped cluster density. Note that the output here may always be the same value such as 100. */

nbr_simulations_performed <--- 0; // initialization

while (nbr_simulations_performed <= max_nbr_simulations) do // determine a value for the "average mapped cluster density" and a likelihood of this value being predictive of an MS location. */

{

representative_cell_cluster_set <--- *get_representative_cell_clusterss_for*(area_type, mesh); /* Note, each activation of this function should provide a different set of cell clusters from a covering from "mesh" of an (sub)area of type, "area_type". There should ideally be at least enough substantially different sets of representative cell clusters so that there is a distinct sets of cell clusters for each simulation number, j. Further note that, in one embodiment, each of the "representative cell cluster sets" (as used here) may include at least a determined proportion of the number of cells distributed over the area type. Moreover, each cell cluster (within a representative cell cluster set) satisfies the following:

A. The cell cluster is a minimal covering (from "mesh") of a non-empty area, A, of type "area_type" ("A" being referred to herein as the **associated area** for the cell cluster);

B. The cells of the cluster form a connected area; note this is not absolutely necessary; however, it is preferred that the associated area "A" of "area_type" covered by the cell cluster have a "small" boundary with other area types since the "image_areas" computed below will be less likely to include large areas of other area types than "area_type;"

C. There is at least a predetermined minimal number (>= 1) of verified location signature clusters from the location signature data base whose locations are in the associated area "A".

D. The cell cluster has no cell in common with any other cell cluster output as an entry in "representative_cell_cluster_set". */

if (representative_cell_cluster_set is NULL) then /* another representative collection of cell clusters could not be found; so cease further simulation processing here, calculate return values and return */

break; // jump out of "simulation loop"

else /* there is another representative collection of cell clusters to use as a simulation */

{

for each cell cluster, C, in "representative_cell_clusters" do /* determine an approximation to the predictiveness of the mappings between: (a) cluster set areas wherein each cluster set area is an area around a (FOM_ID) FOM estimate that has its corresponding verified location in "C," and (b) the corresponding image areas for these cluster set areas. Note, the location signature data base includes at least one (and preferably more)

```
location signature clusters having verified locations in each cell cluster C as per the comment at (C) above.
*/
{ random_list <--- randomly_select_verified_MS_locs_in(C); /* select one or more verified MS
                                    locations from C. */
  mapped_density_sum <--- 0; // initialization
  for each verified location, "rand_verif_loc", in "random_list" do /* Let X denote the MS 140 estimate by the
                    present FOM of the verified location signature cluster of "rand_verif_loc"; let CS(X) denote
                    the cluster set obtained from the cluster set area (i.e., pt_area) surrounding X; this loop
                    determines whether the associated image area for the set CS(X) - X, (i.e., the image area for
                    CS(X) without "rand_verif_loc") includes "rand_verif_loc"; i.e., try to predict the location
                    area of "rand_verif_loc". */
  { loc_est <--- get_loc_est_for(rand_verif_loc, FOM_ID); /* get the FOM MS location
                    estimate for an MS actually located at "rand_verif_loc". */
    cluster_set <--- get_loc_ests_surrounding(loc_est, mesh); /* expand about "loc_est" until a minimal
                    number of other location estimates from this FOM are obtained that are different from
                    "loc_est", or until a maximum area is reached. Note, "cluster_set" could be empty, but
                    hopefully not. Also note that in one embodiment of the function here, the following functions
                    may be invoked: "get_min_area_surrounding," "get_max_area_surrounding" and
                    "get_min_nbr_of_clusters" (as in "get_adjusted_loc_hyp_list_for", the second function
                    of Appendix D): */
    image_set <--- get_image_of(cluster_set); /* "image_set" could be empty, but hopefully not */
    image_area <--- get_image_area(image_est); /* get convex hull of "image_set". Note, "image_area"
                    could be an empty area, but hopefully not. */
    if (rand_verif_loc is in image_area)
       then /* this is one indication that the mapped cluster density: (sizeof[image_set]/image_area) is
               sufficiently high to be predictive */
               predictions <--- predictions + 1;
    if (image_set is not empty) then
    {
       density <--- sizeof(image_set) / sizeof(image_area); /* Get an approximation to the mapped cluster
                    density that results from "image_set" and "image_area." Note, that there is no
                    guarantee that "image_area" is entirely within the area type of "area_type." Also
                    note, it is assumed that as this mapped cluster density increases, it is more likely that
                    "rndm_verif_loc" is in "image_area". */
```

```
                mapped_density_sum <--- mapped_density_sum + density;
              }
          } /* end loop for predicting location of a random MS verified location in cell cluster C. */
          total_possible_predictions <--- sizeof(random_list); // One prediction per element on list.
          /* Now get average mapped density for the cell cluster C. */
          avg_mapped_density[C] <--- mapped_density_sum / total_possible_predictions;
          /* Now get the prediction probability for the cell cluster C. */
          prediction_probability[C] <--- predictions / total_possible_predictions;
      } /* end loop over cell clusters C in "representative_cell_clusters" */
      nbr_simulations_performed <--- nbr_simulations_performed + 1;
  } // end else
  /* It would be nice to use the set of pairs (avg_mapped_density[C], prediction_probability[C]) for extrapolating a mapped
     density value for the area type that gives a very high prediction probability. However, due to the potentially small
     number of verified MS locations in many cells (and cell clusters), the prediction probabilities may provide a very small
     number of distinct values such as: 0, 1/2, and 1. Thus, by averaging these pairs over the cell clusters of
     "representative_cell_clusters", the coarseness of the prediction probabilities may be accounted for. */
  avg_mapped_cluster_density[nbr_simulations_performed] <---
                                  avg_of_cell_mapped_densities(avg_mapped_density);
  avg_prediction_probability[nbr_simulations_performed] <---
                                  avg_of_cell_prediction_probabilities(prediction_probability);
} /* end simulation loop */
/* Now determine a measure as to how reliable the simulation was. Note that "reliability" computed in the next statement is in
   the range [0, 1]. */
reliability <--- nbr_simulations_performed / max_nbr_simulations;
if (reliability < system_defined_epsilon) then /* simulation too unreliable; so use a default high value for
                                              "prediction_mapped_cluster_density" */
      prediction_mapped_cluster_density <--- get_default_high_density_value_for(area_type);
else /* simulation appears to be sufficiently reliable to use the entries of "avg_mapped_cluster_density" and
        "avg_prediction_probability" */
{
   /* A more easily discernible pattern between mapped cluster density and prediction probability may be provided by the set
      of pairs:
      S = {(avg_mapped_cluster_density[j], avg_prediction_probability[j])}, so that a mapped cluster density value
      having a high prediction probability (e.g., 0.95) may be extrapolated in the next statement. However, if it is
```

```
        determined (in the function) that the set S does not extrapolate well (due to for example all ordered pairs of S being
        clustered in a relatively small region), then a "NULL" value is returned. */
      prediction_mapped_cluster_density <--- mapped_cluster_density_extrapolation(avg_mapped_cluster_density,
                          avg_prediction_probability, 0.95);
      if ( (prediction_mapped_cluster_density = = NULL)  then
          /* set this value to a default "high" value for the present area type*/
          prediction_mapped_cluster_density<--- get_default_high_density_value_for(area_type);
      else // So both "prediction_mapped_cluster_density" and it's reliability are minimally OK.
          /* Now take the "reliability" of the "prediction_mapped_cluster_density" into account. Accordingly, as the
             reliability decreases then the prediction mapped cluster density should be increased. However, there is a system
             defined upper limit on the value to which the prediction mapped cluster density  may be increased.  The next
             statement is one embodiment that takes all this into account.  Of course other embodiments are also possible.
             */
         prediction_mapped_cluster_density<---
                          min {(prediction_mapped_cluster_density / reliability),
                                 get_default_high_density_value_for(area_type)};
    } // end else for simulation appearing reliable
    RETURN(prediction_mapped_cluster_density);
  }ENDOF get_prediction_mapped_cluster_density_for
```

A Second Embodiment of the Context Adjuster.

Note that in this second embodiment of the Context Adjuster, it uses various heuristics to increment/decrement the confidence value of the location hypotheses coming from the First Order Models. These heuristics are implemented using fuzzy mathematics, wherein linguistic, fuzzy "if-then" rules embody the heuristics. That is, each fuzzy rule includes terms in both the "if" and the "then" portions that are substantially described using natural language — like terms to denote various parameter value classifications related to, but not equivalent to, probability density functions. Further note that the Context Adjuster and/or the FOM's may be calibrated using the location information from LBSs (i.e., fixed location BS transceivers), via the Location Base Station Model since such LBS's have well known and accurate predetermined locations._

Regarding the heuristics of the present embodiment of the context adjuster, the following is an example of a fuzzy rule that might appear in this embodiment of the Context Adjuster:

If <the season is Fall> then <the confidence level of Distance Model is increased by 5%>.

In the above sample rule, "Distance Model" denotes a First Order Model utilized by the present invention. To apply this sample rule, the fuzzy system needs a concrete definition of the term "Fall." In traditional expert systems, the term Fall would be described by a particular set of months, for example, September through November, in which traditional set theory is applied. In traditional set theory, an entity, in this case a date, is either in a set or it is not in a set, e.g. its degree of membership in a set is either 0, indicating that the entity is not in a particular set, or 1, indicating that the entity is in the set. However, the traditional set theory employed in expert systems does not lend itself well to entities that fall on set boundaries. For example, a traditional expert system could take dramatically different actions for a date of August 31 than it could for a date of September 1 because August 31 might belong to the set "Summer" while the date September 1 might belong to the set "Fall." This is not a desirable behavior since it is extremely difficult if not impossible to determine such lines of demarcation so accurately. However, fuzzy mathematics allows for the possibility of an entity belonging to multiple sets with varying degrees of confidence ranging from a minimum value of 0 (indicating that the confidence the entity belongs to the particular set is minimum) to 1 (indicating that the confidence the entity belongs to the particular set is maximum). The "fuzzy boundaries" between the various sets are described by fuzzy membership functions which provide a membership function value for each value on the entire range of a variable. As a consequence of allowing entities to belong to multiple sets simultaneously, the fuzzy rule base might have more than one rule that is applicable for any situation. Thus, the actions prescribed by the individual rules are averaged via a weighting scheme where each rule is implemented in proportion to its minimum confidence. For further information regarding such fuzzy heuristics, the following references are incorporated herein by reference: (McNeil and Freiberger, 1993; Cox, 1994; Klir and Folger, 1999; Zimmerman, 1991).

Thus, the rules defined in the fuzzy rule base in conjunction with the membership functions allow the heuristics for adjusting confidence values to be represented in a linguistic form more readily understood by humans than many other heuristic representations and thereby making it easier to maintain and modify the rules. The fuzzy rule base with its membership functions can be thought of as an extension to a traditional expert system. Thus, since traditional expert systems are subsets of fuzzy systems, an alternative to a fuzzy rule base is a traditional expert system, and it is implicit that anywhere in the description of the current invention that a fuzzy rule base can be replaced with an expert system.

Also, these heuristics may evolve over time by employing adaptive mechanisms including, but not limited to, genetic algorithms to adjust or tune various system values in accordance with past experiences and past performance of the Context Adjuster for increasing the accuracy of the adjustments made to location hypothesis confidence values. For example, in the sample rule presented above:

If <the season is Fall> then <the confidence level of Distance Model is increased by 5%>

an adaptive mechanism or optimization routine can be used to adjust the percent increase in the confidence level of the Distance Model. For example, by accessing the MS Status Repository, a genetic algorithm is capable of adjusting the fuzzy rules and membership functions such that the location hypotheses are consistent with a majority of the verified MS locations. In this way, the Context Adjuster is able to employ a genetic algorithm to improve its performance over time. For further information regarding such adaptive mechanisms, the following references are incorporated herein by reference: (Goldberg, 1989; Holland, 1975). For further information regarding the tuning of fuzzy systems using such adaptive mechanisms, the following references are incorporated herein by reference: (Karr, 1991a, 1991b).

In one embodiment, the Context Adjuster alters the confidence values of location hypotheses according to one or more of the following environmental factors: (1) the type of region (e.g., dense urban, urban, rural, etc.), (2) the month of the year, (3) the time of day, and (4) the operational status of base stations (e.g., on-line or off-line), as well as other environmental factors that may substantially impact the confidence placed in a location hypothesis. Note that in this embodiment, each environmental factor has an associated set of linguistic heuristics and associated membership functions that prescribe changes to be made to the confidence values of the input location hypotheses.

The context adjuster begins by receiving location hypotheses and associated confidence levels from the First Order Models. The Context Adjuster takes this information and improves and refines it based on environmental information using the modules described below.

B.1 COA Calculation Module

As mentioned above each location hypothesis provides an approximation to the MS position in the form of a geometric shape and an associated confidence value, a. The COA calculation module determines a center of area (COA) for each of the geometric shapes, if such a COA is not already provided in a location hypothesis. The COA Calculation Module receives the following information from each First Order Model: (1) a geometrical shape and (2) an associated confidence value, a. The COA calculation is made using traditional geometric computations (numerical algorithms are readily available). Thus, following this step, each location hypothesis includes a COA as a single point that is assumed to represent the most likely approximation of the location of the MS. The COA Calculation Module passes the following information to the fuzzification module: (1) a geometrical shape associated with each first order model 1224, (2) an associated confidence value, and (3) an associated COA.

B.2 Fuzzification Module

A fuzzification module receives the following information from the COA Calculation Module: (1) a geometrical shape associated with each First Order Model, (2) an associated confidence value, and (3) an associated COA. The Fuzzification Module uses this information to compute a membership function value (μ) for each of the M location hypotheses received from the COA calculation module (where the individual models are identified with an i index) for each of the N environmental factors (identified with a j index). In addition to the information received from the COA Calculation Module, the Fuzzification Module receives information from the Location Center Supervisor. The fuzzification module uses current environmental information such as the current time of day, month of year, and information about the base stations on-line for communicating with the MS associated with a location hypothesis currently being processed (this information may include, but is not limited to, the number of base stations of a given type, e.g., location base stations, and regular base stations, that have a previous history of being detected in an area about the COA for a location hypothesis). The base station coverage information is used to compute a percentage of base stations reporting for each location hypothesis.

The fuzzification is achieved in the traditional fashion using fuzzy membership functions for each environmental factor as, for example, is described in the following references incorporated herein by reference: (McNeil and Freiberger, 1993; Cox, 1994; Klir and Folger, 1999; Zimmerman, 1991).

Using the geographical area types for illustration purposes here, the following procedure might be used in the Fuzzification Module. Each value of COA for a location hypothesis is used to compute membership function values (μ) for each of five types of areas: (1) dense urban (μ_{DU}), (2) urban (μ_U), (3) suburban (μ_S), (4) rural plain (μ_{RP}), and (5) rural mountains (μ_{RM}). These membership function values provide the mechanism for representing degrees of membership in the area types, these area types being determined from an area map that has been sectioned off. In accordance with fuzzy theory, there may be geographical locations that include, for example, both dense urban and urban areas; dense urban and rural plane areas; dense urban, urban, and rural plane areas, etc. Thus for a particular MS location area estimate (described by a COA), it may be both dense urban and urban at the same time. The resolution of any apparent conflict in applicable rules is later resolved in the Defuzzification Module using the fuzzy membership function values (μ) computed in the Fuzzification Module.

Any particular value of a COA can land in more than one area type. For example, the COA may be in both dense urban and urban. Further, in some cases a location hypothesis for a particular First Order Model i may have membership functions μ_{DU}^i, μ_U^i, μ_S^i, μ_{RP}^i, and μ_{RM}^i wherein they all potentially have non-zero values. Additionally, each geographical area is contoured. Note that the membership function contours allow for one distinct value of membership function to be determined for each COA location (i.e., there will be distinct values of μ_{DU}^i, μ_U^i, μ_S^i, μ_{RP}^i, and μ_{RM}^i for any single COA value associated with a particular model i). For example, the COA would have a dense urban membership function value, μ_{DU}^i, equal to 0.5. Similar contours would be used to compute values of μ_U^i, μ_S^i, μ_{RP}^i, and μ_{RM}^i.

Thus, for each COA, there now exists an array or series of membership function values; there are K membership function values (K = number of descriptive terms for the specified environmental factor) for each of M First Order Models. Each COA calculation has associated with it a definitive value for μ_{DU}^i, μ_U^i, μ_S^i, μ_{RP}^i, and μ_{RM}^i. Taken collectively, the M location hypotheses with membership function values for the K descriptive terms for the particular environmental factor results in a membership function value matrix. Additionally, similar membership function values are computed for each of the N environmental factors, thereby resulting in a corresponding membership function value matrix for each of the N environmental factors.

The Fuzzification Module passes the N membership function value matrices described above to the Rule Base Module along with all of the information it originally received from the COA Calculation Module.

B.3 Rule Base Module

The Rule Base Module receives from the Fuzzification Module the following information: (1) a geometrical shape associated with each First Order Model, (2) an associated confidence value, (3) an associated COA, and (4) N membership function value matrices. The Rule Base Module uses this information in a manner consistent with typical fuzzy rule bases to determine a set of active or applicable rules. Sample rules were provided in the general discussion of the Context Adjuster. Additionally, references have been supplied that describe the necessary computations. Suffice it to say that the Rule Base Modules employ the information provided by the Fuzzification Module to compute confidence value adjustments for each of the m location hypotheses. Associated with each confidence value adjustment is a minimum membership function value contained in the membership function matrices computed in the Fuzzification Module.

For each location hypothesis, a simple inference engine driving the rule base queries the performance database to determine how well the location hypotheses for the First Order Model providing the current location hypothesis has performed in the past (for a geographic area surrounding the MS location estimate of the current location hypothesis) under the present environmental conditions. For example, the performance database is consulted to determine how well this particular First Order Model has performed in the past in locating an MS for the given time of day, month of year, and area type. Note that the performance value is a value between 0 and 1 wherein a value of 0 indicates that the model is a poor performer, while a value of 1 indicates that the model is always (or substantially always) accurate in determining an MS location under the conditions (and in the area) being considered. These performance values are used to compute values that are attached to the current confidence of the current location hypothesis; i.e., these performance values serve as the "then" sides of the fuzzy rules; the First Order Models that have been effective in the past have their confidence levels incremented by large amounts while First Order Models that have been ineffective in the past have their confidence levels incremented by small amounts. This information is received from the Performance Database in the form of an environmental factor, a First Order Model number, and a performance value. Accordingly, an intermediate value for the adjustment of the confidence value for the current location hypothesis is computed for each environmental condition (used by Context Adjuster) based on the performance value retrieved from the Performance Database. Each of these intermediate adjustment values are computed according to the following equation which is applicable to area information:

$$adjustment_j^i = Da_j^i = performance\_value_j^i * Da_{REGION}^{MAX}$$

where a is the confidence value of a particular location hypothesis, performance_value is the value obtained from the Performance Database, Da_{REGION}^{MAX} is a system parameter that accounts for how important the information is being considered by the context adjuster. Furthermore, this parameter is initially provided by an operator in, for example, a system start-up configuration and a reasonable value for this parameter is believed to be in the range 0.05 to 0.1, the subscript j represents a particular environmental factor, and the superscript i represents a particular First Order Model. However, it is an important aspect of the present invention that this value can be repeatedly altered by an adaptive mechanism such as a genetic algorithm for improving the MS location accuracy of the present invention. In this way, and because the rules are "written" using current performance information as stored in the Performance Database, the Rule Module is dynamic and becomes more accurate with time.

The Rule Base Module passes the matrix of adjustments to the Defuzzification Module along with the membership function value matrices received from the Fuzzification Module.

B.6 Defuzzification Module

The Defuzzification Module receives the matrix of adjustments and the membership function value matrices from the Rule Base Module. The final adjustment to the First Order Model confidence values as computed by the Context Adjuster is computed according to:

$$\Delta \alpha_j^i(k) = \frac{\sum_{j=1}^{N} \mu_j^i(k)\, \Delta \alpha_j^i}{\sum_{j=1}^{N} \mu_j^i(k)}$$

such as, but not limited to, time of day, month of year, and base station coverage, there are a number of system start-up configuration parameters that can be adjusted in attempts to improve system performance. These adjustments are, in effect, adjustments computed depending on the previous performance values of each model under similar conditions as being currently considered. These adjustments are summed and forwarded to the blackboard. Thus, the Context Adjuster passes the following information to the blackboard: adjustments in confidence values for each of the First Order Models based on environmental factors and COA values associated with each location hypothesis.

Summary

The Context Adjuster uses environmental factor information and past performance information for each of i First Order Models to compute adjustments to the current confidence values. It retrieves information from the First Order Models, interacts with the Supervisor and the Performance Database, and computes adjustments to the confidence values. Further, the Context Adjuster employs a genetic algorithm to improve the accuracy of its calculations. The algorithm for the Context Adjuster is included in algorithm BE.B below:

Algorithm BE.B: Pseudocode for the Context Adjuster.

Context_Adjuster (geometries, alpha)

/* This program implements the Context Adjuster. It receives from the First Order Models geometric areas contained in a data structure called geometries, and associated confidence values contained in an array called alpha. The program used environmental information to compute improved numerical values of the confidence values. It places the improved values in the array called alpha, destroying the previous values in the process.

*/

// pseudo code for the Context Adjuster

// assume input from each of i models includes a

// geographical area described by a number of points

```
// and a confidence value alpha(i). alpha is such
// that if it is 0.0 then the model is absolutely
// sure that the MS is not in the prescribed area;
// if it is 1.0 then the model is absolutely
// sure that the MS is in the prescribed area.
// calculate the center of area for each of the i model areas
for i = 1 to number_of_models
 calculate center of area  // termed coa(i) from here on out
// extract information from the "outside world" or the environment
find time_of_day
find month_of_year
find number_of_BS_available
find number_of_BS_reporting
// calculate percent_coverage of base stations
percent_coverage = 100.0 * (number_of_BS_reporting / number_of_BS_available)
// use these j = 4 environmental factors to compute adjustments to the i confidence values
// associated with the i models - alpha(i)
for i = 1 to number_of_models // loop on the number of models
 for j = 1 to number_env_factors // loop on the number of environmental factors
  for k = 1 to number_of_fuzzy_classes // loop on the number of classes
                    // used for each of the environmental
                    // factors
   // calculate mu values based on membership function definitions
   calculate mu(i,j,k) values
   // go to the performance database and extract current performance information for each of the i
       //models, in the k fuzzy classes, for the j environmental factors
   fetch performance(i,j,k)

   // calculate the actual values for the right hand sides of the fuzzy rules

   delta_alpha(i,j,k) = performance(i,j,k) * delta_alpha_max(j)
   // delta_alpha_max(j) is a maximum amount each environmental
   // factor can alter the confidence value; it is eventually
```

```
// determined by a genetic algorithm

// compute a weighted average; this is traditional fuzzy mathematics
delta_alpha(i,j,k) = sum[mu(i,j,k) * delta_alpha(i,j,k) / sum[mu(i,j,k)]

end loop on k  // number of fuzzy classes

// compute final delta_alpha values
delta_alpha(i) = sum[delta_alpha(i,j)]
end loop on j    // number of environmental factors
alpha(i) += delta_alpha(i)
end loop on i     // number of models

// send alpha values to blackboard
send delta_alpha(i) to blackboard

// see if it is time to interact with a genetic algorithm
if (in_progress)
 then continue to calculate alpha adjustments
else
 call the genetic algorithm to adjust alpha_max parameters and mu functions
```

APPENDIX E: Historical Data Confidence Adjuster Program

```
Historical_data_confidence_adjuster(loc_hyp)
/* This function adjusts the confidence of location hypothesis, "loc_hyp", according to how well its location signature cluster fits with verified
  location signature clusters in the location signature data base. */
{
        mesh <--- get_mesh_for(loc_hyp.FOM_ID); // each FOM has a mesh of the Location Center service area
        covering <--- get_mesh_covering_of_MS_estimate_for(loc_hyp); /* get the cells of "mesh" that minimally cover the most
                        pertinent target MS estimate in "loc_hyp". */
        total_per_unit_error <--- 0; // initialization
        for each cell, C, of "covering" do /* determine an error measurement between the location signature cluster of "loc_hyp" and
                                    the verified location signature clusters in the cell */
        {
                centroid <--- get_centroid(C);
                error_obj <--- DB_Loc_Sig_Error_Fit(centroid, C, loc_hyp.loc_sig_cluster, "USE ALL LOC SIGS IN
                                                DB");
                                /* The above function call computes an error object, "error_obj", providing a
                                measure of how similar the location signature cluster for "loc_hyp" is with the verified
                                location signature clusters in the location signature data base, wherein the verified
                                location signature clusters are in the area represented by the cell, C. See APPENDIX C
                                for details of this function. */
                total_per_unit_error <--- total_per_unit_error + [error_obj.error * error_obj.confidence / sizeof(C)];
                                /* The above statement computes an "error per unit of cell area" term as:
                                  [error_obj.error * error_obj.confidence / sizeof(C)], wherein the error is the term:
                                  error_obj.error * error_obj.confidence. Subsequently, this error per unit of cell
                                  area term accumulated in "total_relative_error" */
        }
        avg_per_unit_error <-- total_per_unit_error / nbr_cells_in(mesh);
                /* Now get a tunable constant, "tunable_constant", that has been determined by the Adaptation Engine 1382
                (shown in Figs. 5, 6 and 8), wherein "tunable_constant" may have been adapted to environmental characteristics. */
        tunable_constant <--- get_tuneable_constant_for("Historical_Location_Reasoner", loc_hyp);
                /* Now decrement the confidence value of "loc_hyp" by an error amount that is scaled by "tunable_constant"
                */
```

```
        loc_hyp.confidence <--- loc_hyp.confidence - [avg_per_unit_error * sizeof(covering) * tunable_constant];
        RETURN(loc_hyp);
}ENDOF Historical_data_confidence_adjuster
```

What is claimed is:

1. A method for locating a wireless mobile station using wireless signal measurements obtained from transmissions between said mobile station and a plurality of base stations capable of wirelessly detecting said mobile station, comprising:

providing first and second mobile station location estimators, wherein said location estimators provide location estimates of said mobile station when said location estimators receive wireless signal measurements obtained from transmissions between said mobile station and the base stations, wherein:

(A) said first location estimator is capable of performing one or more of the techniques:

(a) a triangulation technique to determine, for each of three or more of the base stations, a distance between the mobile station and the base station using the wireless signal measurements;

(b) a learning technique, wherein said learning technique determines an association for associating: the wireless signal measurements, and data indicative of a location for the mobile station, wherein said association is determined by a training process using a plurality of data pairs, each said pair including: first information indicative of a location of some mobile station, and second information from wireless signal measurements between said some mobile station and one or more of the base stations when said some mobile station is at the location;

(c) a stochastic technique, wherein each said stochastic technique uses a statistical correlation for correlating: the wireless signal measurements, and data indicative of a location for the mobile station, wherein said correlation is used for determining a probability that the mobile station is within an area, and

(B) for at least a particular one of said techniques performed by said first location estimator, said second location estimator does not perform said particular technique;

first supplying said first location estimator with first data from the wireless signal measurements;

first generating, by said first location estimator, first location related information having at least a first estimate of the mobile station's location;

second supplying said second location estimator with second data from the wireless signal measurements;

second generating, by said second location estimator, second location related information having at least a second estimate of the mobile station's location;

determining a resulting location estimate of the mobile station using: (a) a first value obtained from said first location related information, and (b) a second value obtained from said second location related information.

2. A method as claimed in Claim 1, further including a step of receiving said measurements during a wireless communication between said mobile station and said plurality of base stations for contacting an emergency response center.

3. A method as claimed in Claim 2, further including a step of transmitting said resulting location estimate to the emergency response center during said wireless communication.

4. A method as claimed in Claim 1, wherein said step of providing includes:

transmitting through a telecommunications network, said first location estimator from a source site to a site having said second location estimator;

operably integrating said first location estimator with said second location estimator for performing at least said step of determining.

5. A method as claimed in Claim 8, wherein said step of transmitting includes sending an encoding of said first location estimator using the Internet.

6. A method as claimed in Claim 1, wherein said step of determining includes retrieving historical location data related to said first initial location estimate and said second initial location estimate, wherein said historical location data includes:

(a1) location estimates by said first location estimator for some of said mobile stations at a first plurality of locations, and data identifying said locations of said first plurality of locations;

(b1) location estimates by said second location estimator for some of said mobile stations at a second plurality of locations, and data identifying said locations of said second plurality of locations;

wherein said first successive location estimate is determined using said historical location data of (a1), and said successive estimate is determined using said historical location data of (b1).

7. A method as claimed in Claim 1, further including, for at least one location estimate of said first and second estimates, a step of obtaining one of a likelihood value and a probability that a location of said mobile station is in said one location estimate, wherein said likelihood value is obtained using historical location estimates generated by the location estimator that generated said one location estimate when the location estimator is supplied with wireless signal measurements obtained from transmissions between one or more mobile stations and said plurality of base stations at a plurality of locations.

8. A method as claimed in Claim 1, wherein said step of providing includes providing some one mobile station location estimator, wherein said one mobile station location estimator generates an estimate of where said mobile station is unlikely to be located.

9. A method as claimed in Claim 1, wherein said wireless signal measurements are obtained from transmissions between said mobile station and said plurality of base stations, wherein said transmissions occur within an interval of time wherein one of: said mobile station is expected to be in substantially a same location, and said interval is less than a predetermined duration.

10. A method as claimed in Claim 1, wherein one of: said first data includes said second estimate, and said second data includes said first estimate.

11. A method as claimed in Claim 1, further including:

performing a first simulation for predicting a likelihood of said mobile station being at said first estimate, wherein said simulation uses pairs of location representations, a first member of each pair including a location estimate obtained from said first location estimator and a second member of the pair including a representation of an independently determined location of a mobile station used for obtaining wireless signal measurements that are obtained from transmissions with said plurality of base stations.

12. A method as claimed in Claim 1, wherein at least one of said first and second location estimators each utilize one of the following:

(a) a pattern recognition location technique for estimating a location of said mobile station by recognizing a pattern of characteristics of said data obtained from wireless signal measurements;

(b) a mobile base station estimator for estimating a location of said mobile station from location information received from a mobile base station detecting wireless transmissions of said mobile station;

(c) a coverage area location technique for estimating a location of said mobile station by intersecting wireless coverage areas for different sets of one or more of said base stations;

(d) a negative logic location for estimating where said mobile station is unlikely to be located.

13. A method as claimed in Claim 1, wherein at least one of the following holds:

(a) said learning technique is capable of providing an artificial neural network for generating a mobile station location estimate by training said artificial neural network to recognize a pattern of characteristics of location information obtained from said wireless signal measurements;

(b) said triangulation technique is capable of providing the distances between the mobile station and said three or more of the base stations using one or more of: a wireless signal time of arrival, a wireless signal time difference of arrival, a wireless signal strength indication;

(c) said stochastic technique is capable of providing said statistical correlation using one of: principle decomposition, least squares, partial least squares, and Bollenger Bands.

14. A method as claimed in Claim 1, wherein said first location estimator includes an artificial neural network, wherein said artificial neural network is one of: a multilayer perceptron, an adaptive resonance theory model, and radial basis function network.

15. A method as claimed in Claim 1, wherein said step of determining includes deriving a likelihood measurement that said mobile station is in said resulting location estimate, wherein said likelihood measurement is dependent upon a first likelihood measurement that said mobile station is in said first estimate, and a second likelihood measurement that said mobile station is in said second estimate.

16. A method as claimed in Claim 1, further including a step of deriving one of said first estimate, said second estimate, and said resulting location estimate using one of:

(a) an expected maximum velocity of said mobile station;

(b) an expected maximum acceleration of said mobile station;

(c) an expected route of said mobile station.

17. A location system for locating a mobile station, wherein said mobile station is one of a plurality of mobile stations, and wireless signal measurements are capable of being obtained from wireless transmissions between the plurality of mobile stations and a plurality of base stations, the improvement characterized by:

one or more location estimators, each said location estimator for estimating a location for each of one or more individual mobile stations of the plurality of mobile stations, when said location estimator is supplied with data from a set of said wireless signal measurements obtained from wireless transmissions between the individual mobile station and said plurality of base stations;

an archive for storing a plurality of data item collections, wherein for each geographical location of a plurality geographical locations, there is one of said data item collections having (a1) and (a2):

(a1) a representation of the geographical location, and

(a2) a set of said] wireless signal measurements corresponding to one of the plurality of mobile stations transmitting from approximately the geographical location of (a1);

a performance estimator for determining, for each one of said location estimators, corresponding one or more performance measurements indicative of a previous performance of said one location estimator in locating one or more of the plurality of mobile stations, wherein said corresponding performance measurements are determined using location estimates generated by said one location estimator when said set of (a2), for some of said data item collections, is supplied to said one location estimator;

a controller for activating a group of at least one of said location estimators for generating corresponding location estimates of said mobile station when a first said set of wireless signal measurements is obtained from wireless transmissions between said mobile station and said plurality of base stations, wherein one or more location hypotheses are generated, each said location hypothesis having:

(b1) an hypothesized location estimate of said mobile station obtained using the corresponding location estimate generated by a location estimator of said group,

(b2) a likelihood value indicating a likelihood of said mobile station being at a location represented by said hypothesized location estimate of (b1), wherein said corresponding performance measurements for said location estimator providing the location estimate of (b1) are used in determining said likelihood value;

a location estimator for determining a resulting location estimate of said mobile station, said resulting location estimate being derived using said hypothesized location estimates and said likelihood values from said one or more location hypotheses.

18. A method as claimed in Claim 55, further including a step of transmitting said resulting location estimate to an emergency response center during a wireless communication wherein said first set of wireless signal measurements is obtained.

19. A location system as claimed in Claim 55, further including an hypothesis estimate generator for generating one of said hypothesized location estimates using a time series of location estimates for said mobile station output by said one or more location estimators.

20. A method for locating a mobile station, wherein said mobile station is one of a plurality of mobile stations, and wireless signal measurements are capable of being obtained from wireless transmissions between the plurality mobile stations and a

network of base stations, wherein said base stations in the network are cooperatively linked for providing wireless communication with each of the mobile stations, the improvement characterized by:

providing a mobile station location estimator for estimating locations of one or more individual mobile stations of said plurality of mobile stations when said location estimator is supplied with said wireless signal measurements obtained from wireless transmissions between the individual mobile station and said network of base stations;

storing a plurality of data item collections, wherein for each of a plurality of geographical locations, there is one of said data item collections having:

(a1) a representation of the geographical location, and

(a2) a representation of said wireless signal measurements between one of the mobile stations and the base stations when said one mobile station is approximately at the geographical location of (a1);

generating, from said wireless signal measurements between said mobile and said base stations, an initial location estimate of said mobile;

obtaining a first set of one or more additional location estimates generated by said location estimator, wherein each said additional location estimate is generated from said representations of wireless signal measurements of (a2) for one of said data item collections, and wherein at least a majority of said additional location estimates are within a predetermined distance of said initial location estimate;

deriving an adjusted location estimate from said initial location estimate using a second set of said geographical location representations of (a1) for said data item collections whose representations of wireless signal measurements of (a2) were used to generate one of said additional location estimates of said set.

21. A method as claimed in Claim 20, wherein said step of deriving includes determining an area boundary of said adjusted location estimate as a function of said geographical locations in said second set.

22. A location system for locating mobile stations from received wireless signal measurements obtained from transmissions between said mobile stations and a network of base stations, wherein said base stations in the network are cooperatively linked for providing wireless communication, the improvement characterized by:

one or more location estimators for estimating locations of said mobile stations, such that for each of said mobile stations, when said location estimators are supplied with measurements of wireless signals obtained from transmissions between:

the mobile station, at a corresponding geographical location from which the mobile station is transmitting, and said network of base stations, at least one location estimate is generated;

a location estimate adjuster for deriving a first adjusted location estimate from a first location estimate generated by a first of said location estimators supplied with said wireless signal measurements obtained from transmissions between: (i) a particular one of said mobile stations, at a particular location, and (ii) said base stations, wherein:

(a1) said first adjusted location estimate has a corresponding confidence value indicative of a likelihood of the particular geographical location being a location represented by the first adjusted location estimate, (a2) said first adjusted location estimate is determined using additional location estimates generated: (i) previously to the generation of said first initial location estimate, and (ii) by said first location estimator;

a most likely estimator for determining a most likely location estimate of the particular geographical location of the particular mobile station, said most likely location estimate being derived using said first adjusted location estimate and its corresponding confidence value.

23. A location system, as claimed in Claim 22, wherein, said location estimate adjuster includes a statistical simulation module for deriving a one or more likelihood values indicative of said first location estimator generating mobile station location estimates that include their corresponding geographical locations.

24. A location system, as claimed in Claim 22, wherein, said location estimate adjuster includes a statistical simulation module for deriving a one or more likelihood values indicative of said first location estimator generating mobile station location estimates that include their corresponding geographical locations.

25. A location system for locating mobile stations from received wireless signal measurements obtained from transmissions between said mobile stations and a network of fixed location transceivers, wherein said transceivers in the network are cooperatively linked for providing wireless communication with said mobile stations, the improvement characterized by:

an archive for storing a plurality of data item collections, wherein for each location of a plurality geographical locations, there is one of said data item collections having (a1) and (a2):

(a1) a representation of the geographical location,

(a2) a set of said wireless signal measurements obtained from transmissions between one of said mobile stations and said fixed location transceivers, wherein the one mobile station transmits from approximately the geographical location;

a plurality of trainable location estimators, each said trainable location estimator for generating a geographical location estimates for said mobile stations, wherein for each said trainable location estimator:

(b1) there is a corresponding group of wireless signal measurement parameters, wherein for said trainable location estimator to generate a location estimate of an individual one of said mobile stations, at least some of said parameters must be instantiated with values obtained from transmissions between said individual mobile station and said fixed location transceivers,

(b2) there is a different corresponding group of wireless signal measurement parameters for another of said trainable location estimators, and

(b3) said trainable location estimator learns by associating, for each of at least some of said data item collections, said geographical location representation (a1) of the data item collection with said set of said wireless signal measurements (a2) of the data item collection;

a location estimator selector for selecting one or more of said plurality of trainable location estimators for generating mobile station location estimates, wherein when each of said selected location estimators has its corresponding group of wireless signal measurement parameters instantiated with values obtained from transmissions between one of said mobile stations and said fixed location transceivers, said selected location estimator generates a location estimate of the one mobile station;

wherein for locating a particular one of said mobile stations, said location estimator selector selects a particular set of said trainable location estimators whose corresponding group of wireless signal measurement parameters can have at least some said parameters instantiated using wireless signal measurements obtained from transmissions between said particular mobile station and said fixed location transceivers;

a location estimator for determining a resulting location estimate of said particular mobile station, said location estimator receiving location estimates from trainable location estimators of said particular set.

26. A location system, as claimed in Claim 92, wherein at least one of said trainable location estimators includes an artificial neural network.

27. A method as claimed in Claim 94, further including a different trainable location estimator utilizing a different artificial neural network for generating a different geographical location estimate of said one mobile station.

28. A method as claimed in Claim 94, wherein said artificial neural network is one of: a multilayer perceptron, an adaptive resonance theory model, and radial basis function network.

29. A method as claimed in Claim 92, wherein said trainable location estimator utilizes an artificial neural network with an input neuron for receiving a value related to wireless transmissions between said particular mobile station and a particular one of said fixed location transceivers, wherein said value is indicative of at least one of the following conditions:

(a) said particular transceiver is active for wireless communication with said particular mobile station and a pilot signal by said particular transceiver is detected by said particular mobile station;

(b) said particular transceiver is active for wireless communication with said particular mobile station and said particular transceiver detects wireless transmissions by said particular mobile station;

(c) said particular transceiver is active for wireless communication with said particular mobile station and said particular transceiver does not detect wireless transmissions by said particular mobile station;

(d) said particular transceiver is active for wireless communication with said particular mobile station and said particular mobile station does not detect wireless transmissions by said particular transceiver;

(e) said particular transceiver is not active for wireless communication with said particular mobile station.

30. A location system for receiving wireless signal measurements of wireless signals transmitted between a plurality mobile stations and a network of base stations, wherein said base stations in the network are cooperatively linked for providing wireless communication, the improvement characterized by:

a plurality of mobile station location estimators for estimating locations of said mobile stations, such that when said location estimators are supplied with said measurements of wireless signals transmitted between one of the mobile stations and said network of base stations, said location estimators output corresponding initial location estimates of a geographical location of said one mobile station, wherein at least two of said mobile station location estimators of said plurality of mobile station location estimators include a different one of the following (a) through (f):

(a) a pattern recognition component for estimating a location of said one mobile station from a pattern in the wireless signal measurements of transmissions between the network and said one mobile station;

(b) a trainable mobile station location estimating component for estimating a location of said one mobile station, wherein said trainable mobile station location estimating component is capable of being trained to associate: (i) each location of a plurality of geographical locations with (ii) corresponding measurements of wireless signals transmitted between a specified one of said mobile stations and the network, wherein said specified mobile station is approximately at the location;

(c) a triangulation component for estimating a location of said one mobile station, wherein said triangulation component utilizes said measurements of wireless signals between said one mobile station and three of the base stations for triangulating a location estimate of said one mobile station;

(d) a statistical component utilizing a statistical regression technique for estimating a location of said one mobile station;

(e) a mobile base station component for estimating a location of said one mobile station, wherein said mobile base station component utilizes location information received from a mobile base station that detects said one mobile station;

(f) a negative logic component for estimating an area of where said one mobile station is unlikely to be located; and

a most likely estimator for determining a most likely location estimate of said one mobile station, said most likely location estimate being a function of said plurality of location estimates.

31. A location system, as claimed in Claim 101, wherein one or more of said mobile station location estimators are capable of being at least one of: added, replaced and deleted by Internet transmissions between said location system and a site remote from said location system.

32. A location system for receiving wireless signal measurements of wireless signals transmitted between a plurality mobile stations and a network of base stations, wherein said base stations in the network are cooperatively linked for providing wireless communication, the improvement characterized by:

a mobile station location providing means for estimating locations of said mobile stations, such that when said providing means is supplied with said measurements of wireless signals transmitted between a particular one of the mobile stations and said network of base stations, said providing means determines a first collection of one or more location estimates for said particular mobile station;

an expert system for activating expert system rules for one of: (a) modifying one of said location estimates of said first collection, and (b) obtaining additional location estimates of the particular location;

a most likely estimator for determining a most likely location estimate of the particular location, said most likely location estimate being a function of one or more location estimates provided by said expert system.

33. A location system for locating wireless mobile stations that communicate with a plurality of networked base stations, comprising:

a wireless transceiver means: (a) for at least detecting a direction of wireless signals transmitted from a wireless mobile station, and (b) for communicating with said networked base stations information related to a location of said wireless mobile station;

a means for detecting whether a detected wireless signal from said mobile station has been one of: reflected and deflected;

a means for estimating a location of said mobile station by using wireless signals transmitted from said mobile station that are not detected by said means for detecting as one of: reflected and deflected.

34. A location system as claimed in Claim 106, wherein said means for detecting includes a means for comparing: (a) a distance of said mobile station from said mobile location system using a signal strength of said wireless signals from said mobile station, and (b) a distance of said mobile station from said location system using a signal time delay measurement of wireless signal from said mobile station.

35. A location system as claimed in Claim 106, further including

one or more location estimators for estimating a location of said location system, wherein said at least one of said location estimators uses wireless signals transmitted from one of: said networked base stations and a global positioning system.

36. A location system as claimed in Claim 108, further including

a deadreckoning means for estimating a change in a location of said location system, wherein said deadreckoning means provides incremental updates to said one or more location estimates of said mobile location system output by said at least one location estimator.

37. A method for locating a particular wireless mobile station using measurements of particular wireless signals, wherein at least one of: said measurements and said particular wireless signals are transmitted between said wireless mobile station and at least one of a plurality of transceivers, wherein said transceivers are capable of at least wireless detection of a plurality of wireless transmitting mobile stations including said particular mobile station, comprising:

providing a first and second mobile station location estimators, wherein each of said location estimators is capable of providing a location estimate for each mobile station of at least some of said mobile stations when said location estimator is supplied with corresponding data obtained from received wireless signal measurements communicated between the mobile station and one or more of said plurality of transceivers, wherein:

said first location estimator performs one or more triangulation techniques, wherein each said triangulation technique determines for each of one or more of said mobile stations, and for each transceiver of a set of three or more of said transceivers, a distance between the mobile station, and said transceiver, each said distance determined from data resulting from received measurements of wireless signals communicated between the mobile station and said transceiver, and said second location estimator does not perform any said triangulation technique;

first supplying said first location estimator with first corresponding data obtained from received wireless signal measurements communicated between said particular mobile station and one or more of said plurality of transceivers;

second supplying said second location estimator with second corresponding data obtained from received wireless signal measurements communicated between said particular mobile station and one or more of said plurality of transceivers;

first generating, by said first location estimator, first location related information having at least a first estimate for the mobile station's location;

second generating, by said second location estimator, second location related information having at least a second estimate for the mobile station's location;

determining a resulting location estimate of the mobile station using: (a) a first value obtained from said first location related information, and (b) a second value obtained from said second location related information.

38. A method for locating a particular wireless mobile station using measurements of particular wireless signals, wherein at least one of: said measurements and said particular wireless signals are transmitted between said wireless mobile station and at least one of a plurality of transceivers, wherein said transceivers are capable of at least wireless detection of a plurality of wireless transmitting mobile stations including said particular mobile station, comprising:

providing a first and second mobile station location estimators, wherein each of said location estimators is capable of providing a location estimate for each mobile station of at least some of said mobile stations when said location estimator is supplied with corresponding data obtained from received wireless signal measurements communicated between the mobile station and one or more of said plurality of transceivers, wherein:

said first location estimator performs one or more global positioning techniques, wherein each said global positioning technique determines for each of one or more of said mobile stations, corresponding data resulting from received measurements of wireless signals from one or more global positioning satellites, said corresponding data for determining a location of the mobile station, and said second location estimator does not perform any said global positioning technique;

first supplying said first location estimator with first corresponding data obtained from wireless signal measurements communicated between said particular mobile station and one or more of said plurality of transceivers;

second supplying said second location estimator with second corresponding data obtained from wireless signal measurements communicated between said particular mobile station and one or more of said plurality of transceivers;

first generating, by said first location estimator, first location related information having at least a first estimate for said particular mobile station's location;

second generating, by said second location estimator, second location related information having at least a second estimate for said particular mobile station's location;

determining a resulting location estimate of said particular mobile station using: (a) a first value obtained from said first location related information, and (b) a second value obtained from said second location related information.

39. A method for locating a particular wireless mobile station using measurements of particular wireless signals, wherein at least one of: said measurements and said particular wireless signals are transmitted between said wireless mobile station and at least one of a plurality of transceivers, wherein said transceivers are capable of at least wireless detection of a plurality of wireless transmitting mobile stations including said particular mobile station, comprising:

providing a first and second mobile station location estimators, wherein each of said location estimators is capable of providing a location estimate for each mobile station of at least some of said mobile stations when said location estimator is supplied with corresponding data obtained from received wireless signal measurements communicated between the mobile station and one or more of said plurality of transceivers, wherein:

said first location estimator performs one or more coverage area analysis techniques, wherein each said coverage area analysis technique determines for each of one or more of said mobile stations, an area: (i) included in a corresponding coverage area for each of one or more of said transceivers that detect the mobile station, and (ii) excluded from a corresponding coverage area for each of one or more of said transceivers that can not detect the mobile station, and said second location estimator does not perform any said coverage area analysis technique;

first supplying said first location estimator with first corresponding data obtained from wireless signal measurements communicated between said particular mobile station and one or more of said plurality of transceivers;

second supplying said second location estimator with second corresponding data obtained from wireless signal measurements communicated between said particular mobile station and one or more of said plurality of transceivers;

generating, by said first and a second of said location estimators, respectively, first and second different initial location estimates of said particular mobile station;

determining a location estimate of said particular mobile station as a function of at least one of: (a) said first and second initial location estimates, and (b) a rating of said first and second initial location estimates.

40. A method for locating a wireless mobile station capable of wireless communication with a plurality of base stations, comprising:

providing a plurality of mobile station location estimators, wherein said location estimators provide different location estimates of said mobile station when said location estimators are supplied with location information derived from signal measurements that are transmitted between said mobile station and said plurality of base stations;

receiving measurements of wireless signals transmitted: (a) from one or more global positioning satellites, and (b) between said wireless mobile station and said plurality of base stations;

first generating, by a first of said location estimators, a first time series of one or more location estimates of said mobile station when at least a portion of said measurements are obtained for global positioning satellite signals;

second generating, by a second of said location estimators, a second time series of one or more location estimates of said mobile station when at least a portion of said measurements provide measurements of wireless signals transmitted between said mobile station and at least one of base stations of said plurality of base stations;

determining a resulting time series of one or more resulting location estimates of said mobile station, wherein for each time of said resulting time series when one of said resulting location estimates is derived, said derivation uses at least one location estimate: (a) that is most recently generated by said first location estimator, and (b) that is most recently generated by said second location estimator.

41. A method as claimed in Claim 40, wherein said step of determining includes:

establishing a priority between said first initial location estimate and said second initial location estimate.

42. A method as claimed in Claim 41, wherein said step of establishing includes obtaining a confidence value corresponding to at least one of said first initial location estimate and said second initial location estimate, wherein each said confidence value is indicative of a likelihood of said mobile station being its said corresponding initial location estimate.

43. A method as claimed in Claim 41, wherein said step of establishing includes using a first time value associated with said first initial location estimate, and a second time value associated with said second initial location estimate.

44. A method as claimed in Claim 40, wherein said step of determining includes preferring said first initial location estimate over said second initial location estimate when both are available for substantially a same location of said mobile station.

45. A method as claimed in Claim 40, wherein said step of receiving includes receiving a first portion of said measurements in a first time period and a second portion of said measurements in a second time period different from said first time period, wherein said first portion is obtained from a global positioning satellite, and said second portion is derived from wireless signals transmitted between said mobile station and at least one of base station of said first plurality of base stations.

46. A method as claimed in Claim 40, wherein said mobile station is in a vehicle and said step of determining uses deadreckoning estimates of changes in the location of the vehicle.

47. A method as claimed in Claim 40, wherein said step of determining includes evaluating one or more constraints related to one or more of: a velocity of said mobile station, an acceleration of said mobile station, an estimated location of said mobile station in relation of a terrain of said estimated location.

ABSTRACT

A location system is disclosed for commercial wireless telecommunication infrastructures. The system is an end-to-end solution having one or more location centers for outputting requested locations of commercially available handsets or mobile stations (MS) based on, e.g., CDMA, AMPS, NAMPS or TDMA communication standards, for processing both local MS location requests and more global MS location requests via, e.g., Internet communication between a distributed network of location centers. The system uses a plurality of MS locating technologies including those based on: (1) two-way TOA and TDOA; (2) pattern recognition ; (3) distributed antenna provisioning; and (4) supplemental information from various types of very low cost non-infrastructure base stations for communicating via a typical commercial wireless base station infrastructure or a public telephone switching network. Accordingly, the traditional MS location difficulties, such as multipath, poor location accuracy and poor coverage are alleviated via such technologies in combination with strategies for: (a) automatically adapting and calibrating system performance according to environmental and geographical changes; (b) automatically capturing location signal data for continual enhancement of a self-maintaining historical data base retaining predictive location signal data; (c) evaluating MS locations according to both heuristics and constraints related to, e.g., terrain, MS velocity and MS path extrapolation from tracking and (d) adjusting likely MS locations adaptively and statistically so that the system becomes progressively more comprehensive and accurate. Further, the system can be modularly configured for use in location signaling environments ranging from urban, dense urban, suburban, rural, mountain to low traffic or isolated roadways. Accordingly, the system is useful for 911 emergency calls, tracking, routing, people and animal location including applications for confinement to and exclusion from certain areas.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	Group Art Unit: 3662
DUPRAY et al.	)	Examiner: Dao L. Phan
Serial No.: 09/770,838	)	REQUEST FOR EXTENSION OF TIME
Filed: January 26, 2001	)	
Atty. File No.: 1003-1	)	"EXPRESS MAIL" MAILING LABEL NUMBER: EV737752064US DATE OF DEPOSIT: Dec 12, 2005
For: "A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION"	)	I HEREBY CERTIFY THAT THIS PAPER OR FEE IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE "EXPRESS MAIL POST OFFICE TO ADDRESSEE" SERVICE UNDER 37 CFR 1.10 ON THE DATE INDICATED ABOVE AND IS ADDRESSED TO THE COMMISSIONER FOR PATENTS, P.O. BOX 1450, ALEXANDRIA, VA 22313-1450

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

TYPED OR PRINTED NAME: Aimee Thuerk
SIGNATURE: Aimee Thuerk

Dear Sir:

Applicant respectfully petitions for an extension of time under 37 CFR § 1.136(a) of two (2) months to respond to the Office Action mailed on July 12, 2005, with respect to the above-identified application, thereby extending the period for response from October 12, 2005, to December 12, 2005.

Enclosed is a check in the amount of $225.00 as payment for the extension fee.

Respectfully submitted,

By: [signature]

Dennis J. Dupray
Registration No. 46,299
1801 Belvedere Street
Golden, Colorado 80401
(303) 863-9700

Date: Dec. 12, 2005

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	Group Art Unit: 3662
Dupray et al.	Examiner: Dao L. Phan
Serial No.: 09/770,838	INFORMATION DISCLOSURE STATEMENT
Filed: January 26, 2001	EXPRESS MAIL MAILING LABEL NUMBER: EV 788579285 US DATE OF DEPOSIT: January 31, 2006
Atty. File No.: 1003-1	I HEREBY CERTIFY THAT THIS CORRESPONDENCE IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE "EXPRESS MAIL POST OFFICE TO ADDRESSEE" SERVICE UNDER 37 CFR 1.10 ON THE DATE INDICATED ABOVE AND IS ADDRESSED TO THE COMMISSIONER FOR PATENTS, P.O. BOX 1450, ALEXANDRIA, VA 22313-1450
For: A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION	TYPED OR PRINTED NAME: Corina K. Aschenbrenner SIGNATURE: Corina K. Aschenbrenner

Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Sir:

The references cited on attached Form PTO-1449 are being called to the attention of the Examiner.

☒ Copies of the cited non-patent and/or foreign references are enclosed herewith.

☐ Copies of the cited U.S. patents and/or patent applications are enclosed herewith.

☒ Copies of the cited U.S. patents/patent application publications are not enclosed in accordance with the waiver dated July 11, 2003, whereby patent applications filed after June 30, 2003 and international applications that have entered the national stage under 35 U.S.C. § 371 after June 30, 2003 need not submit copies of U.S. patents and U.S. patent application publications.

☐ Copies of the cited references are not enclosed, in accordance with 37 C.F.R. 1.98(d), because the references were cited by or submitted to the U.S. Patent and Trademark Office in prior application Serial No. __________ filed _______________, which is relied upon for an earlier filing date under 35 U.S.C. § 120.

☐ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English abstracts and in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☒ Examiner's attention is drawn to the following co-pending applications, and for at least such applications to which the present application does not claim priority, copies have been or are being submitted:

Serial No.09/194,367	filed	Nov. 24, 1998 (docket no. 1003-PUS)
Serial No.10/262,413	filed	Sept. 30, 2002 (docket no. 1003-2)
Serial No. 10/262,338	filed	Sept. 30, 2002 (docket no. 1003-3)
Serial No. 11/069,441	filed	March 1, 2005 (docket no. 1004-1-1)
Serial No.09/176,587	filed	Oct. 21, 1998 (docket no. 1005-DJD)
Serial No. 10/297,449	filed	Dec. 5, 2002 (docket no. 1010-PUS)
Serial No. 10/337,807	filed	Jan. 6, 2003 (docket no. 1011)

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

It is respectfully requested that the cited information be expressly considered during the prosecution of this application and the references made of record therein.

FEES

☒	**37 CFR 1.97(b)**: No fee is believed due in connection with this submission, because the information disclosure statement submitted herewith is satisfies one of the following conditions ("X" indicates satisfaction): ☐ Within three months of the filing date of a national application other than a continued prosecution application under 37 CFR 1.53(d), or ☐ Within three months of the date of entry into the national stage of an international application as set forth in 37 CFR 1.491 or ☐ Before the mailing date of a first Office Action on the merits, or ☒ Before the mailing of a first Office action after the filing of a request for continued examination under 37 CFR 1.114. Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970.
☐	**37 CFR 1.97(c)**: The information disclosure statement transmitted herewith is being filed after all the above conditions (37 CFR 1.97(b)), but before the mailing date of one of the following conditions: (1) a final action under 37 C.F.R. 1.113 or (2) a notice of allowance under 37 C.F.R. 1.311, or (3) an action that otherwise closes prosecution in the application. This Information Disclosure Statement is accompanied by: ☐ A Certification (below) as specified by 37 C.F.R. 1.97(e). Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970. OR ☐ A check in the amount of $180.00 for the fee set forth in 37 C.F.R. 1.17(p) for submission of an information disclosure statement. Please credit any overpayment or charge any underpayment to Deposit Account No. 19-1970. Election to pay the fee should not be taken as an indication that applicant(s) cannot execute a certification.

☐	**37 CFR 1.97(d)**: This Information Disclosure Statement is being submitted after the period specified in 37 CFR 1.97(c). ☐ This information Disclosure Statement includes a Certification (below) as specified by 37 C.F.R. 1.97(e) AND ☐ Applicants hereby requests consideration of the reference(s) disclosed herein. Enclosed is the fee in the amount of $180.00 under 37 C.F.R. 1.17(p). Please credit any overpayment or charge any underpayment to Deposit Account No. 19-1970.

Respectfully submitted,

By: [signature]

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Date: Jan. 31, 2006

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SHEET 1 OF 1

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	ATTY. DOCKET NO. 1003-1	SERIAL NO. 09/770,838
	APPLICANT DUPRAY, Dennis J.	
	FILING DATE January 26, 2001	GROUP ART 3662

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUB CLASS	FILING DATE IF APPROP.
	1.	6,952,181	10-04-2005	Karr et al.	342	457	
	2.	5,740,048	04-14-1998	Abel et al.	701	200	
	3.	5,515,285	05-07-1996	Garrett, Sr., et al.	701	300	
	4.						
	5.						
	6.						

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUB CLASS	TRANSLATION	
							YES	NO
	7.	WO 96/20542	07-04-1996	PCT	H04B	15/00		
	8.	WO 98/14018	04-02-1998	PCT	HO4Q	7/20		
	9.							

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

	10.	
	11.	

EXAMINER	DATE CONSIDERED
*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

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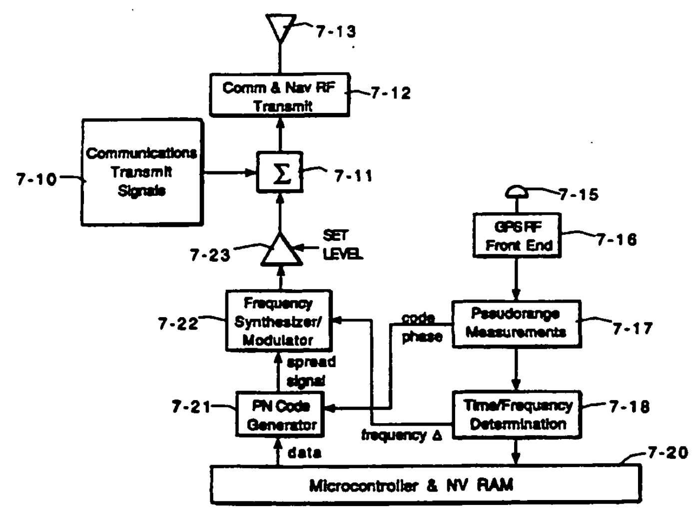

(57) Abstract

A cellular telephone system (figure 1) having three or more cell sites with each cell site having a source of cellular communication signals (7-10) and an RF transmitter (7-12) and antenna (7-13) for broadcasting the cellular communication signals. A direct sequence spread spectrum waveform carrying navigation signals is embedded in the cellular communication signals, including controlling the signal strength of the navigation signals so that the combined energy of the navigation signals from all cell sites at any location is at least a predetermined energy level below the energy level of the cellular communication signals. Each cell site includes timing for timing the operation of a GPS receiver.

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Position enhanced communication system

BACKGROUND OF THE INVENTION:

Wireless communications are rapidly augmenting conventional telephone communications. In conventional telephone communications, emergency 911 service has been in existence for a number of years and has evolved and been upgraded over time. Currently, from most wired telephone systems, an "Enhanced 911" service is available. In Enhanced 911 service, the emergency center receiving the call automatically learns the phone number, location and identity of the calling party. Such information is necessary for rapidly dispatching the required help to the correct location, and for call-back to the party that reported the emergency, if required. Indeed, Enhanced 911 is so common, that there is an expectation and assumption by the public, that such service is available in the wireless world. However, at the current time, Enhanced 911 service does not exist for cellular telephony which is the most mature wireless communication system in the United States. At the current time, an emergency center that receives a call dialed from a cellular telephone, has no idea where the party is calling from and does not know the phone number or identity of the phone subscriber. Furthermore, there exists no infrastructure or standard for providing Enhanced 911 service in cellular and other wireless communications systems.

Determining the position of the calling terminal making a wireless call is a key requirement for providing Enhanced 911. A number of alternatives for determining position of a caller are based upon the calling terminal estimating its position with the support of auxiliary equipment and/or the use of broadcast RF beacons. Available options for position location at the calling terminal are as follows:

1. Broadcast Navigation RF Beacons: GPS and Loran are two examples.

2. Commercial Broadcasts as Navigation Beacon Surrogates: such as using the broadcasts of AM, FM or TV for determining position. (See, for example, U.S. Serial No. 08/203,257, and PCT Application No. PCT/US93/12179, incorporated herein by reference)

3. Base Station to Mobile/Portable Terminal Broadcasts as Navigation Beacon Surrogates: such as using the broadcasts from multiple cellular base stations.

4. Dead Reckoning and other forms of Inertial Navigation: such as using the speedometer output of a vehicle in combination with a gyroscope to detect turns.

Because of the variety of wireless environments and services, none of these options provides a universal solution for determining position of the calling terminal. For example, in the cellular world, there are two distinctly different environments for mobiles and portables. Mobile terminals are defined as those that are installed in and operate from vehicles. Thus the locations for the mobile environment are restricted to places that a vehicle may go. Portable terminals are defined as hand-held devices and so portables will be used anywhere that a person may go with or without a vehicle. Thus mobiles and portables are different insofar as the places that they are required to operate in. Mobiles must work primarily on streets and highways where there is often a clear view of the GPS constellation; and when there is not, such as in the "urban canyon," GPS position fixing is still possible, albeit on an interrupted basis. Portables however, will be used inside buildings, shopping malls, and parking garages where cellular communications signals penetrate, but GPS signals do not. Furthermore, mobiles (unlike portables) are not particularly constrained with respect to size and power; thus, the vehicle that hosts the mobile can support the power required for continuous position fixing; they can support the equipment needed for dead reckoning; and finally, they provide a platform on which to attach antennas (i.e., GPS) that must be mounted in a fixed orientation.

DESCRIPTION OF THE INVENTION:

The object of this invention is to provide a system with world-wide capability for position determination via broadcast of RF navigation signals.

The overall system comprises the following three elements: 1) the GPS system, 2) GPS-like signals broadcast at an alternative frequency, and 3) GPS-like RF signposts.

The first element of the system, GPS, provides world-wide positioning as long as the view to the GPS constellation is not obstructed. With GPS, a receiver determines its position by measuring the pseudorange of spread spectrum signals broadcast by the GPS satellites at 1575.42 MHz.

The second element is the novel concept embedding GPS-like signals within the communications bandwidth of a wireless communications systems. This is similar to the concept of GPS pseudolites that have been proposed for aviation navigation, but the navigation signals proposed here are not at GPS frequencies.

Rather they are at and share the same bandwidth with communications frequencies. The concept is flexible so that a variety of existing communications systems can have embedded navigation signals. Because of its widespread implementation, the US cellular telephone system is a particularly attractive environment for embedding navigation signals. However, the concept of embedded navigation signals applies to digital TDMA and CDMA cellular, GSM, and emerging systems in the PCS bands as well as those that operate in the ISM bands. The position determination supported by this second element serves as a supplement or replacement of the GPS system in any region or environment that is covered by that wireless communication system. This includes the urban canyon, but also indoor environments such as shopping malls and buildings which are serviceable by cellular telephone and other wireless communications systems. In this second element, a GPS-like receiver in the mobile/portable communications transceiver makes pseudorange measurements on the broadcast sources and calculates the position of the receiver from these measurements. The operation of this system is described below.

The third element is another novel concept that involves the use of GPS-like RF broadcasts that mark the location of the broadcast. The range of this broadcast is designed to be short (≈ 100 feet) so that the mere reception of this broadcast and reading the data location marker in the signal determines the position of the receiver to within 100 ft. These broadcast signals are referred to as RF Signposts. RF Signposts can be used indoors and can successfully convey address and floor of a building or locations in a shopping mall, etc., while ranging systems that are inherently corrupted by severe multipath in the indoor environment cannot.

DESCRIPTION OF THE DRAWINGS:

The above and other objects, advantages, and features of the invention will become more apparent when considered with the following specification and accompanying drawings wherein:

FIG. 1 is a block diagram of a cellular base station having incorporated therein a navigation signal generator,

FIG. 2 is a diagram depicting the overall system for seamless and comprehensive position locations,

FIG. 3 is a diagram illustrating a mobile terminal taking pseudorange measurements to three cellular telephone base stations,

FIG. 4a is a diagrammatic analysis of the impact of a spread spectrum navigation signal on the signal-to-noise ratio (SNR) of a conventional communications signal,

FIG. 4b is a diagrammatic analysis of the impact of a set of communication signals on the SNR of a navigation signal,

FIG. 5 is an illustration of a mobile terminal in a 7-cell cluster of a cellular communication system,

FIG. 6a is an analysis of the impact of navigation signals on the SNR of a communications signal with the mobile unit being located at Point E in Fig. 5,

FIG. 6b is an analysis of the impact of the communication signals on the SNR of a navigation signal when the mobile unit is located at Point E in fig. 5,

FIG. 6c is an analysis of the impact of a navigation signal from a far base station with the mobile unit at Point F in Fig. 5,

FIG. 7 is a block diagram of one configuration of a navigation signal generator embedded in a cellular base station,

FIG. 8a is a block diagram of a low power RF position signpost,

FIG. 8b is a diagrammatic layout of a large building in which the position signposts are distributed,

FIG. 8c is a diagrammatic layout of a large shopping mall or center where the RF position signposts are distributed at fixed locations,

FIG. 9 is a block diagram of one embodiment of a communication terminal with universal position determination capability.

DETAILED DESCRIPTION OF THE INVENTION:

GPS-like Signals Embedded Within Wireless Communications Systems

Application Serial No. 08/203,257 discloses the use of commercial radio and TV broadcast signals to supplement or even replace GPS positioning in environments where the GPS signals are frequently blocked, or do not penetrate at all. The present invention incorporates another alternative for supplementing or replacing GPS that involves adding a GPS-like navigation signal to the communications broadcasts from cellular and other wireless base station transmitters. As will be shown below, the navigation signal may simultaneously reside in the same frequency band that is used to carry the communications channels. As will be described herein, it is possible to set the navigation (location or position) signal low enough to have no interference impact on the communications, while at the same time, be high enough to be detected, tracked, and support a data rate of 50 bps. Like GPS, the proposed navigation signal is a direct sequence spread spectrum waveform with a chipping rate of 1.023 Mcps and thus occupies a bandwidth (null to null) of about 2 MHz. The chipping phase would be synchronized to a uniform time base and, preferably, is slaved to the GPS system (see fig. 7). The information payload of 50 bps would include such data as the position of the broadcast tower, time markers, and ancillary data to correct phase and frequency offsets of the signal.

The system concept is illustrated in Figure 3 which shows a mobile user MU enclosed or bounded within 3 base stations 10-1, 10-2, 10-3 of a cellular communications system. At any point in time, the mobile unit MU tracks the navigation signals from at least 3 base stations and measures the pseudorange to each of them. Measurements from three base stations are required for a 2D solution and if a 3D solution is desired, then measurements from 4 base stations are required. For the 2D case this may be understood as follows:

- 3 Measurements result in three equations that embody the range from the mobile to the base station; these three equations are:

$$PR_1 = \sqrt{(x_1 - x)^2 + (y_1 - y)^2} + c\Delta$$
$$PR_2 = \sqrt{(x_2 - x)^2 + (y_2 - y)^2} + c\Delta$$
$$PR_3 = \sqrt{(x_3 - x)^2 + (y_3 - y)^2} + c\Delta$$

- The PR_i are the values of the 3 pseudorange measurements, the x_i, y_i are the 2D coordinates of the 3 base stations, and c is the speed of light.
- Each equation shares 3 common unknowns: the x,y coordinates of the mobile, and the uncertainty in the time of measurement (Δ).

Thus the 3 equations are sufficient to solve the 3 unknowns that determine the position and time offset of the mobile. The algorithm for a 3D solution is a simple generalization of the 2D algorithm.

GPS-Like RF Signposts

Like GPS, the RF Signpost navigation signal of this invention is a direct sequence spread spectrum waveform with a chipping rate of 1.023 Mcps and thus occupies a bandwidth (null to null) of about 2 MHz. The chipping phase would not have to be synchronized with any time base so that the cost of an RF Signpost would be very low. As shown in Fig. 8a, the data source 8-1 supplied with position or location information (floor, shops, wing. etc. of a building, or walkway, shops, etc. and direction in a shopping mall) is stored in an EPROM 8-2 or other data storage device encoded 8-3 with a PN code 8-4 and phase modulator 8-5 on a carrier 8-6, and broadcast at very low power by antenna 8-7. The information payload of 50 bps would include, at a minimum, data that conveys the position of the signpost. The position data would include a signpost ID which would map to an address based position (e.g., 100 Simeon Way, 10th floor, suite #1024) and possibly also to a 3D coordinate position. The RF Signposts are of sufficiently low power so that they have a very limited range. The transmission of a Signpost ID would convey the fact that the mobile/portable terminal is within some 100 feet or so of the signpost. The frequency of the RF Signpost broadcast is flexible. In the indoors, the Signposts could actually be at the GPS frequency w/o causing interference to the signals broadcast by the GPS constellation. Signposts can also broadcast at the communications frequencies (of cellular and PCS systems) as well as at ISM frequencies. In addition, Signposts may also be broadcast in signal structures that are different from that of GPS.

Interference Analysis of Embedded Navigation Signals

This section illustrates how navigation signals may be embedded under the communications signals of a communications system without causing any significant mutual interference between the two signals. In Fig. 4, the analysis is shown for broadcasts from a single source. In Fig. 6, the interference analysis is expanded to include broadcasts from multiple base stations within a cellular system. In this discussion, the AMPS cellular telephone communications system is assumed, but the methodology and results are applicable to any similar communications system, both analog and digital. In fact, the invention will work whenever the following constraint can be obeyed:

$$\text{Spreading Gain} > SNR_C \cdot SNR_N$$

Where the spreading gain applies to the embedded SS navigation signal (=43 dB=100 Mcps/50 bps) and SNR_C and SNR_N are the desired signal to noise ratios for the communications and navigation signals, respectively.

Navigation and Communications Broadcasts from a Single Common Base Station

In order to support the required pseudorange measurements, the navigation signals must be broadcast at a level such that the signal to noise ratios (SNR) of the communications channels are not affected, but the SNR of the navigation signal is sufficient to support 50 bps. In this discussion, the noise term in the SNR is assumed to include interference terms as well as contribution from thermal noise. Below, an interference analysis between communications and navigation signals in a cellular communications system is described.

Consider a wireless cellular communications base station that broadcasts a number of communications channels that are separated by frequency. The communications broadcasts from this system are as follows:

- B_C = the bandwidth of the communications channels
- E_C = signal strength of a single communications with bandwidth B_C
- I_C = Interference to E_C from other communications channels of the system; this includes:

-adjacent channel interference from signals broadcast by the cell site base stations and from signals broadcast by other cell site base stations.

-co-channel interference from signals broadcast by other cell site base stations.

For a system in which the receiver noise density is given by N_0, the signal to noise for the communications signal is given by:

$$\left(\frac{S}{N}\right)_{Comm} = \frac{E_C}{I_C + N_o B_C}$$

In typical cellular environments, the communications signal to noise is typically 18 dB or greater in order to support good voice quality. This is illustrated in the signal level diagram in Figure 4a. Now imagine an additional navigation signal with an energy E_N that is spread across M communications channels. In such a case the signal to noise ratio of the communications signals are degraded slightly as follows:

$$\left(\frac{S}{N}\right)_{Comm} = \frac{E_C}{E_N/M + I_C + N_o B_C}$$

However, as indicated in Figure 4a, it is proposed that the level of E_N/M be set 10 dB below the level of I_C (or 28 dB below E_C) so that the impact of a navigation signal on the communications signal to noise ratio is negligible.

While, the impact of the navigation signal is negligible, the set magnitude of E_N is sufficiently high so that the signal to noise ratio of the navigation signal can support a 50 bps data rate. The navigation signal to noise may be derived by noting that the sum of the communications signal energy and interference (E_C + I_C) divided by the communications bandwidth (B_C) acts as an additional term to the noise spectral density. Thus the signal to noise density of the navigation signal to noise ratio is as follows:

$$\left(\frac{S}{N}\right)_{Nav} = \frac{E_N}{\left[(E_C + I_C)/B_C + N_o\right] B_N}$$

where B_N is the noise bandwidth associated with the 50 bps data rate of the navigation signal. As seen in Figure 4a, E_C dominates I_C so that the navigation SNR is very nearly approximated as follows:

$$\left(\frac{S}{N}\right)_{Nav} = \frac{E_N}{\left[E_C/B_C + N_o\right]B_N}$$

As illustrated, in Figure 4b, for the set of assumed parameters, this signal to noise ratio is 15dB and thus is easily able to support reliable data transfer. In addition, it is significant to note that the navigation signal is 15dB higher than the communications signals are above their respective thermal noise floors. Thus the navigation signals should have the same or better margin for building penetration as the communications signals.

Interference Among Broadcasts within a Cellular System

In Figure 5, the geometry and interference scenarios among broadcasts from a cluster of 7 adjacent base stations 5-1, 5-2, 5-3, 5-4, 5-5, 5-6, and 5-7 are illustrated. It is assumed that each base station uses roughly 1/7 of the allocated spectrum and that the channels used by each base station are distributed throughout the spectrum. This assumption is roughly consistent with channel assignment in the current AMPS cellular telephone system. Thus within the 2 MHz of the navigation signal, each base station transmits communications signals on 1/7 of the spectrum. The interference analysis is considered at two positions: E and F. The analysis at point E is a worst case for the interference impact of the navigation signals on the communications signals and it determines the relative level that the navigation signals must be set at. The analysis at point F is a worst case for the interference impact of the communications signals have on the navigation signal.

At point E which is midway between 3 base stations, there are 3 navigation signals of equal strength converging there. If we assume that all navigation signals share the same frequency, then these 3 signals interfere with a communications channel within the 2 MHz band. In this environment, the SNR of a communications signal is as follows:

$$\left(\frac{S}{N}\right)_{Comm.,E}=\frac{E_C}{3E_N/M+I_C+N_oB_C}$$

If the strength of the navigation signals are set (as indicated by "set level" in Fig. 7) so that the combined interference from the 3 signals is 28dB below the energy in a communications channel, the navigation signals will not have any significant degrading impact on the communications. This is illustrated in Figure 6a.

In Figure 6b, the interference analysis at point E of the communications signals on the navigation signals is illustrated. In this case, we assume that the three surrounding base stations have communications channels that occupy 3/7 of the 2 MHz band. Thus the navigation SNR is as approximately expressed as follows:

$$\left(\frac{S}{N}\right)_{Nav.,E}=\frac{E_N}{\left[3E_C/7B_C+N_o\right]B_N}$$

Then since, $3E_N$ is set 28dB below E_C, it follows that E_N is 29dB below (3/7)M E_C. With a spreading gain of 43dB, it follows that the SNR of the navigation signal is 14dB since the contributions to interference from other terms are negligible.

At point E, all the signals are equidistant from the base stations, so that there is no range loss differential to consider. However, when the mobile is at point F it is very close to base station #1 and the range loss differential between the signals broadcast by #1 vs the 6 adjacent base stations can be quite large. In this case, the energy of the communications signals broadcast from base station #1 are far stronger than the interfering navigation signals so that there is no significant interference impact of the navigation signals on the communications signals. Figure 6c shows the results of the interference analysis of the communications signals on the navigation signals when the mobile is at point F. In particular, this shows the analysis for receiving a navigation signal that is transmitted by one of the adjacent base stations that is relatively far away and therefore suffers a range loss. In this simplified analysis, the range loss differential is accounted for by adding a gain coefficient G on all the signals broadcast by base station #1. There are 3 sources of potentially significant interference to consider for a navigation signal broadcast by an adjacent base station:

1. The communications signals from the 6 adjacent base stations.
2. The communications signals from base station #1.

3. The navigation signal from base station #1.

The SNR of the navigation signal considering these interference sources are as follows:

$$\left(\frac{S}{N}\right)_{Nav,F} = \frac{E_N}{\left[(6E_C/7 + GE_C + GE_N/M)/B_C + N_o\right]B_N}$$

With respect to the first source, the adjacent stations are assumed to occupy 6/7 of the 2 MHz navigation signal bandwidth. Figure 6c indicates that the SNR between this and navigation signal and this source is 12.5dB.

With respect to the second interference source, it is seen that the SNR is about 20.5 dB-10 logG. This term is clearly problematic since it says that whenever G is as large as 10, the SNR is less than 10 dB and we cannot operate reliably. In typical cellular systems, the differential range losses are much larger than 10. This would mean that whenever the mobile was close to a base station, the navigation signals of the adjacent stations would be jammed and only the local navigation signal could be received. This interference situation can be significantly ameliorated if the local navigation signal broadcasts the channel numbers of the occupied communications frequencies. Then, the mobile receiver for the navigation signals could notch out the occupied frequencies, thereby greatly reducing the interference. The penalty for this action is a signal loss of 1/7 or about 0.7 dB. With such a loss, the 12.5 dB SNR with respect to the first interference source would be reduced to just below 12 dB.

With respect to the third interference source (not shown in Figure 6c), it noted that the navigation signal from base station #1 is 10 logG above a navigation signal from an adjacent base station. Considering the 43 dB spreading gain, the SNR of a weak navigation signal with respect to interference from a strong navigation signal is 43 dB-10logG. This leads to a good SNR even with G as large as 1000. This is a significant amount of differential gain variation which means that pseudorange measurements can be made to multiple base stations over most of the cellular area. The coverage can be further improved by addressing the problem of rear broadcasts interfering with a broadcast from a far base station. This can be accomplished in two ways: 1) multiple frequencies (3 at a minimum) can be for navigation signals and allocated so that no neighboring base stations broadcast at the same frequency, 2) navigation signals can be pulsed in coordination with adjacent base stations so that adjacent base stations do not broadcast simultaneously (e.g., in 3 second cycles in which 3 adjacent stations take turns with broadcasting of 1 second duration.

Referring now to Fig. 7, the base station includes a source 7-10 of conventional base station communication transmit signals which are supplied via summer 7-11 to conventional base station transmitter 7-12 and broadcast on base station antenna 7-13 in the usual manner for any given cellular telephone system. The present invention embeds the CDMA navigation beacon discussed above under the communication signals at the base station. In this embodiment, a GPS antenna 7-15 supplies GPS signals to the conventional GPS RF front end 7-16 and conventional pseudorange computations in 7-17 and time/frequency determinations 7-18 provided to microcontroller 7-20, which has a non-volatile RAM. Data for that base station (such as station identity, location, etc. corresponding in general to data transmitted from a GPS satellite) from microcontroLler 7-20 are overlaid or spread with the PN code 7-12 (whose phase is controlled by a signal based on the pseudorange measurements). The spread signal is modulated in modulator 7-22 (which incorporates a frequency synthesizer which receives a control signal from time frequency circuit 7-18 of the GPS portion of the circuit so that the accurate GPS clock is used as a common time base for all of the base stations. According to the invention, the strength of the navigation signal is set so that the combined interference from a predetermined number N of navigation signals at any point is at least a predetermined level below the energy in the communication channel. In the embodiment illustrated in Fig. 7, the level is set by control amplifier 7-23. The controlled signal level of the navigation (location or position) signal is summed in summer 7-11 with the conventional base station communication signals and then processed and broadcast in the usual manner.

Description of System Operation

With the 3 system elements described above, a mobile or portable communications terminal will be able to determine its position at any location and in virtually any environment. Figure 9 illustrates the logical block diagram of the most general terminal that would be used for position determination. The diplexer 9-21, amplifier 9-24S, 9-24R, modulator 9-25, demodulator 9-26 are conventional. Note that there are three potential RF paths into the terminal. Path A (from coupler 9-10, amplifier 9-11, and filter and downconverter 9-12) intercepts navigation signals that are embedded within the communication frequencies and pseudorange measurements made in 9-13 from which a position calculation 9-14 is made and provided to microcontroller 9-15, and utilization device 9-16, which may be a display (LCD or printed) a recorder, or a speaker. Path B includes GPS RF front end 9-17 which intercepts the navigation signals from the GPS satellites with an antenna and low-noise pre-amplifier in the RF front end. Path B could also receive transmissions of the RF Signposts as well, if on that frequency . Finally, path C uses an RF path at an alternative frequency (e.g., 900 MHz ISM) to receive, either GPS-like signals or other Signpost signals at that frequency. Note that all three paths, A, B, and C have separate front ends, but share the middle and end stages of the GPS receiver that:

1) acquires and tracks the signals, thereby making the pseudorange measurements, and
2) demodulates and interprets the received data, and calculates the terminal position.

In regions where there are no RF navigation signals other than GPS, the terminal will determine its position via the GPS constellation. The GPS receiver has an interface with communications terminal so that position can be sent via a control channel or assigned channel of the communication system.

When the terminal is in a region where the communications system provides embedded navigation signals, the terminal receives these signals via the same antenna 9-20 and diplexer 9-21 as for communication signals. Some of the received signal power split off by coupler 9-10 at the receiver front end for the processing of the navigation signals. After filtering and downconversion 9-12 to a common IF, the received signal is routed to the Pseudorange Measurement stage 9-13 of the GPS receiver. Typically, the strongest signal will be acquired and demodulated first. Sometimes, as discussed above, when a mobile/portable is near the base station, the communications broadcast will jam the navigation signals from more distant base stations. However, the navigation signal from the same base station will always be strong enough to be demodulated. This signal will have data that identifies the occupied communication channels of the nearby base station. With this information, the receiver will implement a notch filter within the 2 MHz band of the navigation signal that will effectively eliminate the interference of the strong communications signals. In this manner, the receiver will be capable of simultaneously measuring the pseudorange to multiple stations, even when the receiver may be quite near a base station.

Finally, when the portable phone passes by or is near an RF Signpost, the signal will be received and demodulated along path C. Sometimes, the position may be also determined from multiple RF signals. For example, at an indoor location with a region served by a cellular communications system with navigation signals, the receiver will typically determine a position via pseudorange measurements. However, if the building contains RF Signposts, the receiver will also have a position of the last Signpost seen. This is advantageous for two reasons:

1) Multipath in the indoor environment will typically prevent position sufficiently accurate to determine the floor level.
2) Even if altitude was determined with sufficient accuracy, there may not be a database that maps the altitude/lat/lon coordinates into the floor level of a building address.

As described above, the Signpost data will contain an ID and other information that will map to a building address, floor number, or even suite.

As a prelude to establishing a communication connection, the communications terminal in Figure 9 will make a positioning measurement as described. As part of the communications setup, the terminal will convey the position to the communications system (e.g., using the control/set-up channel in amps). Thus the communications system can route the call based on knowledge of position, and may also provide that position to the call destination. Once the call is connected, the communications terminal can also send the position to the call destination. With such position capabilities, the requirement of Enhanced 911 to know the position of a calling terminal is satisfied. These capabilities can also support the services of roadside assistance and fleet management via other special dialing codes. Finally, if positional information is embedded in all calls, this capability can also deter theft, fraud and abuse of wireless communications services.

The Invention Features the Following

1) The use of direct sequence spread spectrum (DSSS) waveform in a cellular coverage arrangement to provide terrestrial navigation to augment or replace GPS navigation.

2) The use of RF broadcasts (RF Signposts) that convey the location to a receiver using GPS-like or other digital RF waveform.

3) The reuse of communications frequencies of a cellular communications system to broadcast navigation beacons from the cell site base stations.

4) The level-setting technique for embedding the DSSS navigation beacon within the same band that is occupied by the communications frequencies so that the mutual interference between the communications signal and the navigation beacons are negligible.

5) The use of frequency notching within the navigation receiver to eliminate the interference caused by any narrow band communications broadcasts of the cellular communication system.

6) The use of navigation beacons at multiple frequencies to avoid near-far interference in a cellular array of navigation beacon. A 3 frequency system would be comprised of a center frequency and a frequency on either side offset by about 1 MHz (e.g. in the first null).

7) The use of time pulsing to avoid the near-far interference problem in an array of navigation beacons so that adjacent navigation beacons do not broadcast simultaneously, but

coordinated in a time-division multiplexed scheme.

8) The integrated system composed of GPS, navigation beacon broadcasts in a cellular coverage, and RF Signpost broadcasts, that provide seamless positioning worldwide in outdoor and indoor environments.

It will be appreciated that the CDMA navigation or position information embedded in the communication signals of the wireless communications system can be used separately without any GPS channels and without the RF signpost feature.

While the invention and preferred embodiments have been shown and described, it will be appreciated that various other embodiments, modifications and adaptations of the invention will be readily apparent to those skilled in the art.

WHAT IS CLAIMED IS:

CLAIMS

1. In a cellular telephone system having three or more cell sites with each cell site having a source of cellular communication signals and an RF transmitter and antenna for broadcasting said cellular communication signals, the improvement comprising:

means for embedding a direct sequence spread spectrum waveform carrying navigation signals in said cellular communication signals, including means for controlling the signal strength of said navigation signals so that the combined energy of said navigation signals from all said cell sites at any location is at least a predetermined energy level below the energy level of said cellular communication signals.

2. The cellular telephone system defined in claim 1 wherein the following constraint is applied:

$$\text{Spreading Gain} > SNR_C \bullet SNR_N$$

where the spreading gain applies to the embedded SS navigation signal (=43 dB-100 Mcps/50 bps) and SNR_C and SNR_N are the desired signal to noise ratios for the communications and navigation signals, respectively.

3. The cellular telephone system defined in claim 1 wherein said system is an AMPS cellular telephone communications system and said predetermined energy level is 28db.

4. The cellular telephone system defined in claim 1 or claim 2 or claim 3 wherein each said cell site includes timing means and means for timing the operation of said means for embedding, GPS receiver means for receiving and detecting GPS satellite signals, and means to derive control signals from said GPS satellite signals and controlling said timing means by said control signals.

5. The cellular telephone system defined in claim 1 including mobile cellular transceiver means having transmit channel and receive channel for voice and data communications, means coupled to said receive channel for extracting said embedded navigation signals and means to process the extracted navigation signals to determine the position of said mobile cellular transceiver means.

6. The cellular telephone system defined in claim 5 including a GPS receiver for producing GPS position information and a utilization device connected to selectively receive the position information from said extracted navigation signals and said GPS position information.

7. The cellular telephone system defined in claim 6 including a plurality of low power RF broadcast means, one each at a plurality of scattered geographic locations, each low powered RF broadcast means broadcasting a digital RF waveform of the format of said GPS satellite signal and means to modulate said digital RF waveform with location information identifying said geographic locations, respectively.

8. The cellular telephone system defined in claim 7 including further receiver means for receiving said digital RF waveform and deriving therefrom the geographic location information carried thereby.

9. An RF signpost system comprising a plurality of low powered RF broadcast stations, one each at a plurality of scattered geographic locations, each low powered RF broadcast station broadcasting a direct sequence spread spectrum digital RF waveform or other RF modulation format and means to modulate said digital RF waveform with location information identifying said geographic locations, respectively.

10. In a cellular array of navigation signal beacons, the method of avoiding near-far interference problems, comprising, pulsing the navigation signals from adjacent navigation signal beacons so that adjacent navigation beacons do not broadcast navigation signals simultaneously and coordinating the broadcasts of the navigation signal beacons in a time-division multiplexed manner.

11. In a cellular array of navigation signal beacons, the method of avoiding near-far interference, comprising, using multiple frequencies and time-division multiplexing and coordinating the use of said multiple frequencies and said time division multiplexing to assure avoidance of said near-far interference.

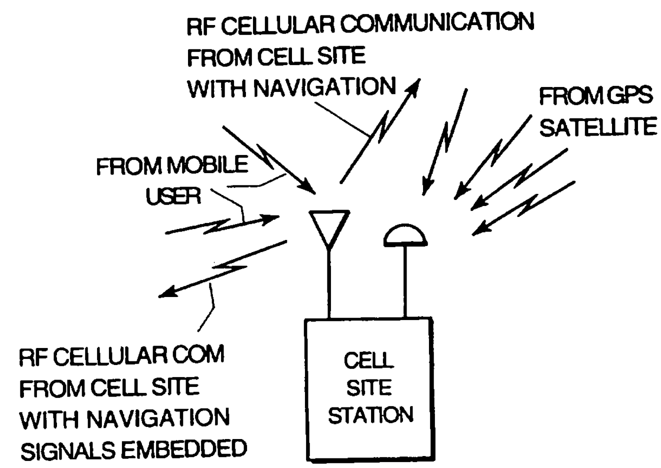

RF CELLULAR COMMUNICATION
FROM CELL SITE
WITH NAVIGATION
FROM GPS
SATELLITE
FROM MOBILE
USER
RF CELLULAR COM
FROM CELL SITE
WITH NAVIGATION
SIGNALS EMBEDDED
CELL
SITE
STATION

FIG. 1

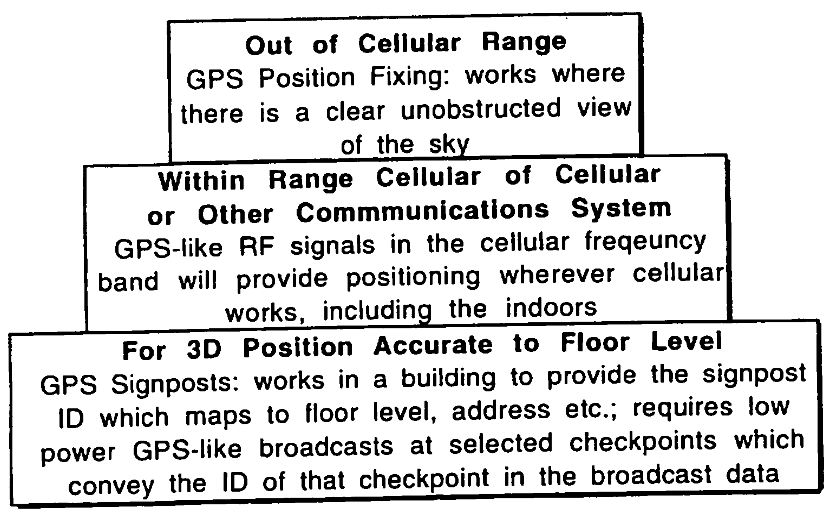

Out of Cellular Range
GPS Position Fixing: works where there is a clear unobstructed view of the sky
Within Range Cellular of Cellular or Other Commmunications System
GPS-like RF signals in the cellular freqeuncy band will provide positioning wherever cellular works, including the indoors
For 3D Position Accurate to Floor Level
GPS Signposts: works in a building to provide the signpost ID which maps to floor level, address etc.; requires low power GPS-like broadcasts at selected checkpoints which convey the ID of that checkpoint in the broadcast data

FIG. 2

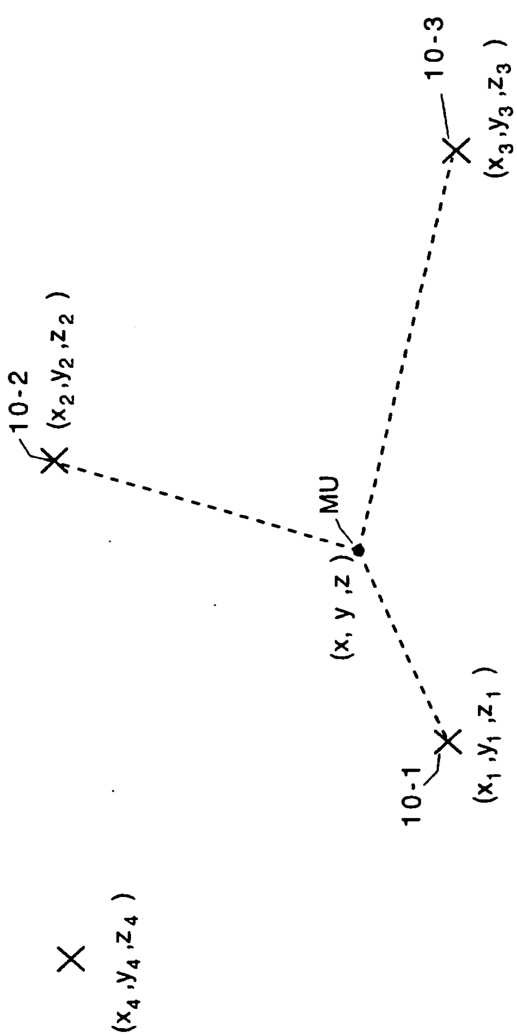


FIGURE 3

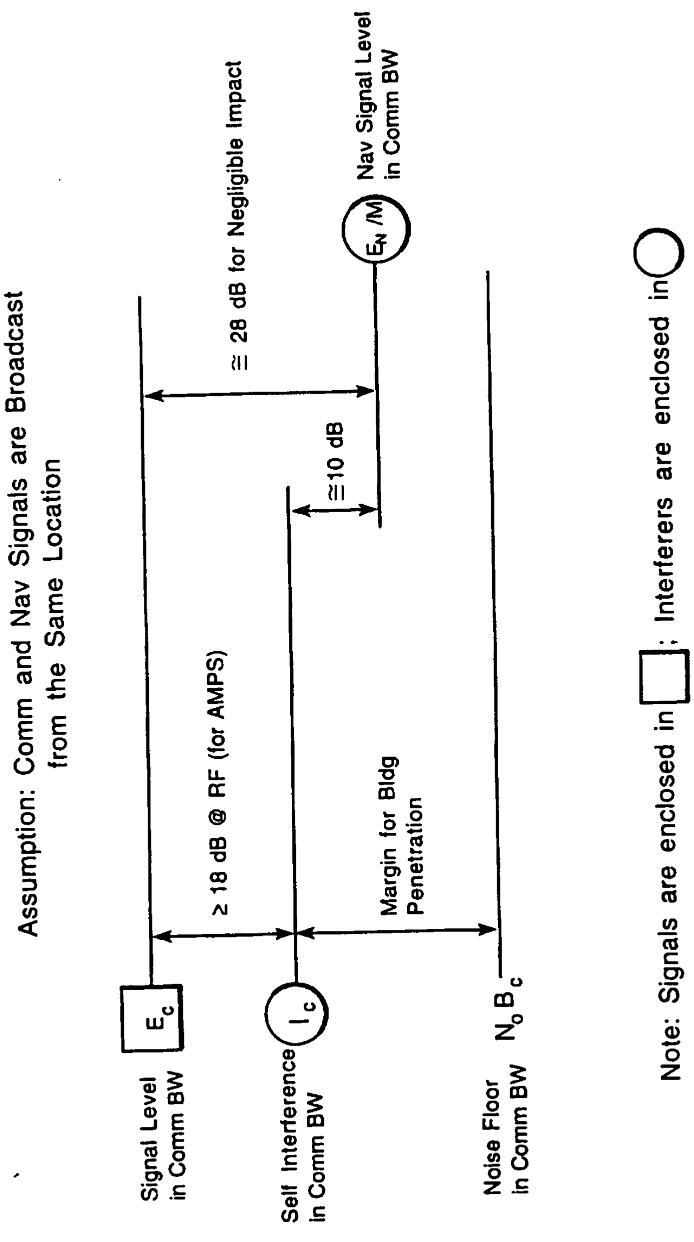
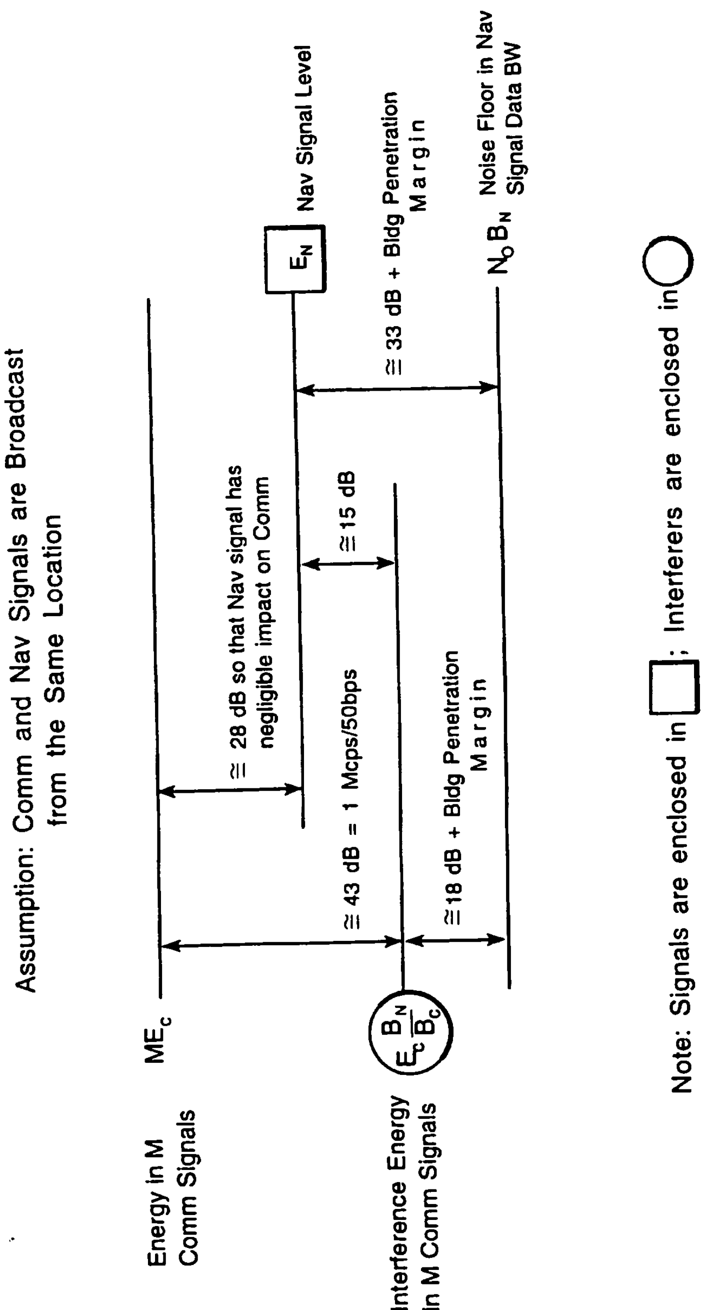

Assumption: Comm and Nav Signals are Broadcast
from the Same Location
Signal Level
in Comm BW
E_c
Self Interference
in Comm BW
I_c
Noise Floor
in Comm BW
$N_o B_c$
≥ 18 dB @ RF (for AMPS)
Margin for Bldg
Penetration
≅10 dB
≅ 28 dB for Negligible Impact
E_N /M
Nav Signal Level
in Comm BW
Note: Signals are enclosed in ☐; Interferers are enclosed in ○

FIGURE 4A



Assumption: Comm and Nav Signals are Broadcast from the Same Location
Energy in M Comm Signals
ME_c
Interference Energy in M Comm Signals
$E_c \frac{B_N}{B_c}$
≅ 43 dB = 1 Mcps/50bps
≅ 18 dB + Bldg Penetration Margin
≅ 28 dB so that Nav signal has negligible impact on Comm
≅ 15 dB
E_N
Nav Signal Level
≅ 33 dB + Bldg Penetration Margin
$N_o B_N$
Noise Floor in Nav Signal Data BW
Note: Signals are enclosed in ☐; Interferers are enclosed in ◯

FIGURE 4B

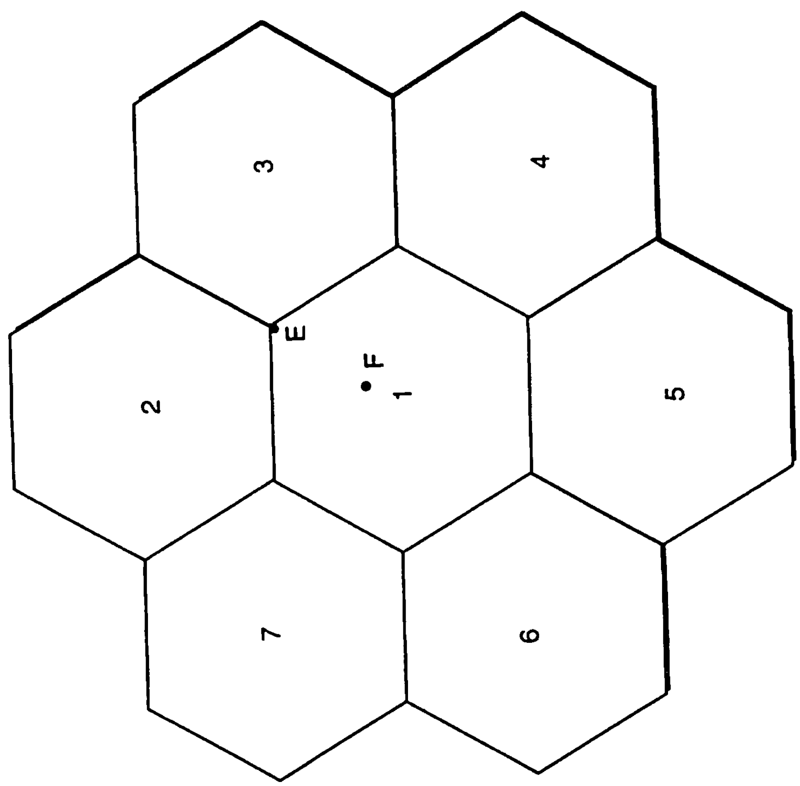


FIGURE 5

Assumption: Mobile is Located at Point E in Figure 5

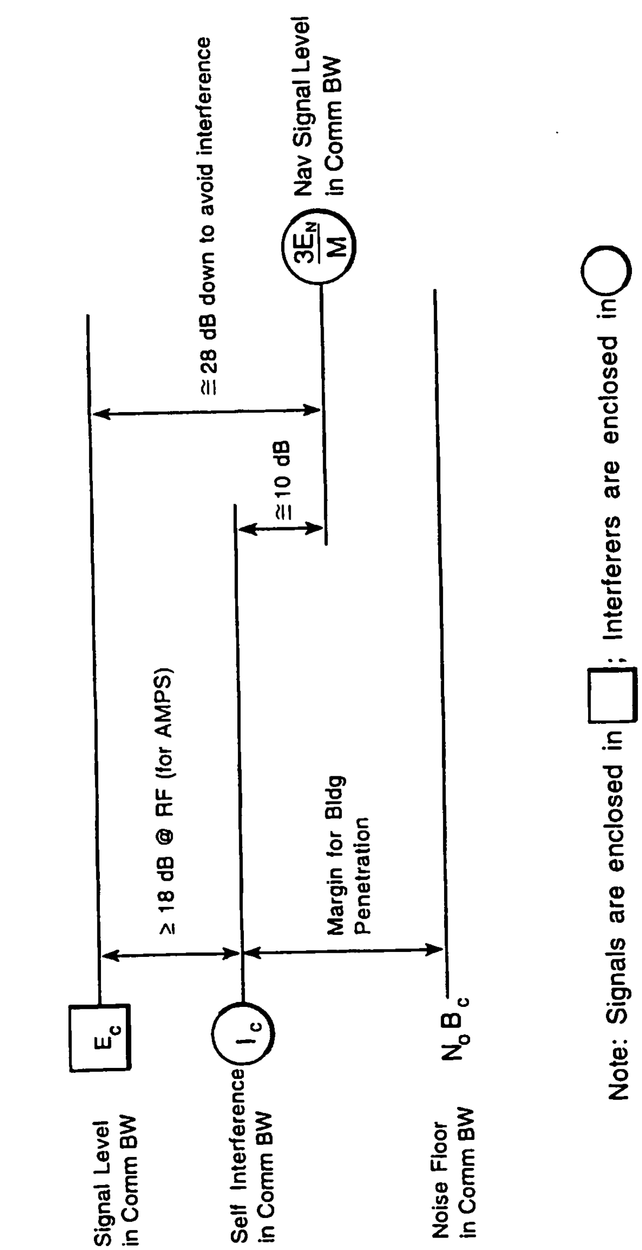


FIGURE 6A

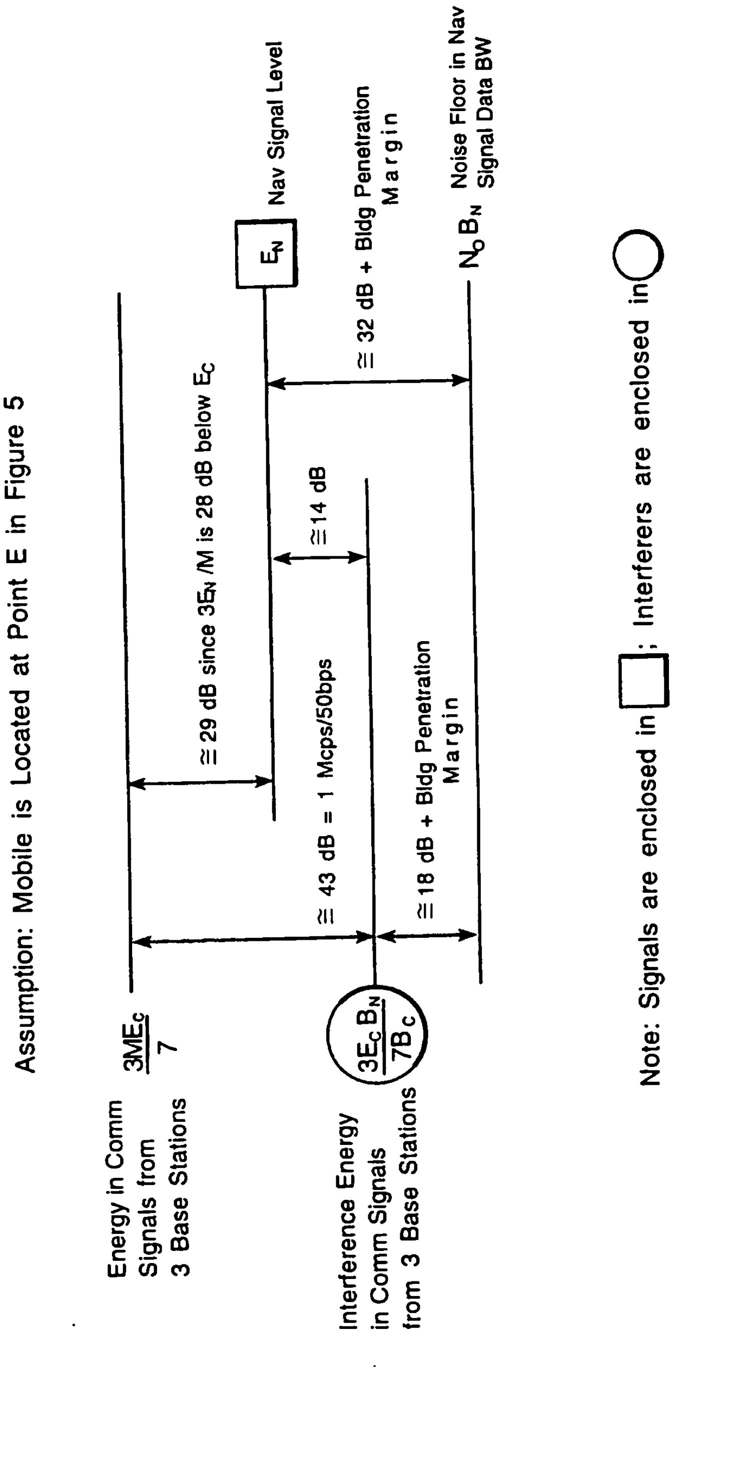

Assumption: Mobile is Located at Point E in Figure 5
Energy in Comm Signals from 3 Base Stations
$\frac{3ME_C}{7}$
≅ 29 dB since $3E_N/M$ is 28 dB below E_C
E_N
Nav Signal Level
≅ 43 dB = 1 Mcps/50bps
≅ 14 dB
Interference Energy in Comm Signals from 3 Base Stations
$\frac{3E_C B_N}{7B_C}$
≅ 18 dB + Bldg Penetration Margin
≅ 32 dB + Bldg Penetration Margin
$N_O B_N$
Noise Floor in Nav Signal Data BW
Note: Signals are enclosed in ; Interferers are enclosed in

FIGURE 6B

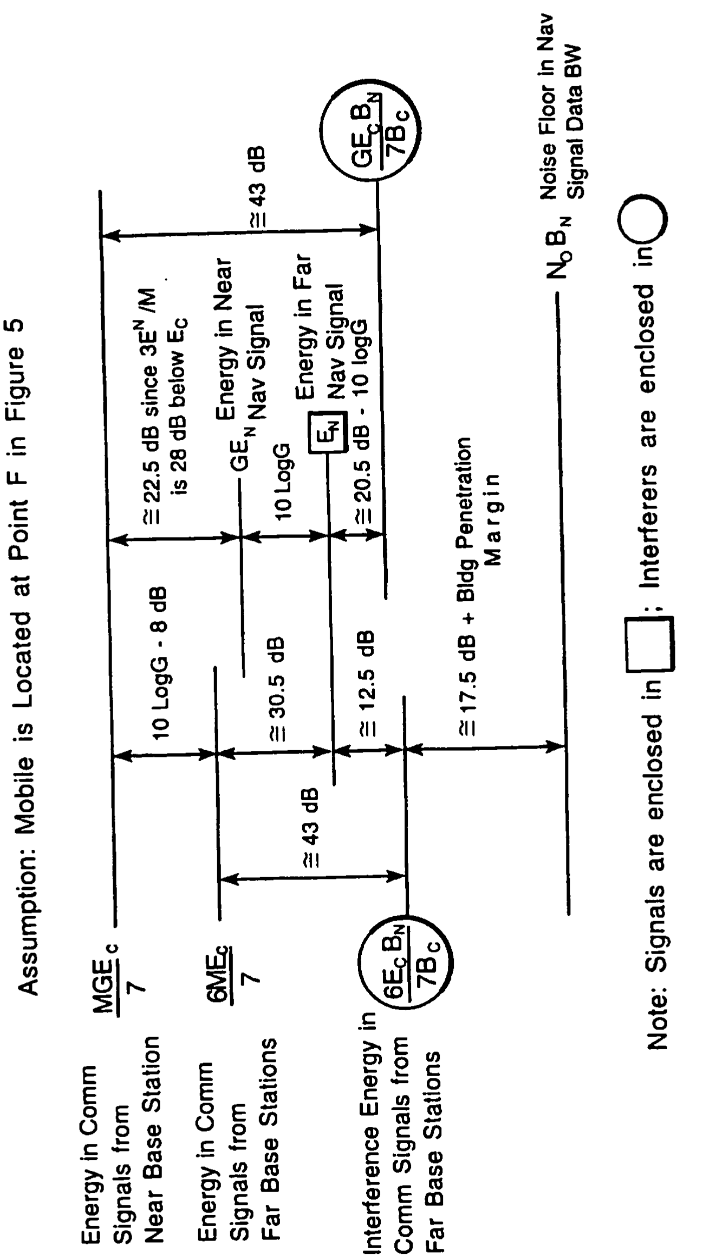

Assumption: Mobile is Located at Point F in Figure 5
Energy in Comm Signals from Near Base Station
MGE_c / 7
Energy in Comm Signals from Far Base Stations
6ME_c / 7
Interference Energy in Comm Signals from Far Base Stations
6E_cB_N / 7B_c
10 LogG - 8 dB
≅ 30.5 dB
≅ 12.5 dB
≅ 17.5 dB + Bldg Penetration Margin
≅ 43 dB
≅ 22.5 dB since 3E^N /M is 28 dB below E_C
GE_N Energy in Near Nav Signal
10 LogG
E_N Energy in Far Nav Signal
≅ 20.5 dB - 10 logG
≅ 43 dB
GE_cB_N / 7B_c
N_oB_N Noise Floor in Nav Signal Data BW
Note: Signals are enclosed in □; Interferers are enclosed in ○

FIGURE 6C

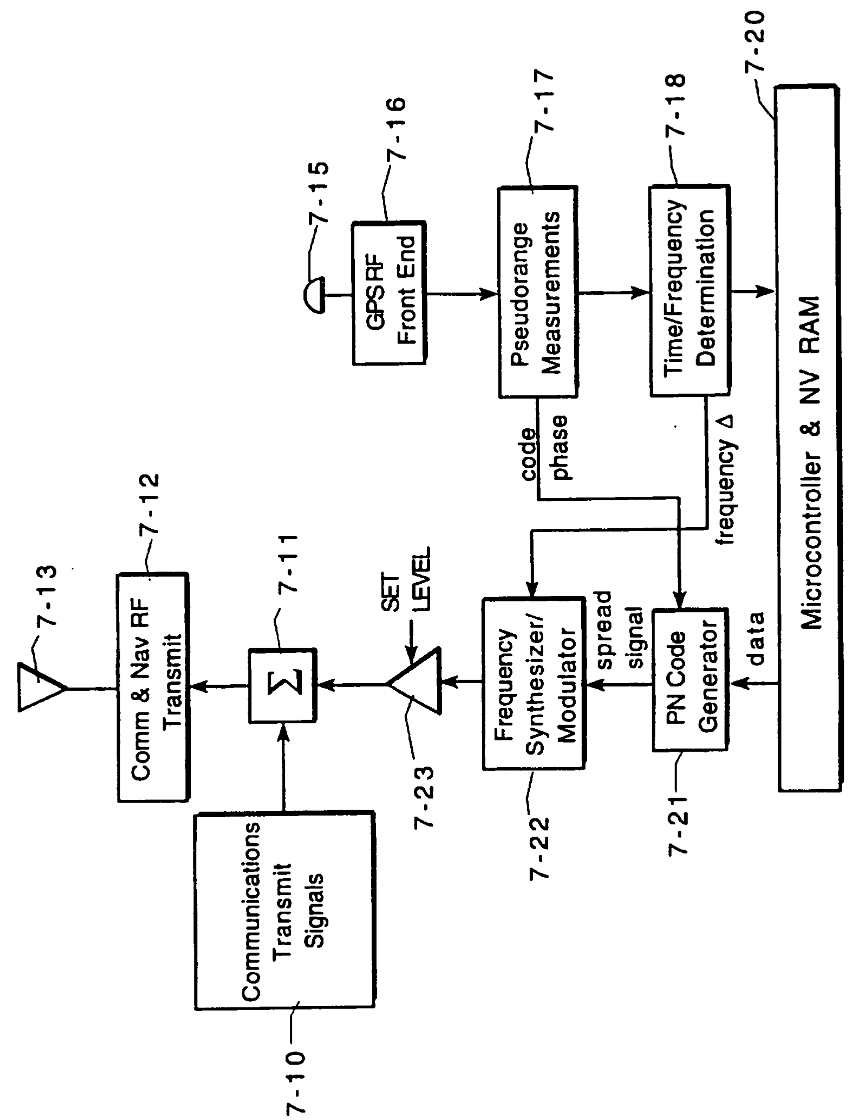

7-10
Communications
Transmit
Signals
7-11
Σ
7-12
Comm & Nav RF
Transmit
7-13
SET
LEVEL
7-23
7-15
7-16
GPS RF
Front End
7-17
Pseudorange
Measurements
code
phase
7-18
Time/Frequency
Determination
frequency Δ
7-20
Microcontroller & NV RAM
Frequency
Synthesizer/
Modulator
7-22
spread
signal
PN Code
Generator
7-21
data

FIGURE 7

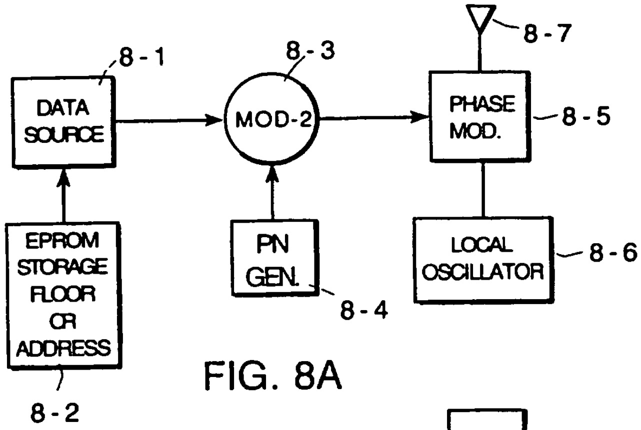


FIG. 8A

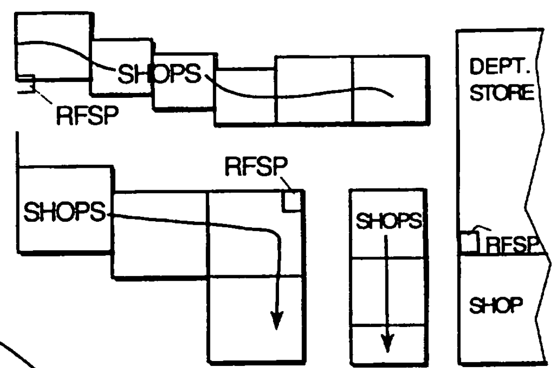


FIG. 8C

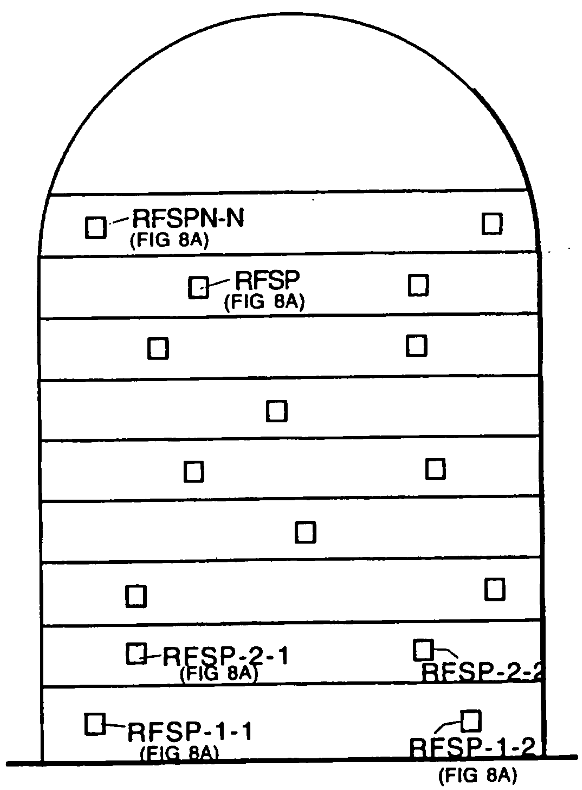


FIG. 8B

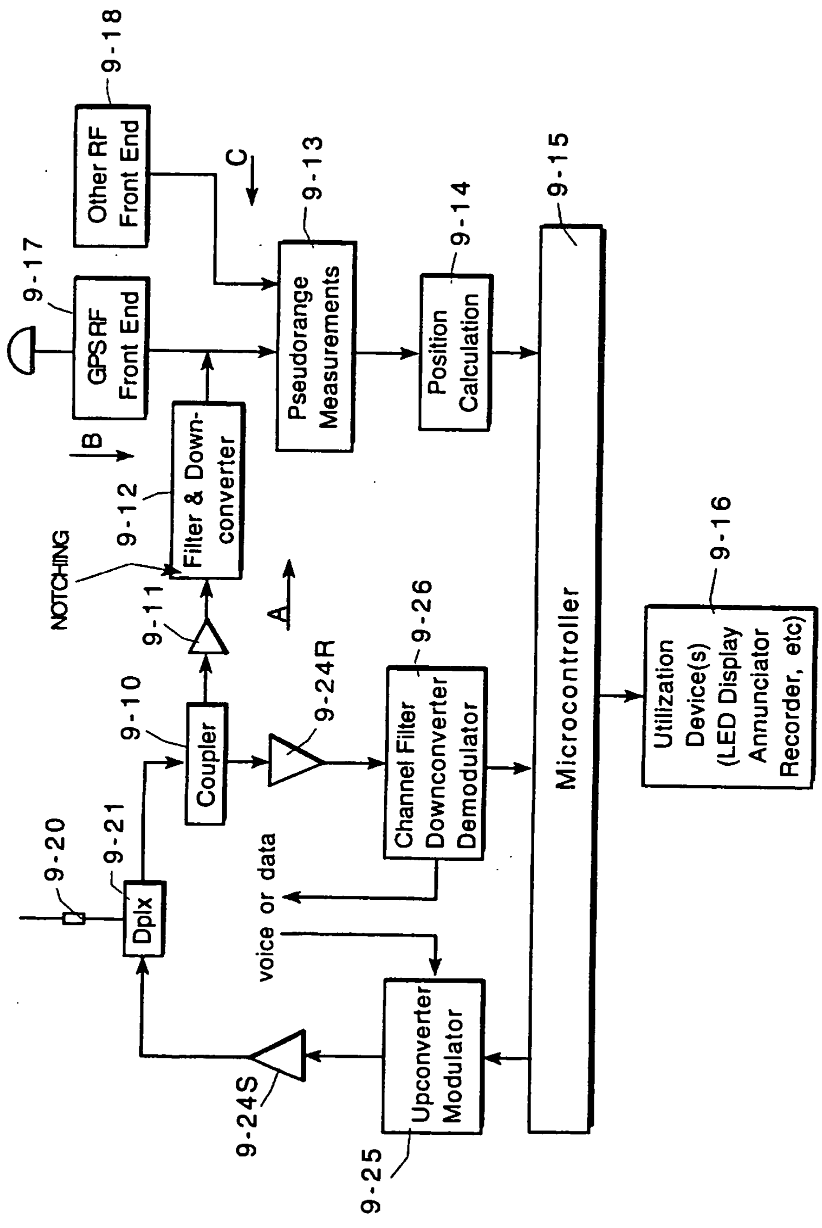

9-18
Other RF Front End
C
9-13
9-17
GPS RF Front End
Pseudorange Measurements
9-14
Position Calculation
9-15
B
9-12
NOTCHING
Filter & Down-converter
9-11
A
9-26
9-24R
9-10
Coupler
Channel Filter Downconverter Demodulator
Microcontroller
9-16
Utilization Device(s) (LED Display Annunciator Recorder, etc)
9-20
9-21
Dplx
voice or data
Upconverter Modulator
9-24S
9-25

FIGURE 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/16019

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL : 375/200, 205, 206; 370/110.4; 342/57; 455/33.1
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 375/200, 205, 206; 370/110.4; 342/57, 58; 455/33.1, 38.3, 54.1, 56.1; 379/59, 63

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS search terms: signpost and geographic location; navigation? and (time division multiplex? or tdm?) and beacon; cellular and gps and (embed? or superimpos? or super impos?)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 4,232,317 (FREENY, Jr.) 04 November 1980, figure 1, abstract, column 1, lines 15-23 and column 2, lines 24-60.	9
A	US, A, 5,235,633 (DENNISON ET AL) 10 August 1993, figure 7, abstract, column 5, line 19 to column 6, line 12.	1-8
X	US, A, 4,914,651 (LUSIGNAN) 03 April 1990, figures 1 & 9 column 1, lines 34-62.	10-11
X	US, A, 5,319,374 (DESAI ET AL) 07 June 1994, figures 1 and 2, abstract, column 4, line 65 to column 5, line 23.	10-11

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 MARCH 1996	05 APR 1996

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	DON N. VO
Facsimile No. (703) 305-3230	Telephone No. (703) 305-4885

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/16019

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

H04B 15/00; H04K 1/00; H04L 27/30; H04J 3/12; G01S 13/00; H04Q 7/00, 9/00

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

Group I, claim(s) 1-9, drawn to a cellular telephone system wherein the direct sequence spread spectrum waveform carrying navigational signals is embedded in the cellular communication signal to form the communicated signals.
Group II, claim(s) 10-11, drawn to a method of avoiding near-far interference problems in a cellular array of navigation signal beacons by using time division multiplexing.

The inventions listed as Groups I and II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:
Group I, claims 1-9, directs to a cellular telephone system in which a direct sequence spread spectrum waveform carrying navigational signals is embedded in the cellular communication signal to form the communicated signals. The energy level of the navigational signals is controlled to the level of at least a predetermined energy level below the energy level of said cellular communication signals.
Group II, claims 10-11, directs to a method of avoiding near-far interference problems in a cellular array of navigation signal beacons by using time division multiplexing.
Apparently, the special technical features of Groups I and II differ in modes of operation and their recognized divergent subject matter.

Form PCT/ISA/210 (extra sheet)(July 1992)*

PCT

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(21) International Application Number: PCT/US97/17786

(22) International Filing Date: 29 September 1997 (29.09.97)

(30) Priority Data:
60/027,453 27 September 1996 (27.09.96) US

(71) Applicant: RUTGERS UNIVERSITY [US/US]; Office of Corporate Liaison & Technology Transfer, Administrative Services Building, Annex II, Piscataway, NJ 08854-1179 (US).

(72) Inventors: WYLIE, Marilynn, P.; 1621 North Robinson Road, Philadelphia, PA 19151 (US). HOLTZMAN, Jack, M.; Apartment 2A, 10 West Court, Westfiled, NJ 07090 (US).

(74) Agent: McKAY, Diane, Dunn; Mathews, Collins, Shepherd & Gould, Suite 306, 100 Thanet Circle, Princeton, NJ 08540 (US).

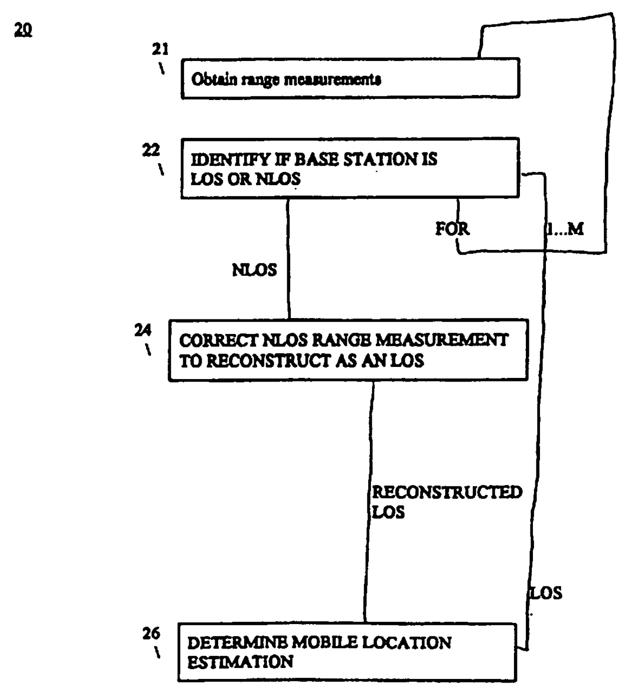
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: METHOD AND SYSTEM FOR MOBILE LOCATION ESTIMATION

(57) Abstract

The present invention relates to a method and system for mobile location estimation in which range measurements between the mobile station and a base station are discriminated as being either from a base station which is line of sight with the mobile station or a base station that is non-line of sight with the mobile station (22). Non-line of sight error present in range measurements from base stations that are non-line of sight with the mobile station is corrected (24). A reconstructed line of sight range measurement is established from the correction of the non-line of sight error. The reconstructed line of sight range measurements can be used with range measurements of base stations determined to be line of sight for accurately locating the mobile station (26).



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METHOD AND SYSTEM FOR MOBILE LOCATION ESTIMATION

This application claims the benefit of U.S. Provisional Application No. 60/027,453 entitled Non-Line Of Sight Problem in Mobile Location Estimation filed by Applicants on September 27, 1996 hereby incorporated by reference into this application.

Background of the Invention

1. Field of the Invention:

The present invention relates to a method and system for mobile station location estimation in which base stations that are in line of sight of the mobile station and base stations that are not in the line of sight of the base station can be determined. Errors in base station signals generated from determined non-line of sight base stations are reduced for providing improved mobile station location estimation.

2. Description of the Related Art

Mobile location estimation determines a geographical estimate of the location of a mobile station. Mobile location estimation is useful in management of fleets of mobile stations, location dependent information services, location dependent billing services and Emergency 911 location of a mobile station. Enhanced 911 is designed to automatically forward the number of a caller to a public safety answering point (PSAP). In implementing enhanced 911 in a wireless network, wireless service providers provide two dimensional location of the vehicle to the public safety answering point (PSAP). The Federal Communications Commission (FCC) has regulated by the year 2001 that wireless service providers have the capability of locating callers in two dimensions within 125 meters 67% of the time.

One conventional method for locating a mobile station in two dimensions would use the measurement of the line of sight distance between the mobile station and at least three base stations. U.S. Patent No. 5,365,516 describes a method for determining the location of a transponder unit in which a radio signal is sent by the mobile station. The arrival time of the radio signal is measured at each of three base stations. Each distance measurement between the mobile station and one of the base stations can be used to generate a circle which is centered at the measuring base station. The circle has a radius which is equal to the distance between the mobile station and the base station. Accordingly, three circles are generated, one for each of the base stations. In the absence of any measurement error of the distance between the base stations and the mobile station, the intersection of the three circles unambiguously determines the location of the mobile station. This method has the drawback that the distance measurements can be corrupted by noise resulting in errors in determining the location of the mobile station.

A conventional solution for providing more accurate position estimates is to reduce the error due to noise with a least squares analysis. Accordingly, the least squares analysis provides a more accurate position estimate. This solution has the limitation of not accounting for the possibility of a lack of a direct path between the base station and the mobile station. For example, in an urban environment, a building or buildings may be in the path between the mobile station and the base station. A propagating signal between the mobile station and the base station can be reflected and defracted by the object in the path of the mobile station to the base station resulting in the signal traveling excess path lengths. The excess path lengths can be on the order of a hundred meters.

The lack of direct path between the mobile station and the base station can be defined as a non-line of sight (NLOS). The importance of detecting and reducing the NLOS measurements between a mobile station and a base station is recognized in M.I. Silventoinen, et al., "Mobile Station Locating in GSM", IEEE Wireless Communication System Symposium, Long Island NY, November 1995 and J.L. Caffrey et al., "Radio Location in Urban CDMA Microcells", Proceedings of the Personal, Indoor and Mobile Radio Environment, 1995.

U.S. Patent No. 5,365,516 ('516 patent) describes an embodiment of a transreceiver locating system operating in an environment susceptible to multipath interference. The system includes a transponder which is operable within a prescribed coverage area to transmit a burst of data symbols in a coded carrier pulse. Each base station includes a receiver for detecting and responding to the data symbol at a given time, interrupting the data symbol and rejecting echoes resulting from multipath interference. A comparison circuit responds to the receiver for comparing respectively identified given times and decorrelating the time difference to improve data quality. Although the '516 patent addresses multipath interference, it does not attempt to detect base stations for reducing multipath NLOS with mobile stations.

It is desirable to provide a method and system for providing improved mobile location estimation which is robust to NLOS error.

Summary of the Invention

Briefly described, the present invention relates to a method and a system for mobile location estimation in which base stations are identified to be either line of sight (LOS) or non-line of sight (NLOS) with a mobile station. A range measurement is determined as the distance between the base station and the mobile station. NLOS ranging error is corrected for base stations identified to be NLOS with the mobile station by reconstructing the LOS measurement. From the range measurements of base stations identified as LOS and the reconstructed LOS range measurements the location of the mobile station is estimated.

The base station can be identified as being NLOS by comparing the standard deviation of standard measurement noise from the environment to the standard deviation of a smoothed range measurement obtained from the range measurements between the base station and mobile station. The smoothed range measurement can be obtained using an N^{th} order polynomial fit. It has been found that when the standard deviation of the smoothed range measurement is on the order of the standard deviation of the standard measurement noise, the base station corresponds to an LOS environment and when the standard deviation of the smoothed range measurement is greater than the standard deviation due to standard measurement noise, the base station corresponds to an NLOS environment. Alternatively, the residuals from a least squares analysis can be used to determine the presence of NLOS range measurements.

NLOS error can be corrected when the standard measurement noise dominates the NLOS error and there is predetermined identification of the approximate support of the standard measurement noise over the real axis. A reconstructed LOS range measurement can be determined by graphing a curve of the smoothed range measurements. The point of maximum deviation of the smoothed range measurement below the curve is determined. The curve is displaced downwards to pass through the point of maximum deviation. Thereafter, the curve is displaced upwards by the value of the maximum standard measurement noise deviation from an LOS measurement with negligible noise, thereby providing a reconstructed range measurement.

The mobile location estimation can be determined using at least three range measurements between LOS base stations and the mobile station or reconstructed LOS range measurements in a multilateration analysis. In this analysis, a circle is generated from each range measurement. The circle is centered at the base station and the range measurement is the radius of the circle. The estimated intersection of the three circles determines the location of the mobile station. Alternatively, two range measurements and information directed to the position angle of the mobile station can be used for estimating the location of the mobile station.

The present invention has the advantages of accurately determining the location of a mobile station by reducing NLOS error. In addition, the present invention can provide confidence in an LOS environment that all base stations are LOS with the mobile station. Results indicate that position range bias due to NLOS error can be reduced several orders of magnitude with the method of the present invention.

The present invention will be more fully described by reference to the following drawings.

Brief Description of the Drawings

Fig. 1A is a schematic diagram of an environment in which there is an unobstructed line of sight radio signal path between a mobile station and a base station.

Fig. 1B is a schematic diagram of an environment in which there is a non-line sight radio signal path between a mobile station and a base station.

Fig. 2 is a flow diagram of the system and method for mobile location estimation in accordance with the teachings of the present invention.

Fig. 3 is a schematic diagram of distance measurements of a reconstructed line of sight base station and determined line of sight base stations.

Fig. 4 is a flow diagram of a method for identifying non-line of sight base stations of the present invention.

Fig. 5 is a flow diagram of an alternate method for identifying non-line of sight base stations.

Fig. 6 is a flow diagram of a method for reconstructing a line of sight base station for non-line of sight measurements.

Fig. 7 is a graph of a comparison of NLOS measurements and reconstructed LOS measurements.

Fig. 8 is a schematic diagram of a system for implementing the method of the present invention.

Fig. 9 is a schematic diagram of positioning of base stations used in examples of performance of the method of the present invention.

Fig. 10A is a graph of two dimensional tracking without non line of sight error detection and correction.

Fig. 10B is a graph of two dimensional tracking with non line of sight error detection and correction.

Fig. 11A is a graph of two dimensional tracking without non line of sight error detection and correction.

Fig. 11B is a graph of two dimensional tracking with non line of sight error detection and correction.

Fig. 12 is a graph of the fraction of time a base station was declared NLOS using the residual rank analysis method.

Detailed Description of the Present Invention

During the course of this description like numbers will be used to identify like elements according to the different figures which illustrate the invention.

Fig. 1A illustrates a schematic diagram of a line of sight (LOS) path 10 between a base station 12 and mobile station 14. Signal 13 can be transmitted from base station 12 to mobile station 14 and returned from mobile station 14 to base station 12. Fig. 1B illustrates a schematic non-line of sight (NLOS) path 11 between base station 12 and mobile station 14. Building 15 is positioned between base station 12 and mobile station 14 resulting in reflection of signal 16. For example, signal 13 and signal 16 can be a radio signal.

A range measurement for measuring the distance between base station 12 and mobile station 14 can be measured as the time it takes a signal sent between base station 12 and mobile station 14:

$$r = cT \qquad (1)$$

in which the mobile station to base station range measurement is represented by r, c represents the speed of light which is the same speed as the propagation of radio waves and T represents the one-way travel time of the signal. A range measurement of the distance between mobile station 14 and base station 12 in Fig. 1A and 1B can be determined using equation (1) based on travel time of signal 13 and signal 16, respectively, between base station 12 and mobile station 14. The value of r generated from signal 16 is greater than the value of r generated for signal 13.

Fig. 2 is a flow diagram of the system and method of the present invention for mobile location estimation 20. In block 21, a range measurement is obtained between mobile station 14 and base station 12 using equation (1). In block 22, base station 12 is identified as being in line of sight (LOS) or non-line of sight (NLOS) with mobile station 14. Block 22 is repeated for a plurality of base stations 12 positioned at different locations from mobile station 14. If base station 12 is identified to be LOS in block 22, the range measurement obtained from block 21 is forwarded to block 26. If base station 12 is identified to be NLOS in block 22, block 24 is implemented for reducing the error of the range measurement between base station 12 and mobile station 14, thereby rendering the range measurement between base station 12 and mobile station 14 as a reconstructed LOS base station 13, as shown in Fig. 3.

In Fig. 3, base station 12 labeled BS1 has a range measurement labeled LOS RANGE 1 determined to be LOS. Base station 12 labeled BS2 has a range measurement labeled LOS RANGE 2 determined to be LOS. Base station 13 labeled BS3 has a range measurement labeled NLOS RANGE 3 determined to be NLOS. A range measurement for the reconstructed LOS base station labeled RECONSTRUCTED RANGE 3 is forwarded to block 26. Range measurements from determined LOS base stations from block 22 labeled LOS RANGE 1, and LOS RANGE 2 are also forwarded to block 26. From the range measurements of the reconstructed LOS base stations or the determined LOS base stations, or a combination of range measurements of the reconstructed LOS the mobile location estimation can be identified using a conventional multilateration technique, such as described in U.S. Patent No. 5,365,516, hereby incorporated by reference into this application. Alternatively, the mobile location estimation can be determined from time difference of arrival time measurements as the difference of propagation delays between the mobile station 14 and pairs of base stations 12. In this case, the position estimate is at the intersection of hyperbolas. The number of base stations can be reduced below three if there is also angle of arrival information. These methods are described in T.S. Rappaport et al., " Position Location Using Wireless Communication On Highways Of the Future", IEEE Communications Magazine, October 1996.

One method for identifying if a base station is LOS or NLOS in block 22 is illustrated in Fig. 4. In this method, the time history of range measurements between base station 12 and mobile station 14 is combined with predetermined standard deviation from conventional measurement noise in a radio signal environment.

The arrival time of signals sent from base station 12 to a mobile station 14 and transponded back to the base station 12 can be converted to a range measurement, in block 30. The range measurement at the m[th] base station at time t_k can be represented as:

$$r_m(t_i) = L_m(t_i) + n_m(t_i) + NLOS_m(t_i) \qquad (2)$$

for $m = 1, \ldots, M$ $i = 0, \ldots$ K-1, wherein

$L_m(t_i)$ is the LOS distance between a mobile station and the m[th] base station in two dimensions which is given by:

$$L_m(t_i) = |x(t_i) + j * y(t_i) - x_m - j * y_m|; \qquad (3)$$

$x(t_i)$, $y(t_i)$ and (x_m, y_m) are respectively the coordinates of the mobile station at time, t_i, and those of the m^{th} base station; $n_m(t_i)$ represents conventional measurement noise such as additive white Gaussian measurement noise and $NLOS_m(t_i)$ represents NLOS measurement error at time t_i; and M is the total number of base stations; and K is the total number of time samples.

In block 30, an LOS range measurement with negligible noise is obtained for base station 12 in LOS with mobile station 14. The LOS range measurement can be obtained by physically measuring a range between base station 12 and mobile station 14 or can be obtained as a range measurement determined by equation (1) in a negligible noise environment. In block 31, a noisy range measurement is determined as a range measurement which is LOS with a base station taken in a noisy environment. In block 32, the standard deviation of the noisy range measurement from the LOS measurement without noise is determined. Blocks 30, 31 and 32 can be predetermined before identifying base station 12 as either LOS or NLOS in block 22. The standard deviation due to noise $n_m(t)$ can be represented by σ_m.

In block 32, the range measurement obtained from block 21 is smoothed by modeling

$$r_m(t_i) = \sum_{n=0}^{N-1} a_m(n) t_i^n \qquad (4)$$

and solving for the unknown coefficients, $\{a_m(n)\}_{n=0}^{N-1}$ with a least squares technique. The smoothed range measurement can be represented as:

$$s_m(t_i) = \sum_{n=0}^{N-1} \hat{a}_m(n) t_i^n. \qquad (5)$$

In block 34, the standard deviation of the smoothed range measurement from a noisy range measurement (i.e., the residual) is determined. The standard deviation of the residual from block 34 can be represented as $\hat{\sigma}_m$ since $\sigma_m^2 = E\{n_m^2(t)\}$. The smoothed range measurements along with the noisy range measurement can be used to determine standard deviation $\hat{\sigma}_m$ with the formulation of:

$$\hat{\sigma}_m = \sqrt{\frac{1}{K}\sum_{i=0}^{K-1}(s_m(t_i) - r_m(t_i))^2} \qquad (6)$$

From the value of the standard deviation, $\hat{\sigma}_m$ and the standard deviation σ_m, the range measurement can be determined as either the result of base station 12 being LOS or NLOS, in block 36. When the range measurement has NLOS error, the value of the standard deviation $\hat{\sigma}_m$ is significantly larger than the value of the standard deviation σ_m. Accordingly, range measurement for base station 12 that is NLOS with mobile station 14 is determined when the $\hat{\sigma}_m$ is greater than the standard deviation σ_m. A range measurement of base station 12 that is LOS with mobile station 14 is determined when the standard deviation $\hat{\sigma}_m$ is on the order of the standard deviation σ_m.

Alternatively, a residual analysis ranking method can be used to identify a range measurement as being from a base station 13 NLOS with mobile station 14. Range measurements between mobile station 12 and base station 14 which have been obtained in block 21 are inputted to block 41. At each instance of time t_i, estimated coordinates $\hat{x}_{LS}(t_i), \hat{y}_{LS}(t_i)$ of mobile station 14 are determined as least squares estimates in block 41. The estimated coordinates

$\hat{x}_{LS}(t_i), \hat{y}_{LS}(t_i))$ are selected to minimize the formulation:

$$F_i = \sum_{m=1}^{M} (r_m(t_i) - \hat{L}_m(t_i))^2 \qquad (7)$$

where $\hat{L}_m(t_i) = |\hat{x}(t_i) - x_m + j*\hat{y}(t_i) - j*y_m|$.

In block 41, a calculated range measurement is determined from the estimated coordinates. In block 42, a residual difference of the range measurement between mobile station 12 and base station 14 with the calculated range measurement is determined. The residual difference can be represented as:

$$e_m(t_i) = r_m(t_i) - \hat{L}_m(t_i) \qquad (8)$$

In block 44, the number of times the residual difference of a range measurement to a base station 12 has the largest value in comparison to the residual difference determined for range measurements at other base stations is counted for each time instant t_i. It has been found that base stations having a range measurement between a base station NLOS with a mobile station have a significantly larger number of greatest absolute residual differences than the number of greatest absolute residual differences from other base stations. From the value of the counted number of residual differences, base station 14 can be defined as a base station 12 that is a LOS or a base station 12 that is NLOS with mobile station 14.

Fig. 6 illustrates a method for correction of range measurements between a base station 12 that has been determined NLOS with mobile station 14 to reconstruct a LOS range measurement. Data related to the range measurements from block 21 are smoothed using an N^{th} order polynomial fit described in block 32. The smooth range measurements are inputted to block 52. The maximum deviation below the smoothed curve due to NLOS error in determined in block 56. It has been found that NLOS error is a non-negative random variable which can be approximately represented in a real axis as follows:

$$0 \leq NLOSm\,(t_i) \leq \beta m$$

in which βm is the maximum value of NLOS error. The standard measurement noise, $n_m(t_i)$ can be represented as a zero-mean random variable which can be approximately represented in a real axis as follows: $-\alpha_m \leq n_m(t_i) \leq \alpha_m$, so that in a range measurement in which there is also an NLOS error, the total noise component can be approximated represented over the real axis as follows:

$$-\alpha_m \leq n_m(t) + NLOS_m\,(t) \leq \beta_m - \alpha_m$$

It has been found that the point of maximum deviation of the measured range below the smoothed curve is about α_m below the LOS function represented as $L_m(t_i)$. In block 58, the smoothed curve is displaced mathematically downward to the point of maximum deviation. The smoothed curve is displaced mathematically upward by a value of the noise deviation α_m in block 60 to provide a reconstructed curve representing a reconstructed LOS base station.

Fig. 7 represents a graph of a comparison of simulated range measurements. Curve 90 represents the true time range measurement between a base station 12 which is LOS with a mobile station 14. Curve 91 represents determined range measurements having NLOS error. Curve 92 represents a smoothed range measurement of block station 12 and mobile station 14 determined from block 30 of Fig. 4. Curve 93 represents base station 12 which is reconstructed LOS with the mobile station 14 from block 60 of Fig. 6.

Fig. 8 is a schematic diagram of a system 80 for implementing the method for mobile location estimation. System 80 includes base station server 81. Base station server 81 can be a computer located at base station 12 or networked thereto. Base station server 81 communicates with base station 12 for requesting and receiving data related to range measurements of mobile station 14 and base station 12. Base station server 81 also collects information on range measurements between mobile station 14 and each of base stations 81A-81N. The information is reported to base station server 81 either by mobile station 14 or base station servers 81A-81N. The functions of modules shown in Figs. 4-6 which are coded with a standard programming language, such as C++ programming language. The coded modules can be executed by base station server 81.

Results for examples of mobile location estimates with system 80 are shown in Tables I - IV and Fig. 9 through Fig. 12. In all of the examples, the vehicle's position in the x-y plane at any is given by:

$$x(t) = x_o + v_x t$$

$$y(t) = y_o + v_y t$$

$x(t)$ represents the x - coordinate in x - y plane at time instant, t,

$y(t)$ represents the y - coordinate in x - y plane at time instant, t,

x_o represents the initial x - coordinate,

y_o represents the initial y - coordinate,

v_x represents the speed in x - direction,

v_y represents the speed in y - direction.

The sampling period was chosen to be 0.5s and 200 samples were taken. The velocity remained constant at v_x = 9.7 m/s and v_y = 16.8 m/s. Base stations 12 were assigned to have NLOS or LOS range measurements. Standard deviation of the standard measurement noise was represented as a σ_m was 150m and B_m was chosen as 1300m. In each example three base stations 101, 102, 103 were used uniformly spaced around a circle of 5 kilometers and a fourth base station 104 was located at the center of the circle, as shown in Fig. 9.

In a first example, base station 101 and base station 102 provide NLOS range measurements and base stations 103 and base station 104 provide LOS range measurements. The standard deviation $\hat{\sigma}_m$ (m) of the smoothed curve determined in Fig. 4 is shown in Table 1.

TABLE 1
STANDARD DEVIATION OF MEASUREMENTS FROM SMOOTHED CURVE FOR 2 NLOS MEASUREMENTS

Base	NLOS	$\hat{\sigma}_m$ (m)
101	Yes	467.3
102	Yes	447.6
103	No	163.1
104	No	142.1

The results indicate base stations 101 and 102 have NLOS range measurements with a significantly larger standard deviation than base station 103 and base station 104 having a LOS range measurement.

Fig. 10A shows two-dimensional tracking error without NLOS identification and correction Fig. 10B shows two dimensional tracking error after the method of mobile location estimation of the present invention is performed. The results indicate improvement of estimated vehicle trajectory after NLOS identification and correction.

In a second example, base stations 101, 102, 103 and 104 have NLOS range measurements. The standard deviation $\hat{\sigma}_m$ (m) of the smoothed curve determined in Fig. 4 is shown in Table 2.

TABLE 2
STANDARD DEVIATION OF MEASUREMENTS FROM SMOOTHED CURVE FOR FOUR NLOS MEASUREMENTS

Base	NLOS	$\hat{\sigma}_m$ (m)
101	Yes	440.2
102	Yes	444.4
103	Yes	463.6
104	Yes	450.2

The results indicate a similar standard deviation $\hat{\sigma}(m)$ for all four base stations 101, 102, 103 and 104 having NLOS.

In a third example, three results were determined using x_o = -118.3m y_o = -3.7m with the residual analysis tracking method shown in Fig. 5. In test 1, base station 104 was NLOS. In test 2, base station 103 and base station 104 are NLOS. In test 3, base station 102, base station 103 and base station 104 were non-line of sight. The number of times each base station had the largest absolute residual difference is shown in Table 3.

TABLE 3

PERCENTAGE OF TIME BS HAD LARGEST RESIDUAL

TEST		BS101	BS102	BS103	BS104
1	LOS	10	11.	18.5	
	NLOS				60
2	LOS	18.5	15		
	NLOS			26.5	40
3	LOS	12.5			
	NLOS		20	40.5	27

The results indicate NLOS base stations having larger percentages of residual differences.

In a fourth example, results of the method for location estimation at the present invention were compared with a conventional least square analysis, a least square analysis with all range measurements are line of sight and a conventional Cramer Rao Lower Bound analysis. The Cramer Rao Lower Bound represents a lower bound on the rms error of any unbiased estimator. Table 4 represents the present method shown in column 2, the conventional least squares analysis shown in column 1, a least square analysis with all measurements LOS in column 3 and the conventional Cramer Rao Lower Bound analysis shown in column 4. The location and speed errors in each coordinates were measured in meters and meters/second respectively.

μ_{xo} = mean error in estimating x_o σ_{xo} = standard deviation of $\hat{x}_0$

μ_{yo} = mean error in estimating y_o σ_{yo} = standard deviation of $\hat{y}_o$

μ_{vx} = mean error in estimating v_x σ_{vo} = standard deviation of $\hat{v}_x$

μ_{vy} = mean error in estimating v_y σ_{vy} = standard deviation of $\hat{v}_y$

TABLE 4

COMPARISON OF ESTIMATOR PERFORMANCE

	LEAST SQUARES PRIOR ART METHOD	METHOD OF PRESENT INVENTION	LOS	$\sqrt{CRLB}$
μ_{xo}	297.8	-3.98	0.17	--
σ_{xo}	32.9	28.30	16.42	15.88
μ_{yo}	-306.1	-2.36	0.54	--
σ_{yo}	55.5	45.13	14.15	14.18
μ_{vx}	0.18	-0.09	-0.005	--
σ_{vx}	0.55	0.49	0.27	0.27
μ_{vy}	4.49	-.01	-0.005	--
σ_{vy}	0.84	0.64	0.25	0.25

The results indicate that the mobile location estimation method of the present invention significantly reduced the estimation bias as compared to results without NLOS error correction.

Fig. 12 is a comparison of the probability of detecting an NLOS range measurement. The sampling period was 0.5 seconds. The number of samples varied between 5 and 150. X_o was 200m and y_o was 100m. Base station 101 and base station 104 were LOS. Base station 102 and base station 103 were NLOS. The results indicate NLOS can be detected with high probability for a small number of samples.

It is to be understood that the above-described embodiments are illustrative of only a few of the many possible specific embodiments which can represent applications of the principles of the invention. Numerous and varied other arrangements can be readily devised in accordance with these principles by those skilled in the art without departing from the spirit and scope of the invention.

We claim:

1. A method for mobile station location estimation comprising the steps of:

a. obtaining range measurements between said mobile station and a base station;

b. identifying whether said base station is line of sight with said mobile station or non-line of sight with said mobile station at the time at which a mobile location estimate is made;

c. correcting non-line of sight range measurements for a base station identified as non-line of sight with said mobile station in step b to determine reconstructed line of sight range measurements;

d. repeating steps a through c for a predetermined number of said base stations; and

e. determining said mobile station location estimation from said reconstructed line of sight range measurements determined in step c or said range measurements determined in step a for an identified line of sight base station in step b, or the combination of said reconstructed line of sight range measurements determined in step c, and said range measurements determined in step a for an identified line of sight base station in step b.

2. The method of claim 1 wherein step b comprises the steps of:

obtaining line of sight range measurements between said mobile station and a base station without noise;

obtaining noisy line of sight range measurements between said mobile station and said base station;

predetermining a first standard deviation of the difference of said line of sight range measurements with said noisy line of sight range measurements,

smoothing said range measurements determined in step a;

determining a second standard deviation of the difference between said smoothed range measurements and said noisy line of sight range measurements; and

discriminating between said base station being line of sight or said base station being non-line of sight from said first standard deviation and said second standard deviation, wherein said base station is determined to be non-line of sight when said second standard deviation is greater than said first standard deviation and line of sight when said second standard deviation is on the order of said first standard deviation.

3. The method of claim 1 wherein the range measurement obtained in step a is represented by:

$$r_m(t_i) = L_m(t_i) + n_m(t_i) + NLOS_m(t_i)$$

for $m = 1, \ldots, M$ $i = 0, \ldots K-1$, wherein

$L_m(t_i)$ is the LOS distance between a mobile station and the m[th] base station in two dimensions which is given by:

$$L_m(t_i) = |x(t_i) + j * y(t_i) - x_m - j * y_m|;$$

$j = \sqrt{-1}$, | | is absolute value,

$x(t_i), y(t_i)$ and (x_m, y_m) are respectively the coordinates of the mobile station at time, t_i, and those of the m^{th} base station; $n_m(t_i)$ represents conventional measurement noise such as additive white Gaussian measurement noise and $NLOS_m(t_i)$ represents NLOS measurement error at time t_i; and M is the total number of base stations; and K is the total number of time samples.

4. The method of claim 3 where the range measurement is smoothed by modeling:

$$r_m(t_i) = \sum_{n=0}^{N-1} a_m(n) t_i^n$$

and solving for the unknown coefficients, $\{a_m(n)\}_{n=0}^{N-1}$ with a least squares technique.

5. The method of claim 4 wherein the second standard deviation is represented by

$$\hat{\sigma}_m = \sqrt{\frac{1}{K}\sum_{i=0}^{K-1}(s_m(t_i) - r_m(t_i))^2}$$

wherein

$$s_m(t_i) = \sum_{n-0}^{N-1} \hat{a}_m(n) t_i^n.$$

6. The method of claim 1 wherein step b comprises the steps of:

estimating coordinates of said mobile station from said range measurement obtained in step a over time;

calculating a range measurement from said estimated coordinates;

determining a residual from the difference of said range measurement obtained in step a and said calculated range measurement;

counting the number of times the residual is the greatest at each base station for each time instant; and defining said base station as non-line of sight from the base station which has the greatest value of the number of times the greatest residual was counted.

7. The method of claim 6 wherein said estimated coordinates are represented by $\hat{x}_{LS}(t_i), \hat{y}_{LS}(t_i)$ at each instance of time t_i , said estimated coordinates are determined as least squares estimates to

$$F_i = \sum_{m=1}^{M}(r_m(t_i) - \hat{L}_m(t_i))^2$$

where $\hat{L}_m(t_i) = \mid \hat{x}(t_i) - x_m + j * \hat{y}(t_i) - j * y_m \mid$.

8. The method of claim 1 wherein step c comprises the steps of:

determining a value of maximum noise deviation and standard deviation from said range measurements obtained in step a and a predetermined line of sight range measurement with negligible noise;

smoothing said range measurements obtained from step a;

graphing a curve of said smoothed range measurements;

determining a point of maximum deviation of said range measurement below said curve;

displacing said curve downwards to pass through said point of maximum deviation; and

displacing said curve upwards by said value of said maximum noise deviation, thereby providing said reconstructed range measurement.

9. The method of claim 1 wherein said steps a through c are repeated for at least two base stations and further comprising the step of determining angle arrival information,

wherein said mobile station location is estimated from range measurements or reconstructed line of sight range measurements of said two base stations and said angle arrival information.

10. The method of claim 1 wherein steps a through c are repeated for three base stations.

11. A system for mobile station location estimation comprising:

means for obtaining range measurements between said mobile station and a plurality of base stations;

identifying means for identifying whether each of said base stations is line of sight with said mobile station as a line of sight base station or non-line of sight with said mobile station as a non-line of sight base station;

correcting means for correcting said range measurement for each of said non-line of sight base stations to determine a reconstructed line of sight range measurement; and

estimating means for determining said mobile station location estimation from said reconstructed line of sight range measurements or said range measurements for said line of sight base station, or the combination of said reconstructed line of sight range measurements, and said range measurements for said line of sight base stations.

12. The system of claim 11 wherein said identifying means comprises:

means for obtaining a line of sight range measurement without noise between said mobile station and each of said base station;

means for obtaining a noisy line of sight range measurement between said mobile station and each of said base station;

means for predetermining a first standard deviation of the difference of said line of sight range measurement with said noisy line of sight range measurements,

means for smoothing said range measurements;

means for determining a second standard deviation of the difference between said smoothed range measurements and said noisy line of sight range measurement; and

means for discriminating each of said base stations as being line of sight or being non-line of sight from said first standard deviation and said second standard deviation, wherein said base station is determined to be non-line of sight when said second standard deviation is significantly greater than said first standard deviation and line of sight when said second standard deviation is on the order of said first standard deviation.

13. The system of claim 12 wherein the range measurement is represented by:

$$r_m(t_i) = L_m(t_i) + n_m(t_i) + NLOS_m(t_i)$$

for $m = 1, \ldots, M$ $i = 0, \ldots$ K-1, wherein

$L_m(t_i)$ is the LOS distance between a mobile station and the m[th] base station in two dimensions which is given by:

$$L_m(t_i) = |x(t_i) + j * y(t_i) - x_m - j * y_m|;$$

$j = \sqrt{-1}$, $|\ |$ is absolute value,

$x(t_i)$, $y(t_i)$ and (x_m, y_m) are respectively the coordinates of the mobile station at time, t_i, and those of the m^{th} base station; $n_m(t_i)$ represents conventional measurement noise such as additive white Gaussian measurement noise and $NLOS_m(t_i)$ represents NLOS measurement error at time t_i; and M is the total number of base stations; and K is the total number of time samples.

14. The system of claim 13 where the range measurement is smoothed by modeling:

$$r_m(t_i) = \sum_{n=0}^{N-1} a_m(n) t_i^n$$

and solving for the unknown coefficients, $\{a_m(n)\}_{n=0}^{N-1}$ with a least squares technique.

15. The system of claim 14 wherein the second standard deviation is represented by

$$\hat{\sigma}_m = \sqrt{\frac{1}{K}\sum_{i=0}^{K-1}(s_m(t_i) - r_m(t_i))^2}$$

wherein

$$s_m(t_i) = \sum_{n=0}^{N-1} \hat{a}_m(n) t_i^n.$$

16. The system of claim 12 wherein said identifying means comprises:

means for estimating coordinates of said mobile station from said range measurements from a plurality of base stations received over time;

means for calculating a calculated range measurement from said estimated coordinates;

means for determining a residual from the difference of said range measurements and said calculated range measurement;

means for counting the number of times the residual is the greatest at each base station for each time instant; and

means for defining said base station as non-line of sight from the base station which has the greatest value of the number of times the greatest residual was counted.

17. The system of claim 14 wherein said estimated coordinates are represented by $\hat{x}_{LS}(t_i), \hat{y}_{LS}(t_i)$ at each instance of time t_i, said estimated coordinates are determined as least squares estimates to $$F_i = \sum_{m=1}^{M} (r_m(t_i) - \hat{L}_m(t_i))^2$$

where $\hat{L}_m(t_i) = |\hat{x}(t_i) - x_m + j \cdot \hat{y}(t_i) - j * y_m|$.

18. The system of claim 12 wherein said estimating means comprises:

means for determining a value of maximum noise deviation and standard deviation for each of said range measurements and a predetermined line of sight range measurement with negligible noise;

means for smoothing said range measurements;

means for graphing a curve of said smoothed range measurements;

means for determining a point of maximum deviation of said range measurements below said curve;

means for displacing said curve downwards to pass through said point of maximum deviation; and

means for displacing said curve upwards by said value of said maximum noise deviation, thereby providing said reconstructed range measurement.

19. The system of claim 12 further comprises means for obtaining angle arrival information wherein said mobile station location is estimated from range measurements or reconstructed line of sight range measurement of said base stations and said angle arrival information.

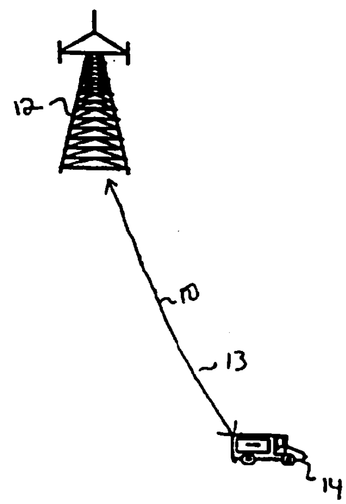


FIG 1A

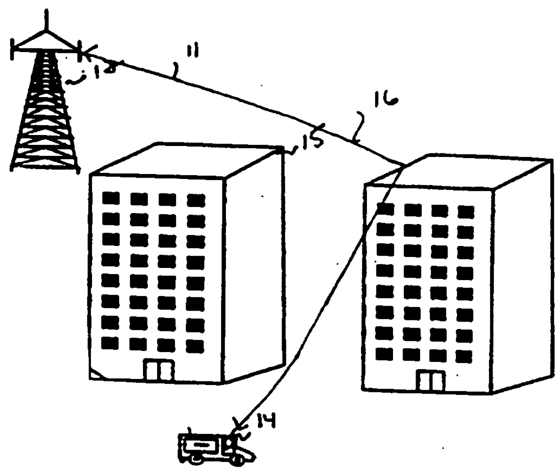


FIG 1B

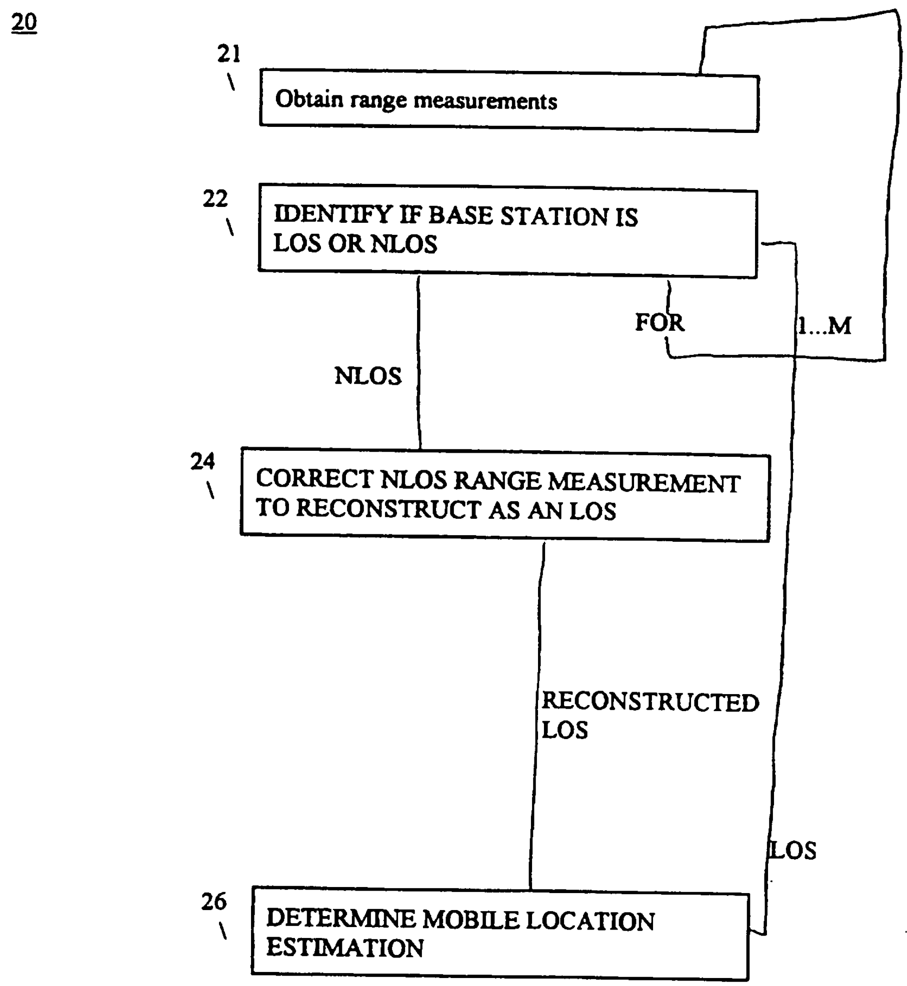

20
21
Obtain range measurements
22
IDENTIFY IF BASE STATION IS LOS OR NLOS
FOR
1...M
NLOS
24
CORRECT NLOS RANGE MEASUREMENT TO RECONSTRUCT AS AN LOS
RECONSTRUCTED LOS
LOS
26
DETERMINE MOBILE LOCATION ESTIMATION

FIG. 2

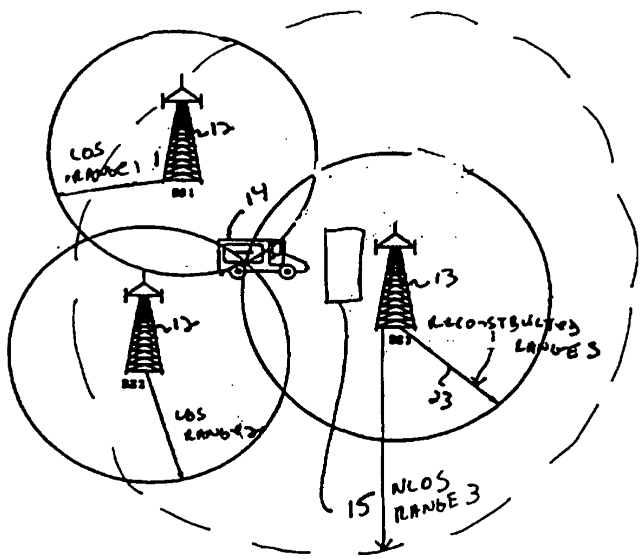

LOS
RANGE 1
12
14
12
LOS
RANGE 2
13
RECONSTRUCTED
RANGES
23
15
NLOS
RANGE 3

FIG 3

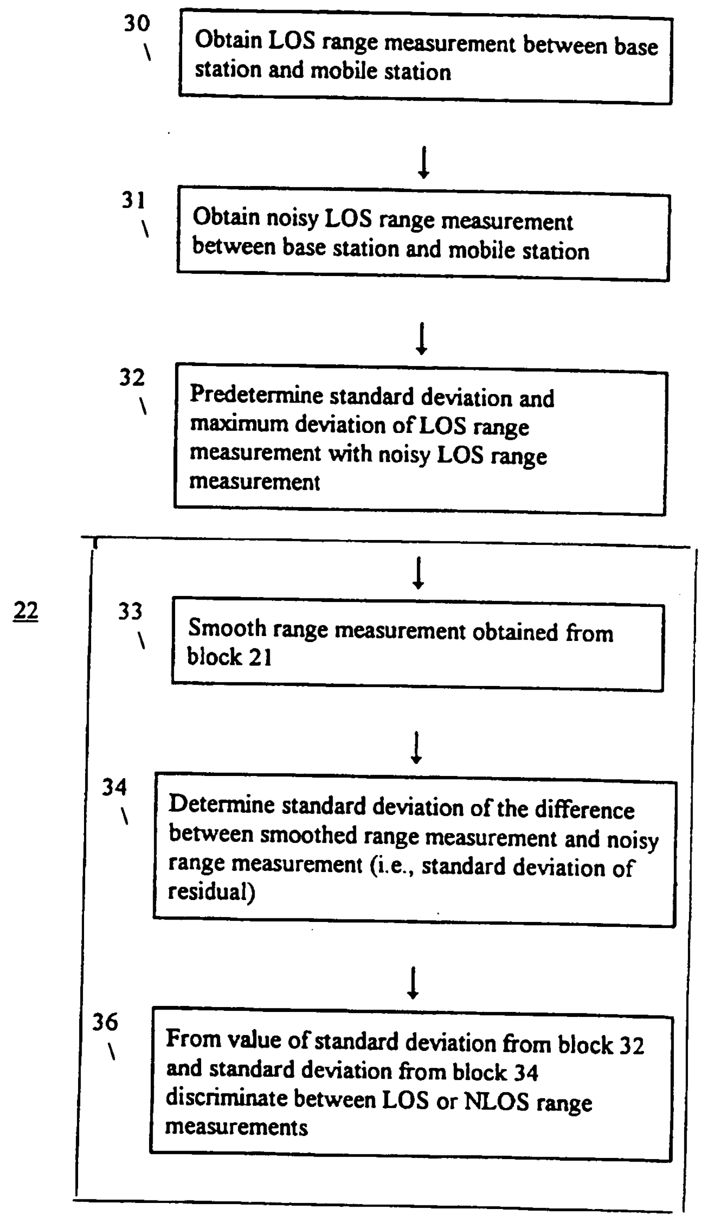

30
Obtain LOS range measurement between base station and mobile station
31
Obtain noisy LOS range measurement between base station and mobile station
32
Predetermine standard deviation and maximum deviation of LOS range measurement with noisy LOS range measurement
22
33
Smooth range measurement obtained from block 21
34
Determine standard deviation of the difference between smoothed range measurement and noisy range measurement (i.e., standard deviation of residual)
36
From value of standard deviation from block 32 and standard deviation from block 34 discriminate between LOS or NLOS range measurements

FIG. 4

22

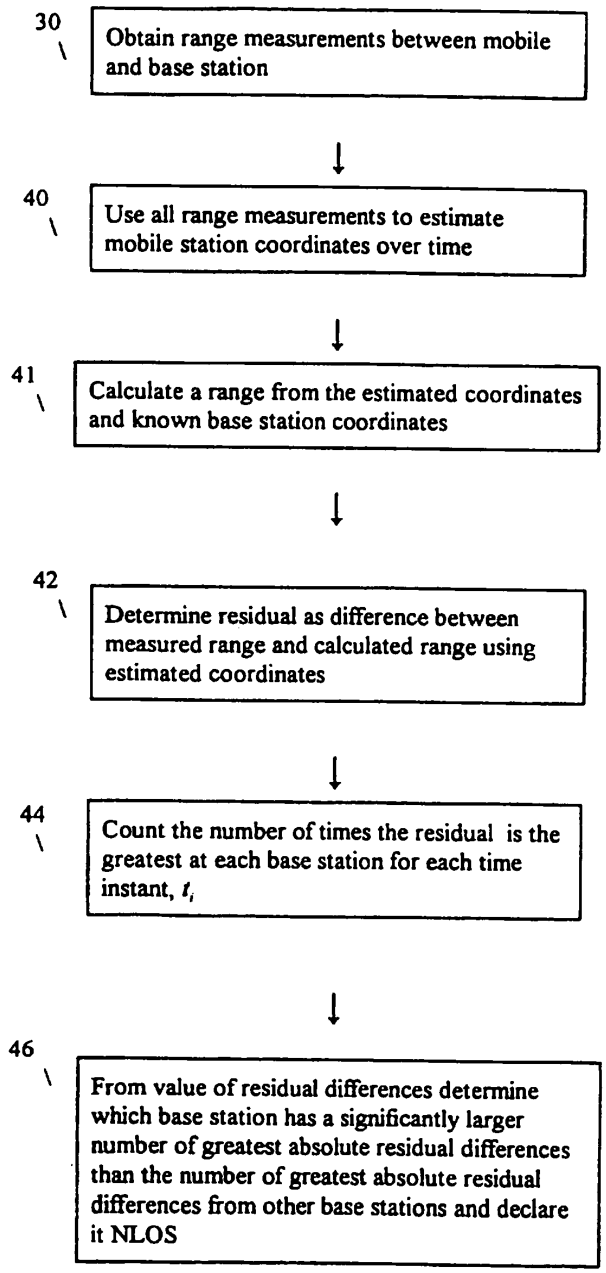

30
Obtain range measurements between mobile and base station
40
Use all range measurements to estimate mobile station coordinates over time
41
Calculate a range from the estimated coordinates and known base station coordinates
42
Determine residual as difference between measured range and calculated range using estimated coordinates
44
Count the number of times the residual is the greatest at each base station for each time instant, t_i
46
From value of residual differences determine which base station has a significantly larger number of greatest absolute residual differences than the number of greatest absolute residual differences from other base stations and declare it NLOS

FIG. 5

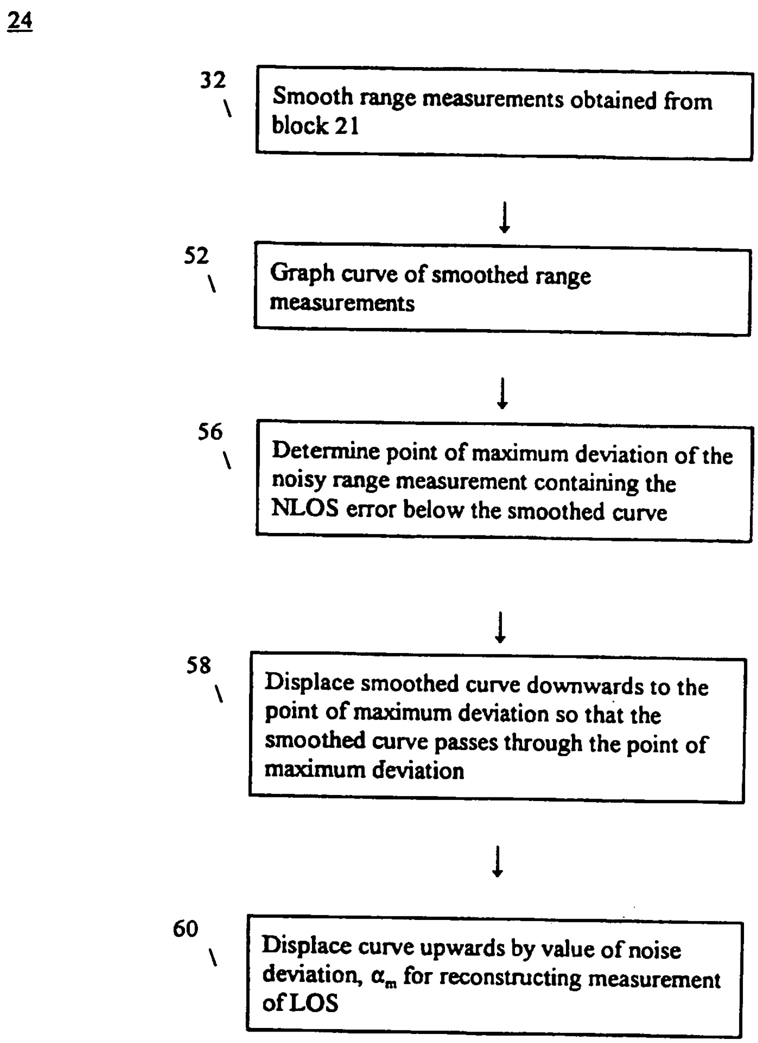
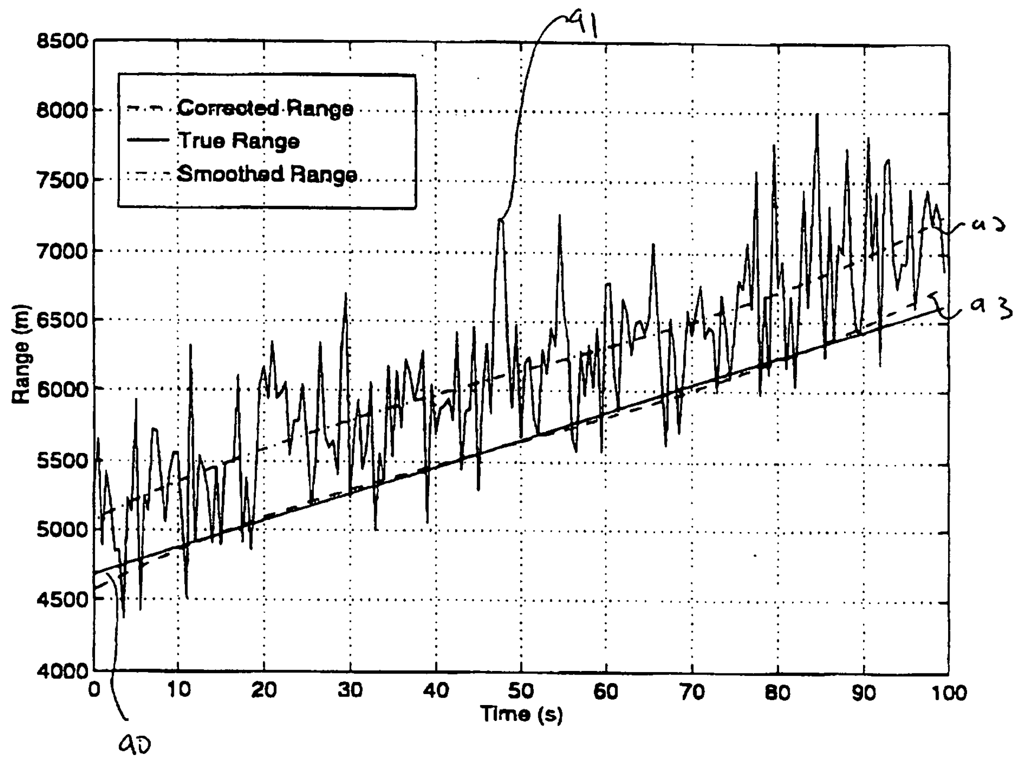

24
32
Smooth range measurements obtained from block 21
52
Graph curve of smoothed range measurements
56
Determine point of maximum deviation of the noisy range measurement containing the NLOS error below the smoothed curve
58
Displace smoothed curve downwards to the point of maximum deviation so that the smoothed curve passes through the point of maximum deviation
60
Displace curve upwards by value of noise deviation, α_m for reconstructing measurement of LOS

FIG. 6



91
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
Range (m)
Corrected Range
True Range
Smoothed Range
92
93
0
10
20
30
40
50
60
70
80
90
100
Time (s)
90

FIG 7

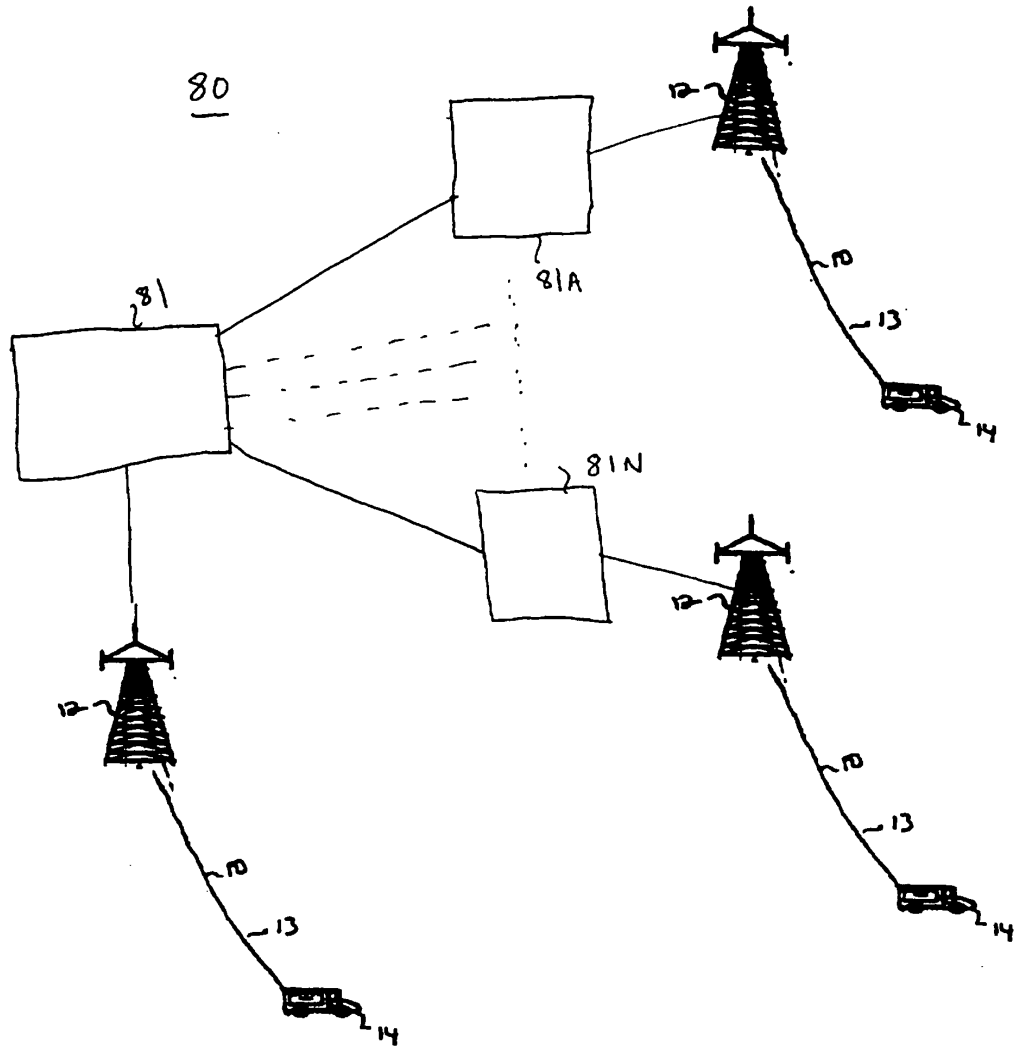


FIG 8

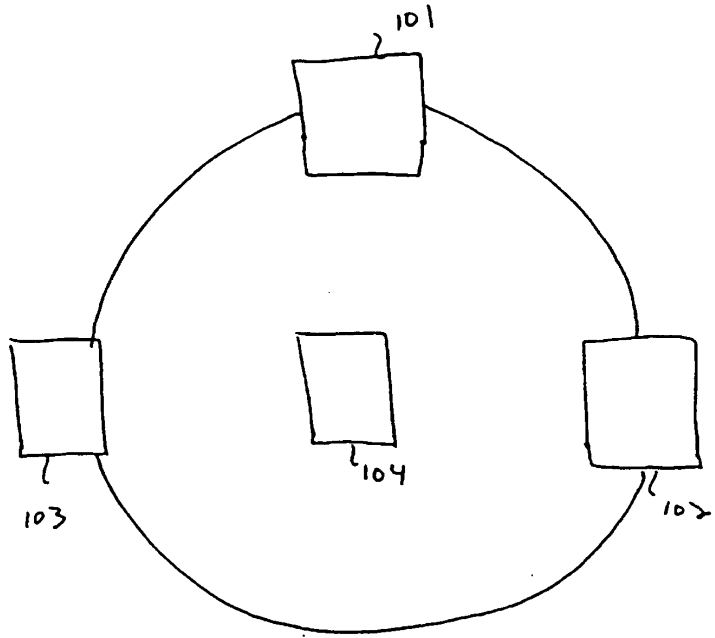
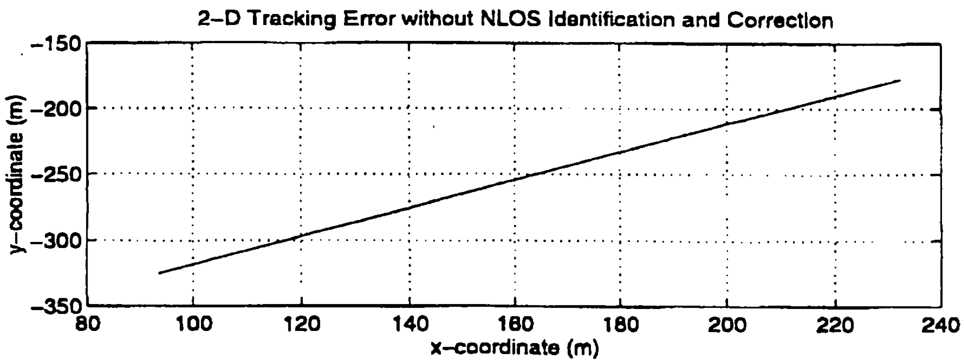


FIG 9

FIG 10 A



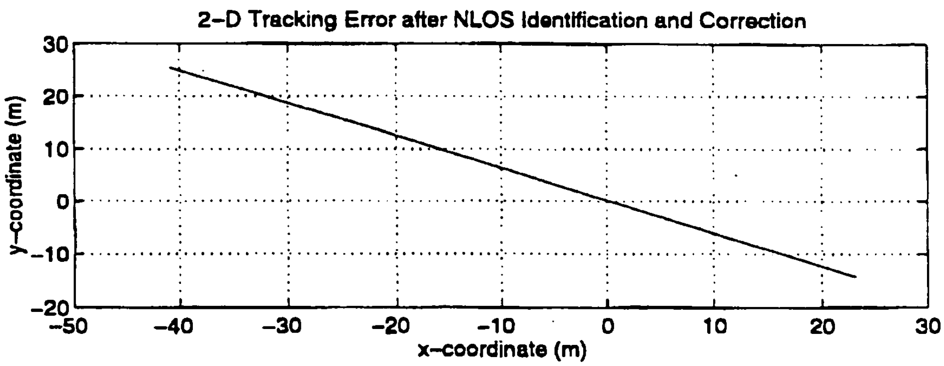
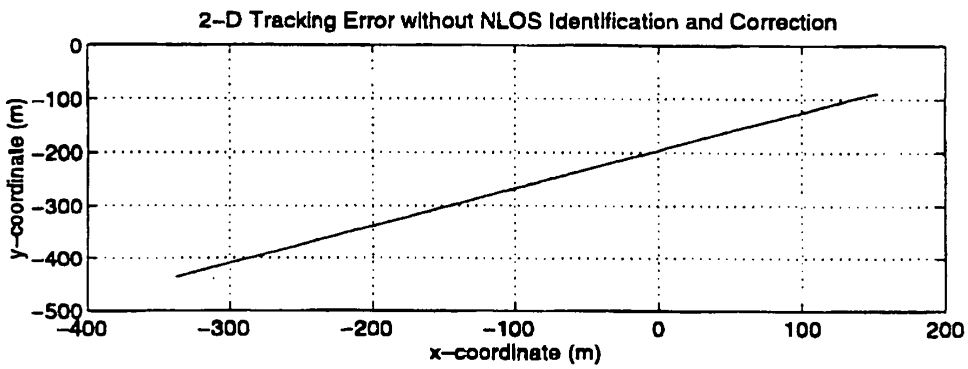


FIG 10 B

FIG 11A



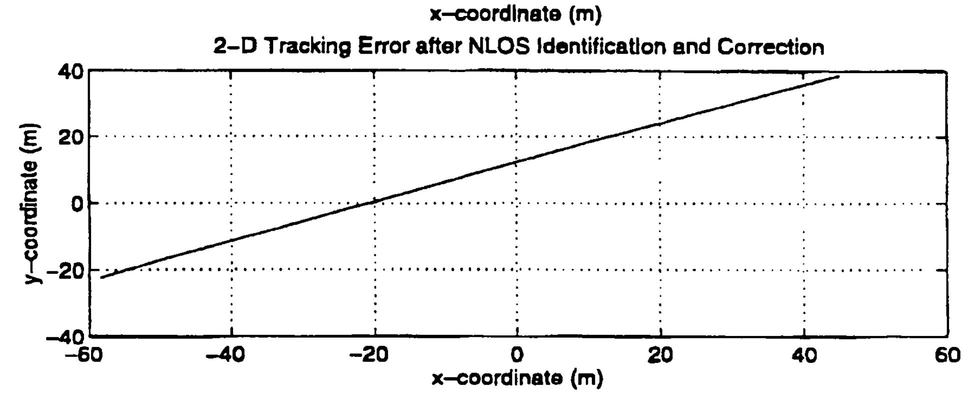


FIG 11B

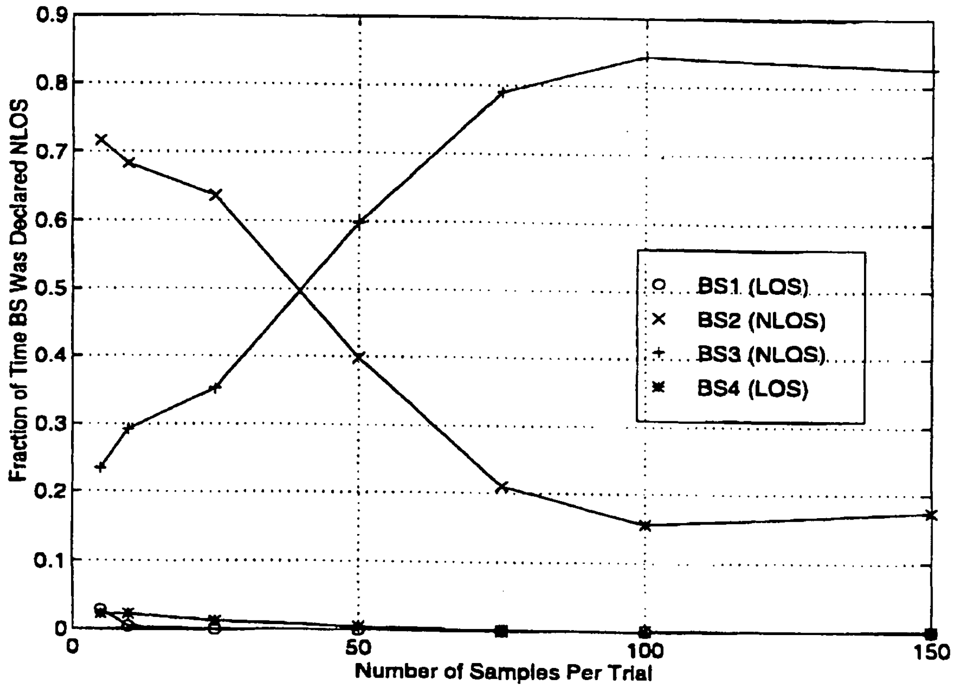

0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Fraction of Time BS Was Declared NLOS
0
50
100
150
Number of Samples Per Trial
BS1 (LOS)
BS2 (NLOS)
BS3 (NLOS)
BS4 (LOS)

FIG 12

INTERNATIONAL SEARCH REPORT	International application No. PCT/US97/17786

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04Q 07/20
US CL :455/456
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 455/456, 403, 422, 435, 457, 504, 506, 550; 701/214, 215; 342/450, 357, 457

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, IEEE
search terms: LOS, NLOS, line of sight, multipath fading, standard deviation, curve fit, smoothing.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y, P	US, 5,629,707 A (HEUVEL et al) 13 May 1997, see Col. 6;55 - Col.10;65.	1-2, 6, 8-12, 16, 18-19
Y	US 5,257,405 A (REITBERGER) 26 October 1993, see Col. 9;55 - Col. 10;56.	1-2, 6, 8-12, 16, 18-19
Y	US 5,327,144 A (STILIP et al) 05 July 1994, see Col. 14;15-45, Col. 16;5 - Col. 17;65.	1-2, 6, 8-12, 16, 18-19
A	US 5,390,124 A (KYRTSOS) 14 February 1995, see whole document.	1-19
A	BORJESON et al, Outdoor Microcell Measurements at 1700 MHz, IEEE Vehicular Technology Conference, 1992, pp. 927-931	1-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 DECEMBER 1997	10 FEB 1998

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	WILLIAM TROST
Facsimile No. (703) 305-3230	Telephone No. (703) 308-5318

Form PCT/ISA/210 (second sheet)(July 1992)★

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

7590 02/08/2006

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

EXAMINER	
PHAN, DAO LINDA	

ART UNIT	PAPER NUMBER
3662	

DATE MAILED: 02/08/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

Office Action Summary	Application No. 09/770,838	Applicant(s) DUPRAY ET AL.	
	Examiner Dao L. Phan	Art Unit 3662	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *12 December 2005*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☐ Claim(s) _____ is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☐ Claim(s) _____ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

1. Most sets of claims and specification of the instant application have been lost. So the last currently amended claims of the instant application are requested for examination.

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dao L. Phan whose telephone number is (571)272-6976. The examiner can normally be reached on M-F 9:00-5:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Thomas Tarcza can be reached on (571)272-6979. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

3. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

03-24-06

IFW 3662

OIPE IAP14 MAR 2 2 2006 PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	) Group Art Unit: 3662
Dupray et al.	) Examiner: Dao L. Phan
Serial No.: 09/770,838	) RESPONSE TO OFFICE ACTION DATED FEBRUARY 8, 2006
Filed: January 26, 2001	)
Atty. File No.: 1003-1	) EXPRESS MAIL MAILING LABEL NUMBER: **EV737751758US** DATE OF DEPOSIT: **March 22, 2006**
For: A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION	) I HEREBY CERTIFY THAT THIS CORRESPONDENCE IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE "EXPRESS MAIL POST OFFICE TO ADDRESSEE" SERVICE UNDER 37 CFR 1.10 ON THE DATE INDICATED ABOVE AND IS ADDRESSED TO THE COMMISSIONER FOR PATENTS, P.O. BOX 1450, ALEXANDRIA, VA 22313-1450

TYPED OR PRINTED NAME: **Aimee M. Thuerk**

Aimee M. Thuerk

Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Sir:

In response to the Office Action having a mailing date of February 8, 2006, the applicant hereby submits a copy of the Preliminary Amendment dated February 20, 2002, which contains the claims to be examined.

Respectfully submitted,

By: [signature]

Dennis J. Dupray
Registration No. 46,299
1801 Belvedere Street
Golden, Colorado 80401
(303) 863-9700

Date: MARCH 22, 2006

PATENT APPLICATION

In Re the Application of:

DUPRAY et al.

Serial No.: 09/770,838

Filed: January 26, 2001

Atty. File No.: 1003-1

For: "WIRELESS LOCATION USING SIGNAL FINGERPRINTING"

Prior Group Art Unit: 3662

Prior Examiner: Dao Phan

PRELIMINARY AMENDMENT

CERTIFICATE OF MAILING

I HEREBY CERTIFY THAT THIS CORRESPONDENCE IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE AS FIRST CLASS MAIL IN AN ENVELOPE ADDRESSED TO THE ASSISTANT COMMISSIONER FOR PATENTS, WASHINGTON, DC 20231 ON February 20, 2002.

SHERIDAN ROSS P.C.

BY: *Chasity C. Rossum* [signature]
Chasity C. Rossum

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Applicants herewith submit an additional voluntary preliminary amendment. Accompanying this amendment is an additional Information Disclosure Statement. Also accompanying this amendment is a transmittal requesting changes to the drawings. The requested changes to the drawings are consistent with the changes to the specification requested herein. Accordingly, Applicants request the Examiner to reconsider the present application in view of the requested amendments and the additional Information Disclosure Statement.

If there are any questions regarding the present amendment, the request for changes to the drawings, or the newly filed Information Disclosure Statement, it is requested that the named Applicant hereinbelow (Dennis Dupray) be contacted at 303-863-2975.

IN THE SPECIFICATION:

Applicants have provided herein a replacement set of amendments to the specification. The amendments to the specification herein are to replace all previous specification amendments **with the exception of the change in the claim for priority filed which were provided in a transmittal to the USPTO filed on January 26, 2001.** Accordingly, it is requested that all previous amendments to the specification, **except for the change in the claim for priority**, be replaced with the specification amendments provided herein following.

Please replace the title of application with the following new title:

"A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION"

Please replace the paragraph beginning on page 8, line 3 with the following paragraph:

Loss due to slow fading includes shadowing due to clutter blockage (sometimes included in Lp). Fast fading is composed of multipath reflections which cause: 1) delay spread; 2) random phase shift or Rayleigh fading; and 3) random frequency modulation due to different Doppler shifts on different paths.

Please replace the paragraph beginning on page 10, line 3 through page 10, line 20 with the following paragraphs:

It is an objective of the present invention to provide a system and method for to wireless telecommunication systems for accurately locating people and/or objects in a cost effective manner. Additionally, it is an objective of the present invention to provide such location capabilities using the measurements from wireless signals communicated between mobile stations and a network of base stations, wherein the same communication standard or protocol is utilized for location as is used by the network of base stations for providing wireless communications with mobile stations for other purposes such as voice communication and/or visual communication (such as text paging, graphical or video communications). Related objectives for various embodiments of the present invention include providing a system and method that:

(1.1) can be readily incorporated into existing commercial wireless telephony systems with few, if any, modifications of a typical telephony wireless infrastructure;

(1.2) can use the native electronics of typical commercially available, or likely to be available, telephony wireless mobile stations (e.g., handsets) as location devices;

(1.3) can be used for effectively locating people and/or objects wherein there are few (if any) line-of-sight wireless receivers for receiving location signals from a mobile station (herein also denoted MS);

(1.4) can be used not only for decreasing location determining difficulties due to multipath phenomena but in fact uses such multipath for providing more accurate location estimates;

(1.5) can be used for integrating a wide variety of location techniques in a straight-forward manner;

(1.6) can substantially automatically adapt and/or (re)train and/or (re)calibrate itself according to changes in the environment and/or terrain of a geographical area where the present invention is utilized;

(1.7) can utilize a plurality of wireless location estimators based on different wireless location technologies (e.g., GPS location techniques, terrestrial base station signal timing techniques for triangulation and/or trilateration, wireless signal angle of arrival location techniques, techniques for determining a wireless location within a building, techniques for determining a mobile station location using wireless location data collected from the wireless coverage area for, e.g., location techniques using base station signal coverage areas, signal pattern matching location techniques and/or stochastic techniques), wherein each such estimator may be activated independently of one another, whenever suitable data is provided thereto and/or certain conditions, e.g., specific to the estimator are met;

(1.8) can provide a common interface module from which a plurality of the location estimators can be activated and/or provided with input;

(1.9) provides resulting mobile station location estimates to location requesting applications (e.g., for 911 emergency, the fire or police departments, taxi services, vehicle location, etc.) via an output gateway, wherein this gateway:

(a) routes the mobile station location estimates to the appropriate location application(s) via a communications network such as a wireless network, a public switched telephone network, a short messaging service (SMS), and the Internet,

(b) determines the location granularity and representation desired by each location application requesting a location of a mobile station, and/or

(c) enhances the received location estimates by, e.g., performing additional processing such as "snap to street" functions for mobile stations known to reside in a vehicle.

Please replace the paragraph beginning on page 11, line 15 with the following paragraph:

(3.3) The term, "infrastructure", denotes the network of telephony communication services, and more particularly, that portion of such a network that receives and processes wireless communications with wireless mobile stations. In particular, this infrastructure includes telephony wireless base stations (BS) such as those for radio mobile communication systems based on CDMA, AMPS, NAMPS, TDMA, and GSM wherein the base stations provide a network of cooperative communication channels with an air interface with the MS, and a conventional telecommunications interface with a Mobile Switch Center (MSC). Thus, an MS user within an area serviced by the base stations may be provided with wireless communication throughout the area by user transparent communication transfers (i.e., "handoffs") between the user's MS and these base stations in order to maintain effective telephony service. The mobile switch center (MSC) provides communications and control connectivity among base stations and the public telephone network 124.

Please replace the paragraph beginning on page 12, line 6 with the following paragraphs:

The present invention relates to a wireless mobile station location system, and in particular, various subsystems related thereto such as a wireless location gateway, and the combining or hybriding of a plurality of wireless location techniques.

Regarding a wireless location gateway, this term refers to a communications network node whereat a plurality of location requests are received for locating various mobile stations from various sources (e.g., for E911 requests, for stolen vehicle location, for tracking of vehicles traveling cross country, etc.), and for each such request and the corresponding mobile station to be located, this node: (a) activates one or more wireless location estimators for locating the mobile station, (b) receives one or more location estimates of the mobile station from the location estimators, and (c) transmits a resulting location estimate(s) to, e.g., an application which made the request. Moreover, such a gateway typically will likely activate location estimators according to the particulars of each individual wireless location request, e.g., the availability of input data needed by particular location estimators. Additionally, such a gateway will typically have sufficiently well defined uniform interfaces so that such location estimators can be added and/or deleted to, e.g., provide different location estimators for performing wireless location different coverage areas.

The present invention encompasses such wireless location gateways. Thus, for locating an identified mobile station, the location gateway embodiments of the present invention may activate one or more of a plurality of location estimators depending on, e.g., (a) the availability of particular types of wireless location data for locating the mobile station, and (b) the location estimators accessable by the location gateway. Moreover, a plurality of location estimators may be activated for locating the mobile station in a single location, or different ones of such location estimators may be activated to locate the mobile station at different locations. Moreover, the location gateway of the present invention may have incorporated therein one or more of the location estimators, and/or may access geographically distributed location estimators via requests through a communications network such as the Internet.

In particular, the location gateway of the present invention may access, in various instances of locating mobile stations, various location estimators that utilize one or more of the following wireless location techniques:

(a) A GPS location technique such as, e.g., one of the GPS location techniques as described in the Background section hereinabove;

(b) A technique for computing a mobile station location that is dependent upon geographical offsets of the mobile station from one or more terrestrial transceivers (e.g., base stations of a commercial radio service provider). Such offsets may be determined from signal time delays between such transceivers and the mobile station, such as by time of arrival (TOA) and/or time difference of arrival (TDOA) techniques as is discussed further hereinbelow. Moreover, such offsets may be determined using both the forward and reverse wireless signal timing measurements of transmissions between the mobile station and such terrestrial transceivers. Additionally, such offsets may be directional offsets, wherein a direction is determined from such a transceiver to the mobile station;

(c) Various wireless signal pattern matching, associative, and/or stochastic techniques for performing comparisons and/or using a learned association between:

   (i) characteristics of wireless signals communicated between a mobile station to be located and a network of wireless transceivers (e.g., base stations), and

   (ii) previously obtained sets of characteristics of wireless signals (from each of a plurality of locations), wherein each set was communicated, e.g., between a network of transceivers (e.g., the fixed location base stations of a commercial radio service provider), and, some one of the mobile stations available for communicating with the network;

(d) Indoor location techniques using a distributed antenna system;

(e) Techniques for locating a mobile station, wherein, e.g., wireless coverage areas of individual fixed location transceivers (e.g., fixed location base stations) are utilized for determining the mobile station's location (e.g., intersecting such coverage areas for determining a location);

(f) Location techniques that use communications from low power, low functionality base stations (denoted "location base stations"); and

(g) Any other location techniques that may be deemed worthwhile to incorporate into an embodiment of the present invention.

Accordingly, some embodiments of the present invention may be viewed as platforms for integrating wireless location techniques in that wireless location computational models (denoted "first order models" or "FOMs" hereinbelow) may be added and/or deleted from such embodiments of the invention without changing the interface to further downstream processes. That is, one aspect of the invention is the specification of a common data interface between such computational models and subsequent location processing such as processes for combining of location estimates, tracking mobile stations, and/or outputting location estimates to location requesting applications.

Moreover, it should be noted that the present invention also encompasses various hybrid approaches to wireless location, wherein various combinations of two or more of the location techniques (a) through (g) immediately above may be used in locating a mobile station at substantially a single location. Thus, location information may be obtained from a plurality of the above location techniques for locating a mobile station, and the output from such techniques can be synergistically used for deriving therefrom an enhanced location estimate of the mobile station.

It is a further aspect of the present invention that it may be used to wirelessly locate a mobile station: (a) from which a 911 emergency call is performed, (b) for tracking a mobile station (e.g., a truck traveling across country), (c) for routing a mobile station, and (d) locating people and/or animals, including applications for confinement to (and/or exclusion from) certain areas.

It is a further aspect of the present invention that it may be decomposed into: (i) a first low level wireless signal processing subsystem for receiving, organizing and conditioning low level wireless signal measurements from a network of base stations cooperatively linked for providing wireless communications with mobile stations (MSs); and (ii) a second high level signal processing subsystem for performing high level data processing for providing most likelihood location estimates for mobile stations.

Please replace the paragraph beginning on page 12, line 11 with the following paragraph:

Thus, the present invention may be considered as a novel signal processor that includes at least the functionality for the high signal processing subsystem mentioned hereinabove. Accordingly, assuming an appropriate ensemble of wireless signal measurements characterizing the wireless signal communications between a particular MS and a networked wireless base station infrastructure have been received and appropriately filtered of noise and transitory values (such as by an embodiment of the low level signal processing subsystem disclosed in a copending PCT patent application PCT/US97/15933 titled, "Wireless Location Using A Plurality of Commercial Network Infrastructures," by F. W. LeBlanc et al., filed September 8, 1997 from which U.S. Patent 6,236,365, filed July 8, 1999 is the U.S. national counterpart; these two references being herein fully incorporated by reference), the present invention uses the output from such a low level signal processing system for determining a most likely location estimate of an MS.

Please replace the paragraph beginning on page 12, line 19 (and ending on this same line 19) with the following paragraph:

That is, once the following steps are appropriately performed (e.g., by the LeBlanc U.S. Patent 6,236,365):

Please replace the paragraph beginning on page 12, line 28 has been replaced with the following paragraph:

(4.3) providing the composite signal characteristic values to one or more MS location hypothesizing computational models (also denoted herein as "first order models" and also "location estimating models"), wherein each such model subsequently determines one or more initial estimates of the location of the target MS based on, for example, the signal processing techniques 2.1 through 2.3 above. Moreover, each of the models output MS location estimates having substantially identical data structures (each such data structure denoted a "location hypothesis"). Additionally, each location hypothesis may also include a confidence value indicating the likelihood or probability that the target MS whose location is desired resides in a corresponding location estimate for the target MS;

Please replace the paragraph beginning on page 13, line 14 with the following paragraph:

Referring now to (4.3) above, the filtered and aggregated wireless signal characteristic values are provided to a number of location hypothesizing models (denoted First Order Models, or FOMs), each of which yields a location estimate or location hypothesis related to the location of the target MS. In particular, there are location hypotheses for both providing estimates of where the target MS is likely to be and where the target MS is not likely to be. Moreover, it is an aspect of the present invention that confidence values of the location hypotheses are provided as a continuous range of real numbers from, e.g., -1 to 1, wherein the most unlikely areas for locating the target MS are given a confidence value of -1, and the most likely areas for locating the target MS are given a confidence value of 1. That is, confidence values that are larger indicate a higher likelihood that the target MS is in the corresponding MS estimated area, wherein -1 indicates that the target MS is absolutely NOT in the estimated area, 0 indicates a substantially neutral or unknown likelihood of the target MS being in the corresponding estimated area, and 1 indicates that the target MS is absolutely within the corresponding estimated area.

Please replace the paragraph beginning on page 15, line 22 with the following paragraph:

It is a further aspect of the present invention that the personal communication system (PCS) infrastructures currently being developed by telecommunication providers offer an appropriate localized infrastructure base upon which to build various personal location systems (PLS) employing the present invention and/or utilizing the techniques disclosed herein. In particular, the present invention is especially suitable for the location of people and/or objects using code division multiple access (CDMA) wireless infrastructures, although other wireless infrastructures, such as, time division multiple access (TDMA) infrastructures and GSM are also contemplated. Note that CDMA personal communications systems are described in the Telephone Industries Association standard IS-95, for frequencies below 1 GHz, and in the Wideband Spread- Spectrum Digital Cellular System Dual-Mode Mobile Station-Base Station Compatibility Standard, for frequencies in the 1.8-1.9 GHz frequency bands, both of which are incorporated herein by reference. Furthermore, CDMA general principles have also been described, for example, in U. S. Patent 5,109,390, to Gilhausen, et al, filed November 7, 1989, and CDMA Network Engineering Handbook by Qualcomm, Inc., each of which is also incorporated herein by reference.

The paragraph beginning on page 16, line 6 has been replaced with the following paragraph:

As mentioned in the discussion of classification FOMs above, the present invention can substantially automatically retrain and/or recalibrate itself to compensate for variations in wireless signal characteristics (e.g., multipath) due to environmental and/or topographic changes to a geographic area serviced by the present invention. For example, in one embodiment, the present invention optionally includes low cost, low power base stations, denoted location base stations (LBS) above, providing, for example, CDMA pilot channels to a very limited area about each such LBS. The location base stations may provide limited voice traffic capabilities, but each is capable of gathering sufficient wireless signal characteristics from an MS within the location base station's range to facilitate locating the MS. Thus, by positioning the location base stations at known locations in a geographic region such as, for instance, on street lamp poles and road signs, additional MS location accuracy can be obtained. That is, due to the low power signal output by such location base stations, for there to be signaling control communication (e.g., pilot signaling and other control signals) between a location base station and a target MS, the MS must be relatively near the location base station. Additionally, for each location base station not in communication with the target MS, it is likely that the MS is not near to this location base station. Thus, by utilizing information received from both location base stations in communication with the target MS and those that are not in communication with the target MS, the present invention can substantially narrow the possible geographic areas within which the target MS is likely to be. Further, by providing each location base station (LBS) with a co-located stationary wireless transceiver (denoted a built-in MS above) having similar functionality to an MS, the following advantages are provided:

Please replace the paragraph beginning on page 17, line 12 with the following paragraph:

It is also an aspect of the present invention to automatically (re)calibrate as in (6.3) above with signal characteristics from other known or verified locations. In one embodiment of the present invention, portable location verifying electronics are provided so that when such electronics are sufficiently near a located target MS, the electronics: (i) detect the proximity of the target MS; (ii) determine a highly reliable measurement of the location of the target MS; (iii) provide this measurement to other location determining components of the present invention so that the location measurement can be associated and archived with related signal characteristic data received from the target MS at the location where the location measurement is performed. Thus, the use of such portable location verifying electronics allows the present invention to capture and utilize signal characteristic data from verified, substantially random locations for location system calibration as in (6.3) above. Moreover, it is important to note that such location verifying electronics can verify locations automatically wherein it is unnecessary for manual activation of a location verifying process.

Please replace the paragraph beginning on page 18, line 6 with the following paragraph:

Furthermore, a mobile location base station includes modules for integrating or reconciling distinct mobile location base station location estimates that, for example, can be obtained using the components and devices of (7.1) through (7.4) above. That is, location estimates for the mobile location base station may be obtained from: GPS satellite data, mobile location base station data provided by the location processing center, deadreckoning data obtained from the mobile location base station vehicle deadreckoning devices, and location data manually input by an operator of the mobile location base station.

Please replace the paragraph beginning on page 18, line 11 with the following paragraph:

The location estimating system of the present invention offers many advantages over existing location systems. The system of the present invention, for example, is readily adaptable to existing wireless communication systems and can accurately locate people and/or objects in a cost effective manner. In particular, the present invention requires few, if any, modifications to commercial wireless communication systems for implementation. Thus, existing personal communication system infrastructure base stations and other components of, for example, commercial CDMA infrastructures are readily adapted to the present invention. The present invention can be used to locate people and/or objects that are not in the line-of-sight of a wireless receiver or transmitter, can reduce the detrimental effects of multipath on the accuracy of the location estimate, can potentially locate people and/or objects located indoors as well as outdoors, and uses a number of wireless stationary transceivers for location. The present invention employs a number of distinctly different location computational models for location which provides a greater degree of accuracy, robustness and versatility than is possible with existing systems. For instance, the location models provided include not only the radius-radius/TOA and TDOA techniques but also adaptive artificial neural net techniques. Further, the present invention is able to adapt to the topography of an area in which location service is desired. The present invention is also able to adapt to environmental changes substantially as frequently as desired. Thus, the present invention is able to take into account changes in the location topography over time without extensive manual data manipulation. Moreover, the present invention can be utilized with varying amounts of signal measurement inputs. Thus, if a location estimate is desired in a very short time interval (e.g., less than approximately one to two seconds), then the present location estimating system can be used with only as much signal measurement data as is possible to acquire during an initial portion of this time interval. Subsequently, after a greater amount of signal measurement data has been acquired, additional more accurate location estimates may be obtained. Note that this capability can be useful in the context of 911 emergency response in that a first quick coarse wireless mobile station location estimate can be used to route a 911 call from the mobile station to a 911 emergency response center that has responsibility for the area containing the mobile station and the 911 caller. Subsequently, once the 911 call has been routed according to this first quick location estimate, by continuing to receive additional wireless signal measurements, more reliable and accurate location estimates of the mobile station can be obtained.

Please replace the paragraph beginning on page 19, line 5 through page 19, line 19 with the following paragraph:

At a more general level, it is an aspect of the present invention to demonstrate the utilization of various novel computational paradigms such as:

(8.1) providing a multiple hypothesis computational architecture (as illustrated best in Figs. 8) wherein the hypotheses are:

(8.1.1) generated by modular independent hypothesizing computational models;

(8.1.2) the models are embedded in the computational architecture in a manner wherein the architecture allows for substantial amounts of application specific processing common or generic to a plurality of the models to be straightforwardly incorporated into the computational architecture;

(8.1.3) the computational architecture enhances the hypotheses generated by the models both according to past performance of the models and according to application specific constraints and heuristics without requiring feedback loops for adjusting the models;

(8.1.4) the models are relatively easily integrated into, modified and extracted from the computational architecture;

(8.2) providing a computational paradigm for enhancing an initial estimated solution to a problem by using this initial estimated solution as, effectively, a query or index into an historical data base of previous solution estimates and corresponding actual solutions for deriving an enhanced solution estimate based on past performance of the module that generated the initial estimated solution.

Please replace the paragraph beginning on page 20, line 19 with the following paragraph:

In other embodiments of the present invention, a fast, albeit less accurate location estimate may be initially performed for very time critical location applications where approximate location information may be required. For example, less than 1 second response for a mobile station location embodiment of the present invention may be desired for 911 emergency response location requests. Subsequently, once a relatively coarse location estimate has been provided, a more accurate most likely location estimate can be performed by repeating the location estimation processing a second time with, e.g., additional with measurements of wireless signals transmitted between a mobile station to be located and a network of base stations with which the mobile station is communicating, thus providing a second, more accurate location estimate of the mobile station.

Please replace the paragraph beginning on page 21, line 1 with the following paragraph:

Note that in some embodiments of the present invention, since there is a lack of sequencing between the FOMs and subsequent processing of location hypotheses, the FOMs can be incorporated into an expert system, if desired. For example, each FOM may be activated from an antecedent of an expert system rule. Thus, the antecedent for such a rule can evaluate to TRUE if the FOM outputs a location hypothesis, and the consequent portion of such a rule may put the output location hypothesis on a list of location hypotheses occurring in a particular time window for subsequent processing by the location center. Alternatively, activation of the FOMs may be in the consequents of such expert system rules. That is, the antecedent of such an expert system rule may determine if the conditions are appropriate for invoking the FOM(s) in the rule's consequent.

Please replace the paragraph beginning on page 21, line 8 with the following two paragraphs. Note that the only difference here is the commencement of a new paragraph at –Further features and advantages–.

Of course, other software architectures may also to used in implementing the processing of the location center without departing from scope of the present invention. In particular, object-oriented architectures are also within the scope of the present invention. For example, the FOMs may be object methods on an MS location estimator object, wherein the estimator object receives substantially all target MS location signal data output by the signal filtering subsystem. Alternatively, software bus architectures are contemplated by the present invention, as one skilled in the art will understand, wherein the software architecture may be modular and facilitate parallel processing.

Further features and advantages of the present invention are provided by the figures and detailed description accompanying this invention summary.

Please replace the paragraph beginning on page 22, line 5 with the following paragraph:

Fig. 3 provides a typical example of how the statistical power budget is calculated in design of a Commercial Mobile Radio Service Provider (CMRS) network.

Please replace the paragraph beginning on page 22, line 14 with the following paragraph:

Figs. 9And 9B is a high level data structure diagram describing the fields of a location hypothesis object generated by the first order models 1224 of the location center.

Please replace the paragraph beginning on page 23, line 16 with the following paragraph:

Figs. 23A through 23C present a high level flowchart of the steps performed by function, "GET_DIFFERENCE_MEASUREMENT," for updating location signatures in the location signature data base 1320; note, this flowchart corresponds to the description of this function in APPENDIX C.

Please replace the paragraph beginning on page 28, line 9 with the following paragraph:

The MBS 148 acts as a low cost, partially-functional, moving base station, and is, in one embodiment, situated in a vehicle where an operator may engage in MS 140 searching and tracking activities. In providing these activities using CDMA, the MBS 148 provides a forward link pilot channel for a target MS 140, and subsequently receives unique BS pilot strength measurements from the MS 140. The MBS 148 also includes a mobile station for data communication with the LC 142, via a BS 122. In particular, such data communication includes telemetering the geographic position of the MBS 148 as well as various RF measurements related to signals received from the target MS 140. In some embodiments, the MBS 148 may also utilize multiple-beam fixed antenna array elements and/or a moveable narrow beam antenna, such as a microwave dish 182. The antennas for such embodiments may have a known orientation in order to further deduce a radio location of the target MS 140 with respect to an estimated current location of the MBS 148. As will be described in more detail herein below, the MBS 148 may further contain a global positioning system (GPS), distance sensors, deadreckoning electronics, as well as an on-board computing system and display devices for locating both the MBS 148 itself as well as tracking and locating the target MS 140. The computing and display provides a means for communicating the position of the target MS 140 on a map display to an operator of the MBS 148.

Please replace the paragraph beginning on page 29, line 15 with the following <u>two</u> paragraphs. Note that the only difference here is the commencement of a new paragraph at –Thus, LBSs 152–.

It should be noted that an LBS 152 will normally deny hand-off requests, since typically the LBS does not require the added complexity of handling voice or traffic bearer channels, although economics and peak traffic load conditions would dictate preference here. GPS timing information, needed by any CDMA base station, is either achieved via a the inclusion of a local GPS receiver or via a telemetry process from a neighboring conventional BS 122, which contains a GPS receiver and timing information. Since energy requirements are minimal in such an LBS 152, (rechargeable) batteries or solar cells may be used to power the LBS. No expensive terrestrial transport link is typically required since two-way communication is provided by the included MS 140 (or an electronic variation thereof).

Thus, LBSs 152 may be placed in numerous locations, such as:

(a) in dense urban canyon areas (e.g., where signal reception may be poor and/or very noisy);

(b) in remote areas (e.g., hiking, camping and skiing areas);

(c) along highways (e.g., for emergency as well as monitoring traffic flow), and their rest stations; or

(d) in general, wherever more location precision is required than is obtainable using other wireless infrastructure network components.

Please replace the paragraph beginning on page 29, line 29 with the following paragraph:

A location application programming interface or L-API 14 (see Fig. 30, and including L-API-Loc_APP 135, L-API-MSC 136, and L-API-SCP 137 shown in Fig. 4), is required between the location center 142 (LC) and the mobile switch center (MSC) network element type, in order to send and receive various control, signals and data messages. The L-API 14 should be implemented using a preferably high-capacity physical layer communications interface, such as IEEE standard 802.3 (10 baseT Ethernet), although other physical layer interfaces could be used, such as fiber optic ATM, frame relay, etc. Two forms of API implementation are possible. In the first case the signals control and data messages are realized using the MSC 112 vendor's native operations messages inherent in the product offering, without any special modifications. In the second case the L-API includes a full suite of commands and messaging content specifically optimized for wireless location purposes, which may require some, although minor development on the part of the MSC vendor.

Please replace the paragraph beginning on page 30, line 6 with the following paragraph:

Referring to Fig. 30, the signal processing subsystem 1220 receives control messages and signal measurements and transmits appropriate control messages to the wireless network via the location applications programming interface referenced earlier, for wireless location purposes. The signal processing subsystem additionally provides various signal identification, conditioning and pre-processing functions, including buffering, signal type classification, signal filtering, message control and routing functions to the location estimate modules.

Please replace the paragraph beginning on page 30, line 11 with the following paragraph:

There can be several combinations of Delay Spread/Signal Strength sets of measurements made available to the signal processing subsystem 1220. In some cases the mobile station 140 (Fig. 4) may be able to detect up to three or four Pilot Channels representing three to four Base Stations, or as few as one Pilot Channel, depending upon the environment. Similarly, possibly more than one BS 122 can detect a mobile station 140 transmitter signal, as evidenced by the provision of cell diversity or soft hand-off in the CDMA standards, and the fact that multiple CMRS' base station equipment commonly will overlap coverage areas. For each mobile station 140 or BS 122 transmitted signal detected by a receiver group at a station, multiple delayed signals, or "fingers" may be detected and tracked resulting from multipath radio propagation conditions, from a given transmitter.

Please replace the paragraph beginning on page 30, line 23 with the following paragraph:

From the mobile receiver's perspective, a number of combinations of measurements could be made available to the Location Center. Due to the disperse and near-random nature of CDMA radio signals and propagation characteristics, traditional TOA/TDOA location methods have failed in the past, because the number of signals received in different locations are different. In a particularly small urban area, of say less than 500 square feet, the number of RF signals and their multipath components may vary by over 100 percent.

Please replace the paragraph beginning on page 31, line 19 with the following paragraph:

Although Rayleigh fading appears as a generally random noise generator, essentially destroying the correlation value of either $RRSS_{BS}$ or $SRSS_{MS}$ measurements with distance individually, several mathematical operations or signal processing functions can be performed on each measurement to derive a more robust relative signal strength value, overcoming the adverse Rayleigh fading effects. Examples include averaging, taking the strongest value and weighting the strongest value with a greater coefficient than the weaker value, then averaging the results. This signal processing technique takes advantage of the fact that although a Rayleigh fade may often exist in either the forward or reverse path, it is much less probable that a Rayleigh fade also exists in the reverse or forward path, respectively. A shadow fade however, similarly affects the signal strength in both paths.

Please replace the paragraph beginning on page 31, line 26 with the following paragraph:

At this point a CDMA radio signal direction independent of "net relative signal strength measurement" can be derived which can be used to establish a correlation with either distance or shadow fading, or both. Although the ambiguity of either shadow fading or distance cannot be determined, other means can be used in conjunction, such as the fingers of the CDMA delay spread measurement, and any other TOA/TDOA calculations from other geographical points. In the case of a mobile station with a certain amount of shadow fading between its BS 122 (Fig. 2), the first finger of a CDMA delay spread signal is most likely to be a relatively shorter duration than the case where the mobile station 140 and BS 122 are separated by a greater distance, since shadow fading does not materially affect the arrival time delay of the radio signal.

Please replace the paragraph beginning on page 31, line 33 with the following paragraph:

By performing a small modification in the control electronics of the CDMA base station and mobile station receiver circuitry, it is possible to provide the signal processing subsystem 1220 (reference Fig. 30) within the location center 142 (Fig. 1) with data that exceed the one-to-one CDMA delay-spread fingers to data receiver correspondence. Such additional information, in the form of additional CDMA fingers (additional multipath) and all associated detectable pilot channels, provides new information which is used to enhance the accuracy of the location center's location estimators.

Please replace the paragraph beginning on page 32, line 4 with the following paragraph:

This enhanced capability is provided via a control message, sent from the location center 142 to the mobile switch center 12, and then to the base station(s) in communication with, or in close proximity with, mobile stations 140 to be located. Two types of location measurement request control messages are needed: one to instruct a target mobile station 140 (i.e., the mobile station to be located) to telemeter its BS pilot channel measurements back to the primary BS 122 and from there to the mobile switch center 112 and then to the location system 42. The second control message is sent from the location system 42 to the mobile switch center 112, then to first the primary BS, instructing the primary BS' searcher receiver to output (i.e., return to the initiating request message source) the detected target mobile station 140 transmitter CDMA pilot channel offset signal and their corresponding delay spread finger (peak) values and related relative signal strengths.

Please replace the paragraph beginning on page 32, line 24 with the following paragraph:

Fig. 30 illustrates the components of the Signal Processing Subsystem 1220 (also shown in Figs. 5, 6 and 8). The main components consist of the input queue(s) 7, signal classifier/filter 9, digital signaling processor 17, imaging filters 19, output queue(s) 21, router/distributor 23, (also denoted as the "Data Capture And Gateway" in Fig. 8(2)), a signal processor database 26 and a signal processing controller 15.

Please replace the paragraph beginning on page 33, line 3 with the following paragraph:

The signal processing subsystem 1220 supports a variety of wireless network signaling measurement capabilities by detecting the capabilities of the mobile and base station through messaging structures provided by the location application programming interface (L-API 14, Fig. 30). Detection is accomplished in the signal classifier 9 (Fig. 30) by referencing a mobile station database table within the signal processor database 26, which provides, given a mobile station identification number, mobile station revision code, other mobile station characteristics. Similarly, a mobile switch center table 31 provides MSC characteristics and identifications to the signal classifier/filter 9. The signal classifier/filter adds additional message header information that further classifies the measurement data which allows the digital signal processor and image filter components to select the proper internal processing subcomponents to perform operations on the signal measurement data, for use by the location estimate modules.

Please replace the paragraph beginning on page 33, line 11 and ending at page 33, line 18 with the following paragraph.

Regarding service control point messages (of L-API-SCP interface 137, Fig. 4) autonomously received from the input queue 7 (Figs. 30 and 31), the signal classifier/filter 9 determines via a signal processing database 26 query whether such a message is to be associated with a home base station module. Thus appropriate header information is added to the message, thus enabling the message to pass through the digital signal processor 17 unaffected to the output queue 21, and then to the router/distributor 23. The router/distributor 23 then routes the message to the HBS first order model. Those skilled in the art will understand that associating location requests from Home Base Station configurations require substantially less data: the mobile identification number and the associated wireline telephone number transmission from the home location register are on the order of less than 32 bytes. Consequentially the home base station message type could be routed without any digital signal processing.

The paragraph beginning on page 33. line 19 has been replaced with the following paragraph:

Output queue(s) 21 (Fig. 30) are required for similar reasons as input queues 7: relatively large amounts of data must be held in a specific format for further location processing by the location estimate modules 1224.

Please replace the paragraph beginning on page 33, line 21 through page 33. line 23 with the following paragraph.

The router and distributor component 23 (Fig. 30) is responsible for directing specific signal measurement data types and structures to their appropriate modules. For example, the HBS FOM has no use for digital filtering structures, whereas the TDOA module would not be able to process an HBS response message.

Please replace the paragraph beginning on page 33, line 27 with the following paragraph:

In addition the controller 15 receives autonomous messages from the MSC, via the location applications programming interface or L-API 14 (Fig. 30) and the input queue 7, whenever a 9-1-1 wireless call is originated. The mobile switch center provides this autonomous notification to the location system as follows: by specifying the appropriate mobile switch center operations and maintenance commands to surveil calls based on certain digits dialed such as 9-1-1, the location applications programming interface 14, in communications with the MSCs, receives an autonomous notification whenever a mobile station user dials 9-1-1. Specifically, a bi-directional authorized communications port is configured, usually at the operations and maintenance subsystem of the MSCs, or with their associated network element manager system(s), with a data circuit, such as a DS-1, with the location applications programming interface 14. Next, the "call trace" capability of the mobile switch center is activated for the respective communications port. The exact implementation of the vendor-specific man-machine or Open Systems Interface (OSI) command(s) and their associated data structures generally vary among MSC vendors. However, the trace function is generally available in various forms, and is required in order to comply with Federal Bureau of Investigation authorities for wire tap purposes. After the appropriate surveillance commands are established on the MSC, such 9-1-1 call notifications messages containing the mobile station identification number (MIN) and, in U.S. FCC phase 1 E9-1-1 implementations, a pseudo-automatic number identification (a.k.a. pANI) which provides an association with the primary base station in which the 9-1-1 caller is in communication. In cases where the pANI is known from the onset, the signal processing subsystem 1220 avoids querying the MSC in question to determine the primary base station identification associated with the 9-1-1 mobile station caller.

The paragraph beginning on page 33, line 34 has been replaced with the following paragraph:

The controller 15 (Fig. 30) is responsible for staging the movement of data among the signal processing subsystem 1220 components input queue 7, digital signal processor 17, router/distributor 23 and the output queue 21, and to initiate signal measurements within the wireless network, in response from an internet 468 location request message in Fig. 5, via the location application programming interface.

The paragraph beginning on page 34, line 10 has been replaced with the following paragraph:

After the signal processing controller 15 receives the first message type, the autonomous notification message from the mobile switch center 112 to the location system 142, containing the mobile identification number and optionally the primary base station identification, the controller 15 queries the base station table 13 (Fig. 30) in the signal processor database 26 to determine the status and availability of any neighboring base stations, including those base stations of other CMRS in the area. The definition of neighboring base stations include not only those within a provisionable "hop" based on the cell design reuse factor, but also includes, in the case of CDMA, results from remaining set information autonomously queried to mobile stations, with results stored in the base station table. Remaining set information indicates that mobile stations can detect other base station (sector) pilot channels which may exceed the "hop" distance, yet are nevertheless candidate base stations (or sectors) for wireless location purposes. Although cellular and digital cell design may vary, "hop" distance is usually one or two cell coverage areas away from the primary base station's cell coverage area.

Please replace the paragraph beginning on page 34, line 20 with the following paragraph:

Having determined a likely set of base stations which may both detect the mobile station's transmitter signal, as well as to determine the set of likely pilot channels (i.e., base stations and their associated physical antenna sectors) detectable by the mobile station in the area surrounding the primary base station (sector), the controller 15 initiates messages to both the mobile station and appropriate base stations (sectors) to perform signal measurements and to return the results of such measurements to the signal processing system regarding the mobile station to be located. This step may be accomplished via several interface means. In a first case the controller 15 utilizes, for a given MSC, predetermined storage information in the MSC table 31 to determine which type of commands, such as man-machine or OSI commands are needed to request such signal measurements for a given MSC. The controller generates the mobile and base station signal measurement commands appropriate for the MSC and passes the commands via the input queue 7 and the locations application programming interface 14 in Fig. 30, to the appropriate MSC, using the authorized communications port mentioned earlier. In a second case, the controller 15 communicates directly with base stations within having to interface directly with the MSC for signal measurement extraction.

Please replace the paragraph beginning on page 34, line 31 with the following paragraph:

Upon receipt of the signal measurements, the signal classifier 9 in Fig. 30 examines location application programming interface-provided message header information from the source of the location measurement (for example, from a fixed BS 122, a mobile station 140, a distributed antenna system 168 in Fig. 4 or message location data related to a home base station), provided by the location applications programming interface (L-API 14) via the input queue 7 in Fig. 30 and determines whether or not device filters 17 or image filters 19 are needed, and assesses a relative priority in processing, such as an emergency versus a background location task, in terms of grouping like data associated with a given location request. In the case where multiple signal measurement requests are outstanding for various base stations, some of which may be associated with a different CMRS network, and additional signal classifier function includes sorting and associating the appropriate incoming signal measurements together such that the digital signal processor 17 processes related measurements in order to build ensemble data sets. Such ensembles allow for a variety of functions such as averaging, outlier removal over a time_period, and related filtering functions, and further prevent association errors from occurring in location estimate processing.

Please replace the paragraph beginning on page 35, line 10 with the following paragraph:

Another function of the signal classifier/low pass filter component 9 is to filter information that is not useable, or information that could introduce noise or the effect of noise in the location estimate modules. Consequently low pass matching filters are used to match the in-common signal processing components to the characteristics of the incoming signals. Low pass filters match: Mobile Station, base station, CMRS and MSC characteristics, as well as to classify Home Base Station messages.

Please replace the paragraph beginning on page 35, line 14 with the following paragraph:

The signal processing subsystem 1220 contains a base station database table 13 (Fig. 30) which captures the maximum number of CDMA delay spread fingers for a given base station.

Please replace the paragraph beginning on page 35, line 21 with the following paragraph:

Just as an upgraded base station may detect additional CDMA delay spread signals, newer or modified mobile stations may detect additional pilot channels or CDMA delay spread fingers. Additionally different makes and models of mobile stations may acquire improved receiver sensitivities, suggesting a greater coverage capability. A table may establish the relationships among various mobile station equipment suppliers and certain technical data relevant to this location invention.

Please replace the paragraph beginning on page 35, line 25 with the following paragraph:

Although not strictly necessary, the MIN can be populated in this table from the PCS Service Provider's Customer Care system during subscriber activation and fulfillment, and could be changed at deactivation, or anytime the end-user changes mobile stations. Alternatively, since the MIN, manufacturer, model number, and software revision level information is available during a telephone call, this information could extracted during the call, and the remaining fields populated dynamically, based on manufacturer's specifications information previously stored in the signal processing subsystem 1220. Default values are used in cases where the MIN is not found, or where certain information must be estimated.

Please replace the paragraph beginning on page 35, line 31 with the following paragraph:

A low pass mobile station filter, contained within the signal classifier/low pass filter 9 of the signal processing subsystem 1220, uses the above table data to perform the following functions: 1) act as a low pass filter to adjust the nominal assumptions related to the maximum number of CDMA fingers, pilots detectable; and 2) to determine the transmit power class and the receiver thermal noise floor. Given the detected reverse path signal strength, the required value of $SRSS_{MS}$, a corrected indication of the effective path loss in the reverse direction (mobile station to BS), can be calculated based on data contained within the mobile station table 11, stored in the signal processing database 26.

Please replace the paragraph beginning on page 36, line 3 with the following paragraph:

The effects of the maximum number of CDMA fingers allowed and the maximum number of pilot channels allowed essentially form a low pass filter effect, wherein the least common denominator of characteristics are used to filter the incoming RF signal measurements such that a one for one matching occurs. The effect of the transmit power class and receiver thermal noise floor values is to normalize the characteristics of the incoming RF signals with respect to those RF signals used.

Please replace the paragraph beginning on page 36, line 7 with the following paragraph:

The signal classifier/filter 9 (Fig. 30) is in communication with both the input queue 7 and the signal processing database 26. In the early stage of a location request the signal processing subsystem 1220 shown in, e.g., Figs. 5, 30 and 31, will receive the initiating location request from either an autonomous 9-1-1 notification message from a given MSC, or from a location application, for which mobile station characteristics about the target mobile station 140 (Fig. 4) is required. Referring to Fig. 30, a query is made from the signal processing controller 15 to the signal processing database 26, specifically the mobile station table 11, to determine if the mobile station characteristics associated with the MIN to be located is available in table 11. If the data exists then there is no need for the controller 15 to query the wireless network in order to determine the mobile station characteristics, thus avoiding additional real-time processing which would otherwise be required across the air interface, in order to determine the mobile station MIN characteristics. The resulting mobile station information my be provided either via the signal processing database 26 or alternatively a query may be performed directly from the signal processing subsystem 1220 to the MSC in order to determine the mobile station characteristics.

Please replace the paragraph beginning on page 36, line 18 with the following paragraph. Note that a new Fig. 31 is provided with the label "139" changed to –239–. This is being done since the label "139" is already being used to denote the "location engine."

Referring now to Fig. 31, another location application programming interface, L-API-CCS 239 to the appropriate CMRS customer care system provides the mechanism to populate and update the mobile station table 11 within the database 26. The L-API-CCS 239 contains its own set of separate input and output queues or similar implementations and security controls to ensure that provisioning data is not sent to the incorrect CMRS, and that a given CMRS cannot access any other CMRS' data. The interface 1155a to the customer care system for CMRS-A 1150a provides an autonomous or periodic notification and response application layer protocol type, consisting of add, delete, change and verify message functions in order to update the mobile station table 11 within the signal processing database 26, via the controller 15. A similar interface 155b is used to enable provisioning updates to be received from CMRS-B customer care system 1150b.

Please replace the paragraph beginning on page 36, line 26 with the following paragraph:

Although the L-API-CCS application message set may be any protocol type which supports the autonomous notification message with positive acknowledgment type, the T1M1.5 group within the American National Standards Institute has defined a good starting point in which the L-API-CCS 239 could be implemented, using the robust OSI TMN X-interface at the service management layer. The object model defined in Standards proposal number T1M1.5/96-22R9, Operations Administration, Maintenance, and Provisioning (OAM&P) - Model for Interface Across Jurisdictional Boundaries to Support Electronic Access Service Ordering: Inquiry Function, can be extended to support the L-API-CCS information elements as required and further discussed below. Other choices in which the L-API-CCS application message set may be implemented include ASCII, binary, or any encrypted message set encoding using the Internet protocols, such as TCP/IP, simple network management protocol, http, https, and email protocols.

Please replace the paragraph beginning on page 37, line 12 with the following paragraph:

In the general case where a mobile station is located in an environment with varied clutter patterns, such as terrain undulations, unique man-made structure geometries (thus creating varied multipath signal behaviors), such as a city or suburb, although the first CDMA delay spread finger may be the same value for a fixed distance between the mobile station and BS antennas, as the mobile station moves across such an area, different finger-data are measured. In the right image for the defined BS antenna sector, location classes, or squares numbered one through seven, are shown across a particular range of line of position (LOP).

Please replace the paragraph beginning on page 37, line 17 with the following paragraph:

A traditional TOA/TDOA ranging method between a given BS and mobile station only provides a range along an arc, thus introducing ambiguity error. However a unique three dimensional image can be used in this method to specifically identify, with recurring probability, a particular unique location class along the same Line Of Position, as long as the multipath is unique by position but generally repeatable, thus establishing a method of not only ranging, but also of complete latitude, longitude location estimation in a Cartesian space. In other words, the unique shape of the "mountain image" enables a correspondence to a given unique location class along a line of position, thereby eliminating traditional ambiguity error.

Please replace the paragraph beginning on page 38, line 17 with the following paragraph:

The DSP 17 may provide data ensemble results, such as extracting the shortest time delay with a detectable relative signal strength, to the router/distributor 23, or alternatively results may be processed via one or more image filters 19, with subsequent transmission to the router/distributor 23. The router/distributor 23 examines the processed message data from the DSP 17 and stores routing and distribution information in the message header. The router/distributor 23 then forwards the data messages to the output queue 21, for subsequent queuing then transmission to the appropriate location estimator FOMs.

Please replace the paragraph beginning on page 38, line 24 and ending at page 39, line 14 with the following paragraph:

At a very high level the location center 142 computes location estimates for a wireless Mobile Station 140 (denoted the "target MS" or "MS") by performing the following steps:

(23.1) receiving signal transmission characteristics of communications communicated between the target MS 140 and one or more wireless infrastructure base stations 122;

(23.2) filtering the received signal transmission characteristics (by a signal processing subsystem 1220 illustrated in Fig. 5) as needed so that target MS location data can be generated that is uniform and consistent with location data generated from other target MSs 140. In particular, such uniformity and consistency is both in terms of data structures and interpretation of signal characteristic values provided by the MS location data;

(23.3) inputting the generated target MS location data to one or more MS location estimating models (denoted First order models or FOMs, and labeled collectively as 1224 in Fig. 5), so that each such model may use the input target MS location data for generating a "location hypothesis" providing an estimate of the location of the target MS 140;

(23.4) providing the generated location hypotheses to an hypothesis evaluation module (denoted the hypothesis evaluator 1228 in Fig. 5):

(a) for adjusting at least one of the target MS location estimates of the generated location hypotheses and related confidence values indicating the confidence given to each location estimate, wherein such adjusting uses archival information related to the accuracy of previously generated location hypotheses,

(b) for evaluating the location hypotheses according to various heuristics related to, for example, the radio coverage area 120 terrain, the laws of physics, characteristics of likely movement of the target MS 140; and

(c) for determining a most likely location area for the target MS 140, wherein the measurement of confidence associated with each input MS location area estimate is used for determining a "most likely location area"; and

(23.5) outputting a most likely target MS location estimate to one or more applications 146 (Fig. 5) requesting an estimate of the location of the target MS 140.

Please replace the paragraph beginning on page 42, line 1 with the following paragraph:

Additionally, in utilizing location hypotheses in, for example, the location evaluator 1228 as in (23.4) above, it is important to keep in mind that each location hypothesis confidence value is a relative measurement. That is, for confidences, cf_1 and cf_2, if $cf_1 <= cf_2$, then for a location hypotheses H_1 and H_2 having cf_1 and cf_2, respectively, the target MS 140 is expected to more likely reside in a target MS estimate of H_2 than a target MS estimate of H_1. Moreover, if an area, A, is such that it is included in a plurality of location hypothesis target MS estimates, then a confidence score, CS_A, can be assigned to A, wherein the confidence score for such an area is a function of the confidences (both positive and negative) for all the location hypotheses whose (most pertinent) target MS location estimates contain A. That is, in order to determine a most likely target MS location area estimate for outputting from the location center 142, a confidence score is determined for areas within the location center service area. More particularly, if a function, "f", is a function of the confidence(s) of location hypotheses, and f is a monotonic function in its parameters and $f(cf_1, cf_2, cf_3, \ldots, cf_N) = CS_A$ for confidences cf_i of location hypotheses H_i, $i=1,2,\ldots,N$, with CS_A contained in the area estimate for H_i, then "f" is denoted a confidence score function. Accordingly, there are many embodiments for a confidence score function f that may be utilized in computing confidence scores with the present invention; e.g.,

(a) $f(cf_1, cf_2, \ldots, cf_N) = \Sigma\, cf_i = CS_A$;

(b) $f(cf_1, cf_2, \ldots, cf_N) = \Sigma\, cf_i^n = CS_A$, $n = 1, 3, 5, \ldots$;

(c) $f(cf_1, cf_2, \ldots, cf_N) = \Sigma\, (K_i * cf_i) = CS_A$, wherein K_i, $i = 1, 2, \ldots$ are positive system (tunable) constants (possibly dependent on environmental characteristics such as topography, time, date, traffic, weather, and/or the type of base station(s) 122 from which location signatures with the target MS 140 are being generated, etc.).

Please replace the paragraph beginning on page 43, line 27 and ending on page 44, line 23 with the following paragraph:

In one embodiment of a method and system for determining such (transmission) area type approximations, a partition (denoted hereinafter as P_0) is imposed upon the radio coverage area 120 for partitioning for radio coverage area into subareas, wherein each subarea is an estimate of an area having included MS 140 locations that are likely to have is at least a minimal amount of similarity in their wireless signaling characteristics. To obtain the partition P_0 of the radio coverage area 120, the following steps are performed:

(23.8.4.1) Partition the radio coverage area 120 into subareas, wherein in each subarea is: (a) connected, (b) variations in the lengths of chords sectioning the subarea through the centroid of the subarea are below a predetermined threshold, (c) the subarea has an area below a predetermined value, and (d) for most locations (e.g., within a first or second standard deviation) within the subarea whose wireless signaling characteristics have been verified, it is likely (e.g., within a first or second standard deviation) that an MS 140 at one of these locations will detect (forward transmission path) and/or will be detected (reverse transmission path) by a same collection of base stations 122. For example, in a CDMA context, a first such collection may be (for the forward transmission path) the active set of base stations 122, or, the union of the active and candidate sets, or, the union of the active, candidate and/or remaining sets of base stations 122 detected by "most" MSs 140 in the subarea. Additionally (or alternatively), a second such collection may be the base stations 122 that are expected to detect MSs 140 at locations within the subarea. Of course, the union or intersection of the first and second collections is also within the scope of the present invention for partitioning the radio coverage area 120 according to (d) above. It is worth noting that it is believed that base station 122 power levels will be substantially constant. However, even if this is not the case, one or more collections for (d) above may be determined empirically and/or by computationally simulating the power output of each base station 122 at a predetermined level. Moreover, it is also worth mentioning that this step is relatively straightforward to implement using the data stored in the location signature data base 1320 (i.e., the verified location signature clusters discussed in detail hereinbelow). Denote the resulting partition here as P_1.

(23.8.4.2) Partition the radio coverage area 120 into subareas, wherein each subarea appears to have substantially homogeneous terrain characteristics. Note, this may be performed periodically substantially automatically by scanning radio coverage area images obtained from aerial or satellite imaging. For example, EarthWatch Inc. of Longmont, CO can provide geographic with 3 meter resolution from satellite imaging data. Denote the resulting partition here as P_2.

(23.8.4.3) Overlay both of the above partitions of the radio coverage area 120 to obtain new subareas that are intersections of the subareas from each of the above partitions. This new partition is P_0 (i.e., $P_0 = P_1$ intersect P_2), and the subareas of it are denoted as "P_0 subareas".

Please replace the paragraph beginning on page 47, line 4 and ending at page 47, line 22 with the following paragraph:

There are four fundamental entity types (or object classes in an object oriented programming paradigm) utilized in the location signature data base 1320. Briefly, these data entities are described in the items (24.1) through (24.4) that follow:

(24.1) (verified) location signatures: Each such (verified) location signature describes the wireless signal characteristic measurements between a given base station (e.g., BS 122 or LBS 152) and an MS 140 at a (verified or known) location associated with the (verified) location signature. That is, a verified location signature corresponds to a location whose coordinates such as latitude-longitude coordinates are known, while simply a location signature may have a known or unknown location corresponding with it. Note that the term (verified) location signature is also denoted by the abbreviation, "(verified) loc sig" hereinbelow;

(24.2) (verified) location signature clusters: Each such (verified) location signature cluster includes a collection of (verified) location signatures corresponding to all the location signatures between a target MS 140 at a (possibly verified) presumed substantially stationary location and each BS (e.g., 122 or 152) from which the target MS 140 can detect the BS's pilot channel regardless of the classification of the BS in the target MS (i.e., for CDMA, regardless of whether a BS is in the MS's active, candidate or remaining base station sets, as one skilled in the art will understand). Note that for simplicity here, it is presumed that each location signature cluster has a single fixed primary base station to which the target MS 140 synchronizes or obtains its timing;

(24.3) "composite location objects (or entities)": Each such entity is a more general entity than the verified location signature cluster. An object of this type is a collection of (verified) location signatures that are associated with the same MS 140 at substantially the same location at the same time and each such loc sig is associated with a different base station. However, there is no requirement that a loc sig from each BS 122 for which the MS 140 can detect the BS's pilot channel is included in the "composite location object (or entity)"; and

(24.4) MS location estimation data that includes MS location estimates output by one or more MS location estimating first order models 1224, such MS location estimate data is described in detail hereinbelow.

Please replace the paragraph beginning on page 47, line 30 with the following paragraph:

In particular, for each (verified) loc sig includes the following:

(25.1) MS_type: the make and model of the target MS 140 associated with a location signature instantiation; note that the type of MS 140 can also be derived from this entry; e.g., whether MS 140 is a handset MS, car-set MS, or an MS for location only. Note as an aside, for at least CDMA, the type of MS 140 provides information as to the number of fingers that may be measured by the MS, as one skilled in the will appreciate.

Please replace the paragraph beginning on page 48, line 24 with the following paragraph:

(25.7) signal topography characteristics: In one embodiment, the signal topography characteristics retained can be represented as characteristics of at least a two-dimensional generated surface. That is, such a surface is generated by the signal processing subsystem 1220 from signal characteristics accumulated over (a relatively short) time interval. For example, in the two-dimensional surface case, the dimensions for the generated surface may be, for example, signal strength and time delay. That is, the accumulations over a brief time interval of signal characteristic measurements between the BS 122 and the MS 140 (associated with the loc sig) may be classified according to the two signal characteristic dimensions (e.g., signal strength and corresponding time delay). That is, by sampling the signal characteristics and classifying the samples according to a mesh of discrete cells or bins, wherein each cell corresponds to a different range of signal strengths and time delays a tally of the number of samples falling in the range of each cell can be maintained. Accordingly, for each cell, its corresponding tally may be interpreted as height of the cell, so that when the heights of all cells are considered, an undulating or mountainous surface is provided. In particular, for a cell mesh of appropriate fineness, the "mountainous surface", is believed to, under most circumstances, provide a contour that is substantially unique to the location of the target MS 140. Note that in one embodiment, the signal samples are typically obtained throughout a predetermined signal sampling time interval of 2-5 seconds as is discussed elsewhere in this specification. In particular, the signal topography characteristics retained for a loc sig include certain topographical characteristics of such a generated mountainous surface. For example, each loc sig may include: for each local maximum (of the loc sig surface) above a predetermined noise ceiling threshold, the (signal strength, time delay) coordinates of the cell of the local maximum and the corresponding height of the local maximum. Additionally, certain gradients may also be included for characterizing the "steepness" of the surface mountains. Moreover, note that in some embodiments, a frequency may also be associated with each local maximum. Thus, the data retained for each selected local maximum can include a quadruple of signal strength, time delay, height and frequency. Further note that the data types here may vary. However, for simplicity, in parts of the description of loc sig processing related to the signal characteristics here, it is assumed that the signal characteristic topography data structure here is a vector;

Please replace the paragraph beginning on page 49, line 19 with the following paragraph:

(25.13) repeatable: TRUE iff the loc sig is "repeatable" (as described hereinafter), FALSE otherwise. Note that each verified loc sig is designated as either "repeatable" or "random". A loc sig is repeatable if the (verified/known) location associated with the loc sig is such that signal characteristic measurements between the associated BS 122 and this MS can be either replaced at periodic time intervals, or updated substantially on demand by most recent signal characteristic measurements between the associated base station and the associated MS 140 (or a comparable MS) at the verified/known location. Repeatable loc sigs may be, for example, provided by stationary or fixed location MSs 140 (e.g., fixed location transceivers) distributed within certain areas of a geographical region serviced by the location center 142 for providing MS location estimates. That is, it is an aspect of the present invention that each such stationary MS 140 can be contacted by the location center 142 (via the base stations of the wireless infrastructure) at substantially any time for providing a new collection (i.e., cluster) of wireless signal characteristics to be associated with the verified location for the transceiver. Alternatively, repeatable loc sigs may be obtained by, for example, obtaining location signal measurements manually from workers who regularly traverse a predetermined route through some portion of the radio coverage area; i.e., postal workers.

Please replace the paragraph beginning on page 50, line 17 with the following paragraph:

(26.1) A "normalization" method for normalizing loc sig data according to the associated MS 140 and/or BS 122 signal processing and generating characteristics. That is, the signal processing subsystem 1220, one embodiment being described in the PCT patent application PCT/US97/15933, titled, "Wireless Location Using A Plurality of Commercial Network Infrastructures," by F. W. LeBlanc and the present inventors, filed September 8, 1997 (which has a U.S. national filing that is now U.S. Patent No. 6,236,365, filed July 8, 1999, note, both PCT/US97/15933 and U.S. Patent No. 6,236,365 are incorporated fully by reference herein) provides (methods for loc sig objects) for "normalizing" each loc sig so that variations in signal characteristics resulting from variations in (for example) MS signal processing and generating characteristics of different types of MS's may be reduced. In particular, since wireless network designers are typically designing networks for effective use of hand set MS's 140 having a substantially common minimum set of performance characteristics, the normalization methods provided here transform the loc sig data so that it appears as though the loc sig was provided by a common hand set MS 140. However, other methods may also be provided to "normalize" a loc sig so that it may be compared with loc sigs obtained from other types of MS's as well. Note that such normalization techniques include, for example, interpolating and extrapolating according to power levels so that loc sigs may be normalized to the same power level for, e.g., comparison purposes.

Normalization for the BS 122 associated with a loc sig is similar to the normalization for MS signal processing and generating characteristics. Just as with the MS normalization, the signal processing subsystem 1220 provides a loc sig method for "normalizing" loc sigs according to base station signal processing and generating characteristics.

Please replace the paragraph beginning on page 52, line 10 with the following paragraph:

A first functional group of location engine 139 modules is for performing signal processing and filtering of MS location signal data received from a conventional wireless (e.g., CDMA) infrastructure, as discussed in the steps (23.1) and (23.2) above. This group is denoted the signal processing subsystem 1220 herein. One embodiment of such a subsystem is described in the PCT patent application titled, "Wireless Location Using A Plurality of Commercial Network Infrastructures," by F. W. LeBlanc and the present inventors.

Please replace the paragraph beginning on page 52, line 15 with the following paragraph:

A second functional group of location engine 139 modules is for generating various target MS 140 location initial estimates, as described in step (23.3). Accordingly, the modules here use input provided by the signal processing subsystem 1220. This second functional group includes one or more signal analysis modules or models, each hereinafter denoted as a first order model 1224 (FOM), for generating location hypotheses for a target MS 140 to be located. Note that it is intended that each such FOM 1224 use a different technique for determining a location area estimate for the target MS 140. A brief description of some types of first order models is provided immediately below. Note that Figs. 8 illustrates another, more detailed view of the location system for the present invention. In particular, this figure illustrates some of the FOMs 1224 contemplated by the present invention, and additionally illustrates the primary communications with other modules of the location system for the present invention. However, it is important to note that the present invention is not limited to the FOMs 1224 shown and discussed herein. That is, it is a primary aspect of the present invention to easily incorporate FOMs using other signal processing and/or computational location estimating techniques than those presented herein. Further, note that each FOM type may have a plurality of its models incorporated into an embodiment of the present invention.

Please insert the following paragraph immediately before the paragraph beginning on page 53, line 10:

In one embodiment, such a distance model may perform the following steps:

(a) Determines a minimum distance between the target MS and each BS using TOA, TDOA, signal strength on both forward and reverse paths;

(b) Generates an estimated error;

(c) Outputs a location hypothesis for estimating a location of a MS: each such hypothesis having: (i) one or more (nested) location area estimates for the MS, each location estimate having a confidence value (e.g., provided using the estimated error) indicating a perceived accuracy, and (ii) a reason for both the location estimate (e.g., substantial multipath, etc) and the confidence.

Please replace the paragraph beginning on page 53, line 10 with the following paragraph:

Another type of FOM 1224 is a statistically based first order model 1224, wherein a statistical technique, such as regression techniques (e.g., least squares, partial least squares, principle decomposition), or e.g., Bollenger Bands (e.g., for computing minimum and maximum base station offsets). In general, models of this type output location hypotheses that are determined by performing one or more statistical techniques or comparisons between the verified location signatures in location signature data base 1320, and the wireless signal measurements from a target MS. Models of this type are also referred to hereinafter as a "stochastic signal (first order) model" or a "stochastic FOM" or a "statistical model."

Please insert the following paragraph immediately before the paragraph beginning on page 53, line 16:

In one embodiment, such a stochastic signal model may output location hypotheses determined by one or more statistical comparisons with loc sigs in the Location Signature database 1320 (e.g., comparing MS location signals with verified signal characteristics for predetermined geographical areas).

Please insert the following paragraph immediately before the paragraph beginning on page 53, line 24:

In one embodiment, an adaptive learning model such as a model based on an artificial neural network may determine an MS 140 location estimate using base station IDs, data on signal-to-noise, other signal data (e.g., a number of signal characteristics including, e.g., all CDMA fingers). Moreover, the output from such a model may include: a latitude and longitude for a center of a circle having radius R (R may be an input to such an artificial neural network), and is in the output format of the distance model(s).

Please replace the paragraph beginning on page 53, line 24 with the following paragraph:

Yet another type of FOM 1224 can be based on a collection of dispersed low power, low cost fixed location wireless transceivers (also denoted "location base stations 152" hereinabove) that are provided for detecting a target MS 140 in areas where, e.g., there is insufficient base station 122 infrastructure coverage for providing a desired level of MS 140 location accuracy. For example, it may uneconomical to provide high traffic wireless voice coverage of a typical wireless base station 122 in a nature preserve or at a fair ground that is only populated a few days out of the year. However, if such low cost location base stations 152 can be directed to activate and deactivate via the direction of a FOM 1224 of the present type, then these location base stations can be used to both locate a target MS 140 and also provide indications of where the target MS is not. For example, if there are location base stations 152 populating an area where the target MS 140 is presumed to be, then by activating these location base stations 152, evidence may be obtained as to whether or not the target MS is actually in the area; e.g., if the target MS 140 is detected by a location base station 152, then a corresponding location hypothesis having a location estimate corresponding to the coverage area of the location base station may have a very high confidence value. Alternatively, if the target MS 140 is not detected by a location base station 152, then a corresponding location hypothesis having a location estimate corresponding to the coverage area of the location base station may have a very low confidence value. Models of this type are referred to hereinafter as "location base station models."

Please insert the following paragraph immediately before the paragraph beginning on page 54, line 3:

In one embodiment, such a location base station model may perform the following steps:

(a) If an input is received then the target MS 140 is detected by a location base station 152 (i.e., a LBS being a unit having a reduced power BS and a MS).

(b) If an input is obtained, then the output is a hypothesis data structure having a small area of the highest confidence.

(c) If no input is received from a LBS then a hypothesis having an area with highest negative confidence is output.

Please replace the paragraph beginning on page 54, line 3 with the following paragraph:

Yet another type of FOM 1224 can be based on input from a mobile base station 148, wherein location hypotheses may be generated from target MS 140 location data received from the mobile base station 148. In one embodiment, such a mobile base station model may provide output similar to the distance FOM 1224 described hereinabove.

Please replace the paragraph beginning on page 54, line 8 and ending on page 54, line 23 with the following paragraphs. Note the commencement of two new paragraphs inserted at –Additionally, FOMS 1224—, and at –Moreover, other FOMs—.

Note that the FOM types mentioned here as well as other FOM types are discussed in detail hereinbelow. Moreover, it is important to keep in mind that a novel aspect of the present invention is the simultaneous use or activation of a potentially large number of such first order models 1224, wherein such FOMs are not limited to those described herein. Thus, the present invention provides a framework for incorporating MS location estimators to be subsequently provided as new FOMs in a straightforward manner. For example, a FOM 1224 based on wireless signal time delay measurements from a distributed antenna system 168 for wireless communication may be incorporated into the present invention for locating a target MS 140 in an enclosed area serviced by the distributed antenna system (such a FOM is more fully described in the U.S. Patent 6,236,365 filed July 8, 1999 which is incorporated fully by reference herein). Accordingly, by using such a distributed antenna FOM 1224 (Fig. 8(1)), the present invention may determine the floor of a multi-story building from which a target MS is transmitting. Thus, MSs 140 can be located in three dimensions using such a distributed antenna FOM 1224.

In one embodiment, such a distributed antenna model may perform the following steps:

(a) Receives input only from a distributed antenna system.

(b) If an input is received, then the output includes a lat-long and height of highest confidence.

Additionally, FOMs 1224 for detecting certain registration changes within, for example, a public switched telephone network 124 can also be used for locating a target MS 140. For example, for some MSs 140 there may be an associated or dedicated device for each such MS that allows the MS to function as a cordless phone to a line based telephone network when the device detects that the MS is within signaling range. In one use of such a device (also denoted herein as a "home base station"), the device registers with a home location register of the public switched telephone network 124 when there is a status change such as from not detecting the corresponding MS to detecting the MS, or visa versa, as one skilled in the art will understand. Accordingly, by providing a FOM 1224 (denoted the "Home Base Station First Order Model" in Fig. 8(1)) that accesses the MS status in the home location register, the location engine 139 can determine whether the MS is within signaling range of the home base station or not, and generate location hypotheses accordingly.

In one embodiment, such a home base station model may perform the following steps:

(a) Receives an input only from the Public Telephone Switching Network.

(b) If an input is received then the target MS 140 is detected by a home base station associated with the target MS.

(c) If an input is obtained, then the output is a hypothesis data structure having a small area of the highest confidence.

(d) If no input and there is a home base station then a hypothesis having a negative area is of highest confidence is output.

Moreover, other FOMs based on, for example, chaos theory and/or fractal theory are also within the scope of the present invention.

Please replace the paragraph beginning on page 54, line 24 with the following paragraph:

It is important to note the following aspects of the present invention relating to FOMs 1224:

(28.1) Each such first order model 1224 may be relatively easily incorporated into and/or removed from the present invention. For example, assuming that the signal processing subsystem 1220 provides uniform input interface to the FOMs, and there is a uniform FOM output interface, it is believed that a large majority (if not substantially all) viable MS location estimation strategies may be accommodated. Thus, it is straightforward to add or delete such FOMs 1224.

Please replace the paragraph beginning on page 56, line 1 with the following paragraph:

(30.2) it enhances the accuracy of an initial location hypothesis generated by a FOM by using the initial location hypothesis as, essentially, a query or index into the location signature data base 1320 for obtaining a corresponding enhanced location hypothesis, wherein the enhanced location hypothesis has both an adjusted target MS location area estimate and an adjusted confidence based on past performance of the FOM in the location service surrounding the target MS location estimate of the initial location hypothesis;

Please replace the paragraph beginning on page 61, line 8 and ending on page 6, line 24 with the following paragraph:

A fourth functional group of location engine 139 modules is the control and output gating modules which includes the location center control subsystem 1350, and the output gateway 1356. The location control subsystem 1350 provides the highest level of control and monitoring of the data processing performed by the location center 142. In particular, this subsystem performs the following functions:

(a) controls and monitors location estimating processing for each target MS 140. Note that this includes high level exception or error handling functions;

(b) receives and routes external information as necessary. For instance, this subsystem may receive (via, e.g., the public telephone switching network 124 and Internet 468) such environmental information as increased signal noise in a particular service area due to increase traffic, a change in weather conditions, a base station 122 (or other infrastructure provisioning), change in operation status (e.g., operational to inactive);

(c) receives and directs location processing requests from other location centers 142 (via, e.g., the Internet 468);

(d) performs accounting and billing procedures;

(e) interacts with location center operators by, for example, receiving operator commands and providing output indicative of processing resources being utilized and malfunctions;

(f) provides access to output requirements for various applications requesting location estimates. For example, an Internet 468 location request from a trucking company in Los Angeles to a location center 142 in Denver may only want to know if a particular truck or driver is within the Denver area. Alternatively, a local medical rescue unit is likely to request a precise a location estimate as possible.

Please replace the paragraph beginning on page 61, line 25 with the following paragraph:

Note that in Fig. 6, (a) - (d) above are, at least at a high level, performed by utilizing the operator interface 1374.

Please replace the paragraph beginning on page 61, line 26 with the following paragraph:

Referring now to the output gateway 1356, this module routes target MS 140 location estimates to the appropriate location application(s). For instance, upon receiving a location estimate from the most likelihood estimator 1344, the output gateway 1356 may determine that the location estimate is for an automobile being tracked by the police and therefore must be provided according to a particular protocol.

Please replace the paragraph beginning on page 63, line 8 with the following paragraph:

Taking a CDMA or TDMA base station network as an example, each base station (BS) 122 is required to emit a constant signal-strength pilot channel pseudo-noise (PN) sequence on the forward link channel identified uniquely in the network by a pilot sequence offset and frequency assignment. It is possible to use the pilot channels of the active, candidate, neighboring and remaining sets, maintained in the target MS, for obtaining signal characteristic measurements (e.g., TOA and/or TDOA measurements) between the target MS 140 and the base stations in one or more of these sets.

Please replace the paragraph beginning on page 63, line 26 with the following paragraph:

Accordingly, some embodiments of distance FOMs may attempt to mitigate such ambiguity or inaccuracies by, e.g., identifying discrepancies (or consistencies) between arrival time measurements and other measurements (e.g., signal strength), these discrepancies (or consistencies) may be used to filter out at least those signal measurements and/or generated location estimates that appear less accurate. In particular, such identifying by filtering can be performed by, for example, an expert system residing in the distance FOM.

Please replace the paragraph beginning on page 65, line 1 with the following paragraph:

In one embodiment, a coverage area model utilizes both the detection and non-detection of base stations 122 by the target MS 140 (conversely, of the MS by one or more base stations 122) to define an area where the target MS 140 may likely be. A relatively straightforward application of this technique is to:

(a) find all areas of intersection for base station RF coverage area representations, wherein: (i) the corresponding base stations are on-line for communicating with MSs 140; (ii) the RF coverage area representations are deemed reliable for the power levels of the on-line base stations; (iii) the on-line base stations having reliable coverage area representations can be detected by the target MS; and (iv) each intersection must include a predetermined number of the reliable RF coverage area representations (e.g., 2 or 3); and

(b) obtain new location estimates by subtracting from each of the areas of intersection any of the reliable RF coverage area representations for base stations 122 that can not be detected by the target MS.

Please replace the paragraph beginning on page 66, line 2 with the following paragraph:

The stochastic first order models may use statistical prediction techniques such as principle decomposition, partial least squares, or other regression techniques for predicting, for example, expected minimum and maximum distances of the target MS from one or more base stations 122, e.g., Bollenger Bands. Additionally, some embodiments may use Markov processes and Random Walks (predicted incremental MS movement) for determining an expected area within which the target MS 140 is likely to be. That is, such a process measures the incremental time differences of each pilot as the MS moves for predicting a size of a location area estimate using past MS estimates such as the verified location signatures in the location signature data base 1320.

Please replace the paragraph beginning on page 66, line 15 with the following paragraph:

Regarding FOMs 1224 using pattern recognition or associativity techniques, there are many such techniques available. For example, there are statistically based systems such as "CART" (an acronym for Classification and Regression Trees) by ANGOSS Software International Limited of Toronto, Canada that may be used for automatically detecting or recognizing patterns in data that were unprovided (and likely previously unknown). Accordingly, by imposing a relatively fine mesh or grid of cells on the radio coverage area, wherein each cell is entirely within a particular area type categorization such as the transmission area types (discussed in the section, "Coverage Area: Area Types And Their Determination" above), the verified location signature clusters within the cells of each area type may be analyzed for signal characteristic patterns. If such patterns are found, then they can be used to identify at least a likely area type in which a target MS is likely to be located. That is, one or more location hypotheses may be generated having target MS 140 location estimates that cover an area having the likely area type wherein the target MS 140 is located. Further note that such statistically based pattern recognition systems as "CART" include software code generators for generating expert system software embodiments for recognizing the patterns detected within a training set (e.g., the verified location signature clusters).

Please replace the paragraph beginning on page 67, line 1 with the following paragraph:

A similar statistically based FOM 1224 to the one above may be provided wherein the radio coverage area is decomposed substantially as above, but in addition to using the signal characteristics for detecting useful signal patterns, the specific identifications of the base station 122 providing the signal characteristics may also be used. Thus, assuming there is a sufficient density of verified location signature clusters in some of the mesh cells so that the statistical pattern recognizer can detect patterns in the signal characteristic measurements, an expert system may be generated that outputs a target MS 140 location estimate that may provide both a reliable and accurate location estimate of a target MS 140.

Please replace the paragraph beginning on page 69, line 11 with the following paragraph:

It is worthwhile to discuss the data representations for the inputs and outputs of a ANN used for generating MS location estimates. Regarding ANN input representations, recall that the signal processing subsystem 1220 may provide various RF signal measurements as input to an ANN (such as the RF signal measurements derived from verified location signatures in the location signature data base 1320). For example, a representation of a histogram of the frequency of occurrence of CDMA fingers in a time delay versus signal strength 2-dimensional domain may be provided as input to such an ANN. In particular, a 2-dimensional grid of signal strength versus time delay bins may be provided so that received signal measurements are slotted into an appropriate bin of the grid. In one embodiment, such a grid is a six by six array of bins such as illustrated in the left portion of Fig. 14. That is, each of the signal strength and time delay axes are partitioned into six ranges so that both the signal strength and the time delay of RF signal measurements can be slotted into an appropriate range, thus determining the bin.

Please replace the paragraph beginning on page 70, line 11 with the following paragraph:

Accordingly, the technique described herein limits the number of input neurons in each ANN constructed and generates a larger number of these smaller ANNs. That is, each ANN is trained on location signature data (or, more precisely, portions of location signature clusters) in an area A_{ANN} (hereinafter also denoted the "net area"), wherein each input neuron receives a unique input from one of:

(A1) location signature data (e.g., signal strength/time delay bin tallies) corresponding to transmissions between an MS 140 and a relatively small number of base stations 122 in the area A_{ANN}. For instance, location signature data obtained from, for example, a collection B of four base stations 122 (or antenna sectors) in the area A_{ANN}., Note, each location signature data cluster includes fields describing the wireless communication devices used; e.g., (i) the make and model of the target MS; (ii) the current and maximum transmission power; (iii) the MS battery power (instantaneous or current); (iv) the base station (sector) current power level; (v) the base station make and model and revision level; (vi) the air interface type and revision level (of, e.g., CDMA, TDMA or AMPS).

Please replace the paragraph beginning on page 71, line 8 with the following paragraph:

Moreover, for each of the smaller ANNs, it is likely that the number of input neurons is on the order of 330; (i.e., 70 inputs per each of four location signatures (i.e., 35 inputs for the forward wireless communications and 35 for the reverse wireless communications), plus 40 additional discrete inputs for an appropriate area surrounding A_{ANN}, plus 10 inputs related to: the type of MS, power levels, etc.). However, it is important to note that the number of base stations (or antenna sectors 130) having corresponding location signature data to be provided to such an ANN may vary. Thus, in some subareas of the coverage area 120, location signature data from five or more base stations (antenna sectors) may be used, whereas in other subareas three (or less) may be used.

Please replace the paragraph beginning on page 72, line 28 with the following paragraph:

In one traditional artificial neural network training process, a relatively tedious set of trial and error steps may be performed for configuring an ANN so that training produces effective learning. In particular, an ANN may require configuring parameters related to, for example, input data scaling, test/training set classification, detecting and removing unnecessary input variable selection. However, the present invention reduces this tedium. That is, the present invention uses mechanisms such as genetic algorithms or other mechanisms for avoiding non-optimal but locally appealing (i.e., local minimum) solutions, and locating near-optimal solutions instead. In particular, such mechanism may be used to adjust the matrix of weights for the ANNs so that very good, near optimal ANN configurations may be found efficiently. Furthermore, since the signal processing system 1220 uses various types of signal processing filters for filtering the RF measurements received from transmissions between an MS 140 and one or more base stations (antenna sectors 130), such mechanisms for finding near-optimal solutions may be applied to selecting appropriate filters as well. Accordingly, in one embodiment of the present invention, such filters are paired with particular ANNs so that the location signature data supplied to each ANN is filtered according to a corresponding "filter description" for the ANN, wherein the filter description specifies the filters to be used on location signature data prior to inputting this data to the ANN. In particular, the filter description can define a pipeline of filters having a sequence of filters wherein for each two consecutive filters, f_1 and f_2 (f_1 preceding f_2), in a filter description, the output of f_1 flows as input to f_2. Accordingly, by encoding such a filter description together with its corresponding

ANN so that the encoding can be provided to a near optimal solution finding mechanism such as a genetic algorithm, it is believed that enhanced ANN locating performance can be obtained. That is, the combined genetic codes of the filter description and the ANN are manipulated by the genetic algorithm in a search for a satisfactory solution (i.e., location error estimates within a desired range). This process and system provides a mechanism for optimizing not only the artificial neural network architecture, but also identifying a near optimal match between the ANN and one or more signal processing filters. Accordingly, the following filters may be used in a filter pipeline of a filter description: Sobel, median, mean, histogram normalization, input cropping, neighbor, Gaussian, Weiner filters.

Please replace the paragraph beginning on page 79, line 12 with the following paragraph. Note the only change herein is the removal of the underlining of the phrase 'there is a "error_rec" here for each loc sig in "loc_sig_bag".'

error_rec_set: A set of error records (objects), denoted "error_recs", providing information as to how much each loc sig in "loc_sig_bag" disagrees with comparable loc sigs in the location signature data base. That is, there is a "error_rec" here for each loc sig in "loc_sig_bag".

Please replace the paragraph beginning on page 79, line 25 and ending on page 80, line 9 has been replaced with the following paragraph:

DB_Loc_Sig_Error_Fit(hypothesis, measured_loc_sig_bag, search_criteria)

/* This function determines how well the collection of loc sigs in "measured_loc_sig_bag" fit with the loc sigs in the location signature data base 1320 wherein the data base loc sigs must satisfy the criteria of the input parameter "search_criteria" and are relatively close to the MS location estimate of the location hypothesis, "hypothesis".

Input: hypothesis: MS location hypothesis;

measured_loc_sig_bag: A collection of measured location signatures ("loc sigs" for short) obtained from the MS (the data structure here is an aggregation such as an array or list). Note, it is assumed that there is at most one loc sig here per Base Station in this collection. Additionally, note that the input data structure here may be a location signature cluster such as the "loc_sig_cluster" field of a location hypothesis (cf. Figs. 9A and 9B). Note that variations in input data structures may be accepted here by utilization of flag or tag bits as one skilled in the art will appreciate;

search_criteria: The criteria for searching the verified location signature data base for various categories of loc sigs. The only limitation on the types of categories that may be provided here is that, to be useful, each category should have meaningful number of loc sigs in the location signature data base. The following categories included here are illustrative, but others are contemplated:

(a) "USE ALL LOC SIGS IN DB" (the default),
(b) "USE ONLY REPEATABLE LOC SIGS",
(c) "USE ONLY LOC SIGS WITH SIMILAR TIME OF DAY".

Please replace the paragraph beginning on page 80, line 21 with the following paragraph:

The following program compares: (a1) loc sigs that are contained in (or derived from) the loc sigs in "target_loc_sig_bag" with (b1) loc sigs computed from verified loc sigs in the location signature data base 1320. That is, each loc sig from (a1) is compared with a corresponding loc sig from (b1) to obtain a measurement of the discrepancy between the two loc sigs. In particular, assuming each of the loc sigs for "target_loc_sig_bag" correspond to the same target MS location, wherein this location is "target_loc", this program determines how well the loc sigs in "target_loc_sig_bag" fit with a computed or estimated loc sig for the location, "target_loc" that is derived from the verified loc sigs in the location signature data base 1320. Thus, this program may be used: (a2) for determining how well the loc sigs in the location signature cluster for a target MS ("target_loc_sig_bag") compares with loc sigs derived from verified location signatures in the location signature data base, and (b2) for determining how consistent a given collection of loc sigs ("target_loc_sig_bag") from the location signature data base is with other loc sigs in the location signature data base. Note that in (b2) each of the one or more loc sigs in "target_loc_sig_bag" have an error computed here that can be used in determining if the loc sig is becoming inapplicable for predicting target MS locations.

Please replace the paragraph beginning on page 85, line 7 with the following paragraph:

This function creates a new list of location hypotheses from the input list, "loc_hyp_list", wherein the location hypotheses on the new list are modified versions of those on the input list. For each location hypothesis on the input list, one or more corresponding location hypotheses will be on the output list. Such corresponding output location hypotheses will differ from their associated input location hypothesis by one or more of the following: (a) the "image_area" field (see Figs. 9A and 9B) may be assigned an area indicative of where the target MS is estimated to be, (b) if "image_area" is assigned, then the "confidence" field will be the confidence that the target MS is located in the area for "image_area", (c) if there are not sufficient "nearby" verified location signature clusters in the location signature data base 1320 to entirely rely on a computed confidence using such verified location signature clusters, then two location hypotheses (having reduced confidences) will be returned, one having a reduced computed confidence (for "image_area") using the verified clusters in the Location Signature data base, and one being substantially the same as the associated input location hypothesis except that the confidence (for the field "area_est") is reduced to reflect the confidence in its paired location hypothesis having a computed confidence for "image_area". Note also, in some cases, the location hypotheses on the input list, may have no change to its confidence or the area to which the confidence applies.

Get_adjusted_loc_hyp_list_for(loc_hyp)

Please replace the paragraph beginning on page 85, line 31 with the following paragraph:

The function, "get_adjusted_loc_hyp_list_for," and functions called by this function presuppose a framework or paradigm that requires some discussion as well as the defining of some terms. Note that some of the terms defined hereinbelow are illustrated in Fig. 24.

Please replace the paragraph beginning on page 86, line 1 with the following paragraph. Note the only change here is the removal of the underlining of the word 'verified.'

Define the term "image cluster set" (for a given First Order Model identified by "loc_hyp.FOM_ID") to mean the set of verified location signature clusters whose MS location point estimates are in "the cluster set".

Please replace the paragraph beginning on page 86, line 27 with the following paragraph. Note the removal of the underlining in the phrase 'per unit of area.'

Define the term "mapped cluster density" to be the number of the verified location signature clusters in an "image cluster set" per unit of area in the "image cluster set area".

Please replace the paragraph beginning on page 89, line 19 has been replaced with the following paragraph:

(35.5) A location extrapolator module 1432 for use in updating previous location estimates for a target MS when a more recent location hypothesis is provided to the location hypothesis analyzer 1332. That is, assume that the control module 1400 receives a new location hypothesis for a target MS for which there are also one or more previous location hypotheses that either have been recently processed (i.e., they reside in the MS status repository 1338, as shown best in Fig. 6), or are currently being processed (i.e., they reside in the run-time location hypothesis storage area 1410). Accordingly, if the active_timestamp (see Figs. 9A and 9B regarding location hypothesis data fields) of the newly received location hypothesis is sufficiently more recent than the active_timestamp of one of these previous location hypotheses, then an extrapolation may be performed by the location extrapolator module 1432 on such previous location hypotheses so that all target MS location hypotheses being concurrently analyzed are presumed to include target MS location estimates for substantially the same point in time. Thus, initial location estimates generated by the FOMs using different wireless signal measurements, from different signal transmission time intervals, may have their corresponding dependent location hypotheses utilized simultaneously for determining a most likely target MS location estimate. Note that this module may also be daemon or expert system rule base.

Please replace the paragraph beginning on page 100, line 30 through page 101, line 2 with the following paragraph:

Accordingly, if a new currently active location hypothesis (e.g., supplied by the context adjuster) is received by the blackboard, then the target MS location estimate of the new location hypothesis may be compared with the predicted location. Consequently, a confidence adjustment value can be determined according to how well the new location hypothesis "i" fits with the predicted location. That is, this confidence adjustment value will be larger as the new MS estimate and the predicted estimate become closer together.

Please replace the paragraph beginning on page 102, line 3 with the following paragraph:

Any collection of mobile electronics (denoted mobile location unit) that is able to both estimate a location of a target MS 140 and communicate with the base station network may be utilized by the present invention to more accurately locate the target MS. Such mobile location units may provide greater target MS location accuracy by, for example, homing in on the target MS and by transmitting additional MS location information to the location center 142. There are a number of embodiments for such a mobile location unit contemplated by the present invention. For example, in a minimal version, such the electronics of the mobile location unit may be little more than an onboard MS 140, a sectored/directional antenna and a controller for communicating between them. Thus, the onboard MS is used to communicate with the location center 142 and possibly the target MS 140, while the antenna monitors signals for homing in on the target MS 140. In an enhanced version of the mobile location unit, a GPS receiver may also be incorporated so that the location of the mobile location unit may be determined and consequently an estimate of the location of the target MS may also be determined. However, such a mobile location unit is unlikely to be able to determine substantially more than a direction of the target MS 140 via the sectored/directional antenna without further base station infrastructure cooperation in, for example, determining the transmission power level of the target MS or varying this power level. Thus, if the target MS or the mobile location unit leaves the coverage area 120 or resides in a poor communication area, it may be difficult to accurately determine where the target MS is located. None-the-less, such mobile location units may be sufficient for many situations, and in fact the present invention contemplates their use. However, in cases where direct communication with the target MS is desired without constant contact with the base station infrastructure, the present invention includes a mobile location unit that is also a scaled down version of a base station 122. Thus, given that such a mobile base station or MBS 148 includes at least an onboard MS 140, a sectored/directional antenna, a GPS receiver, a scaled down base station 122 and sufficient components (including a controller) for integrating the capabilities of these devices, an enhanced autonomous MS mobile location system can be provided that can be effectively used in, for example, emergency vehicles, airplanes and boats. Accordingly, the description that follows below describes an embodiment of an MBS 148 having the above mentioned components and capabilities for use in a vehicle.

Please replace the paragraph beginning on page 104, line 23 with the following paragraph:

Thus, while in the ready state 1708, as the MBS 148 moves, it has its location repeatedly (re)-estimated via, for example, GPS signals, location center 142 location estimates from the base stations 122 (and 152), and an on-board deadreckoning subsystem 1527 having an MBS location estimator according to the programs described hereinbelow. However, note that the accuracy of the base station time synchronization (via the ribidium oscillator 1520) and the accuracy of the MBS 148 location may need to both be periodically recalibrated according to (1a) and (1b) above.

Please replace the paragraph beginning on page 106, line 20 with the following paragraph:

In one embodiment, the MBS 148 (Fig. 11) includes an MBS controller 1533 for controlling the location capabilities of the MBS 148. In particular, the MBS controller 1533 initiates and controls the MBS state changes as described in Fig. 12 above. Additionally, the MBS controller 1533 also communicates with the location controller 1535, wherein this latter controller controls MBS activities related to MBS location and target MS location; e.g., this performs the program, "mobile_base_station_controller" described in APPENDIX A hereinbelow. The location controller 1535 receives data input from an event generator 1537 for generating event records to be provided to the location controller 1535. For example, records may be generated from data input received from: (a) the vehicle movement detector 1539 indicating that the MBS 148 has moved at least a predetermined amount and/or has changed direction by at least a predetermined angle, or (b) the MBS signal processing subsystem 1541 indicating that the additional signal measurement data has been received from either the location center 142 or the target MS 140. Note that the MBS signal processing subsystem 1541, in one embodiment, is similar to the signal processing subsystem 1220 of the location center 142. Moreover, also note that there may be multiple command schedulers. In particular, a scheduler 1528 for commands related to communicating with the location center 142, a scheduler 1530 for commands related to GPS communication (via GPS receiver 1531), a scheduler 1529 for commands related to the frequency and granularity of the reporting of MBS changes in direction and/or position via the MBS deadreckoning subsystem 1527 (note that this scheduler is potentially optional and that such commands may be provided directly to the deadreckoning estimator 1544), and a scheduler 1532 for communicating with the target MS(s) 140 being located. Further, it is assumed that there is sufficient hardware and/or software to perform commands in different schedulers substantially concurrently.

Please replace the paragraph beginning on page 109, line 32 with the following paragraph:

It is assumed that the error with deadreckoning increases with deadreckoning distance. Accordingly, it is an aspect of the embodiment of the MBS location subsystem 1508 that when incrementally updating the location of the MBS 148 using deadreckoning and applying deadreckoning location change estimates to a "most likely area" in which the MBS 148 is believed to be, this area is incrementally enlarged as well as shifted. The enlargement of the area is used to account for the inaccuracy in the deadreckoning capability. Note, however, that the deadreckoning MBS location estimator is periodically reset so that the error accumulation in its outputs can be decreased. In particular, such resetting occurs when there is a high probability that the location of the MBS is known. For example, the deadreckoning MBS location estimator may be reset when an MBS operator manually enters an MBS location or verifies an MBS location, or a computed MBS location has sufficiently high confidence.

Please replace the paragraph beginning on page 110, line 32 with the following paragraph:

Further, the MBS 148 may constrain any location estimates to streets on a street map using the MBS location snap to street module 1562. For example, an estimated MBS location not on a street may be "snapped to" a nearest street location. Note that a nearest street location determiner may use "normal" orientations of vehicles on streets as a constraint on the nearest street location, particularly, if an MBS 148 is moving at typical rates of speed and acceleration, and without abrupt changes in direction. For example, if the deadreckoning MBS location estimator 1544 indicates that the MBS 148 is moving in a northerly direction, then the street snapped to should be a north-south running street. Moreover, the MBS location snap to street module 1562 may also be used to enhance target MS location estimates when, for example, it is known or suspected that the target MS 140 is in a vehicle and the vehicle is moving at typical rates of speed. Furthermore, the snap to street location module 1562 may also be used in enhancing the location of a target MS 140 by either the MBS 148 or by the location engine 139. In particular, the location estimator 1344 or an additional module between the location estimator 1344 and the output gateway 1356 may utilize an embodiment of the snap to street location module 1562 to enhance the accuracy of target MS 140 location estimates that are known to be in vehicles. Note that this may be especially useful in locating stolen vehicles that have embedded wireless location transceivers (MSs 140), wherein appropriate wireless signal measurements can be provided to the location center 142.

Please replace the paragraph beginning on page 111, line 29 with the following paragraph:

There is an MBS location track for storing MBS location entries obtained from MBS location estimation information from each of the MBS baseline location estimators described above (i.e., a GPS location track 1750 for storing MBS location estimations obtained from the GPS location estimator 1540, a location center location track 1754 for storing MBS location estimations obtained from the location estimator 1540 deriving its MBS location estimates from the location center 142, an LBS location track 1758 for storing MBS location estimations obtained from the location estimator 1540 deriving its MBS location estimates from base stations 122 and/or 152, and a manual location track 1762 for MBS operator entered MBS locations). Additionally, there is one further location track, denoted the "current location track" 1766 whose location track entries may be derived from the entries in the other location tracks (described further hereinbelow). Further, for each location track, there is a location track head that is the head of the queue for the location track. The location track head is the most recent (and presumably the most accurate) MBS location estimate residing in the location track. Thus, the GPS location track 1750 has location track head 1770; the location center location track 1754 has location track head 1774; the LBS location track 1758 has location track head 1778; the manual location track 1762 has location track head 1782; and the current location track 1766 has location track head 1786. Additionally, for notational convenience, for each location track, the time series of previous MBS location estimations (i.e., location track entries) in the location track will herein be denoted the "path for the location track." Such paths are typically the length of the location track queue containing the path. Note that the length of each such queue may be determined using at least the following considerations:

Please replace the paragraph beginning on page 115, line 15 and ending on page 115, line 18 with the following paragraph:

MBS_new_est <--- *get_new_MBS_location_using_estimate*(event);

/* Note, whenever a new MBS location estimate is entered as a baseline estimate into one of the location tracks, the other location tracks must be immediately updated with any deadreckoning location change estimates so that all location tracks are substantially updated at the same time. */

Please replace the paragraph beginning on page 120, line 19 with the following paragraph:

/* This information includes error or reliability estimates that may be used in subsequent attempts to determine an MS location estimate when there is no communication with the LC and no exact (GPS) location can be obtained. That is, if the reliability of the target MS's location is deemed highly reliable, then subsequent less reliable location estimates should be used only to the degree that more highly reliable estimates become less relevant due to the MS moving to other locations. */

Please replace the paragraph beginning on page 122, line 28 with the following paragraph. Note the only change here is the insertion of --)—immediately after "event."

MBS_new_est <--- *get_new_MBS_location_est_from_operator*(event); /* The estimate may be obtained, for example, using a light pen on a displayed map */

Please replace the paragraph beginning on page 124, line 1 and ending on page 124, line 12 with the following paragraph:

The confidence value for each MBS location estimate is a measurement of the likelihood of the MBS location estimate being correct. More precisely, a confidence value for a new MBS location estimate is a measurement that is adjusted according to the following criteria:

(a) the confidence value increases with the perceived accuracy of the new MBS location estimate (independent of any current MBS location estimate used by the MBS),

(b) the confidence value decreases as the location discrepancy with the current MBS location increases,

(c) the confidence value for the current MBS location increases when the new location estimate is contained in the current location estimate,

(d) the confidence value for the current MBS location decreases when the new location estimate is not contained in the current location estimate, and

Therefore, the confidence value is an MBS location likelihood measurement which takes into account the history of previous MBS location estimates.

Please replace the paragraph beginning on page 132, line 28 and ending on page 132, line 32 with the following paragraph:

Input: **MBS_new_est** The newest MBS location estimate record.

adjusted_curr_est The version of "MBS_curr_est" adjusted by the deadreckoning location change estimate paired with "MBS_new_est".

MBS_curr_est The location track entry that is the head of the "current" location track. Note that "MBS_new_est.confidence" > "MBS_curr_est.confidence".

Please replace the paragraph beginning on page 143, line 14 and ending on page 143, line 19 with the following paragraph:

measured_loc_sig_bag: A collection of measured location signatures ("loc sigs" for short) obtained from the MS (the data structure here is an aggregation such as an array or list). Note, it is assumed that there is at most one loc sig here per Base Station in this collection. Additionally, note that the input data structure here may be a location signature cluster such as the "loc_sig_cluster" field of a location hypothesis (cf. Figs. 9A and 9B). Note that variations in input data structures may be accepted here by utilization of flag or tag bits as one skilled in the art will appreciate;

Please replace the paragraph beginning on page 147, line 28 with the following paragraph. Note the only change herein is the removal of the underlining of the phrase '*there is an "error_rec" here for each loc sig in "loc_sig_bag".*'.

error_rec_set: The set of "error_recs" providing information as to how much each loc sig in "loc_sig_bag" disagrees with comparable loc sigs in the DB. That is, *there is an "error_rec" here for each loc sig in "loc_sig_bag"*.

Please replace the paragraph beginning on page 161, line 9 with the following paragraph.

This function creates a new list of location hypotheses from the input list, "loc_hyp_list", wherein the location hypotheses on the new list are modified versions of those on the input list. For each location hypothesis on the input list, one or more corresponding location hypotheses will be on the output list. Such corresponding output location hypotheses will differ from their associated input location hypothesis by one or more of the following: (a) the "image_area" field (see Figs. 9A and 9B) may be assigned an area indicative of where the target MS is estimated to be, (b) if "image_area" is assigned, then the "confidence" field will be the confidence that the target MS is located in the area for "image_area", (c) if there are not sufficient "nearby" verified location signature clusters in the location signature data base to entirely rely on a computed confidence using such verified location signature clusters, then two location hypotheses (having reduced confidences) will be returned, one having a reduced computed confidence (for "image_area") using the verified clusters in the Location Signature DB, and one being substantially the same as the associated input location hypothesis except that the confidence (for the field "area_est") is reduced to reflect the confidence in its paired location hypothesis having a computed confidence for "image_area". Note also, in some cases, the location hypotheses on the input list, may have no change to its confidence or the area to which the confidence applies. Note that the steps herein are also provided in flowchart form in Figs. 25a and 25b.

Please replace the paragraph beginning on page 161, line 29 and ending on page 162, line 6 with the following paragraph:

if (NOT loc_hyp[i].adjust) then /* no adjustments will be made to the "area_est" or the "confidence" fields since the "adjust" field indicates that there is assurance that these other fields are correct; note that such designations indicating that no adjustment are presently contemplated are only for the location hypotheses generated by the Home Base

Station First Order Model, the Location Base Station First Order Model and the Mobile Base Station First Order Model. In particular, location hypotheses from the Home Base Station model will have confidences of 1.0 indicating with highest confidence that the target MS is within the area estimate for the location hypothesis. Alternatively, in the Location Base Station model, generated location hypotheses may have confidences of (substantially) +1.0 (indicating that the target MS is absolutely in the area for "area_est"), or, -1.0 (indicating that the target MS is NOT in the area estimate for the generated location hypothesis).*/

Please replace the paragraph beginning on page 162, line 10 with the following paragraph:

else /* the location hypothesis can (and will) be modified; in particular, an "image_area" may be assigned, the "confidence" changed to reflect a confidence in the target MS being in the "image_area". Additionally, in some cases, more than one location hypothesis may be generated from "loc_hyp[i]". See the comments on Figs.. 9A and 9B and the comments for "get_adjusted_loc_hyp_list_for" for a description of the terms here. */

Please replace the paragraph beginning on page 163, line 8 with the following paragraph. Please note that the only change is the removal of underlining of text.

Define the term "**image cluster set**" (for a given First Order Model identified by "loc_hyp.FOM_ID") to mean the set of verified location signature clusters whose MS location point estimates are in "the cluster set".

Please replace the paragraph beginning on page 164, line 1 with the following paragraph. Note the only change herein is the removal of the underlining in the phrase 'identifier may also be dependent on the area type.'

pt_max_area <--- *get_max_area_surrounding_pt*(loc_hyp, mesh); /* Get the maximum area about "pt_est" that is deemed worthwhile for examining the behavior of the "loc_hyp.FOM_ID" First Order Model (FOM) about "pt_est". Note that in at least one embodiment, this value of this identifier may also be dependent on the area type within which "loc_hyp.pt_est" resides. Further, this function may provide values according to an algorithm allowing periodic tuning or adjusting of the values output, via, e.g., a Monte Carlo simulation (more generally, a statistical simulation or regression) or a Genetic Algorithm. In some embodiments of the present invention, the value determined here may be a relatively large proportion of the entire radio coverage area region. However, the tuning process may be used to shrink this value for (for example) various area types as location signature clusters for verified MS location estimates are accumulated in the location signature data base. */

Please replace the paragraph beginning on page 164, line 10 with the following paragraph: Note the removal of the underlining in the phrase 'vary according to area type and/or area size (of "area").

min_clusters <--- *get_min_nbr_of_clusters*(loc_hyp.FOM_ID, area); /* For the area, "area", get the minimum number ("min_clusters") of archived MS estimates, L, desired in generating a new target MS location estimate and a related confidence, wherein this minimum number is likely to provide a high probability that this new target MS location estimate and a related confidence are meaningful enough to use in subsequent Location Center processing for outputting a target MS location estimate. More precisely, this minimum number, "min_clusters," is an estimate of the archived MS location estimates, L, required to provide the above mentioned high probability wherein each L satisfies the following conditions: (a) L is in the area for "area"; (b) L is archived in the location signature data base; (c) L has a corresponding verified location signature cluster in the location signature data base; and (d) L is generated by the FOM identified by "loc_hyp.FOM_ID"). In one embodiment, "min_clusters" may be a constant; however, in another it may vary according to area type and/or area size (of "area"), in some it may also vary according to the FOM indicated by "loc_hyp.FOM_ID". */

The paragraph beginning on page 168, line 15 has been replaced with the following paragraph. Note the removal of underlining of text.

Define the term "**mapped cluster density**" to be the number of the verified location signature clusters in an "image cluster set" per unit of area in the "image cluster set area".

The paragraph beginning on page 170, line 1 has been replaced with the following paragraph. Note the only change herein is the removal of the underlining in the phrase '*positive* confidence.'

/* Given the above two values, a *positive* confidence value for the area, "image_area", can be calculated based on empirical data.

The paragraph beginning on page 171, line 3 has been replaced with the following paragraph:

Note that the product of [CA1.1] and [CA1.2] provide the above desired characteristics for calculating the confidence. However, there is no guarantee that the range of resulting values from such products is consistent with the interpretation that has been placed on (positive) confidence values; e.g., that a confidence of near 1.0 has a very high likelihood that the target MS is in the corresponding area. For example, it can be that this product rarely is greater than 0.8, even in the areas of highest confidence. Accordingly, a "tuning" function is contemplated which provides an additional factor for adjusting of the confidence. This factor is, for example, a function of the area types and the size of each area type in "image_area". Moreover, such a tuning function may be dependent on a "tuning coefficient" per area type. Thus, one such tuning function may be:

$$\mathbf{min}\left(\sum_{i=1}^{\text{number of area types}} [tc_i * \text{sizeof(area type}_i \text{ in "image\_area")} / \text{sizeof ("image\_area")}], 1.0\right)$$

where tc_i is a tuning coefficient (determined in background or off-line processing; e.g., by a Genetic Algorithm or Monte Carlo simulation or regression) for the area type indexed by "i".

IN THE CLAIMS:

Please cancel all pending claims, namely Claims 125 through 220 without prejudice to or disclaimer of the subject matter contained therein, and add the following new claims:

221. (New) A method for use in a wireless network to obtain requested location information regarding a mobile wireless station from any of various location sources and provide the requested location information to a wireless location application, there being a plurality of location estimating sources, including a first location estimating source for obtaining location information and a second location estimating source for obtaining location information for providing information regarding locations of mobile wireless stations in the network, the method comprising the steps of:

first receiving a location request regarding a first of said wireless mobile stations from said first wireless location application, said location request seeking said requested location information;

first obtaining: a first location input obtained using an instance, I_1, of said location information from said first location estimating source, wherein I_1 is indicative of one or more locations of said first wireless mobile station, and

second obtaining a second location input obtained using an instance, I_2, of said location information provided from said second location estimating source, wherein I_2 is indicative of one or more locations of said first wireless mobile station;

wherein said first location estimating source employs a first location finding technology that provides I_1, and said second location estimating source employs a second location finding technology different than said first location finding technology that provides I_2; and

wherein said steps of first and second obtaining includes a step of providing said first and second location inputs in a common standardized format;

storing data in memory relating to said first location input and said second location input;

third obtaining said requested location information by selectively using portions of said data from said memory, wherein said requested location information is determined according to information indicative of a manner in which said first wireless location application prefers said requested location information; and

outputting said requested location information to said first wireless location application.

CLAIMS

222. (New) The method of Claim 221, wherein for locating a second of the mobile stations, there is a further step of requesting activation of each of one or more of said plurality of location estimating sources according to an availability of corresponding wireless signal measurements from the second mobile station for the location estimating source.

223. (New) The method of Claim 221, further including, for locating a second of the mobile stations, a step of obtaining an instance of a third location input from a third of the plurality of location estimating sources different from said first and second location estimating sources.

224. (New) The method of Claim 221, further including, for locating one of the first and a second of the mobile stations, a step of obtaining an instance of a third location input by using a third location finding technology different from the first and second location finding technologies.

225. (New) The method of Claim 224, further including providing said instance of said third location input in said standardized format.

226. (New) The method of Claim 221, wherein said step of providing includes representing each of said first and second location inputs in a common data representation having a plurality of location attributes, including a common representation A_1 for representing a geographical position for the first mobile station, and one or more attributes related to one of: an error in data for A_1, a likelihood of the first mobile station being in the geographical extent represented by A_1, a timestamp related to the first mobile station being in the geographical extent represented by A_1, and descriptor information related to location processing performed by one of said resources in obtaining an instance of said location information for M

227. (New) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to an error in data for A_1.

228. (New) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to a likelihood of the first mobile station being in the geographical extent represented by A_1.

229. (New) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to a timestamp related to the first mobile station being in the geographical extent represented by A_1.

230. (New) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes for descriptor information related to location processing performed by one of said location estimating sources in obtaining an instance of said location information for the first mobile station.

231. (New) The method of Claim 226, wherein for locating a second of the mobile stations, further including a step of providing one or more location input instances of location information by one or more of said location estimating sources in said common data representation.

232. (New) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of said wireless mobile stations including at least a location and a time.

233. (New) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of the wireless mobile stations including one or more values indicative of an uncertainty regarding a location of the individual wireless mobile station.

234. (New) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of said wireless mobile stations including one of a travel speed and a travel direction.

235. (New) A method as set forth in claim 221, wherein said step of first obtaining comprises sending data for requesting activation of one of the first location estimating source and the second location estimating source to obtain the corresponding one of first and second location input.

236. (New) A method as set forth in claim 221, wherein said step of third obtaining comprises determining additional location information including at least a wireless station identification and a location of the first wireless mobile station.

237. (New) A method as set forth in claim 221, wherein said step of third obtaining comprises determining additional location information a including a time and an uncertainty regarding location.

238. (New) A method as set forth in claim 221, wherein said step of third obtaining comprises providing additional location information including one of a speed of travel and direction of travel for the first wireless mobile station.

239. (New) A method as set forth in claim 221, further comprising combining a first portion of said portions of said data obtained using said first location input with a second portion of said portion of said data obtained using said second location to make a location determination.

240. (New) A method as set forth in claim 239, wherein said step of combining comprises obtaining a first set of information including first location information and first time information for said wireless mobile station, obtaining a second set of information including second location information and second time information for said wireless mobile station, determining a time difference between said first and second sets of information, and adjusting one of said first and second sets of information based on said time difference.

241. (New) A method as set forth in claim 240, wherein said adjusting comprising calculating one of a change in position and a value related to an uncertainty in position dependent on said time difference.

242. (New) A method as set forth in claim 239, wherein said step of combining comprises obtaining a first set of position information including a position and first value related to an uncertainty, obtaining a second set of information including a position and second value related to an uncertainty and combining said first set and said second set to yield a third set including a position and an uncertainty for said wireless station, wherein said third set includes a reduced uncertainty relative to said first and second sets.

243. (New) A method as set forth in claim 239, wherein said first location finding technology involves a first location finding controller for receiving first location data from a first source and determining, using said first data, one or more geometric extents for a location of the first mobile station and a value related to an uncertainty of said one or more geometric extents to provide said first location input, and said second location finding technology involves obtaining second location data from a second source and determining, using said second data, one or more geometric extents for a location of the first mobile station and a value related to an uncertainty of said one or more geometric extents to provide said second location input, and said step of combining comprises obtaining said first data from said first source, obtaining said second data from said second source, and said step of combining further comprises using one of said first data and said second data to obtain derived location information

244. (New) A method as set forth in claim 221, further comprising the step of obtaining tracking information regarding movement of said wireless station, and using said tracking information to derive location information.

245. (New) A method for estimating, for each mobile station M of a plurality of mobile stations, an unknown terrestrial location, L_M, for M using wireless signal measurements obtained from transmissions between said mobile station M and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations is substantially co-located with one or more of a transmitter and a receiver for wirelessly communicating with said mobile station M, comprising:

initiating a plurality of requests for information related to the location of said mobile station M, the requests provided to each of at least two mobile station location evaluators, wherein there is at least a first of the requests provided to a first of the location evaluators and a second of the requests, different from the first request, provided to a second of the location evaluators, such that when said location evaluators are supplied with corresponding input data having values obtained using wireless signal measurements obtained via two way wireless communication between said mobile station M, and the communication stations, each of said first and second location evaluators determine corresponding location information related to L_M, and

wherein for at least one location L of one of the mobile stations, said first location evaluator and said second location evaluator output, respectively, first and second position information related to the one mobile station being at L wherein neither of the first and second position information is dependent upon the other;

obtaining a first collection of location information of said mobile station M, wherein the first collection includes first location information from the first location evaluator, and second location information from the second location evaluator;

determining resulting information related to the location L_M of the mobile station M, wherein the resulting information is dependent on geographical information in each of the first and second location information; and

transmitting, to a predetermined destination via a communications network, the resulting information.

246. (New) The method of Claim 245, further including the following steps:

second obtaining, from an additional one or more of the location evaluators, a second collection of location information using values obtained from wireless signal measurements for a time different from a time of the communications between the mobile station M and the communication stations for obtaining the first collection;

determining, as part of said resulting information, a resulting location estimate of the mobile station M, wherein said resulting location estimate is dependent upon a value obtained from said second collection of location estimates.

247. (New) A method for locating mobile stations at one or more unknown terrestrial locations using wireless signal measurements obtained from transmissions between said mobile stations and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile stations, comprising:

receiving, from a plurality of location requesting sources, a plurality of input requests for locations of the mobile stations, wherein for each of the input requests there is a corresponding destination for a responsive output;

for each of the input requests, providing one or more location requests for location information, related to a location of one of said mobile stations, to one or more mobile station location determining sources;

first obtaining, in response to a first of the location requests received from a first of the requesting sources, at least first location information of a first location of a first of said mobile stations, said first location information determined using a first set of one or more wireless location techniques;

first determining, using said first location information, first output location data according to a first output criteria for the corresponding destination for the first request, said first output location data including a representation identifying a first geographical range of the first location;

second obtaining, in response to a second of the location requests received from a second of the requesting sources, at least second location information of a second location of a second of said mobile stations, said second location information determined using a second set of one or more wireless location techniques, wherein the second set determines the second location information by activating at least one computational module for locating the second mobile station that is not activated for determining the first location information;

second determining, using said second location information, second output location data according to a second output criteria for the corresponding destination for the second request, said second output location data including a representation identifying a geographical range of the second location;

wherein for at least one of said first and second output criteria, there is an output criteria for another of the location requests that is different from said at least one output criteria;

first transmitting said first output location data to its corresponding destination via a communications network; and

second transmitting said second output location data to its corresponding destination via a communications network, the first and second locations being different

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248. (New) The method of Claim 247, wherein for at least one of said location techniques of said first set, and for a different one of said location techniques of said second set there is a common predetermined interface at which said first and second location information are received.

249. (New) The method of Claim 247, wherein said steps of first and second determining use at least one common mobile station location related component for determining, respectively, said first output location data and said second output location data

250. (New) The method of Claim 247, wherein said steps of first and second transmitting includes outputting said first and second output location data via a common predetermined network interface.

251. (New) The method of Claim 247, wherein said first determining step includes accessing mobile station location output frequency information of said first output criteria.

252. (New) The method of Claim 247, wherein said first determining step includes determining a coarse location estimate of the first mobile station as a portion of said first output location data, wherein a subsequent location estimate of the first mobile station is an improvement thereof.

253. (New) The method of Claim 247, wherein at least one of said first determining and said first transmitting steps includes determining a particular protocol for outputting said first output location data on the communication network for transmission to the corresponding destination for the first location request.

254. (New) The method of Claim 247, wherein said first output criteria includes information for determining said representation of said first geographical range using a location of a known geographical feature different from the communication stations.

255. (New) The method of Claim 254, wherein the known geographical feature includes a roadway, and said determining step includes snapping to the roadway.

256. (New) The method of Claim 247, wherein said corresponding destination for said first location request is for a first application, and said corresponding destination for said second location request is for a second application, wherein said first and second applications, respectively, use said first and second output location data differently.

257. (New) The method of Claim 256, wherein said first and second applications are for corresponding different ones of the following: responding to emergency calls, tracking, routing, people and animal location including applications for confinement to or exclusion from certain areas, parolee surveillance, responding a mobile station user's request for the user's location.

258. (New) The method of Claim 256, wherein said first output criteria includes information for determining a first location granularity at which a location estimate of the first mobile station is transmitted in said first output location data, wherein said first location granularity is dependent upon said first application.

259. (New) The method of Claim 256, wherein said first output criteria includes information for determining a first representation for said first output location data, wherein said first representation is dependent upon said first application, and said second output criteria includes information for determining a second representation for said second output location data, wherein said second representation is dependent upon said second application.

260. (New) The method of Claim 247, wherein a first predetermined collection of computational components performs said steps of receiving, providing, first obtaining, first determining, second obtaining, second determining, first transmitting, and second transmitting, and wherein a second predetermined collection of computational components performs said steps of receiving, providing, first obtaining, first determining, second obtaining, second determining, first transmitting, and second transmitting;

wherein for at least one of said steps of receiving, providing, first obtaining, first determining, second obtaining, second determining, first transmitting, and second transmitting, there are different components in said first predetermined collection and said second predetermined collection for performing said at least one step, and said first predetermined collection transmits the first request to said second predetermined collection.

261. (New) The method of Claim 260, wherein said first predetermined collection includes a first location center, and said second predetermined collection includes a second location center.

262. (New) The method of Claim 247, wherein at least one of said steps of receiving, first obtaining, second obtaining, first transmitting, and second transmitting receives or transmits wireless location related information on TCP/IP network.

263. (New) The method of Claim 247, wherein said step of first obtaining includes receiving a first location estimate from a first of said location determining sources which

performs an instance, I_1, of a first technique for estimating a location of the first mobile station using signal transmissions to the first mobile station from non-terrestrial transmitters, wherein said instance I_1 also uses wireless signals, S, between the first mobile station and at least one of the communication stations to improve at least one performance characteristic of said instance I_1 over a performance of I_1 without use of the wireless signals between the first mobile station and the at least one communication station.

264. (New) The method of Claim 263, wherein the instance I_1 uses first information for locating the first mobile station, wherein the first information is dependent upon signal timing measurements from the wireless signals S.

265. (New) The method of Claim 263, wherein the instance I_1 uses first information from the wireless signals S, wherein the first information is dependent upon a wireless coverage area of the at least one communication station.

266. (New) The method of Claim 247, further including a step of providing display information for displaying a representation of a location estimate L of the first mobile station, wherein said display information is for displaying a map of an area having the location estimate L, and for concurrently displaying information indicating an accuracy of the location estimate L.

267. (New) The method of Claim 266, wherein said display information is displayed at a mobile station M that has requested a location of the first mobile station.

268. (New) A method for locating a first and second wireless mobile stations using measurements of wireless signals, wherein at least one of: (i) said measurements, and (ii) said wireless signals are transmitted between the first mobile station and at least one of a plurality of terrestrial transceivers, and between the second mobile station and at least one of a plurality of terrestrial transceivers, wherein said transceivers are capable of at least wirelessly detecting a plurality of wireless transmitting mobile stations, including said first and second mobile stations, comprising:

providing access to first and second different mobile station location techniques, wherein each of said location techniques is capable of providing location information for each mobile station of at least some of said mobile stations when said location technique is supplied with corresponding data obtained from wireless signal measurements communicated between the mobile station and one or more of said plurality of transceivers, wherein for at least one location L of one of the mobile stations, said first location technique and said second location technique output, respectively, first and second position information related to the one mobile station being at L wherein neither of the first and second position information is dependent upon a change in the other;

first supplying said first location technique with first corresponding data obtained from wireless signal measurements communicated between one or more of: (a1) said first mobile station and one or more of said plurality of transceivers, and (a2) said second mobile station and one or more of said plurality of transceivers;

second supplying said second location technique with second corresponding data obtained from wireless signal measurements communicated between one or more of: (b1) said first mobile station and one or more of said plurality of transceivers, and (b2) said second mobile station and one or more of said plurality of transceivers;

first receiving from said first location technique, first location related information representing one or more of: a first range of locations for the first mobile station, and a second range of locations for the second mobile station;

second receiving from said second location technique, second location related information representing one or more of: a third range of locations for the first mobile station, and a fourth range of locations for the second mobile station;

determining resulting location information for each of the first and second mobile stations using at least one of: (c1) a first value obtained from said first location related information, and (c2) a second value obtained from said second location related information;

wherein there is at least one predetermined common location related component activated for determining the resulting location information for each of said first and second mobile stations, wherein:

(i) said common component is activated, for locating said first mobile station, after at least one step of said steps of first and second supplying, and

(ii) said common component is activated, for locating said second mobile station, after at least one step of said steps of first and second supplying;

providing said resulting location information for each of the first and second mobile stations for presentation, wherein said presentation for at least one of said first and second mobile stations is determined according to an expected accuracy of said resulting location information

269. (New) A method for locating a wireless mobile station, comprising:

repeatedly performing the following steps (A1) through (A3) for tracking the mobile station, wherein there is at least a first and a second mobile station location technique, each of the location techniques providing an instance of location information for a location of the mobile station to the step (A1) below at some time during said step of repeatedly performing;

wherein for at least one location L of the mobile station, said first mobile station location technique and said second mobile station location technique output location information instances having, respectively, first and second position information for the mobile station being at L, wherein neither of the first and second position information varies substantially as a result in a change in the other;

(A1) receiving an instance, I_1, of location information for the mobile station from at least one of the first and a second mobile station location techniques wherein I_1 includes position information for the mobile station;

(A2) determining at least one resulting instance of location information for said mobile station using at least one of: (a) a first value obtained from an instance of first location information received from said first location technique, and (b) a second value obtained from an instance of second location information received from said second location technique;

wherein said step of determining includes a step of determining a likely roadway upon which the mobile station is located;

(A3) outputting said resulting location information for display on a display device, wherein said resulting location information is displayed as at least one location of the mobile station on a map having roadways thereon.

270. (New) The method of Claim 269, wherein at least one occurrence of said step of outputting includes transmitting said resulting location information via a telephony network.

271. (New) The method of Claim 269, wherein said outputting step includes providing accuracy information indicating an accuracy of said resulting location information, wherein said accuracy information is displayed with said at least one location of the mobile station.

272. (New) The method of Claim 269, wherein for at least one location of the mobile station said step of determining uses both said first and second values.

273. (New) The method of Claim 269, wherein said first location technique includes a step of using wireless signals, S, between the first mobile station and at least one terrestrial transceiver to improve upon of said first location information over a performance of said first location technique without using the wireless signals between the first mobile station and the at least one terrestrial transceiver.

274. (New) The method of Claim 273, wherein said first location technique includes a step of using information dependent upon a wireless coverage area of the at least one transceiver for improving said first location information

275. (New) The method of Claim 274, wherein the at least one transceiver includes a base station for providing two way communication with the mobile station.

276. (New) A method for locating, from a plurality of wireless mobile stations, one of the wireless mobile stations using measurements of wireless signals, wherein at least one of: (i) said measurements and (ii) said wireless signals are transmitted between said one mobile station and at least one of a plurality of fixed location communication stations, each communication station capable of at least one of receiving wireless signals from, and transmitting wireless signals to said one mobile station, comprising:

receiving, from each of at least first and second mobile station location estimators, corresponding first and second information related to a likely geographical approximations for a location of said one mobile station, wherein: (a) for determining a likely geographical approximation, GA_A, for a location, L_A, of a second of the mobile stations at a time T_A, said first location estimator generates GA_A without requiring a prior likely geographical location approximation generated by said second location estimator for locating the second mobile station at substantially the location L_A at substantially the time T_A, and, (b) for estimating a likely geographical approximation, GA_B, for a location, L_B, of a third one of the mobile stations at a time T_B, said second location estimator generates GA_B without requiring a prior likely geographical location approximation generated by said first location estimator for locating the third mobile station at the location L_B at substantially the time T_B;

determining a resulting location estimate of said one mobile station, wherein said step of determining includes at least one of the substeps (B1) through (B2) following:

(B1) when said first and second information include, respectively, first and second likely geographical approximations, combining said first and second likely geographical approximations so that said resulting location estimate is dependent on each of said first and second location likely geographical approximations; and

(B2) selecting one of said first and second information for receiving preference in determining said resulting location, wherein said selecting is dependent upon location related data in at least one of said first and second information.

277. (New) The method of Claim 276, further including a step of providing display information for: (a) displaying a representation of said resulting location estimate, wherein said display information is for displaying with a map of an area having the resulting location estimate, and (b) concurrently displaying information indicative of an accuracy of the resulting location estimate.

278. (New) A method for locating a wireless mobile station capable of wireless two way communication with a plurality of fixed location terrestrial stations, comprising:

providing access to a plurality of mobile station location estimating techniques, wherein said location techniques provide location information related to said mobile station when said location techniques are supplied with corresponding input information upon which their location estimates are dependent, and wherein the corresponding input information is at least partially derived from measurements of wireless signals transmitted from or received at the mobile station;

receiving, over time, a plurality of location estimates of the mobile station:

determining, a plurality of consecutive resulting location estimates for tracking the mobile station, wherein said step of determining includes steps (a) and (c) following:

(a) deriving, for at least one time during the tracking, a corresponding one of said resulting location estimates of the mobile station using one of said first one or more location estimates by said first location technique for a first location of the mobile station;

(b) deriving, for at least one time during the tracking, a corresponding one of said resulting location estimates of the mobile station using one of said second one or more location estimates by said second location technique for a second location of the mobile station;

(c) preferring a location estimate of said first location information over a location estimate of said second location information when both are available for substantially a same location of the mobile station.

279. (New) The method as claimed in Claim 278, wherein said step of determining includes:

establishing a priority between a location estimate of said first location information and a location estimate of said second location information.

280. (New) The method as claimed in Claim 279, wherein said step of establishing includes obtaining a confidence value for one or more of: (a) at least one of said location estimates for said first location information; and (b) at least one of said location estimates for said second location information;

wherein each said confidence value is indicative of a likelihood of the mobile station having a location represented by said corresponding location estimate for the confidence value.

281. (New) The method of Claim 278, further including a step of:

providing communication between the mobile station and another party via at least one of the terrestrial stations, wherein the communication travels through a telephony network.

282. (New) The method of Claim 278, further including the steps of:

requesting one or more of the resulting location estimates via signals transmitted by a commercial mobile radio service provider that wirelessly communicates with the mobile station;

transmitting, via a communication network, at least one location of the mobile station to one of: the mobile station, another mobile station, a police unit, a vehicle, and a party requesting the location of the mobile station.

283. (New)The method of Claim 278, wherein said determining step includes determining at least one of said resulting location estimates as a function of a position of a known geographical feature that is sufficiently close to one of the first or second location estimates so that the closeness is used to determine said more likely location estimate.

284. (New) The method as claimed in Claim 278, wherein said step of determining includes, for at least one of said resulting location estimates, determining one or more of: (a) a velocity of the mobile station, (b) an acceleration of the mobile station, and (c) one or more geographical features near said at least one resulting location estimate.

285. (New) A method for locating a mobile station using wireless signal measurements obtained from transmissions between said mobile station and a plurality of fixed location communication stations, wherein each of said communications stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile station, comprising:

providing access to first and second mobile station location evaluators, wherein said location evaluators are able to determine information related to one or more location estimates of said mobile station when said location evaluators are supplied with data having values obtained during wireless signal two way communication between said mobile station and the communication stations;

wherein for at least one location L of the mobile station, said first mobile station location evaluator and said second mobile station location evaluator output location information instances having, respectively, first and second position information for the mobile station being at L, wherein neither of the first and second position information substantially changes with a change in the other of the first and second position information;

first obtaining, from said first location evaluator, first location related information for identifying a location of the mobile station for at least one of the following situations: a tracking of the mobile station, and in response to a request for a location of the mobile station;

second obtaining, from said second location evaluator, second location related information for identifying a location of the mobile station for said same at least one situation;

determining additional location information of the mobile station dependent upon at least one of: (a) a first value obtained from said first location related information, and (b) a second value obtained from said second location related information;

wherein said determining step includes providing the additional location information with:

(i) data indicative of one of: an error and a likelihood of the mobile station being at a location represented by said additional location information; and

(ii) a timestamp indicative of when the resulting location information corresponds to a location of the mobile station.

286. (New) The method as claimed in Claim 285, wherein said mobile station is co-located with a processor for activating at least one of said location evaluators.

287. (New) The method of Claim 285, further including a step of transmitting said resulting location estimate on a communications network to a destination requesting the location of the mobile station.

288. (New) The method of Claim 285, further including a step of determining, using said resulting location information, output location information according to output criteria corresponding to an application requesting data related to a location of the mobile station.

289. (New) The method of Claim 288, wherein said output criteria includes at least some of:

(a) a transmission protocol;

(b) a granularity of by which a location estimate of the mobile station represented by said resulting location information is to be provided;

(c) a frequency with which repeated location estimates of the mobile station are to be output to the application;

(d) destination data for determining where said resulting location information is to be transmitted;

(e) an indication as to whether a location estimate of the mobile station is to be adjusted according to a known geographical feature different from the communication stations; and

(f) a desired representation of a location estimate of the mobile station represented by said resulting location information.

290. (New) A method for locating one or more mobile stations using wireless signal measurements obtained from transmissions between said mobile stations and a plurality of terrestrial communication stations, wherein each of said communication stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile stations, comprising:

receiving a location request for a location of a first of the mobile stations, wherein the first mobile station is capable of providing wireless telephony transmissions, and a substantially same collection of components are in electronic contact with one another for performing each of at least most wireless telephony transmissions from the first mobile station;

generating one or more messages, for information related to a location of said first mobile station, said messages for requesting activation of one or more mobile station location estimators such that when said location estimators are supplied with corresponding input data having values obtained from wireless signal measurements obtained via transmissions between said first mobile station and the communication stations, said one or more location estimators determine location related information for the first mobile station;

first obtaining, from at least two of said location estimators, first mobile station related location information obtained as a result of an available at least two instances of said corresponding input data;

determining a resulting location estimate of the first mobile station obtained from said first mobile station related location information;

wherein at least one of said steps of generating, first obtaining, and determining includes a substep of one of: (i) transmitting information to a destination via a communication network, and (ii) receiving information from a source via a communication network;

using said resulting location information, to determine output location information according to output criteria corresponding to an application requesting data related to a location of the mobile station, wherein said output criteria includes at least some of:

(a) a transmission protocol;
(b) a granularity of by which a location estimate of the mobile station represented by said resulting location information is to be provided;
(c) a frequency with which repeated location estimates of the mobile station are to be output to the application;
(d) destination data for determining where said resulting location information is to be transmitted;
(e) an indication as to whether a location estimate of the mobile station is to be adjusted according to a known geographical feature different from the communication stations; and
(f) a desired representation of a location estimate of the mobile station represented by said resulting location information.

291. (New) A method for locating a mobile station using wireless signal measurements obtained from transmissions between said mobile station and at least one of a plurality of terrestrial transceivers capable of wirelessly detecting said mobile station, comprising:

providing access to at least two of the location techniques;

determining whether an accessible first of the location techniques has its corresponding input available for determining a first location estimate of said mobile station;

determining a second location estimate of said mobile station by activating an accessible second of said location techniques different from said first location technique when the corresponding input for said second technique is available;

receiving at least one of said first and second location estimates;

obtaining resulting location information for transmitting on a communications network, wherein said resulting location information is obtained using at least one of said first location estimate and said second location estimate;

wherein when said mobile station is at a first location, an instance of at least said first location estimate is used in said obtaining step for obtaining a first corresponding instance of said resulting location information, and when said mobile station is at a second location, an instance of at least said second location estimate is used in said obtaining step for obtaining a second corresponding instance of said resulting location information; and

wherein for the first location, the corresponding performance of said obtaining step includes: (1) a step of improving upon said instance of at least said first location estimate, and (2) a step of providing information indicative of an accuracy of said first corresponding instance of said resulting location information.

292. (New) A mobile station location system, comprising:

a gating module for communicating with two or more mobile station location estimating sources for determining corresponding geographic extents for locations of a plurality of mobile stations, such that for each mobile station M of at least some of the mobile stations, when said one or more estimating sources are supplied with corresponding data obtained from measurements of wireless signals transmitted between the mobile station M, and at least one of (1) and (2) following:

(1) a plurality of communication stations capable of at least one of: wirelessly detecting said mobile stations, and being wirelessly detected by said mobile stations, and

(2) one or more non-terrestrial wireless signal transmitting stations,

then for said one or more location estimating sources supplied with their corresponding data, each such source outputs a corresponding geographic extent of a geographical location of the mobile station M;

wherein for a first of said mobile station location estimating sources, when estimating a location of one of the mobile stations, and for a second of said mobile station location estimating sources, and for at least one instance of locating one of the mobile stations, said first and second sources provide different geographic extents;

wherein said gating module communicates on a communications network with at least the first of the location estimating sources for providing said location system with said corresponding geographic extent for a location L of the mobile station M; and

a resulting estimator for determining a likely location estimate of the location L of the mobile station M using two or more of said corresponding geographic extents for the mobile station M, said resulting estimator activating at least one of: (i) a selector for giving preference, as more indicative of the location L, to at least one geographic extent obtained from said corresponding geographic extents, and (ii) a combiner for combining said two or more corresponding geographic extents for obtaining said likely location estimate.

293. (New) The location system, as claimed in Claim 292, wherein one or more of said estimating sources are capable of being at least one of: added, replaced and deleted by transmissions on a communication network between a portion of said location system and a site remote from said portion.

294. (New) The location system as claimed in Claim 292, wherein one or more of:

(a) at least one of said one or more corresponding geographic extents, GE, has a corresponding value therewith indicative of a likelihood that the mobile station M resides in a geographical area represented by GE, and said combiner uses said corresponding value for obtaining said likely location estimate;

(b) said gating module activates a wireless transceiver for communicating with the plurality of communication stations;

(c) said plurality of communication stations includes base stations for wireless two way communication with said mobile stations;

(d) said non-terrestrial wireless signal transmitting stations include GPS satellites;

(e) said communications network includes a portion of the Internet;

(h) the mobile station M has an ability to communicate with other of the mobile stations as a base station;

(i) said selector includes a filter for reducing a dependence of said likely location estimate on one of the corresponding geographic extents;

(j) said resulting estimator is at least partially included in a mobile base station;

(k) said resulting estimator resides at a location center;

(l) said gating module resides at a location center;

(m) said gating module routes activation information to said two or more estimating sources; and

(n) said gating module resides at a mobile station.

:

295. (New) A mobile station location system, comprising:

a communications controller for selectively communicating with a plurality of mobile station location estimating sources for at least one of (1) and (2) following:

(1) activating a selected one or more of said mobile station location estimating sources; and

(2) receiving location related information for locating a plurality of mobile stations;

wherein for each mobile station M of at least some of the mobile stations, when one or more of said location estimating sources are supplied with corresponding data obtained from measurements of wireless signals transmitted between (i) and (ii) following:

(i) the mobile station M, and

(ii) at least one of: a network of communication stations cooperatively linked for use in locating the mobile stations, and one or more non-terrestrial wireless signal transmitting stations, then each such source supplied with its corresponding data, outputs a corresponding location estimate of a geographical location of the mobile station M;

wherein for a first of said mobile station location estimating sources, when estimating a location of one of the mobile stations, said first source is dependent upon a result from a first component, and for a second of said mobile station location estimating sources, when estimating a location of one of the mobile stations, said second source is dependent upon a result from a different second component, wherein for at least one instance of locating one of the mobile stations, said first and second sources provide different location estimates;

an interface in communication with said controller, said interface for communicating on a communications network with at least one of said first and second location estimating sources for thereby at least one of (3) and (4) following:

(3) requesting activation of said at least one location estimating source, and

(4) receiving, from said at least one location estimating source, said corresponding location estimate of the mobile station M;

a resulting estimator for determining a likely location estimate of a location L of the mobile station M using two or more of said corresponding location estimates for the mobile station M at L, wherein said resulting estimator includes at least one of:

(i) a selector for giving preference, as more indicative of the location L, to at least one preferred location estimate obtained from said corresponding location estimates; and

(ii) a combiner for obtaining said likely location estimate as a function of said two or more of said corresponding location estimates.

Remarks

Amendments To The Specification:

The amendments to the specification which the Applicants request entry herewith are primarily to correct obvious errors, and/or to provide consistency between annotations for identifying the same item in different drawings. However, an additional amount of descriptive text is also requested to be entered into the SUMMARY section of the specification on page 10, line 3 and page 12, line 6. This additional text merely summarizes subject matter from other portions of the originally filed specification so that the SUMMARY section better reflects the aspects of the invention for which patent protection is being requested. This additional summarizing text introduces no new matter to the specification. However, it is believed important to provide this additional descriptive text in that for such a lengthy specification as the present application has, a more easily located description for better understanding the claims is in the public interest.

Specification Amendments For Adding Text That Was In The U.S. Provisional From Which The Present Application Claims Priority:

Additional amendments to the specification include the following paragraphs which were in the U.S Provisional Patent Application No. 60/025,855 filed Sept. 9, 1996 from which the present application claims priority. In particular, the text for which entry is requested is in a figure (Fig. 4) of this provisional, the text was removed when preparing subsequent versions of the drawings, and was not incorporated into the text of the PCT application from which the present application is the U.S. national filing. Note, however, that Fig. 4 of the above-identified provisional corresponds to Fig. 8 in the present application. It is requested that this text now be incorporated into the specification. The paragraphs referred to here are duplicated hereinbelow. For the Examiner's convenience, a copy of Fig. 4 from the above-identified U.S. Provisional Patent Application also accompanies these remarks, and the text of this figure corresponding to the text whose entry is requested in the present application is highlighted in the figure accompanying (Fig. 4).

First requested new text from Provisional Fig. 4 (added on page 53, line 10):

"In one embodiment, such a distance model may perform the following steps:

(a) Determine a minimum distance between the target MS and each BS using TOA, TDOA, signal strength on both forward and reverse paths;

(b) Generates an estimated error;

(c) Outputs a location hypothesis for estimating a location of a MS: each such hypothesis having: (a) one or more (nested) location area estimates for the MS, each location estimate having a confidence value (e.g., provided using the estimated error) indicating a perceived accuracy and (b) a reason for both the location estimate (e.g., substantial multipath, etc) and the confidence."

Second requested new text from Provisional Fig. 4 (added on page 53, line 16):

"In one embodiment, such a stochastic signal model may outputs location hypotheses determined by one or more statistical comparisons with loc sigs in the Location Signature database 1320 (e.g., comparing MS location signals with verified signal characteristics for predetermined geographical areas)."

Third requested new text from Provisional Fig. 4 (added on page 53, line 24):

"In one embodiment, an adaptive learning model such as a model based on an artificial neural network may determine an MS 140 location estimate using base station IDs, data on signal-to-noise, other signal data (e.g., a number of signal characteristics including, e.g., all CDMA fingers). Moreover, the output from such a model may include: a latitude and longitude for a center of a circle having radius R (R may be an input to such an artificial neural network), and is in the output format of the distance model(s)."

Fourth requested new text from Provisional Fig. 4 (added on page 54, line 3):

"In one embodiment, such a location base station model may perform the following steps:

(a) If an input is received then the target MS 140 is detected by a location base station 152 (i.e., a LBS being a unit having a reduced power BS and a MS).

(b) If an input is obtained, then the output is a hypothesis data structure having a small area of the highest confidence.

(c) If no input is received from a LBS then a hypothesis having an area with highest negative confidence is output."

Fifth requested new text from Provisional Fig. 4 (added as second paragraph in the new text starting on page 54, line 8):

"In one embodiment, such a distributed antenna model may perform the following steps:

(a) Receives input only from a distributed antenna system.

(b) If an input is received, then the output is a lat-long and height of highest confidence."

Sixth requested new text from Provisional Fig. 4 (added as the fourth paragraph of the new text on page 54, line 8):

"In one embodiment, such a home base station model may perform the following steps:

(a) Receives an input only from the Public Telephone Switching Network.

(b) If an input is received then the target MS 140 is detected by a home base station associated with the target MS.

(c) If an input is obtained, then the output is a hypothesis data structure having a small area of the highest confidence.

(d) If no input and there is a home base station then a hypothesis having a negative area is of highest confidence is output."

Seventh requested new text from Provisional Fig. 4 (added as the last sentence of the new text starting on page 54, line 3):

"In one embodiment, such a mobile base station model may provide output similar to the distance FOM 1224 described hereinabove."

Claim Amendment Remarks:

Applicants have have cancelled all pending claims and provided new Claims 221-295. Note, that Claim 221 is similar in some respects to Claim 1 of U.S. Patent No. 6,321,092, filed Sept. 15, 1999 which claims the benefit of U.S. Provisional Application No. 60/106,816 filed Nov. 3, 1998. However, the present application is a U.S. National filing of PCT/US97/15892 filed September 8, 1997.

Applicants request entry of all the amendments provided herewith, and reconsideration of the present application. It is believed that all pending claims are now in condition for allowance. Thus, it is requested that the Examiner contact the Applicant named below by phone if the Examiner determines that one or more of the claims are not allowable. Note that the Applicants have previously paid for 5 independent and 96 total claims prior to this Amendment and Response which totals fees of $764 for claims.. The present Amendment and Response cancels all pending claims, and adds 75 total new claims (12 new independent claim and 63new dependent) the fee for claims which totals $495. Accordingly, there is an overpayment of $269. Also included herewith is a check in the amount of $200.00 for a two month extension and a corresponding petition under 37 C.F.R. 1.136(a). No other fees are believed due with this transmittal beyond those identified here.

However, if additional fees are due, then the Applicant respectfully requests notification of the Applicant named below so that any additional fees can be timely paid.

Respectfully submitted,

By: [signature]

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Date: Feb. 20, 2002

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

The paragraph beginning on page 8, line 3 has been replaced with the following paragraph. Note that the only change here is the insertion of a space before the sentence beginning with the phrase "Fast fading...":

Loss due to slow fading includes shadowing due to clutter blockage (sometimes included in Lp). Fast fading is composed of multipath reflections which cause: 1) delay spread; 2) random phase shift or Rayleigh fading; and 3) random frequency modulation due to different Doppler shifts on different paths.

The paragraph beginning on page 10, line 3 through page 10, line 20 has been replaced with the following paragraphs:

It is an objective of the present invention to provide a system and method for to wireless telecommunication systems for accurately locating people and/or objects in a cost effective manner. Additionally, it is an objective of the present invention to provide such location capabilities using the measurements from wireless signals communicated between mobile stations and a network of base stations, wherein the same communication standard or protocol is utilized for location as is used by the network of base stations for providing wireless communications with mobile stations for other purposes such as voice communication and/or visual communication (such as text paging, graphical or video communications). Related objectives for various embodiments of the present invention include providing a system and method that:

(1.1) can be readily incorporated into existing commercial wireless telephony systems with few, if any, modifications of a typical telephony wireless infrastructure;

(1.2) can use the native electronics of typical commercially available, or likely to be available, telephony wireless mobile stations (e.g., handsets) as location devices;

(1.3) can be used for effectively locating people and/or objects wherein there are few (if any) line-of-sight wireless receivers for receiving location signals from a mobile station (herein also denoted MS);

(1.4) can be used not only for decreasing location determining difficulties due to multipath phenomena but in fact uses such multipath for providing more accurate location estimates;

(1.5) can be used for integrating a wide variety of location techniques in a straight-forward manner; [and]

(1.6) can substantially automatically adapt and/or (re)train and/or (re)calibrate itself according to changes in the environment and/or terrain of a geographical area where the present invention is utilized;

(1.7) can utilize a plurality of wireless location estimators based on different wireless location technologies (e.g., GPS location techniques, terrestrial base station signal timing techniques for triangulation and/or trilateration, wireless signal angle of arrival location techniques, techniques for determining a wireless location within a building, techniques for determining a mobile station location using wireless location data collected from the wireless coverage area for, e.g., location techniques using base station signal coverage areas, signal pattern matching location techniques and/or stochastic techniques), wherein each such estimator may be activated independently of one another, whenever suitable data is provided thereto and/or certain conditions, e.g., specific to the estimator are met;

(1.8) can provide a common interface module from which a plurality of the location estimators can be activated and/or provided with input;

(1.9) provides resulting mobile station location estimates to location requesting applications (e.g., for 911 emergency, the fire or police departments, taxi services, vehicle location, etc.) via an output gateway, wherein this gateway:

(a) routes the mobile station location estimates to the appropriate location application(s) via a communications network such as a wireless network, a public switched telephone network, a short messaging service (SMS), and the Internet,

(b) determines the location granularity and representation desired by each location application requesting a location of a mobile station, and/or

(c) enhances the received location estimates by, e.g., performing additional processing such as "snap to street" functions for mobile stations known to reside in a vehicle.

The paragraph beginning on page 11, line 15 has been replaced with the following paragraph:

(3.3) The term, "infrastructure", denotes the network of telephony communication services, and more particularly, that portion of such a network that receives and processes wireless communications with wireless mobile stations. In particular, this infrastructure includes telephony wireless base stations (BS) such as those for radio mobile communication systems based on CDMA, AMPS, NAMPS, TDMA, and GSM wherein the base stations provide a network of cooperative communication channels with an air interface with the MS, and a conventional telecommunications interface with a Mobile Switch Center (MSC). Thus, an MS user within an area serviced by the base stations may be provided with wireless communication throughout the area by user transparent communication transfers (i.e., "handoffs") between the user's MS and these base stations in order to maintain effective telephony service. The mobile switch center (MSC) provides communications and control connectivity among base stations and the public telephone network 124.

The paragraph beginning on page 12, line 6 has been replaced with the following paragraphs:

The present invention relates to a wireless mobile station location system, and in particular, various subsystems related thereto such as a wireless location gateway, and the combining or hybriding of a plurality of wireless location techniques.

Regarding a wireless location gateway, this term refers to a communications network node whereat a plurality of location requests are received for locating various mobile stations from various sources (e.g., for E911 requests, for stolen vehicle location, for tracking of vehicles traveling cross country, etc.), and for each such request and the corresponding mobile station to be located, this node: (a) activates one or more wireless location estimators for locating the mobile station, (b) receives one or more location estimates of the mobile station from the location estimators, and (c) transmits a resulting location estimate(s) to, e.g., an application which made the request. Moreover, such a gateway typically will likely activate location estimators according to the particulars of each individual wireless location request, e.g., the availability of input data needed by particular location estimators. Additionally, such a gateway will typically have sufficiently well defined uniform interfaces so that such location estimators can be added and/or deleted to, e.g., provide different location estimators for performing wireless location different coverage areas.

The present invention encompasses such wireless location gateways. Thus, for locating an identified mobile station, the location gateway embodiments of the present invention may activate one or more of a plurality of location estimators depending on, e.g., (a) the availability of particular types of wireless location data for locating the mobile station, and (b) the location estimators accessable by the location gateway. Moreover, a plurality of location estimators may be activated for locating the mobile station in a single location, or different ones of such location estimators may be activated to locate the mobile station at different locations. Moreover, the location gateway of the present invention may have incorporated therein one or more of the location estimators, and/or may access geographically distributed location estimators via requests through a communications network such as the Internet.

In particular, the location gateway of the present invention may access, in various instances of locating mobile stations, various location estimators that utilize one or more of the following wireless location techniques:

(a) A GPS location technique such as, e.g., one of the GPS location techniques as described in the Background section hereinabove;

(b) A technique for computing a mobile station location that is dependent upon geographical offsets of the mobile station from one or more terrestrial transceivers (e.g., base stations of a commercial radio service provider). Such offsets may be determined from signal time delays between such transceivers and the mobile station, such as by time of arrival (TOA) and/or time difference of arrival (TDOA) techniques as is discussed further hereinbelow. Moreover, such offsets may be determined using both the forward and reverse wireless signal timing measurements of transmissions between the mobile station and such terrestrial transceivers. Additionally, such offsets may be directional offsets, wherein a direction is determined from such a transceiver to the mobile station;

(c) Various wireless signal pattern matching, associative, and/or stochastic techniques for performing comparisons and/or using a learned association between:

(i) characteristics of wireless signals communicated between a mobile station to be located and a network of wireless transceivers (e.g., base stations), and

(ii) previously obtained sets of characteristics of wireless signals (from each of a plurality of locations), wherein each set was communicated, e.g., between a network of transceivers (e.g., the fixed location base stations of a commercial radio service provider), and, some one of the mobile stations available for communicating with the network;

(d) Indoor location techniques using a distributed antenna system;

(e) Techniques for locating a mobile station, wherein, e.g., wireless coverage areas of individual fixed location transceivers (e.g., fixed location base stations) are utilized for determining the mobile station's location (e.g., intersecting such coverage areas for determining a location);

(f) Location techniques that use communications from low power, low functionality base stations (denoted "location base stations"); and

(g) Any other location techniques that may be deemed worthwhile to incorporate into an embodiment of the present invention.

Accordingly, some embodiments of the present invention may be viewed as platforms for integrating wireless location techniques in that wireless location computational models (denoted "first order models" or "FOMs" hereinbelow) may be added and/or deleted from such embodiments of the invention without changing the interface to further downstream processes. That is, one aspect of the invention is the specification of a common data interface between such computational models and subsequent location processing such as processes for combining of location estimates, tracking mobile stations, and/or outputting location estimates to location requesting applications.

Moreover, it should be noted that the present invention also encompasses various hybrid approaches to wireless location, wherein various combinations of two or more of the location techniques (a) through (g) immediately above may be used in locating a mobile station at substantially a single location. Thus, location information may be obtained from a plurality of the above location techniques for locating a mobile station, and the output from such techniques can be synergistically used for deriving therefrom an enhanced location estimate of the mobile station.

It is a further aspect of the present invention that it may be used to wirelessly locate a mobile station: (a) from which a 911 emergency call is performed, (b) for tracking a mobile station (e.g., a truck traveling across country), (c) for routing a mobile station, and (d) locating people and/or animals, including applications for confinement to (and/or exclusion from) certain areas.

It is a further aspect of the present invention that it [In particular, such a wireless mobile station location system] may be decomposed into: (i) a first low level wireless signal processing subsystem for receiving, organizing and conditioning low level wireless signal measurements from a network of base stations cooperatively linked for providing wireless communications with mobile stations (MSs); and (ii) a second high level signal processing subsystem for performing high level data processing for providing most likelihood location estimates for mobile stations.

The paragraph beginning on page 12, line 11 has been replaced with the following paragraph:

Thus[More precisely], the present invention may be considered as [is]a novel signal processor that includes at least the functionality for the high signal processing subsystem mentioned hereinabove. Accordingly, assuming an appropriate ensemble of wireless signal measurements characterizing the wireless signal communications between a particular MS and a networked wireless base station infrastructure have been received and appropriately filtered of noise and transitory values (such as by an embodiment of the low level signal processing subsystem disclosed in a copending PCT patent application PCT/US97/15933 titled, "Wireless Location Using A Plurality of Commercial Network Infrastructures," by F. W. LeBlanc et al.,[and the present applicant(s); this copending patent application] filed September 8, 1997 from which U.S. Patent 6,236,365, filed July 8, 1999 is the U.S. national counterpart; these two references being herein fully incorporated by reference), the present invention uses the output from such a low level signal processing system for determining a most likely location estimate of an MS.

The paragraph beginning on page 12, line 19 (and ending on this same line 19) has been replaced with the following paragraph:

That is, once the following steps are appropriately performed (e.g., by the LeBlanc [copending application] U.S. Patent 6,236,365):

The paragraph beginning on page 12, line 28 has been replaced with the following paragraph:

(4.3) providing the composite signal characteristic values to one or more MS location hypothesizing computational models (also denoted herein as "first order models" and also "location estimating models"), wherein each such model subsequently determines one or more initial estimates of the location of the target MS based on, for example, the signal processing techniques 2.1 through 2.3 above. Moreover, each of the models output MS location estimates having substantially identical data structures (each such data structure denoted a "location hypothesis"). Additionally, each location hypothesis may also include[s] a confidence value indicating the likelihood or probability that the target MS whose location is desired resides in a corresponding location estimate for the target MS;

The paragraph beginning on page 13, line 14 has been replaced with the following paragraph:

Referring now to (4.3) above, the filtered and aggregated wireless signal characteristic values are provided to a number of location hypothesizing models (denoted First Order Models, or FOMs), each of which yields a location estimate or location hypothesis related to the location of the target MS. In particular, there are location hypotheses for both providing estimates of where the target MS is likely to be and where the target MS is not likely to be. Moreover, it is an aspect of the present invention that confidence values of the location hypotheses are provided as a continuous range of real numbers from, e.g., -1 to 1, wherein the most unlikely areas for locating the target MS are given a confidence value of -1, and the most likely areas for locating the target MS are given a confidence value of 1. That is, confidence values that are larger indicate a higher likelihood that the target MS is in the corresponding MS estimated area, wherein [1] -1 indicates that the target MS is absolutely NOT in the estimated area, 0 indicates a substantially neutral or unknown likelihood of the target MS being in the corresponding estimated area, and 1 indicates that the target MS is absolutely within the corresponding estimated area.

The paragraph beginning on page 15, line 22 has been replaced with the following paragraph:

It is a further aspect of the present invention that the personal communication system (PCS) infrastructures currently being developed by telecommunication providers offer an appropriate localized infrastructure base upon which to build various personal location systems (PLS) employing the present invention and/or utilizing the techniques disclosed herein. In particular, the present invention is especially suitable for the location of people and/or objects using code division multiple access (CDMA) wireless infrastructures, although other wireless infrastructures, such as, time division multiple access (TDMA) infrastructures and GSM are also contemplated. Note that CDMA personal communications systems are described in the Telephone Industries Association standard IS-95, for frequencies below 1 GHz, and in the Wideband Spread- Spectrum Digital Cellular System Dual-Mode Mobile Station-Base Station Compatibility Standard, for frequencies in the 1.8-1.9 GHz frequency bands, both of which are incorporated herein by reference. Furthermore, CDMA general principles have also been described, for example, in U. S. Patent 5,109,390, to Gilhausen, et al, filed November 7, 1989, and CDMA Network Engineering Handbook by Qualcomm, Inc., [ ]each of which is also incorporated herein by reference.

The paragraph beginning on page 16, line 6 has been replaced with the following paragraph:

As mentioned [in (1.7) and]in the discussion of classification FOMs above, the present invention can substantially automatically retrain and/or recalibrate itself to compensate for variations in wireless signal characteristics (e.g., multipath) due to environmental and/or topographic changes to a geographic area serviced by the present invention. For example, in one embodiment, the present invention optionally includes low cost, low power base stations, denoted location base stations (LBS) above, providing, for example, CDMA pilot channels to a very limited area about each such LBS. The location base stations may provide limited voice traffic capabilities, but each is capable of gathering sufficient wireless signal characteristics from an MS within the location base station's range to facilitate locating the MS. Thus, by positioning the location base stations at known locations in a geographic region such as, for instance, on street lamp poles and road signs, additional MS location accuracy can be obtained. That is, due to the low power signal output by such location base stations, for there to be signaling control communication (e.g., pilot signaling and other control signals) between a location base station and a target MS, the MS must be relatively near the location base station. Additionally, for each location base station not in communication with the target MS, it is likely that the MS is not near to this location base station. Thus, by utilizing information received from both location base stations in communication with the target MS and those that are not in communication with the target MS, the present invention can substantially narrow the possible geographic areas within which the target MS is likely to be. Further, by providing each location base station (LBS) with a co-located stationary wireless transceiver (denoted a built-in MS above) having similar functionality to an MS, the following advantages are provided:

The paragraph beginning on page 17, line 12 has been replaced with the following paragraph:

It is also an aspect of the present invention to automatically (re)calibrate as in (6.3) above with signal characteristics from other known or verified locations. In one embodiment of the present invention, portable location verifying electronics are provided so that when such electronics are sufficiently near a located target MS, the electronics: (i)[(I)] detect the proximity of the target MS; (ii) determine a highly reliable measurement of the location of the target MS; (iii) provide this measurement to other location determining components of the present invention so that the location measurement can be associated and archived with related signal characteristic data received from the target MS at the location where the location measurement is performed. Thus, the use of such portable location verifying electronics allows the present invention to capture and utilize signal characteristic data from verified, substantially random locations for location system calibration as in (6.3) above. Moreover, it is important to note that such location verifying electronics can verify locations automatically wherein it is unnecessary for manual activation of a location verifying process.

The paragraph beginning on page 18, line 6 has been replaced with the following paragraph:

Furthermore, a mobile location base station includes modules for integrating or reconciling distinct mobile location base station location estimates that, for example, can be obtained using the components and devices of (7.1) through (7.4) above. That is, location estimates for the mobile location base station may be obtained from: GPS satellite data, mobile location base station data provided by the location processing center, [dead reckoning] deadreckoning data obtained from the mobile location base station vehicle [dead reckoning] deadreckoning devices, and location data manually input by an operator of the mobile location base station.

The paragraph beginning on page 18, line 11 has been replaced with the following paragraph:

[ ]The location estimating system of the present invention offers many advantages over existing location systems. The system of the present invention, for example, is readily adaptable to existing wireless communication systems and can accurately locate people and/or objects in a cost effective manner. In particular, the present invention requires few, if any, modifications to commercial wireless communication systems for implementation. Thus, existing personal communication system infrastructure base stations and other components of, for example, commercial CDMA infrastructures are readily adapted to the present invention. The present invention can be used to locate people and/or objects that are not in the line-of-sight of a wireless receiver or transmitter, can reduce the detrimental effects of multipath on the accuracy of the location estimate, can potentially locate people and/or objects located indoors as well as outdoors, and uses a number of wireless stationary transceivers for location.

The present invention employs a number of distinctly different location computational models for location which provides a greater degree of accuracy, robustness and versatility than is possible with existing systems. For instance, the location models provided include not only the radius-radius/TOA and TDOA techniques but also adaptive artificial neural net techniques. Further, the present invention is able to adapt to the topography of an area in which location service is desired. The present invention is also able to adapt to environmental changes substantially as frequently as desired. Thus, the present invention is able to take into account changes in the location topography over time without extensive manual data manipulation. Moreover, the present invention can be utilized with varying amounts of signal measurement inputs. Thus, if a location estimate is desired in a very short time interval (e.g., less than approximately one to two seconds), then the present location estimating system can be used with only as much signal measurement data as is possible to acquire during an initial portion of this time interval. Subsequently, after a greater amount of signal measurement data has been acquired, additional more accurate location estimates may be obtained. Note that this capability can be useful in the context of 911 emergency response in that a first quick [course]coarse wireless mobile station location estimate can be used to route a 911 call from the mobile station to a 911 emergency response center that has responsibility for the area containing the mobile station and the 911 caller. Subsequently, once the 911 call has been routed according to this first quick location estimate, by continuing to receive additional wireless signal measurements, more reliable and accurate location estimates of the mobile station can be obtained.

The paragraph beginning on page 19, line 5 through page 19, line 19 has been replaced with the following paragraph:

At a more general level, it is an aspect of the present invention to demonstrate the utilization of various novel computational paradigms such as:

(8.1) providing a multiple hypothesis computational architecture (as illustrated best in [Fig. 8] Figs. 8) wherein the hypotheses are:

(8.1.1) generated by modular independent hypothesizing computational models;

(8.1.2) the models are embedded in the computational architecture in a manner wherein the architecture allows for substantial amounts of application specific processing common or generic to a plurality of the models to be straightforwardly incorporated into the computational architecture;

(8.1.3) the computational architecture enhances the hypotheses generated by the models both according to past performance of the models and according to application specific constraints and heuristics without requiring feedback loops for adjusting the models;

(8.1.4) the models are relatively easily integrated into, modified and extracted from the computational architecture;

(8.2) providing a computational paradigm for enhancing an initial estimated solution to a problem by using this initial estimated solution as, effectively, a query or index into an historical data base of previous solution estimates and corresponding actual solutions for deriving an enhanced solution estimate based on past performance of the module that generated the initial estimated solution.

The paragraph beginning on page 20, line 19 has been replaced with the following paragraph:

In other embodiments of the present invention, a fast, [abeit]albeit less accurate location estimate may be initially performed for very time critical location applications where approximate location information may be required. For example, less than 1 second response for a mobile station location embodiment of the present invention may be desired for 911 emergency response location requests. Subsequently, once a relatively [course]coarse location estimate has been provided, a more accurate most likely location estimate can be performed by repeating the location estimation processing a second time with, e.g., additional with measurements of wireless signals transmitted between a mobile station to be located and a network of base stations with which the mobile station is communicating, thus providing a second, more accurate location estimate of the mobile station.

The paragraph beginning on page 21, line 1 has been replaced with the following paragraph:

Note that in some embodiments of the present invention, since there is a lack of sequencing between the FOMs and subsequent processing of location hypotheses, the FOMs can be incorporated into an expert system, if desired. For example, each FOM may be activated from an antecedent of an expert system rule. Thus, the antecedent for such a rule can evaluate to TRUE if the FOM outputs a location hypothesis, and the consequent portion of such a rule may put the output location hypothesis on a list of location hypotheses occurring in a particular time window for subsequent processing by the location center. Alternatively, activation of the FOMs may be in the consequents of such expert system rules.

That is, the antecedent of such an expert system rule may determine if the conditions are appropriate for invoking the FOM(s) in the rule's consequent.

The paragraph beginning on page 21, line 8 has been replaced with the following two paragraphs. Note that the only difference here is the commencement of a new paragraph at –Further features and advantages–.

Of course, other software architectures may also to used in implementing the processing of the location center without departing from scope of the present invention. In particular, object-oriented architectures are also within the scope of the present invention. For example, the FOMs may be object methods on an MS location estimator object, wherein the estimator object receives substantially all target MS location signal data output by the signal filtering subsystem. Alternatively, software bus architectures are contemplated by the present invention, as one skilled in the art will understand, wherein the software architecture may be modular and facilitate parallel processing.

Further features and advantages of the present invention are provided by the figures and detailed description accompanying this invention summary.

The paragraph beginning on page 22, line 5 has been replaced with the following paragraph:

Fig. 3 provides a typical example of how the statistical power budget is calculated in design of a Commercial Mobile Radio Service Provider (CMRS) network.

The paragraph beginning on page 22, line 14 has been replaced with the following paragraph:

Figs. 9A and 9A is a high level data structure diagram describing the fields of a location hypothesis object generated by the first order models 1224 of the location center.

The paragraph beginning on page 23, line 16 has been replaced with the following paragraph:

Figs. 23[a]A through 23[b]C present a high level flowchart of the steps performed by function, "GET_DIFFERENCE_MEASUREMENT," for updating location signatures in the location signature data base 1320; note, this flowchart corresponds to the description of this function in APPENDIX C.

PATENT APPLICATION FEE DETERMINATION RECORD
Effective December 8, 2004

Application or Docket Number: 09/770838

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS		
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	minus 20=	*
INDEPENDENT CLAIMS	minus 3 =	*
MULTIPLE DEPENDENT CLAIM PRESENT		☐

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐ RATE	FEE	OR	OTHER THAN SMALL ENTITY RATE	FEE
BASIC FEE	150.00	OR	BASIC FEE	300.00
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL		OR	TOTAL	

CLAIMS AS AMENDED - PART II

AMENDMENT A

3/22/6	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	* 75	Minus	** 75	=
Independent	* 12	Minus	*** 12	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE	OR	RATE	ADDITIONAL FEE
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE	OR	RATE	ADDITIONAL FEE
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

FORM PTO-875 (Rev. 10/04) Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

7590 03/31/2006

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

EXAMINER	
PHAN, DAO LINDA	
ART UNIT	**PAPER NUMBER**
3662	

DATE MAILED: 03/31/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

Notice of Non-Compliant Amendment (37 CFR 1.121)	Application No. 09/770838	Applicant(s)	
	Examiner	Art Unit	

-- *The MAILING DATE of this communication appears on the cover sheet with the correspondence address* --

The amendment document filed on 3/22/6 is considered non-compliant because it has failed to meet the requirements of 37 CFR 1.121. In order for the amendment document to be compliant, correction of the following item(s) is required.

THE FOLLOWING MARKED (X) ITEM(S) CAUSE THE AMENDMENT DOCUMENT TO BE NON-COMPLIANT:

☐ 1. Amendments to the specification:
- ☐ A. Amended paragraph(s) do not include markings.
- ☐ B. New paragraph(s) should not be underlined.
- ☐ C. Other ____.

☐ 2. Abstract:
- ☐ A. Not presented on a separate sheet. 37 CFR 1.72.
- ☐ B. Other ____.

☐ 3. Amendments to the drawings:
- ☐ A. The drawings are not properly identified in the top margin as "Replacement Sheet," "New Sheet," or "Annotated Sheet" as required by 37 CFR 1.121(d).
- ☐ B. The practice of submitting proposed drawing correction has been eliminated. Replacement drawings showing amended figures, without markings, in compliance with 37 CFR 1.84 are required.
- ☐ C. Other ____.

☑ 4. Amendments to the claims:
- ☑ A. A complete listing of all of the claims is not present.
- ☐ B. The listing of claims does not include the text of all pending claims (including withdrawn claims)
- ☐ C. Each claim has not been provided with the proper status identifier, and as such, the individual status of each claim cannot be identified. Note: the status of every claim must be indicated after its claim number by using one of the following status identifiers: (Original), (Currently amended), (Canceled), (Previously presented), (New), (Not entered), (Withdrawn) and (Withdrawn-currently amended).
- ☐ D. The claims of this amendment paper have not been presented in ascending numerical order.
- ☐ E. Other: ____.

For further explanation of the amendment format required by 37 CFR 1.121, see MPEP § 714 and the USPTO website at http://www.uspto.gov/web/offices/pac/dapp/opla/preognotice/officeflyer.pdf .

TIME PERIODS FOR FILING A REPLY TO THIS NOTICE:

1. Applicant is given **no new time period** if the non-compliant amendment is an after-final amendment or an amendment filed after allowance. If applicant wishes to resubmit the non-compliant after-final amendment with corrections, the **entire corrected amendment** must be resubmitted within the time period set forth in the final Office action.
2. Applicant is given **one month**, or thirty (30) days, whichever is longer, from the mail date of this notice to supply the **corrected section** of the non-compliant amendment in compliance with 37 CFR 1.121, if the non-compliant amendment is one of the following: a preliminary amendment, a non-final amendment (including a submission for a request for continued examination (RCE) under 37 CFR 1.114), a supplemental amendment filed within a suspension period under 37 CFR 1.103(a) or (c), and an amendment filed in response to a *Quayle* action.

Extensions of time are available under 37 CFR 1.136(a) only if the non-compliant amendment is a non-final amendment or an amendment filed in response to a *Quayle* action.

Failure to timely respond to this notice will result in:

Abandonment of the application if the non-compliant amendment is a non-final amendment or an amendment filed in response to a *Quayle* action; or

Non-entry of the amendment if the non-compliant amendment is a preliminary amendment or supplemental amendment.

D Bates — 571/272-6573

Legal Instruments Examiner (LIE) — Telephone No.

U.S. Patent and Trademark Office
PTOL-324 (08-05) **Notice of Non-Compliant Amendment (37 CFR 1.121)** Part of Paper No.

05-01-06

3662
1FW

PATENT APPLICATION

In Re the Application of:

DUPRAY et al.

Serial No.: 09/770,838

Filed: January 26, 2001

Atty. File No.: 1003-1

For: "A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION"

Prior Group Art Unit: 3662

Prior Examiner: Dao Phan

DUPLICATE COPY OF CLAIMS FROM PREVIOUSLY FILED PRELIMINARY AMENDMENT

"EXPRESS MAIL" MAILING LABEL NUMBER: EV655365378US
DATE OF DEPOSIT: 4/27/06

I HEREBY CERTIFY THAT THIS PAPER OR FEE IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE "EXPRESS MAIL POST OFFICE TO ADDRESSEE" SERVICE UNDER 37 CFR 1.10 ON THE DATE INDICATED ABOVE AND IS ADDRESSED TO THE COMMISSIONER FOR PATENTS, P.O. BOX 1450, ALEXANDRIA, VA 22313-1450.
TYPED OR PRINTED NAME: Lori R. Brown

SIGNATURE: Lori R Brown

MAIL STOP AMENDMENTS
Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir/Madam:

Amendments corresponding to the amendments now filed for the above-identified patent application were originally submitted in a Preliminary Amendment February 20, 2002 with all fees paid, and in fact, an over payment was made of $269.00. Applicants were notified on February 8, 2006 that the Office had lost the Preliminary Amendment filed February 20, 2002 (or at least lost the amendments to the claims), and the Office has requested that a copy be provided. Applicants filed a copy of the previously file Preliminary Amendment on March 22, 2006. However, between the time of the original filing and the refilling on March 22, 2006, the requirements for filing such amendments have changed so that all claims that have been entered into an application now must be identified as to their status (i.e., cancelled, previously provided, currently amended, etc.). Accordingly, in response to the filing of March 22, 2006 refiling, Applicants received a Notice of Non-Compliant Amendment. It is believed that the Non-Compliant Amendment was issued due to the fact that previously pending claims 1 through 124 where not identified as being previously cancelled. Accordingly, this is corrected in the present copy of the previously filed Preliminary Amendment.

If there are any questions regarding the present amendment, it is requested that the named Applicant hereinbelow (Dennis Dupray) be contacted at 303-863-2975. Note, it is believed that NO FEES are due with this transmittal.

IN THE CLAIMS:

Claims 1 through 124 were previously cancelled.

Please cancel all pending claims, namely Claims 125 through 220 without prejudice to or disclaimer of the subject matter contained therein, and add the following new claims:

221. (New) A method for use in a wireless network to obtain requested location information regarding a mobile wireless station from any of various location sources and provide the requested location information to a wireless location application, there being a plurality of location estimating sources, including a first location estimating source for obtaining location information and a second location estimating source for obtaining location information for providing information regarding locations of mobile wireless stations in the network, the method comprising the steps of:

first receiving a location request regarding a first of said wireless mobile stations from said first wireless location application, said location request seeking said requested location information;

first obtaining: a first location input obtained using an instance, I_1, of said location information from said first location estimating source, wherein I_1 is indicative of one or more locations of said first wireless mobile station, and

second obtaining a second location input obtained using an instance, I_2, of said location information provided from said second location estimating source, wherein I_2 is indicative of one or more locations of said first wireless mobile station;

wherein said first location estimating source employs a first location finding technology that provides I_1, and said second location estimating source employs a second location finding technology different than said first location finding technology that provides I_2; and

wherein said steps of first and second obtaining includes a step of providing said first and second location inputs in a common standardized format;

storing data in memory relating to said first location input and said second location input;

third obtaining said requested location information by selectively using portions of said data from said memory, wherein said requested location information is determined according to information indicative of a manner in which said first wireless location application prefers said requested location information; and outputting said requested location information to said first wireless location application.

222. (New) The method of Claim 221, wherein for locating a second of the mobile stations, there is a further step of requesting activation of each of one or more of said plurality of location estimating sources according to an availability of corresponding wireless signal measurements from the second mobile station for the location estimating source.

223. (New) The method of Claim 221, further including, for locating a second of the mobile stations, a step of obtaining an instance of a third location input from a third of the plurality of location estimating sources different from said first and second location estimating sources.

224. (New) The method of Claim 221, further including, for locating one of the first and a second of the mobile stations, a step of obtaining an instance of a third location input by using a third location finding technology different from the first and second location finding technologies.

225. (New) The method of Claim 224, further including providing said instance of said third location input in said standardized format.

226. (New) The method of Claim 221, wherein said step of providing includes representing each of said first and second location inputs in a common data representation having a plurality of location attributes, including a common representation A_1 for representing a geographical position for the first mobile station, and one or more attributes related to one of: an error in data for A_1, a likelihood of the first mobile station being in the geographical extent represented by A_1, a timestamp related to the first mobile station being in the geographical extent represented by A_1, and descriptor information related to location processing performed by one of said resources in obtaining an instance of said location information for M

227. (New) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to an error in data for A_1.

228. (New) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to a likelihood of the first mobile station being in the geographical extent represented by A_1.

229. (New) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to a timestamp related to the first mobile station being in the geographical extent represented by A_1.

230. (New) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes for descriptor information related to location processing performed by one of said location estimating sources in obtaining an instance of said location information for the first mobile station.

231. (New) The method of Claim 226, wherein for locating a second of the mobile stations, further including a step of providing one or more location input instances of location information by one or more of said location estimating sources in said common data representation.

232. (New) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of said wireless mobile stations including at least a location and a time.

233. (New) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of the wireless mobile stations including one or more values indicative of an uncertainty regarding a location of the individual wireless mobile station.

234. (New) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of said wireless mobile stations including one of a travel speed and a travel direction.

235. (New) A method as set forth in claim 221, wherein said step of first obtaining comprises sending data for requesting activation of one of the first location estimating source and the second location estimating source to obtain the corresponding one of first and second location input.

236. (New) A method as set forth in claim 221, wherein said step of third obtaining comprises determining additional location information including at least a wireless station identification and a location of the first wireless mobile station.

237. (New) A method as set forth in claim 221, wherein said step of third obtaining comprises determining additional location information a including a time and an uncertainty regarding location.

238. (New) A method as set forth in claim 221, wherein said step of third obtaining comprises providing additional location information including one of a speed of travel and direction of travel for the first wireless mobile station.

239. (New) A method as set forth in claim 221, further comprising combining a first portion of said portions of said data obtained using said first location input with a second portion of said portion of said data obtained using said second location to make a location determination.

240. (New) A method as set forth in claim 239, wherein said step of combining comprises obtaining a first set of information including first location information and first time information for said wireless mobile station, obtaining a second set of information including second location information and second time information for said wireless mobile station, determining a time difference between said first and second sets of information, and adjusting one of said first and second sets of information based on said time difference.

241. (New) A method as set forth in claim 240, wherein said adjusting comprising calculating one of a change in position and a value related to an uncertainty in position dependent on said time difference.

242. (New) A method as set forth in claim 239, wherein said step of combining comprises obtaining a first set of position information including a position and first value related to an uncertainty, obtaining a second set of information including a position and second value related to an uncertainty and combining said first set and said second set to yield a third set including a position and an uncertainty for said wireless station, wherein said third set includes a reduced uncertainty relative to said first and second sets.

243. (New) A method as set forth in claim 239, wherein said first location finding technology involves a first location finding controller for receiving first location data from a first source and determining, using said first data, one or more geometric extents for a location of the first mobile station and a value related to an uncertainty of said one or more geometric extents to provide said first location input, and said second location finding technology involves obtaining second location data from a second source and determining, using said second data, one or more geometric extents for a location of the first mobile station and a value related to an uncertainty of said one or more geometric extents to provide said second location input, and said step of combining comprises obtaining said first data from said first source, obtaining said second data from said second source, and said step of combining further comprises using one of said first data and said second data to obtain derived location information.

244. (New) A method as set forth in claim 221, further comprising the step of obtaining tracking information regarding movement of said wireless station, and using said tracking information to derive location information.

245. (New) A method for estimating, for each mobile station M of a plurality of mobile stations, an unknown terrestrial location, L_M, for M using wireless signal measurements obtained from transmissions between said mobile station M and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations is substantially co-located with one or more of a transmitter and a receiver for wirelessly communicating with said mobile station M, comprising:

initiating a plurality of requests for information related to the location of said mobile station M, the requests provided to each of at least two mobile station location evaluators, wherein there is at least a first of the requests provided to a first of the location evaluators and a second of the requests, different from the first request, provided to a second of the location evaluators, such that when said location evaluators are supplied with corresponding input data having values obtained using wireless signal measurements obtained via two way wireless communication between said mobile station M, and the communication stations, each of said first and second location evaluators determine corresponding location information related to L_M, and

wherein for at least one location L of one of the mobile stations, said first location evaluator and said second location evaluator output, respectively, first and second position information related to the one mobile station being at L wherein neither of the first and second position information is dependent upon the other;

obtaining a first collection of location information of said mobile station M, wherein the first collection includes first location information from the first location evaluator, and second location information from the second location evaluator;

determining resulting information related to the location L_M of the mobile station M, wherein the resulting information is dependent on geographical information in each of the first and second location information; and

transmitting, to a predetermined destination via a communications network, the resulting information.

246. (New) The method of Claim 245, further including the following steps:

second obtaining, from an additional one or more of the location evaluators, a second collection of location information using values obtained from wireless signal measurements for a time different from a time of the communications between the mobile station M and the communication stations for obtaining the first collection;

determining, as part of said resulting information, a resulting location estimate of the mobile station M, wherein said resulting location estimate is dependent upon a value obtained from said second collection of location estimates.

247. (New) A method for locating mobile stations at one or more unknown terrestrial locations using wireless signal measurements obtained from transmissions between said mobile stations and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile stations, comprising:

receiving, from a plurality of location requesting sources, a plurality of input requests for locations of the mobile stations, wherein for each of the input requests there is a corresponding destination for a responsive output;

for each of the input requests, providing one or more location requests for location information, related to a location of one of said mobile stations, to one or more mobile station location determining sources;

first obtaining, in response to a first of the location requests received from a first of the requesting sources, at least first location information of a first location of a first of said mobile stations, said first location information determined using a first set of one or more wireless location techniques;

first determining, using said first location information, first output location data according to a first output criteria for the corresponding destination for the first request, said first output location data including a representation identifying a first geographical range of the first location;

second obtaining, in response to a second of the location requests received from a second of the requesting sources, at least second location information of a second location of a second of said mobile stations, said second location information determined using a second set of one or more wireless location techniques, wherein the second set determines the second location information by activating at least one computational module for locating the second mobile station that is not activated for determining the first location information;

second determining, using said second location information, second output location data according to a second output criteria for the corresponding destination for the second request, said second output location data including a representation identifying a geographical range of the second location;

wherein for at least one of said first and second output criteria, there is an output criteria for another of the location requests that is different from said at least one output criteria;

first transmitting said first output location data to its corresponding destination via a communications network; and

second transmitting said second output location data to its corresponding destination via a communications network, the first and second locations being different

.

248. (New) The method of Claim 247, wherein for at least one of said location techniques of said first set, and for a different one of said location techniques of said second set there is a common predetermined interface at which said first and second location information are received.

249. (New) The method of Claim 247, wherein said steps of first and second determining use at least one common mobile station location related component for determining, respectively, said first output location data and said second output location data

250. (New) The method of Claim 247, wherein said steps of first and second transmitting includes outputting said first and second output location data via a common predetermined network interface.

251. (New) The method of Claim 247, wherein said first determining step includes accessing mobile station location output frequency information of said first output criteria.

252. (New) The method of Claim 247, wherein said first determining step includes determining a coarse location estimate of the first mobile station as a portion of said first output location data, wherein a subsequent location estimate of the first mobile station is an improvement thereof.

253. (New) The method of Claim 247, wherein at least one of said first determining and said first transmitting steps includes determining a particular protocol for outputting said first output location data on the communication network for transmission to the corresponding destination for the first location request.

254. (New) The method of Claim 247, wherein said first output criteria includes information for determining said representation of said first geographical range using a location of a known geographical feature different from the communication stations.

255. (New) The method of Claim 254, wherein the known geographical feature includes a roadway, and said determining step includes snapping to the roadway.

256. (New) The method of Claim 247, wherein said corresponding destination for said first location request is for a first application, and said corresponding destination for said second location request is for a second application, wherein said first and second applications, respectively, use said first and second output location data differently.

257. (New) The method of Claim 256, wherein said first and second applications are for corresponding different ones of the following: responding to emergency calls, tracking, routing, people and animal location including applications for confinement to or exclusion from certain areas, parolee surveillance, responding a mobile station user's request for the user's location.

258. (New) The method of Claim 256, wherein said first output criteria includes information for determining a first location granularity at which a location estimate of the first mobile station is transmitted in said first output location data, wherein said first location granularity is dependent upon said first application.

259. (New) The method of Claim 256, wherein said first output criteria includes information for determining a first representation for said first output location data, wherein said first representation is dependent upon said first application, and said second output criteria includes information for determining a second representation for said second output location data, wherein said second representation is dependent upon said second application.

260. (New) The method of Claim 247, wherein a first predetermined collection of computational components performs said steps of receiving, providing, first obtaining, first determining, second obtaining, second determining, first transmitting, and second transmitting, and wherein a second predetermined collection of computational components performs said steps of receiving, providing, first obtaining, first determining, second obtaining, second determining, first transmitting, and second transmitting;

wherein for at least one of said steps of receiving, providing, first obtaining, first determining, second obtaining, second determining, first transmitting, and second transmitting, there are different components in said first predetermined collection and said second predetermined collection for performing said at least one step, and said first predetermined collection transmits the first request to said second predetermined collection.

261. (New) The method of Claim 260, wherein said first predetermined collection includes a first location center, and said second predetermined collection includes a second location center.

262. (New) The method of Claim 247, wherein at least one of said steps of receiving, first obtaining, second obtaining, first transmitting, and second transmitting receives or transmits wireless location related information on TCP/IP network.

263. (New) The method of Claim 247, wherein said step of first obtaining includes receiving a first location estimate from a first of said location determining sources which performs an instance, I_1, of a first technique for estimating a location of the first mobile station using signal transmissions to the first mobile station from non-terrestrial transmitters, wherein said instance I_1 also uses wireless signals, S, between the first mobile station and at least one of the communication stations to improve at least one performance characteristic of said instance I_1 over a performance of I_1 without use of the wireless signals between the first mobile station and the at least one communication station.

264. (New) The method of Claim 263, wherein the instance I_1 uses first information for locating the first mobile station, wherein the first information is dependent upon signal timing measurements from the wireless signals S.

265. (New) The method of Claim 263, wherein the instance I_1 uses first information from the wireless signals S, wherein the first information is dependent upon a wireless coverage area of the at least one communication station.

266. (New) The method of Claim 247, further including a step of providing display information for displaying a representation of a location estimate L of the first mobile station, wherein said display information is for displaying a map of an area having the location estimate L, and for concurrently displaying information indicating an accuracy of the location estimate L.

267. (New) The method of Claim 266, wherein said display information is displayed at a mobile station M that has requested a location of the first mobile station.

268. (New) A method for locating a first and second wireless mobile stations using measurements of wireless signals, wherein at least one of: (i) said measurements, and (ii) said wireless signals are transmitted between the first mobile station and at least one of a plurality of terrestrial transceivers, and between the second mobile station and at least one of a plurality of terrestrial transceivers, wherein said transceivers are capable of at least wirelessly detecting a plurality of wireless transmitting mobile stations, including said first and second mobile stations, comprising:

providing access to first and second different mobile station location techniques, wherein each of said location techniques is capable of providing location information for each mobile station of at least some of said mobile stations when said location technique is supplied with corresponding data obtained from wireless signal measurements communicated between the mobile station and one or more of said plurality of transceivers, wherein for at least one location L of one of the mobile stations, said first location technique and said second location technique output, respectively, first and second position information related to the one mobile station being at L wherein neither of the first and second position information is dependent upon a change in the other;

first supplying said first location technique with first corresponding data obtained from wireless signal measurements communicated between one or more of: (a1) said first mobile station and one or more of said plurality of transceivers, and (a2) said second mobile station and one or more of said plurality of transceivers;

second supplying said second location technique with second corresponding data obtained from wireless signal measurements communicated between one or more of: (b1) said first mobile station and one or more of said plurality of transceivers, and (b2) said second mobile station and one or more of said plurality of transceivers;

first receiving from said first location technique, first location related information representing one or more of: a first range of locations for the first mobile station, and a second range of locations for the second mobile station;

second receiving from said second location technique, second location related information representing one or more of: a third range of locations for the first mobile station, and a fourth range of locations for the second mobile station;

determining resulting location information for each of the first and second mobile stations using at least one of: (c1) a first value obtained from said first location related information, and (c2) a second value obtained from said second location related information;

wherein there is at least one predetermined common location related component activated for determining the resulting location information for each of said first and second mobile stations, wherein:

(i) said common component is activated, for locating said first mobile station, after at least one step of said steps of first and second supplying, and

(ii) said common component is activated, for locating said second mobile station, after at least one step of said steps of first and second supplying;

providing said resulting location information for each of the first and second mobile stations for presentation, wherein said presentation for at least one of said first and second mobile stations is determined according to an expected accuracy of said resulting location information

269. (New) A method for locating a wireless mobile station, comprising:

repeatedly performing the following steps (A1) through (A3) for tracking the mobile station, wherein there is at least a first and a second mobile station location technique, each of the location techniques providing an instance of location information for a location of the mobile station to the step (A1) below at some time during said step of repeatedly performing;

wherein for at least one location L of the mobile station, said first mobile station location technique and said second mobile station location technique output location information instances having, respectively, first and second position information for the mobile station being at L, wherein neither of the first and second position information varies substantially as a result in a change in the other;

(A1) receiving an instance, I_1, of location information for the mobile station from at least one of the first and a second mobile station location techniques wherein I_1 includes position information for the mobile station;

(A2) determining at least one resulting instance of location information for said mobile station using at least one of: (a) a first value obtained from an instance of first location information received from said first location technique, and (b) a second value obtained from an instance of second location information received from said second location technique;

wherein said step of determining includes a step of determining a likely roadway upon which the mobile station is located;

(A3) outputting said resulting location information for display on a display device, wherein said resulting location information is displayed as at least one location of the mobile station on a map having roadways thereon.

270. (New) The method of Claim 269, wherein at least one occurrence of said step of outputting includes transmitting said resulting location information via a telephony network.

271. (New) The method of Claim 269, wherein said outputting step includes providing accuracy information indicating an accuracy of said resulting location information, wherein said accuracy information is displayed with said at least one location of the mobile station.

272. (New) The method of Claim 269, wherein for at least one location of the mobile station said step of determining uses both said first and second values.

273. (New) The method of Claim 269, wherein said first location technique includes a step of using wireless signals, S, between the first mobile station and at least one terrestrial transceiver to improve upon of said first location information over a performance of said first location technique without using the wireless signals between the first mobile station and the at least one terrestrial transceiver.

274. (New) The method of Claim 273, wherein said first location technique includes a step of using information dependent upon a wireless coverage area of the at least one transceiver for improving said first location information

275. (New) The method of Claim 274, wherein the at least one transceiver includes a base station for providing two way communication with the mobile station.

276. (New) A method for locating, from a plurality of wireless mobile stations, one of the wireless mobile stations using measurements of wireless signals, wherein at least one of: (i) said measurements and (ii) said wireless signals are transmitted between said one mobile station and at least one of a plurality of fixed location communication stations, each communication

station capable of at least one of receiving wireless signals from, and transmitting wireless signals to said one mobile station, comprising:

receiving, from each of at least first and second mobile station location estimators, corresponding first and second information related to a likely geographical approximations for a location of said one mobile station, wherein: (a) for determining a likely geographical approximation, GA_A, for a location, L_A, of a second of the mobile stations at a time T_A, said first location estimator generates GA_A without requiring a prior likely geographical location approximation generated by said second location estimator for locating the second mobile station at substantially the location L_A at substantially the time T_A, and, (b) for estimating a likely geographical approximation, GA_B, for a location, L_B, of a third one of the mobile stations at a time T_B, said second location estimator generates GA_B without requiring a prior likely geographical location approximation generated by said first location estimator for locating the third mobile station at the location L_B at substantially the time T_B;

determining a resulting location estimate of said one mobile station, wherein said step of determining includes at least one of the substeps (B1) through (B2) following:

(B1) when said first and second information include, respectively, first and second likely geographical approximations, combining said first and second likely geographical approximations so that said resulting location estimate is dependent on each of said first and second location likely geographical approximations; and

(B2) selecting one of said first and second information for receiving preference in determining said resulting location, wherein said selecting is dependent upon location related data in at least one of said first and second information.

277. (New) The method of Claim 276, further including a step of providing display information for: (a) displaying a representation of said resulting location estimate, wherein said display information is for displaying with a map of an area having the resulting location estimate, and (b) concurrently displaying information indicative of an accuracy of the resulting location estimate.

278. (New) A method for locating a wireless mobile station capable of wireless two way communication with a plurality of fixed location terrestrial stations, comprising:

providing access to a plurality of mobile station location estimating techniques, wherein said location techniques provide location information related to said mobile station when said location techniques are supplied with corresponding input information upon which their location estimates are dependent, and wherein the corresponding input information is at least partially derived from measurements of wireless signals transmitted from or received at the mobile station;

receiving, over time, a plurality of location estimates of the mobile station:

determining, a plurality of consecutive resulting location estimates for tracking the mobile station, wherein said step of determining includes steps (a) and (c) following:

(a) deriving, for at least one time during the tracking, a corresponding one of said resulting location estimates of the mobile station using one of said first one or more location estimates by said first location technique for a first location of the mobile station;

(b) deriving, for at least one time during the tracking, a corresponding one of said resulting location estimates of the mobile station using one of said second one or more location estimates by said second location technique for a second location of the mobile station;

(c) preferring a location estimate of said first location information over a location estimate of said second location information when both are available for substantially a same location of the mobile station.

279. (New) The method as claimed in Claim 278, wherein said step of determining includes:

establishing a priority between a location estimate of said first location information and a location estimate of said second location information.

280. (New) The method as claimed in Claim 279, wherein said step of establishing includes obtaining a confidence value for one or more of: (a) at least one of said location estimates for said first location information; and (b) at least one of said location estimates for said second location information;

wherein each said confidence value is indicative of a likelihood of the mobile station having a location represented by said corresponding location estimate for the confidence value.

281. (New) The method of Claim 278, further including a step of:

providing communication between the mobile station and another party via at least one of the terrestrial stations, wherein the communication travels through a telephony network.

282. (New) The method of Claim 278, further including the steps of:

requesting one or more of the resulting location estimates via signals transmitted by a commercial mobile radio service provider that wirelessly communicates with the mobile station;

transmitting, via a communication network, at least one location of the mobile station to one of: the mobile station, another mobile station, a police unit, a vehicle, and a party requesting the location of the mobile station.

283. (New) The method of Claim 278, wherein said determining step includes determining at least one of said resulting location estimates as a function of a position of a known geographical feature that is sufficiently close to one of the first or second location estimates so that the closeness is used to determine said more likely location estimate.

284. (New) The method as claimed in Claim 278, wherein said step of determining includes, for at least one of said resulting location estimates, determining one or more of: (a) a velocity of the mobile station, (b) an acceleration of the mobile station, and (c) one or more geographical features near said at least one resulting location estimate.

285. (New) A method for locating a mobile station using wireless signal measurements obtained from transmissions between said mobile station and a plurality of fixed location communication stations, wherein each of said communications stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile station, comprising:

providing access to first and second mobile station location evaluators, wherein said location evaluators are able to determine information related to one or more location estimates of said mobile station when said location evaluators are supplied with data having values obtained during wireless signal two way communication between said mobile station and the communication stations;

wherein for at least one location L of the mobile station, said first mobile station location evaluator and said second mobile station location evaluator output location information instances having, respectively, first and second position information for the mobile station being at L, wherein neither of the first and second position information substantially changes with a change in the other of the first and second position information;

first obtaining, from said first location evaluator, first location related information for identifying a location of the mobile station for at least one of the following situations: a tracking of the mobile station, and in response to a request for a location of the mobile station;

second obtaining, from said second location evaluator, second location related information for identifying a location of the mobile station for said same at least one situation;

determining additional location information of the mobile station dependent upon at least one of: (a) a first value obtained from said first location related information, and (b) a second value obtained from said second location related information;

wherein said determining step includes providing the additional location information with:

(i) data indicative of one of: an error and a likelihood of the mobile station being at a location represented by said additional location information; and

(ii) a timestamp indicative of when the resulting location information corresponds to a location of the mobile station.

286. (New) The method as claimed in Claim 285, wherein said mobile station is co-located with a processor for activating at least one of said location evaluators.

287. (New) The method of Claim 285, further including a step of transmitting said resulting location estimate on a communications network to a destination requesting the location of the mobile station.

288. (New) The method of Claim 285, further including a step of determining, using said resulting location information, output location information according to output criteria corresponding to an application requesting data related to a location of the mobile station.

289. (New) The method of Claim 288, wherein said output criteria includes at least some of:

(a) a transmission protocol;

(b) a granularity of by which a location estimate of the mobile station represented by said resulting location information is to be provided;

(c) a frequency with which repeated location estimates of the mobile station are to be output to the application;

(d) destination data for determining where said resulting location information is to be transmitted;

(e) an indication as to whether a location estimate of the mobile station is to be adjusted according to a known geographical feature different from the communication stations; and

(f) a desired representation of a location estimate of the mobile station represented by said resulting location information.

290. (New) A method for locating one or more mobile stations using wireless signal measurements obtained from transmissions between said mobile stations and a plurality of terrestrial communication stations, wherein each of said communication stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile stations, comprising:

receiving a location request for a location of a first of the mobile stations, wherein the first mobile station is capable of providing wireless telephony transmissions, and a substantially same collection of components are in electronic contact with one another for performing each of at least most wireless telephony transmissions from the first mobile station;

generating one or more messages, for information related to a location of said first mobile station, said messages for requesting activation of one or more mobile station location estimators such that when said location estimators are supplied with corresponding input data having values obtained from wireless signal measurements obtained via transmissions between said first mobile station and the communication stations, said one or more location estimators determine location related information for the first mobile station;

first obtaining, from at least two of said location estimators, first mobile station related location information obtained as a result of an available at least two instances of said corresponding input data;

determining a resulting location estimate of the first mobile station obtained from said first mobile station related location information;

wherein at least one of said steps of generating, first obtaining, and determining includes a substep of one of: (i) transmitting information to a destination via a communication network, and (ii) receiving information from a source via a communication network;

using said resulting location information, to determine output location information according to output criteria corresponding to an application requesting data related to a location of the mobile station, wherein said output criteria includes at least some of:

(a) a transmission protocol;

(b) a granularity of by which a location estimate of the mobile station represented by said resulting location information is to be provided;

(c) a frequency with which repeated location estimates of the mobile station are to be output to the application;

(d) destination data for determining where said resulting location information is to be transmitted;

(e) an indication as to whether a location estimate of the mobile station is to be adjusted according to a known geographical feature different from the communication stations; and

(f) a desired representation of a location estimate of the mobile station represented by said resulting location information.

291. (New) A method for locating a mobile station using wireless signal measurements obtained from transmissions between said mobile station and at least one of a plurality of terrestrial transceivers capable of wirelessly detecting said mobile station, comprising:

providing access to at least two of the location techniques;

determining whether an accessible first of the location techniques has its corresponding input available for determining a first location estimate of said mobile station;

determining a second location estimate of said mobile station by activating an accessible second of said location techniques different from said first location technique when the corresponding input for said second technique is available;

receiving at least one of said first and second location estimates;

obtaining resulting location information for transmitting on a communications network, wherein said resulting location information is obtained using at least one of said first location estimate and said second location estimate;

wherein when said mobile station is at a first location, an instance of at least said first location estimate is used in said obtaining step for obtaining a first corresponding instance of said resulting location information, and when said mobile station is at a second location, an instance of at least said second location estimate is used in said obtaining step for obtaining a second corresponding instance of said resulting location information; and

wherein for the first location, the corresponding performance of said obtaining step includes: (1) a step of improving upon said instance of at least said first location estimate, and (2) a step of providing information indicative of an accuracy of said first corresponding instance of said resulting location information.

292. (New) A mobile station location system, comprising:

a gating module for communicating with two or more mobile station location estimating sources for determining corresponding geographic extents for locations of a plurality of mobile stations, such that for each mobile station M of at least some of the mobile stations, when said one or more estimating sources are supplied with corresponding data obtained from measurements of wireless signals transmitted between the mobile station M, and at least one of (1) and (2) following:

(1) a plurality of communication stations capable of at least one of: wirelessly detecting said mobile stations, and being wirelessly detected by said mobile stations, and

(2) one or more non-terrestrial wireless signal transmitting stations,

then for said one or more location estimating sources supplied with their corresponding data, each such source outputs a corresponding geographic extent of a geographical location of the mobile station M;

wherein for a first of said mobile station location estimating sources, when estimating a location of one of the mobile stations, and for a second of said mobile station location estimating sources, and for at least one instance of locating one of the mobile stations, said first and second sources provide different geographic extents;

wherein said gating module communicates on a communications network with at least the first of the location estimating sources for providing said location system with said corresponding geographic extent for a location L of the mobile station M; and

a resulting estimator for determining a likely location estimate of the location L of the mobile station M using two or more of said corresponding geographic extents for the mobile station M, said resulting estimator activating at least one of: (i) a selector for giving preference, as

more indicative of the location L, to at least one geographic extent obtained from said corresponding geographic extents, and (ii) a combiner for combining said two or more corresponding geographic extents for obtaining said likely location estimate.

293. (New) The location system, as claimed in Claim 292, wherein one or more of said estimating sources are capable of being at least one of: added, replaced and deleted by transmissions on a communication network between a portion of said location system and a site remote from said portion.

294. (New) The location system as claimed in Claim 292, wherein one or more of:

(a) at least one of said one or more corresponding geographic extents, GE, has a corresponding value therewith indicative of a likelihood that the mobile station M resides in a geographical area represented by GE, and said combiner uses said corresponding value for obtaining said likely location estimate;

(b) said gating module activates a wireless transceiver for communicating with the plurality of communication stations;

(c) said plurality of communication stations includes base stations for wireless two way communication with said mobile stations;

(d) said non-terrestrial wireless signal transmitting stations include GPS satellites;

(e) said communications network includes a portion of the Internet;

(f) the mobile station M has an ability to communicate with other of the mobile stations as a base station;

(g) said selector includes a filter for reducing a dependence of said likely location estimate on one of the corresponding geographic extents;

(h) said resulting estimator is at least partially included in a mobile base station;

(i) said resulting estimator resides at a location center;

(j) said gating module resides at a location center;

(k) said gating module routes activation information to said two or more estimating sources; and

(l) said gating module resides at a mobile station.

more indicative of the location L, to at least one geographic extent obtained from said corresponding geographic extents, and (ii) a combiner for combining said two or more corresponding geographic extents for obtaining said likely location estimate.

293. (New) The location system, as claimed in Claim 292, wherein one or more of said estimating sources are capable of being at least one of: added, replaced and deleted by transmissions on a communication network between a portion of said location system and a site remote from said portion.

294. (New) The location system as claimed in Claim 292, wherein one or more of:

(a) at least one of said one or more corresponding geographic extents, GE, has a corresponding value therewith indicative of a likelihood that the mobile station M resides in a geographical area represented by GE, and said combiner uses said corresponding value for obtaining said likely location estimate;

(b) said gating module activates a wireless transceiver for communicating with the plurality of communication stations;

(c) said plurality of communication stations includes base stations for wireless two way communication with said mobile stations;

(d) said non-terrestrial wireless signal transmitting stations include GPS satellites;

(e) said communications network includes a portion of the Internet;

(f) the mobile station M has an ability to communicate with other of the mobile stations as a base station;

(g) said selector includes a filter for reducing a dependence of said likely location estimate on one of the corresponding geographic extents;

(h) said resulting estimator is at least partially included in a mobile base station;

(i) said resulting estimator resides at a location center;

(j) said gating module resides at a location center;

(k) said gating module routes activation information to said two or more estimating sources; and

(l) said gating module resides at a mobile station.

295. (New) A mobile station location system, comprising:

a communications controller for selectively communicating with a plurality of mobile station location estimating sources for at least one of (1) and (2) following:

(1) activating a selected one or more of said mobile station location estimating sources; and

(2) receiving location related information for locating a plurality of mobile stations;

wherein for each mobile station M of at least some of the mobile stations, when one or more of said location estimating sources are supplied with corresponding data obtained from measurements of wireless signals transmitted between (i) and (ii) following:

(i) the mobile station M, and

(ii) at least one of: a network of communication stations cooperatively linked for use in locating the mobile stations, and one or more non-terrestrial wireless signal transmitting stations,

then each such source supplied with its corresponding data, outputs a corresponding location estimate of a geographical location of the mobile station M;

wherein for a first of said mobile station location estimating sources, when estimating a location of one of the mobile stations, said first source is dependent upon a result from a first component, and for a second of said mobile station location estimating sources, when estimating a location of one of the mobile stations, said second source is dependent upon a result from a different second component, wherein for at least one instance of locating one of the mobile stations, said first and second sources provide different location estimates;

an interface in communication with said controller, said interface for communicating on a communications network with at least one of said first and second location estimating sources for thereby at least one of (3) and (4) following:

(3) requesting activation of said at least one location estimating source, and

(4) receiving, from said at least one location estimating source, said corresponding location estimate of the mobile station M;

a resulting estimator for determining a likely location estimate of a location L of the mobile station M using two or more of said corresponding location estimates for the mobile station M at L, wherein said resulting estimator includes at least one of:

(i) a selector for giving preference, as more indicative of the location L, to at least one preferred location estimate obtained from said corresponding location estimates; and

(ii) a combiner for obtaining said likely location estimate as a function of said two or more of said corresponding location estimates.

Remarks

Applicants request entry of all the amendments provided herewith, and reconsideration of the present application. It is believed that all pending claims are now in condition for allowance. Thus, it is requested that the Examiner contact the Applicant named below by phone if the Examiner determines that one or more of the claims are not allowable. No other fees are believed due with this transmittal since any fees were paid with the original submittal of these claims. Note that in the previous submittal of these claims on Feb. 20, 2002. Applicants stated the following:

> "Note that the Applicants have previously paid for 5 independent and 96 total claims prior to this Amendment and Response which totals fees of $764 for claims.. The present Amendment and Response cancels all pending claims, and adds 75 total new claims (12 new independent claim and 63 new dependent) the fee for claims which totals $495. Accordingly, there is an **overpayment of $269**."

It is respectfully requested that the Office reimburse Applicants for this overpayment, or otherwise contact Applicant about this matter.

Note that if additional fees are due, then the Applicant respectfully requests notification of the Applicant named below so that any additional fees can be timely paid.

Respectfully submitted,

By: [signature]

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, Colorado 80401
(303) 863-2975

Date: Apr. 27, 2006

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PATENT APPLICATION FEE DETERMINATION RECORD
Effective December 8, 2004

Application or Docket Number: 09/770838

CLAIMS AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA
TOTAL CLAIMS		
TOTAL CHARGEABLE CLAIMS	minus 20=	*
INDEPENDENT CLAIMS	minus 3 =	*
MULTIPLE DEPENDENT CLAIM PRESENT		☐

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐ RATE	FEE	OR	OTHER THAN SMALL ENTITY RATE	FEE
BASIC FEE	150.00	OR	BASIC FEE	300.00
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL		OR	TOTAL	

CLAIMS AS AMENDED - PART II

AMENDMENT A

3/22/6	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	* 75	Minus	** 75	=
Independent	* 12	Minus	*** 12	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT B

4/27/6	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	* 75	Minus	** 75	=
Independent	* 12	Minus	*** 12	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE	OR	RATE	ADDITIONAL FEE
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE	OR	RATE	ADDITIONAL FEE
X$ 25=		OR	X$50=	
X100=		OR	X200=	
+180=		OR	+360=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

FORM PTO-875 (Rev. 10/04) Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE

	Type	L #	Hits	Search Text	DBs	Time Stamp
1	BRS	L1	18380	location$3 with estimat$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:39
2	BRS	L2	41161	position$3 with estimat$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:37
3	BRS	L3	53750	1 or 2	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:31
4	BRS	L4	85704	geographic$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:31
5	BRS	L5	5084	3 and 4	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:32
6	BRS	L6	2609438	mobile$2 or vehicle$2 or automobile42	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:34
7	BRS	L7	3856	5 and 6	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:34
8	BRS	L8	310	location$3 near4 estimator$2	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:38
9	BRS	L9	2092	position$3 with estimator$2	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:37
10	BRS	L10	795	location$3 with estimator$2	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:38
11	BRS	L11	2685	9 or 10	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:38
12	BRS	L12	184	11 and 7	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:38
13	BRS	L13	4475	determin$6 with 1	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:40
14	BRS	L14	2070	comput$6 with 1	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:40
15	BRS	L15	2335	calculat$6 with 1	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:41

	Type	L #	Hits	Search Text	DBs	Time Stamp
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17	BRS	L17	3116	16 and 6	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:42
18	BRS	L18	3029	1 same 6	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:42
19	BRS	L19	1662	17 and 18	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:42
20	BRS	L20	2358	1 with 6	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:43
21	BRS	L21	1356	20 and 17	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:44
22	BRS	L22	2653	receiv$3 with 1	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:47
23	BRS	L23	630	21 and 22	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	2006/06/07 10:48

	Type	L #	Hits	Search Text	DBs	Time Stamp	Comments
1	BRS	L1	6821	location$3 with estimat$3	US-PGPUB	2006/06/07 15:55	
2	BRS	L2	11076	position$3 with estimat$3	US-PGPUB	2006/06/07 15:55	
3	BRS	L3	15630	1 or 2	US-PGPUB	2006/06/07 15:52	
4	BRS	L4	294413	mobile$2 or vehicle$2 or automobile$2	US-PGPUB	2006/06/07 15:54	
5	BRS	L5	850	(3 and 4).clm.	US-PGPUB	2006/06/07 15:54	
6	BRS	L6	33282	geographic$3	US-PGPUB	2006/06/07 15:54	
7	BRS	L7	104	(3 and 4 and 6).clm.	US-PGPUB	2006/06/07 15:55	
8	BRS	L8	313	location$3 with estimator$2	US-PGPUB	2006/06/07 15:55	
9	BRS	L9	621	position$3 with estimator$2	US-PGPUB	2006/06/07 15:56	
10	BRS	L10	852	8 or 9	US-PGPUB	2006/06/07 15:56	
11	BRS	L11	242	10.clm.	US-PGPUB	2006/06/07 15:56	
12	BRS	L12	8	11 and 7	US-PGPUB	2006/06/07 15:56	
13	BRS	L13	1701	determin$6 with 1	US-PGPUB	2006/06/07 15:59	
14	BRS	L14	864	comput$6 with 1	US-PGPUB	2006/06/07 15:59	
15	BRS	L15	907	calculat$6 with 1	US-PGPUB	2006/06/07 15:59	

	Type	L #	Hits	Search Text	DBs	Time Stamp	Comments
16	BRS	L16	2691	determin$6 with 2	US-PGPUB	2006/06/07 15:59	
17	BRS	L17	1258	comput$6 with 2	US-PGPUB	2006/06/07 15:59	
18	BRS	L18	2175	calculat$6 with 2	US-PGPUB	2006/06/07 15:59	
19	BRS	L19	1749	(13 or 14 or 15 or 16 or 17 or 18).clm.	US-PGPUB	2006/06/07 16:00	
20	BRS	L20	86347	4.clm.	US-PGPUB	2006/06/07 16:00	
21	BRS	L21	476	19 and 20	US-PGPUB	2006/06/07 16:01	
22	BRS	L22	5553	6.clm.	US-PGPUB	2006/06/07 16:01	
23	BRS	L23	59	21 and 22	US-PGPUB	2006/06/07 16:02	

UNITED STATES PATENT AND TRADEMARK OFFICE

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NOTICE OF ALLOWANCE AND FEE(S) DUE

7590 06/15/2006

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

EXAMINER	
PHAN, DAO LINDA	
ART UNIT	PAPER NUMBER
3662	

DATE MAILED: 06/15/2006

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

TITLE OF INVENTION: A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$700	$300	$1000	09/15/2006

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 01/06) Approved for use through 04/30/2007.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 06/15/2006

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

TITLE OF INVENTION: A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$700	$300	$1000	09/15/2006

EXAMINER	ART UNIT	CLASS-SUBCLASS
PHAN, DAO LINDA	3662	342-450000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 ____________
2 ____________
3 ____________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are enclosed:

☐ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies ____________

4b. Payment of Fee(s):

☐ A check in the amount of the fee(s) is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☐ The Director is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number ____________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ____________ Date ____________

Typed or printed name ____________ Registration No. ____________

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

7590 06/15/2006

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

EXAMINER	
PHAN, DAO LINDA	
ART UNIT	PAPER NUMBER
3662	

DATE MAILED: 06/15/2006

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)

(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 01/06) Approved for use through 04/30/2007.

Notice of Allowability	**Application No.** 09/770,838	**Applicant(s)** DUPRAY ET AL.	
	Examiner Dao L. Phan	**Art Unit** 3662	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *4/27/06*.

2. ☒ The allowed claim(s) is/are *221-295 (renumbered 1-75)*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

OIPE IAP17 FEB 3 1 2006 PATENT & TRADEMARK OFFICE CANCELLED

OIPE IAP17 JAN 31 2006 PATENT & TRADEMARK OFFICE CANCELLED

OIPE IAP17 JAN 3 1 2006 PATENT & TRADEMARK OFFICE

SHEET 1 OF 1

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	ATTY. DOCKET NO. 1003-1	SERIAL NO. 09/770,838
	APPLICANT DUPRAY, Dennis J.	
	FILING DATE January 26, 2001	GROUP ART 3662

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUB CLASS	FILING DATE IF APPROP.
DP	1.	6,952,181	10-04-2005	Karr et al.	342	457	
DP	2.	5,740,048	04-14-1998	Abel et al.	701	200	
DP	3.	5,515,285	05-07-1996	Garrett, Sr., et al.	701	300	
	4.						
	5.						
	6.						

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUB CLASS	TRANSLATION	
							YES	NO
DP	7.	WO 96/20542	07-04-1996	PCT	H04B	15/00		
DP	8.	WO 98/14018	04-02-1998	PCT	HO4Q	7/20		
	9.							

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

	10.	
	11.	

EXAMINER /Dao Phan/	DATE CONSIDERED 06/07/2006
*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

SHEET 1 OF 1

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 1003-1	SERIAL NO. 09/770,838
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U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUB CLASS	FILING DATE IF APPROP.
DP	1.	6,438,380	8/20/02	Bi et al.	455	456	
DP	2.	5,740,048	4/14/98	ABEL et al.	364	443	
DP	3.	5,634,051	5/27/97	THOMSON	395	605	
DP	4.	5,617,565	4/1/97	AUGENBRAUM et al.	395	604	
DP	5.	5,216,611	6/1/93	McELREATH	364	454	

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUB CLASS	TRANSLATION	
							YES	NO
DP	6.	EP 0 923 817	5/2/02	Europe	H04B 7	26		
DP	7.	WO 98/14018	4/2/98	Europe	H04Q 7	20		
DP	8.	WO 94/01978	1/20/94	Europe	H04Q 7	04		

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

DP	9.	Callan, James P., et al., "SEARCHING DISTRIBUTED COLLECTIONS WITH INFERENCE NETWORKS," 18th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval, 1995
DP	10.	Orphanoudakis, C.E., et al., "I²Cnet: Content-Based Similarity Search in Geographically Distributed Repositories of Medical Images," *vol. 20(4), pp. 193-207, Computerized Medical Imaging and Graphics*, 1996

EXAMINER /Dao Phan/	DATE CONSIDERED 06/07/2006
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SHEET 1 OF 1

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	ATTY. DOCKET NO. 1003-1	SERIAL NO. 09/770,838
	APPLICANT DUPRAY, Dennis J.	
	FILING DATE January 26, 2001	GROUP ART 3662

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUB CLASS	FILING DATE IF APPROP.
DP	AA*	6,240,285	5/29/01	BLUM et al.	455	404	
	AB*	5,959,568	9/28/99	Woolley	342	42	
	AC*	5,787,354	7/28/98	GRAY et al.	455	456	
	AD*	5,774,805	6/30/98	ZICKER	455	426	
	AE*	5,724,648	3/3/98	SHAUGHNESSY et al.	455	56.1	
	AF*	5,594,782	1/14/97	ZICKER et al.	379	63	
	AG*	5,513,243	4/30/96	KAGE	379	58	
DP	AH*	5,193,110	3/9/93	JONES et al.	379	94	

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUB CLASS	TRANSLATION YES	TRANSLATION NO
DP	AI*	EP 0 811 296 B1	9/25/02	EPO	H04Q 7	38		-
DP	AJ*	WO 02/065250 A2	8/22/02	WIPO	G06F			
DP	AK*	WO 01/44998 A2	6/21/01	WIPO	G06F 17	60		

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

EXAMINER /Dao Phan/	DATE CONSIDERED 06/07/2006

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

OIPE JC10
MAY 28 2004
PATENT & TRADEMARK OFFICE

SHEET 1 OF 2

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 1003-1	SERIAL NO. 09/770,838
INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT DUPRAY, Dennis J.	
	FILING DATE January 26, 2001	GROUP ART 3662

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUB CLASS	FILING DATE IF APPROP.
DP	AA*	6,549,130	4/15/03	Joao	340	539	
	AB	6,381,464	4/30/02	Vannucci	455	456	
	AC	6,330,452	12/11/01	Fattouche et al.	455	456	
	AD	6,243,587	6/5/01	Dent et al.	455	456	
	AE*	5,917,405	6/29/99	Joao	340	426	
	AF	5,594,425	1/14/97	Ladner et al.	340	825.06	
	AG	4,542,744	9/24/85	Barnes et al.	128	660	
	AH*	Application No. 10/337,807		Dupray			1/6/03
	AI*	Application No. 10/297,449		Dupray			12/6/02
DP	AJ*	Application No. 09/176,587		Dupray			10/21/98

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUB CLASS	TRANSLATION YES	TRANSLATION NO

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

EXAMINER /Dao Phan/	DATE CONSIDERED 06/07/2006

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SHEET 2 OF 2

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 1003-1	SERIAL NO. 09/770,838
INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT DUPRAY, Dennis J.	
	FILING DATE January 26, 2001	GROUP ART 3662

DP	AK	Smith, Jr., "Passive Location of Mobile Cellular Telephone Terminals," IEEE, CH3031-2/91/0000-0221, 1991 pp. 221-225

EXAMINER /Dao Phan/	DATE CONSIDERED 06/07/2006
*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

SHEET 1 OF 2

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 1003-1	SERIAL NO. 09/770,838
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U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUB CLASS	FILING DATE IF APPROP.
DP	1.	5,857,181	1/5/99	AUGENBRAUN	707	2	
	2.	5,787,235	7/28/98	SMITH et al.	395	50	
	3.	5,625,748	4/29/97	McDONOUGH et al.	395	2.6	
	4.	5,581,490	12/3/96	FERKINHOFF et al.	364	578	
	5.	5,563,931	10/8/96	BISHOP et al.	379	59	
	6.	5,402,524	3/28/95	BAUMAN et al.	395	50	
	7.	5,373,456	12/13/94	FERKINHOFF et al.	364	574	
	8.	5,233,541	8/3/93	CORWIN et al.	364	516	
	9.	5,045,852	9/3/91	MITCHELL et al.	341	51	
DP	10.	4,542,744	9/24/85	BARNES et al.	128	660	

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUB CLASS	TRANSLATION YES	TRANSLATION NO

EXAMINER /Dao Phan/	DATE CONSIDERED 06/07/2006

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 1003-1	SERIAL NO. 09/770,838
INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT DUPRAY, Dennis J.	
	FILING DATE January 26, 2001	GROUP ART 3662

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

DP	11.	Miller, RT, et al., "Protein fold recognition by sequence threading: tools and assessment techniques," Journal Announcement, Department of Biochemistry and Molecular Biology, University College, London, United Kingdom, January 1996
	12.	Dailey, D.J., "Demonstration of an Advanced Public Transportation System in the Context of an IVHS Regional Architecture," paper presented at the First World Congress on Applications of Transport Telematics and Intelligent Vehicle-Highway Systems, Nov. 30-Dec. 3, 1994
	13.	Dailey, D.J., et al., "ITS Data Fusion," Final Research Report, Research Project T9903, Task 9, ATIS/ATMS Regional IVHS Demonstration, University of Washington, April, 1996
	14.	Dartmouth College, "Soldiers, Agents and Wireless Networks: A Report on a Military Application," PAAM 2000.
DP	15.	Bass, Tim, "Intrusion Detection Systems & Multisensor Data Fusion: Creating Cyberspace Situational Awareness," Communications of the ACM, date unknown.

EXAMINER /Dao Phan/	DATE CONSIDERED 06/07/2006
*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Issue Classification	Application/Control No.	Applicant(s)/Patent under Reexamination	
	09/770,838	DUPRAY ET AL.	
	Examiner	Art Unit	
	Dao L. Phan	3662	

ISSUE CLASSIFICATION

ORIGINAL		CROSS REFERENCE(S)							
CLASS	SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)						
342	450	342	457						
INTERNATIONAL CLASSIFICATION									
G01S	3/02								
	/								
	/								
	/								
	/								

(Assistant Examiner) (Date)	DAO PHAN PATENT EXAMINER 6/7/06	Total Claims Allowed: 75
D. Rates 6/13/6 (Legal Instruments Examiner) (Date)	(Primary Examiner) (Date)	O.G. Print Claim(s): 56 — O.G. Print Fig.: 5

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		31		61		91		121		151		181
	2		32		62		92		122		152		182
	3		33		63		93		123		153		183
	4		34		64		94		124		154		184
	5		35		65		95		125		155		185
	6		36		66		96		126		156		186
	7		37		67		97		127		157		187
	8		38		68		98		128		158		188
	9		39		69		99		129		159		189
	10		40		70		100		130		160		190
	11		41		71		101		131		161		191
	12		42		72		102		132		162		192
	13		43		73		103		133		163		193
	14		44		74		104		134		164		194
	15		45		75		105		135		165		195
	16		46		76		106		136		166		196
	17		47		77		107		137		167		197
	18		48		78		108		138		168		198
	19		49		79		109		139		169		199
	20		50		80		110		140		170		200
	21		51		81		111		141		171		201
	22		52		82		112		142		172		202
	23		53		83		113		143		173		203
	24		54		84		114		144		174		204
	25		55		85		115		145		175		205
	26		56		86		116		146		176		206
	27		57		87		117		147		177		207
	28		58		88		118		148		178		208
	29		59		89		119		149		179		209
	30		60		90		120		150		180		210

U.S. Patent and Trademark Office

Part of Paper No. 20060607

Issue Classification	Application/Control No.	Applicant(s)/Patent under Reexamination	
	09/770,838	DUPRAY ET AL.	
	Examiner	Art Unit	
	Dao L. Phan	3662	

ISSUE CLASSIFICATION

ORIGINAL		CROSS REFERENCE(S)							
CLASS	SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)						
342	450	342	457						
INTERNATIONAL CLASSIFICATION									
G 0 1 S	3/02								
	/								
	/								
	/								
	/								

(Assistant Examiner) (Date)	(signature) 6/7/06	Total Claims Allowed: 75
(Legal Instruments Examiner) (Date)	(Primary Examiner) (Date)	O.G. Print Claim(s): 56 — O.G. Print Fig.: 5

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	211	21	241	51	271		301		331		361		391
	212	22	242	52	272		302		332		362		392
	213	23	243	53	273		303		333		363		393
	214	24	244	54	274		304		334		364		394
	215	25	245	55	275		305		335		365		395
	216	26	246	56	276		306		336		366		396
	217	27	247	57	277		307		337		367		397
	218	28	248	58	278		308		338		368		398
	219	29	249	59	279		309		339		369		399
	220	30	250	60	280		310		340		370		400
1	221	31	251	61	281		311		341		371		401
2	222	32	252	62	282		312		342		372		402
3	223	33	253	63	283		313		343		373		403
4	224	34	254	64	284		314		344		374		404
5	225	35	255	65	285		315		345		375		405
6	226	36	256	66	286		316		346		376		406
7	227	37	257	67	287		317		347		377		407
8	228	38	258	68	288		318		348		378		408
9	229	39	259	69	289		319		349		379		409
10	230	40	260	70	290		320		350		380		410
11	231	41	261	71	291		321		351		381		411
12	232	42	262	72	292		322		352		382		412
13	233	43	263	73	293		323		353		383		413
14	234	44	264	74	294		324		354		384		414
15	235	45	265	75	295		325		355		385		415
16	236	46	266		296		326		356		386		416
17	237	47	267		297		327		357		387		417
18	238	48	268		298		328		358		388		418
19	239	49	269		299		329		359		389		419
20	240	50	270		300		330		360		390		420

Search Notes	Application/Control No. 09/770,838	Applicant(s)/Patent under Reexamination DUPRAY ET AL.	
	Examiner Dao L. Phan	Art Unit 3662	

SEARCHED

Class	Subclass	Date	Examiner
342	357.01	3/6/2003	DP
	357.06		
	450		
	453		
	463-465		
	457		
455	456.2		
	456.6		
updated		8/23/2003	DP
updated		4/13/2004	DP
updated		6/7/2006	DP

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner
PGPub text search-See interference search printout		6/7/2006	dp

SEARCH NOTES (INCLUDING SEARCH STRATEGY)

	DATE	EXMR
East text search (See search history printout)	6/7/2006	DP

ok, to enter
DP

IN THE SPECIFICATION:

Applicants have provided herein a replacement set of amendments to the specification. The amendments to the specification herein are to replace all previous specification amendments **with the exception of the change in the claim for priority filed which were provided in a transmittal to the USPTO filed on January 26, 2001.** Accordingly, it is requested that all previous amendments to the specification, **except for the change in the claim for priority**, be replaced with the specification amendments provided herein following.

Please replace the title of application with the following new title:

"A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION"

Please replace the paragraph beginning on page 8, line 3 with the following paragraph:

Loss due to slow fading includes shadowing due to clutter blockage (sometimes included in Lp). Fast fading is composed of multipath reflections which cause: 1) delay spread; 2) random phase shift or Rayleigh fading; and 3) random frequency modulation due to different Doppler shifts on different paths.

Please replace the paragraph beginning on page 10, line 3 through page 10, line 20 with the following paragraphs:

It is an objective of the present invention to provide a system and method for to wireless telecommunication systems for accurately locating people and/or objects in a cost effective manner. Additionally, it is an objective of the present invention to provide such location capabilities using the measurements from wireless signals communicated between mobile stations and a network of base stations, wherein the same communication standard or protocol is utilized for location as is used by the network of base stations for providing wireless communications with mobile stations for other purposes such as voice communication and/or visual communication (such as text paging, graphical or video communications). Related objectives for various embodiments of the present invention include providing a system and method that:

(1.1) can be readily incorporated into existing commercial wireless telephony systems with few, if any, modifications of a typical telephony wireless infrastructure;

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

7590 08/24/2006

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

EXAMINER	
PHAN, DAO LINDA	
ART UNIT	**PAPER NUMBER**
3662	

DATE MAILED: 08/24/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

1. Claims 221-295 have been allowed. However, there are missing texts at the bottom of p. 39 & 40 of the specification filed 12/12/05. Appropriate correction is required.

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dao L. Phan whose telephone number is (571)272-6976. The examiner can normally be reached on M-F 9:00-5:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Thomas Tarcza can be reached on (571)272-6979. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

3. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

DAO PHAN
PATENT EXAMINER

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION

In Re the Application of:

DUPRAY et al.

Serial No.: 09/770,838

Filed: January 26, 2001

Atty. File No.: 1003-1

For: "A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION"

Prior Group Art Unit: 3662

Confirmation No. 8410

Examiner: Dao Phan

Amendment to the Specification

MAIL STOP AMENDMENTS
Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir/Madam:

In response to the Examiner's communication of Aug. 24, 2006 requesting appropriate correction of the missing text at the bottom of page 39 & 40 of the specification filed 12/12/05, Applicant's submit the following Amendment. It is believed that there are no fees due with this response. However, if additional fees are due, the undersigned Applicant requests a phone call regarding such matters. Note, Applicant's believe there has been an overpayment in the present application of $269.00.

IN THE SPECIFICATION:

Please enter the following replacement Table LH-1 as a replacement for the table commencing on page 39, line 23, and extending onto the top of page 41. Note, the following table continues onto the next two pages as well.

Table LH-1

FOM_ID	First order model ID (providing this Location Hypothesis); note, since it is possible for location hypotheses to be generated by other than the FOMs 1224, in general, this field identifies the module that generated this location hypothesis.
MS_ID	The identification of the target MS 140 to this location hypothesis applies.
pt_est	The most likely location point estimate of the target MS 140.
valid_pt	Boolean indicating the validity of "pt_est".
area_est	Location Area Estimate of the target MS 140 provided by the FOM. This area estimate will be used whenever "image_area" below is NULL.
valid_area	Boolean indicating the validity of "area_est" (one of "pt_est" and "area_est" must be valid).
adjust	Boolean (true if adjustments to the fields of this location hypothesis are to be performed in the Context adjuster Module).
pt_covering	Reference to a substantially minimal area (e.g., mesh cell) covering of "pt_est". Note, since this MS 140 may be substantially on a cell boundary, this covering may, in some cases, include more than one cell.
image_area	Reference to a substantially minimal area (e.g., mesh cell) covering of "pt_covering" (see detailed description of the function, "confidence_adjuster"). Note that if this field is not NULL, then this is the target MS location estimate used by the location center 142 instead of "area_est".

extrapolation_area	Reference to (if non-NULL) an extrapolated MS target estimate area provided by the location extrapolator submodule 1432 of the hypothesis analyzer 1332. That is, this field, if non-NULL, is an extrapolation of the "image_area" field if it exists, otherwise this field is an extrapolation of the "area_est" field. Note other extrapolation fields may also be provided depending on the embodiment of the present invention, such as an extrapolation of the "pt_covering".
confidence	A real value in the range [-1.0, +1.0] indicating a likelihood that the target MS 140 is in (or out) of a particular area. If positive: if "image_area" exists, then this is a measure of the likelihood that the target MS 140 is within the area represented by "image_area", or if "image_area" has not been computed (e.g., "adjust" is FALSE), then "area_est" must be valid and this is a measure of the likelihood that the target MS 140 is within the area represented by "area_est". If negative, then "area_est" must be valid and this is a measure of the likelihood that the target MS 140 is NOT in the area represented by "area_est". If it is zero (near zero), then the likelihood is unknown.
Original_Timestamp	Date and time that the location signature cluster (defined hereinbelow) for this location hypothesis was received by the signal processing subsystem 1220.
Active_Timestamp	Run-time field providing the time to which this location hypothesis has had its MS location estimate(s) extrapolated (in the location extrapolator 1432 of the hypothesis analyzer 1332). Note that this field is initialized with the value from the "Original_Timestamp" field.
Processing Tags and environmental categorizations	For indicating particular types of environmental classifications not readily determined by the "Original_Timestamp" field (e.g., weather, traffic), and restrictions on location hypothesis processing.
loc_sig_cluster	Provides access to the collection of location signature signal characteristics derived from communications between the target MS 140 and the base station(s) detected by this MS (discussed in detail

	hereinbelow); in particular, the location data accessed here is provided to the first order models by the signal processing subsystem 1220; i.e., access to the "loc sigs" (received at "timestamp" regarding the location of the target MS)
descriptor	Original descriptor (from the First order model indicating why/how the Location Area Estimate and Confidence Value were determined).

REMARKS

Applicants submit a new copy of Table LH-1 above in response to a request by the Examiner since text for this table at the bottom of pages 39 and 40 of the specification was identified as unreadable. The present version of Table LH-1 is believed to introduce no new matter into the application in that the table provided herewith is a copy of the table from the original PCT filing from which the present application is a continuation.

Applicants request appropriate reconsideration of the application.

Respectfully submitted,

By: [signature]

Dennis J. Dupray
Registration No. 46,299
1801 Belvedere Street
Golden, Colorado 80401
(303) 863-9700

Date: Aug. 31, 2006

Electronic Acknowledgement Receipt

EFS ID:	1180950
Application Number:	09770838
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor:	Dennis J. Dupray
Correspondence Address:	Dennis J. Dupray, Ph.D. - 1801 Belvedere Street - Golden CO 80401 US 3038630223 -
Filer:	Dennis Jay Dupray.
Filer Authorized By:	
Attorney Docket Number:	1003-1
Receipt Date:	31-AUG-2006
Filing Date:	26-JAN-2001
Time Stamp:	15:27:58
Application Type:	Utility
International Application Number:	

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part	Pages
1	Supplemental Response or Supplemental Amendment	Specification_Amendmt_After_Allowance.pdf	364677	no	5

Warnings:

Information:

Total Files Size (in bytes):	364677

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

01

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

7590 10/13/2006

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

EXAMINER	
PHAN, DAO LINDA	
ART UNIT	**PAPER NUMBER**
3662	

DATE MAILED: 10/13/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

Response to Rule 312 Communication	Application No.	Applicant(s)	
	09/770,838	DUPRAY ET AL.	
	Examiner	**Art Unit**	
	Dao L. Phan	3662	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

1. ☒ The amendment filed on *31 August 2006* ~~under 37 CFR 1.312~~ has been considered, and has been:

   a) ☐ entered.

   b) ☒ entered as directed to matters of form not affecting the scope of the invention.

   c) ☐ disapproved because the amendment was filed after the payment of the issue fee.
   Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.

   d) ☐ disapproved. See explanation below.

   e) ☐ entered in part. See explanation below.

DAO PHAN
PATENT EXAMINER

Enter \ DP.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION

In Re the Application of:

DUPRAY et al.

Serial No.: 09/770,838

Filed: January 26, 2001

Atty. File No.: 1003-1

For: "A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION"

Prior Group Art Unit: 3662

Confirmation No. 8410

Examiner: Dao Phan

Amendment to the Specification

MAIL STOP AMENDMENTS
Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir/Madam:

In response to the Examiner's communication of Aug. 24, 2006 requesting appropriate correction of the missing text at the bottom of page 39 & 40 of the specification filed 12/12/05, Applicant's submit the following Amendment. It is believed that there are no fees due with this response. However, if additional fees are due, the undersigned Applicant requests a phone call regarding such matters. Note, Applicant's believe there has been an overpayment in the present application of $269.00.

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	09/770,838	Filing Date	2001-01-26	Docket Number (if applicable)	1003-1	Art Unit	3662
First Named Inventor	Dupray			Examiner Name	Phan, Dao Linda		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on ___________
- ☐ Other ___________

☒ Enclosed

- ☐ Amendment/Reply
- ☒ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other ___________

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months ___________
(Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other ___________

FEES

☐ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No ___________

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature
☐ Applicant Signature

Signature of Registered U.S. Patent Practitioner			
Signature	/Dennis J. Dupray/	Date (YYYY-MM-DD)	2006-10-18
Name	Dennis J. Dupray	Registration Number	46299

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	Group Art Unit: 3662
	)	
Dupray et al.	)	Examiner: Dao L. Phan
	)	
Serial No.: 09/770,838	)	INFORMATION DISCLOSURE STATEMENT
	)	
Filed: January 26, 2001	)	
	)	
Atty. File No.: 1003-1	)	
	)	
For: A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION	)	

Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Sir:

The references cited on attached Form PTO-1449 are being called to the attention of the Examiner.

☐ Copies of the cited non-patent and/or foreign references are enclosed herewith.

☐ Copies of the cited U.S. patents and/or patent applications are enclosed herewith.

☒ Copies of the cited U.S. patents/patent application publications are not enclosed in accordance with the waiver dated July 11, 2003, whereby patent applications filed after June 30, 2003 and international applications that have entered the national stage under 35 U.S.C. § 371 after June 30, 2003 need not submit copies of U.S. patents and U.S. patent application publications.

☐ Copies of the cited references are not enclosed, in accordance with 37 C.F.R. 1.98(d), because the references were cited by or submitted to the U.S. Patent and Trademark Office in prior application Serial No. ___________ filed ________________, which is relied upon for an earlier filing date under 35 U.S.C. § 120.

☐ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English abstracts and in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☒ Examiner's attention is drawn to the following co-pending applications, and for at least such applications to which the present application does not claim priority, copies have been or are being submitted:

Serial No.09/194,367	filed	Nov. 24, 1998 (docket no. 1003-PUS)
Serial No.10/262,413	filed	Sept. 30, 2002 (docket no. 1003-2)
Serial No. 10/262,338	filed	Sept. 30, 2002 (docket no. 1003-3)
Serial No. 11/069,441	filed	March 1, 2005 (docket no. 1004-1-1)
Serial No.09/176,587	filed	Oct. 21, 1998 (docket no. 1005-DJD)
Serial No. 10/297,449	filed	Dec. 5, 2002 (docket no. 1010-PUS)
Serial No. 10/337,807	filed	Jan. 6, 2003 (docket no. 1011)
Serial No. 11/464,880	filed	Aug.. 16, 2006 (docket no. 1000-1010-1)

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

It is respectfully requested that the cited information be expressly considered during the prosecution of this application and the references made of record therein.

FEES

☒	**37 CFR 1.97(b)**: No fee is believed due in connection with this submission, because the information disclosure statement submitted herewith is satisfies one of the following conditions ("X" indicates satisfaction): ☐ Within three months of the filing date of a national application other than a continued prosecution application under 37 CFR 1.53(d), or ☐ Within three months of the date of entry into the national stage of an international application as set forth in 37 CFR 1.491 or ☐ Before the mailing date of a first Office Action on the merits, or ☒ Before the mailing of a first Office action after the filing of a request for continued examination under 37 CFR 1.114. Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970.

☐	**37 CFR 1.97(c)**: The information disclosure statement transmitted herewith is being filed after all the above conditions (37 CFR 1.97(b)), but before the mailing date of one of the following conditions: (1) a final action under 37 C.F.R. 1.113 or (2) a notice of allowance under 37 C.F.R. 1.311, or (3) an action that otherwise closes prosecution in the application. This Information Disclosure Statement is accompanied by: ☐ A Certification (below) as specified by 37 C.F.R. 1.97(e). Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970. OR ☐ A check in the amount of $180.00 for the fee set forth in 37 C.F.R. 1.17(p) for submission of an information disclosure statement. Please credit any overpayment or charge any underpayment to Deposit Account No. 19-1970. Election to pay the fee should not be taken as an indication that applicant(s) cannot execute a certification.
☐	**37 CFR 1.97(d)**: This Information Disclosure Statement is being submitted after the period specified in 37 CFR 1.97(c). ☐ This information Disclosure Statement includes a Certification (below) as specified by 37 C.F.R. 1.97(e) AND ☐ Applicants hereby requests consideration of the reference(s) disclosed herein. Enclosed is the fee in the amount of $180.00 under 37 C.F.R. 1.17(p). Please credit any overpayment or charge any underpayment to Deposit Account No. 19-1970.

Respectfully submitted,

By: /Dennis J. Dupray/

Dennis J. Dupray
Registration No. 46,299
1801 Belvedere Street
Golden, Colorado 80401
(303) 863-9700

Date: Oct. 18, 2006

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	ATTY. DOCKET NO.1003-1	SERIAL NO. 09/770,838
	APPLICANT DUPRAY et al.	
	FILING DATE January 26, 2001	GROUP ART 3662

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUB CLASS	FILING DATE IF APPROP.
	1.	5,895,436	April 20, 1999	Savoie, et al			
	2.	5,223,844	. June 29, 1993	Mansell , et al	379	94	
	3.	5,513,111	April 30, 1996	Wortham			
	4.	5,099,245	March 24, 1992	Sagey			
	5.	5,075,694	Dec. 24, 1991	Donnangelo, et al	342	455	

Electronic Patent Application Fee Transmittal

Application Number:	09770838
Filing Date:	26-Jan-2001
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Filer:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1

Filed as Small Entity

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Petition-revive unintent. abandoned appl	2453	1	750	750
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for continued examination	2801	1	395	395
		Total in USD ($)		**1145**

Electronic Acknowledgement Receipt	
EFS ID:	1261343
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Correspondence Address:	Dennis J. Dupray, Ph.D. - 1801 Belvedere Street - Golden CO 80401 US 3038630223 -
Filer:	Dennis Jay Dupray.
Filer Authorized By:	
Attorney Docket Number:	1003-1
Receipt Date:	18-OCT-2006
Filing Date:	26-JAN-2001
Time Stamp:	20:50:14
Application Type:	Utility

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	$1145
RAM confirmation Number	783

Deposit Account	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part /.zip	Pages (if appl.)
1	Petition for review/processing depending on status	PETITION_TO_REVIVE.pdf	28488	no	2
Warnings:					
Information:					
2	Request for Continued Examination (RCE)	RCE_10-18-06.pdf	662432	no	3
Warnings:					
Information:					
3	Transmittal letter	IDS-14.pdf	43599	no	3
Warnings:					
Information:					
4	Information Disclosure Statement (IDS) Filed	IDS-014-1449.pdf	12982	no	1
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
5	Fee Worksheet (PTO-875)	fee-info.pdf	8307	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	755808		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION

In Re the Application of:

DUPRAY et al.

Serial No.: 09/770,838

Filed: January 26, 2001

Atty. File No.: 1003-1

For: "A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION"

Prior Group Art Unit: 3662

Confirmation No. 8410

Examiner: Dao Phan

PETITION TO REVIVE UNINTENTIONALLY ABANDONED APPLICATION UNDER 37 CFR 1.137(b)

MAIL STOP AMENDMENTS
Assistant Commissioner for Patents
Washington, D.C. 20231

Applicant hereby petitions for revival of the above-identified U.S. patent application for failure to pay issue fee which was to be paid by Sept. 15, 2006, and states that the failure was unintentional.

The Applicant did not realize that the issue fee was due in the present application, and the Applicant was only alerted to this fact when the Applicant queried for the status of the present application via the PAIR system on the USPTO website at the end of September 2006. Accordingly, since that time Applicant has been reviewing the present application, and the prior art as well as new prior art cited by the Examiner in a related pending patent application.

Accompanying this Petition is: (1) the fee for unintentionally delayed payment pursuant to 37 C.F.R. §1.17(m) of $750.00, and (2) a request for continued examination (RCE) together with an information disclosure statement citing additional references.

I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

No additional fees are due. In the event that other fees are required, the Examiner is urgently requested to contact the Applicant by telephone at the number given below.

Respectfully submitted,

By: /Dennis J. Dupray/

Dennis J. Dupray
Registration No. 46,299
1700 Lincoln Street, Suite 3500
Denver, Colorado 80203
(303) 863-9700

Date: Oct. 18, 2006

SHEET 5 OF 9

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 1003-1	SERIAL NO. Not Yet Assigned 09/770,838
INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT DUPRAY et al.	
	FILING DATE Filed Herewith	GROUP ART

OIPE APR 10 2002 PATENT & TRADEMARK OFFICE

DP	130	5,426,745	7/20/95	Baji et al.	395	375	
	131	5,422,813	6/6/95	Schuchman et al.	364	449	
	132	5,420,914	5/30/95	Blumhardt	379	114	
	133	5,410,737	4/25/95	Jones	455	56.1	
	134	5,408,588	4/18/95	Ulug	395	23	
	135	5,408,586	4/18/95	Skeirik	395	23	
	136	5,402,520	3/28/95	Schnitta	395	22	
	137	5,398,302	3/14/95	Thrift	395	23	
	138	5,394,435	2/28/95	Weerackody	375	206	
KRH 11-17-06	139	5,394,1~~85~~58	2/28/95	Chia	342	457	
	140	5,390,339	2/14/95	Bruckert et al.	455	33.2	
	141	5,389,934	2/14/95	Kass	342	357	
	142	5,388,259	2/7/95	Fleischman et al.	395	600	
	143	5,379,224	1/3/95	Brown et al.	364	449	
	144	5,365,544	11/15/94	Schilling	375	1	
	145	5,365,516	11/15/94	Jandrell	370	18	
	146	5,365,450	11/15/94	Schuchman et al.	364	449	
	147	5,365,447	11/15/94	Dennis	364	449	
	148	5,363,110	11/8/94	Inamiya	342	357	
	149	5,359,521	10/25/94	Kyrtsos et al.	364	449	
	150	5,349,631	9/20/94	Lee	379	59	
	151	5,331,550	7/19/94	Stafford et al.	364	413.02	
	152	5,327,144	7/5/94	Stilp et al.	342	387	
	153	5,325,419	6/28/94	Connolly et al.	379	60	
	154	5,319,374	6/7/94	Desai et al.	342	387	
	155	5,317,323	5/31/94	Kennedy et al.	342	457	
	156	5,311,195	5/10/94	Mathis et al.	342	357	
	157	5,295,180	3/15/94	Vendetti et al.	379	59	
	158	5,293,645	3/8/1994	Sood	455	54.1	
	159	5,293,642	3/8/94	Lo	455	33.1	
	160	5,282,261	1/25/94	Skeirik	395	22	
	161	5,280,472	1/18/94	Gilhousen et al.	370	18	
DP	162	5,280,295	1/18/94	Kelley et al.	342	463	

EXAMINER [signature]	DATE CONSIDERED 8/13/02

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

patent applications\1003\-1\pto-ids-0001-1449

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	Phan, Dao Linda
	Attorney Docket Number	1003-1

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code1	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6519463		2003-02-11	Tendler	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code1	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number3	Country Code2 i	Kind Code4	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T5
	1							☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T5

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	Phan, Dao Linda
	Attorney Docket Number	1003-1

	1		☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Application Number		09770838
	Filing Date		2001-01-26
	First Named Inventor	Dupray	
	Art Unit		3662
	Examiner Name	Phan, Dao Linda	
	Attorney Docket Number		1003-1

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Dennis J. Dupray/	Date (YYYY-MM-DD)	2007-02-17
Name/Print	Dennis J. Dupray	Registration Number	46299

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt	
EFS ID:	1525245
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Correspondence Address:	Dennis J. Dupray, Ph.D. - 1801 Belvedere Street - Golden CO 80401 US 3038630223 -
Filer:	Dennis Jay Dupray.
Filer Authorized By:	
Attorney Docket Number:	1003-1
Receipt Date:	18-FEB-2007
Filing Date:	26-JAN-2001
Time Stamp:	10:26:34
Application Type:	Utility

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed	US_IDS_Form__SB_08a.pdf	673674	no	4
Warnings:					
Information:					
		Total Files Size (in bytes):	673674		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

DENNIS J. DUPRAY, Ph.D.
1801 BELVEDERE STREET
GOLDEN, CO 80401

COPY MAILED

MAR 22 2007

OFFICE OF PETITIONS

In re Application of :
Dupray et al. :
Application No. 09/770,838 : ON PETITION
Filed: January 26, 2001 :
Attorney Docket No. 1003-1 :

This is a decision on the petition under 37 C.F.R. § 1.137(b), filed October 18, 2006, to revive the above-identified application.

The petition is **DISMISSED**.

Any request for reconsideration must be submitted within TWO (2) MONTHS from the mail date of this decision. No further petition fee is required for the request. Extensions of time under 37 CFR 1.136(a) are permitted. The reconsideration request should include a cover letter entitled "Renewed Petition under 37 CFR 1.137(b)." This is **not** a final agency action within the meaning of 5 U.S.C. § 704.

The above-identified application became abandoned for failure to submit the issue fee and publication fee in a timely manner in reply to the Notice of Allowance mailed June 15, 2006, which set a statutory period for reply of three (3) months. Accordingly, the above-identified application became abandoned on September 16, 2006.

A grantable petition under 37 CFR 1.137(b) must be accompanied by:
(1) the required reply,[1]
(2) the petition fee,
(3) a statement that the entire delay in filing the required reply from the due date for the reply until the filing of a grantable petition pursuant to 37 CFR 1.137(b) was unintentional, and
(4) a terminal disclaimer and fee if the application was filed on or before June 8, 1995 or if the application is a design application.

Where there is a question as to whether either the abandonment or the delay in filing a petition under 37 CFR 1.137 was unintentional, the Commissioner may require additional information.[2]

---

[1] In a nonprovisional application abandoned for failure to prosecute, the required reply may be met by the filing of a continuing application. In an application or patent, abandoned or lapsed for failure to pay the issue fee or any portion thereof, the required reply must be the payment of the issue fee or any outstanding balance thereof.

[2] See MPEP 711.03(c)(III)(C) and (D).

The instant petition lacks item (1). Petitioner submitted a Request for Continued Examination (RCE) and an Information Disclosure Statement (IDS). 35 U.S.C. 41(a)(7) and 151 each require payment of the issue fee as a condition of reviving an application abandoned or patent lapsed for failure to pay the issue fee. Therefore, the filing of a continuing application without payment of the issue fee or any outstanding balance thereof is not an acceptable reply in an application abandoned or patent lapsed for failure to pay the issue fee or any portion thereof. Once the issue and publication fees have been submitted, the instant application will be returned to the Technology Center for consideration of the RCE concurrently filed.

Petitioner is advised that, once submitted, the issue fee cannot be refunded. If, however, this application is again allowed, petitioner may request that it be applied towards the issue fee required by the new Notice of Allowance.[1]

Further correspondence with respect to this matter should be addressed as follows:

By mail: Mail Stop PETITIONS
Commissioner for Patents
Post Office Box 1450
Alexandria, VA 22313-1450

By hand: Customer Window located at:

U.S. Patent and Trademark Office
Customer Service Window Randolph Building
401 Dulany Street
Alexandria, VA 22314

By fax: (571) 273-8300
ATTN: Office of Petitions

Any questions concerning this matter may be directed to the undersigned at (571) 272-3206.

Liana Walsh
Liana Walsh
Petitions Examiner
Office of Petitions

---

[1] *The request to apply the issue fee to the new Notice may be satisfied by completing and returning the new Part B – Fee(s) Transmittal Form (along with any balance due at the time of submission). Petitioner is advised that the Issue Fee Transmittal Form must be completed and timely submitted to avoid abandonment of the application.*

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 06/15/2006

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

TITLE OF INVENTION: A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$700	$300	$1000	09/15/2006

EXAMINER	ART UNIT	CLASS-SUBCLASS
PHAN, DAO LINDA	3662	342-450000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 __________
2 __________
3 __________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE
TracBeam LLC

(B) RESIDENCE: (CITY and STATE OR COUNTRY)
1801 Belvedere Dr., Golden, Colorado

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are enclosed:

☒ Issue Fee
☒ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies __________

4b. Payment of Fee(s):

☐ A check in the amount of the fee(s) is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☐ The Director is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number __________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27. ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /Dennis J. Dupray/ Date April 28, 2007

Typed or printed name Dennis J. Dupray Registration No. 46,299

Electronic Patent Application Fee Transmittal

Application Number:	09770838
Filing Date:	26-Jan-2001
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Filer:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1

Filed as Small Entity

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	2501	1	700	700
Publication fee for republication	1505	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1000**

Electronic Acknowledgement Receipt

EFS ID:	1726282
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Correspondence Address:	Dennis J. Dupray, Ph.D. - 1801 Belvedere Street - Golden CO 80401 US 3038630223 -
Filer:	Dennis Jay Dupray.
Filer Authorized By:	
Attorney Docket Number:	1003-1
Receipt Date:	28-APR-2007
Filing Date:	26-JAN-2001
Time Stamp:	16:03:16
Application Type:	Utility

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	$1000
RAM confirmation Number	1622

Deposit Account	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part /.zip	Pages (if appl.)
1	Post Allowance Communication - Incoming	Renewed_Petition_Revival.pdf	84571	no	2
Warnings:					
Information:					
2	Issue Fee Payment (PTO-85B)	Issue_Fee_Transmittal.pdf	99187	no	1
Warnings:					
Information:					
3	Fee Worksheet (PTO-06)	fee-info.pdf	8258	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	192016		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	Group Art Unit: 3662
Dupray et al.	)	**CONFIRMATION NO. 8410**
	)	Examiner: Dao L. Phan
Serial No.: 09/770,838	)	
Filed: January 26, 2001	)	**Renewed Petition under 37 CFR 1.137(b)**
Atty. File No.: 1003-1	)	
For: A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION	)	**Electronically Filed**

Mail Stop: PETITIONS
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

To Whom It May Concern:

In the Office's correspondence having a mailing date of March 22, 2007, Applicant's previously filed Petition for Unintentional Abandonment of the above-identified patent application was dismissed. In dismissing the petition, the Office stated that the required reply for responding to the Notice of Allowance on the above-identified application was not provided. With the previously filed Petition for Unintentional Abandonment, Applicants filed an RCE. However, the Office stated in the dismissal of the petition that the payment of the issue fee is the appropriate response to the previous Notice of Allowance. Moreover, the Office stated that: "Once the issue and publication fees have been submitted, the instant application will be returned to the Technology Center for consideration of the RCE concurrently filed."

Accordingly, Applicants submit this renewed petition under 37 CFR 1.137(b), wherein the FEE(S) TRANSMITTAL form, and the issue fee for the above-identified application is paid concurrently with the electronic filing of this request for the renewal of the previously filed Petition for Unintentional Abandonment having a filing date of Oct. 18, 2006.

It is believed that no additional fees are due with this transmittal. However, if additional fees are due, it is respectfully requested that the undersigned Applicant be contacted via the phone numbers provided hereinbelow

Respectfully submitted,
By: /Dennis J. Dupray/
Dennis J. Dupray

Date: April 28, 2007

Registration No. 46,299
1801 Belvedere Drive
Golden, Colorado 80401
Phone Nos.: (303) 863-2975
(303) 273-0167

M

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

7590 05/23/2007

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

EXAMINER	
PHAN, DAO LINDA	
ART UNIT	PAPER NUMBER
3662	

DATE MAILED: 05/23/2007

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

TITLE OF INVENTION: GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$700	$0	$700	$700	08/23/2007

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 07/06) Approved for use through 05/31/2007.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 05/23/2007

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

TITLE OF INVENTION: GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$700	$0	$700	$700	08/23/2007

EXAMINER	ART UNIT	CLASS-SUBCLASS
PHAN, DAO LINDA	3662	342-450000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
   (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
   1 ____________
   2 ____________
   3 ____________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☐ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies ____________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number ____________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ____________ Date ____________

Typed or printed name ____________ Registration No. ____________

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

7590 05/23/2007

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

EXAMINER	
PHAN, DAO LINDA	
ART UNIT	PAPER NUMBER
3662	

DATE MAILED: 05/23/2007

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 76 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 76 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 07/06) Approved for use through 05/31/2007.

Notice of Allowability	**Application No.** 09/770,838	**Applicant(s)** DUPRAY ET AL.	
	Examiner Dao L. Phan	**Art Unit** 3662	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to 10/18/06 & 2/18/07.
2. ☒ The allowed claim(s) is/are 221-295 (renumbered 1-75).
3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).
   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application. **THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☒ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

DAO PHAN
PRIMARY EXAMINER

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

The claims on p.22 are duplicated claims on p. 23. Therefore, p.23 has been removed.

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dao L. Phan whose telephone number is (571)272-6976. The examiner can normally be reached on M-F 9:00-5:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Thomas Tarcza can be reached on (571)272-6979. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

3. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	Phan, Dao Linda
	Attorney Docket Number	1003-1

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code1	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
/DP/	1	6519463		2003-02-11	Tendler	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code1	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number3	Country Code2 j	Kind Code4	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T5
	1							☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T5

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	Phan, Dao Linda
	Attorney Docket Number	1003-1

	1		☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/Dao Phan/	Date Considered	04/19/2007

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO.1003-1	SERIAL NO. 09/770,838
INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT DUPRAY et al.	
	FILING DATE January 26, 2001	GROUP ART 3662

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUB CLASS	FILING DATE IF APPROP.
/DP/	1.	5,895,436	April 20, 1999	Savoie, et al			
/DP/	2.	5,223,844	. June 29, 1993	Mansell , et al	379	94	
/DP/	3.	5,513,111	April 30, 1996	Wortham	—	—	
/DP/	4.	5,099,245	March 24, 1992	Sagey	—	—	
/DP/	5.	5,075,694	Dec. 24, 1991	Donnangelo, et al	342	455	

/Dao Phan/
04/19/2007

IN THE CLAIMS:

Claims 1 through 124 were previously cancelled.

Please cancel all pending claims, namely Claims 125 through 220 without prejudice to or disclaimer of the subject matter contained therein, and add the following new claims:

221. (New) A method for use in a wireless network to obtain requested location information regarding a mobile wireless station from any of various location sources and provide the requested location information to a wireless location application, there being a plurality of location estimating sources, including a first location estimating source for obtaining location information and a second location estimating source for obtaining location information for providing information regarding locations of mobile wireless stations in the network, the method comprising the steps of:

first receiving a location request regarding a first of said wireless mobile stations from said first wireless location application, said location request seeking said requested location information;

first obtaining: a first location input obtained using an instance, I_1, of said location information from said first location estimating source, wherein I_1 is indicative of one or more locations of said first wireless mobile station, and

second obtaining a second location input obtained using an instance, I_2, of said location information provided from said second location estimating source, wherein I_2 is indicative of one or more locations of said first wireless mobile station;

wherein said first location estimating source employs a first location finding technology that provides I_1, and said second location estimating source employs a second location finding technology different than said first location finding technology that provides I_2; and

wherein said steps of first and second obtaining includes a step of providing said first and second location inputs in a common standardized format;

storing data in memory relating to said first location input and said second location input;

third obtaining said requested location information by selectively using portions of said data from said memory, wherein said requested location information is determined according to information indicative of a manner in which said first wireless location application prefers said requested location information; and outputting said requested location information to said first wireless location application.

222. (New) The method of Claim 221, wherein for locating a second of the mobile stations, there is a further step of requesting activation of each of one or more of said plurality of location estimating sources according to an availability of corresponding wireless signal measurements from the second mobile station for the location estimating source.

223. (New) The method of Claim 221, further including, for locating a second of the mobile stations, a step of obtaining an instance of a third location input from a third of the plurality of location estimating sources different from said first and second location estimating sources.

224. (New) The method of Claim 221, further including, for locating one of the first and a second of the mobile stations, a step of obtaining an instance of a third location input by using a third location finding technology different from the first and second location finding technologies.

225. (New) The method of Claim 224, further including providing said instance of said third location input in said standardized format.

226. (New) The method of Claim 221, wherein said step of providing includes representing each of said first and second location inputs in a common data representation having a plurality of location attributes, including a common representation A_1 for representing a geographical position for the first mobile station, and one or more attributes related to one of: an error in data for A_1, a likelihood of the first mobile station being in the geographical extent represented by A_1, a timestamp related to the first mobile station being in the geographical extent represented by A_1, and descriptor information related to location processing performed by one of said resources in obtaining an instance of said location information for M

227. (New) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to an error in data for A_1.

228. (New) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to a likelihood of the first mobile station being in the geographical extent represented by A_1.

229. (New) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to a timestamp related to the first mobile station being in the geographical extent represented by A_1.

230. (New) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes for descriptor information related to location processing performed by one of said location estimating sources in obtaining an instance of said location information for the first mobile station.

231. (New) The method of Claim 226, wherein for locating a second of the mobile stations, further including a step of providing one or more location input instances of location information by one or more of said location estimating sources in said common data representation.

232. (New) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of said wireless mobile stations including at least a location and a time.

233. (New) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of the wireless mobile stations including one or more values indicative of an uncertainty regarding a location of the individual wireless mobile station.

234. (New) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of said wireless mobile stations including one of a travel speed and a travel direction.

235. (New) A method as set forth in claim 221, wherein said step of first obtaining comprises sending data for requesting activation of one of the first location estimating source and the second location estimating source to obtain the corresponding one of first and second location input.

236. (New) A method as set forth in claim 221, wherein said step of third obtaining comprises determining additional location information including at least a wireless station identification and a location of the first wireless mobile station.

237. (New) A method as set forth in claim 221, wherein said step of third obtaining comprises determining additional location information a including a time and an uncertainty regarding location.

238. (New) A method as set forth in claim 221, wherein said step of third obtaining comprises providing additional location information including one of a speed of travel and direction of travel for the first wireless mobile station.

239. (New) A method as set forth in claim 221, further comprising combining a first portion of said portions of said data obtained using said first location input with a second portion of said portion of said data obtained using said second location to make a location determination.

240. (New) A method as set forth in claim 239, wherein said step of combining comprises obtaining a first set of information including first location information and first time information for said wireless mobile station, obtaining a second set of information including second location information and second time information for said wireless mobile station, determining a time difference between said first and second sets of information, and adjusting one of said first and second sets of information based on said time difference.

241. (New) A method as set forth in claim 240, wherein said adjusting comprising calculating one of a change in position and a value related to an uncertainty in position dependent on said time difference.

242. (New) A method as set forth in claim 239, wherein said step of combining comprises obtaining a first set of position information including a position and first value related to an uncertainty, obtaining a second set of information including a position and second value related to an uncertainty and combining said first set and said second set to yield a third set including a position and an uncertainty for said wireless station, wherein said third set includes a reduced uncertainty relative to said first and second sets.

243. (New) A method as set forth in claim 239, wherein said first location finding technology involves a first location finding controller for receiving first location data from a first source and determining, using said first data, one or more geometric extents for a location of the first mobile station and a value related to an uncertainty of said one or more geometric extents to provide said first location input, and said second location finding technology involves obtaining second location data from a second source and determining, using said second data, one or more geometric extents for a location of the first mobile station and a value related to an uncertainty of said one or more geometric extents to provide said second location input, and said step of combining comprises obtaining said first data from said first source, obtaining said second data from said second source, and said step of combining further comprises using one of said first data and said second data to obtain derived location information.

244. (New) A method as set forth in claim 221, further comprising the step of obtaining tracking information regarding movement of said wireless station, and using said tracking information to derive location information.

245. (New) A method for estimating, for each mobile station M of a plurality of mobile stations, an unknown terrestrial location, L_M, for M using wireless signal measurements obtained from transmissions between said mobile station M and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations is substantially co-located with one or more of a transmitter and a receiver for wirelessly communicating with said mobile station M, comprising:

initiating a plurality of requests for information related to the location of said mobile station M, the requests provided to each of at least two mobile station location evaluators, wherein there is at least a first of the requests provided to a first of the location evaluators and a second of the requests, different from the first request, provided to a second of the location evaluators, such that when said location evaluators are supplied with corresponding input data having values obtained using wireless signal measurements obtained via two way wireless communication between said mobile station M, and the communication stations, each of said first and second location evaluators determine corresponding location information related to L_M, and

wherein for at least one location L of one of the mobile stations, said first location evaluator and said second location evaluator output, respectively, first and second position information related to the one mobile station being at L wherein neither of the first and second position information is dependent upon the other;

obtaining a first collection of location information of said mobile station M, wherein the first collection includes first location information from the first location evaluator, and second location information from the second location evaluator;

determining resulting information related to the location L_M of the mobile station M, wherein the resulting information is dependent on geographical information in each of the first and second location information; and

transmitting, to a predetermined destination via a communications network, the resulting information.

246. (New) The method of Claim 245, further including the following steps:

second obtaining, from an additional one or more of the location evaluators, a second collection of location information using values obtained from wireless signal measurements for a time different from a time of the communications between the mobile station M and the communication stations for obtaining the first collection;

determining, as part of said resulting information, a resulting location estimate of the mobile station M, wherein said resulting location estimate is dependent upon a value obtained from said second collection of location estimates.

247. (New) A method for locating mobile stations at one or more unknown terrestrial locations using wireless signal measurements obtained from transmissions between said mobile stations and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile stations, comprising:

receiving, from a plurality of location requesting sources, a plurality of input requests for locations of the mobile stations, wherein for each of the input requests there is a corresponding destination for a responsive output;

for each of the input requests, providing one or more location requests for location information, related to a location of one of said mobile stations, to one or more mobile station location determining sources;

first obtaining, in response to a first of the location requests received from a first of the requesting sources, at least first location information of a first location of a first of said mobile stations, said first location information determined using a first set of one or more wireless location techniques;

first determining, using said first location information, first output location data according to a first output criteria for the corresponding destination for the first request, said first output location data including a representation identifying a first geographical range of the first location;

second obtaining, in response to a second of the location requests received from a second of the requesting sources, at least second location information of a second location of a second of said mobile stations, said second location information determined using a second set of one or more wireless location techniques, wherein the second set determines the second location information by activating at least one computational module for locating the second mobile station that is not activated for determining the first location information;

second determining, using said second location information, second output location data according to a second output criteria for the corresponding destination for the second request, said second output location data including a representation identifying a geographical range of the second location;

wherein for at least one of said first and second output criteria, there is an output criteria for another of the location requests that is different from said at least one output criteria;

first transmitting said first output location data to its corresponding destination via a communications network; and

second transmitting said second output location data to its corresponding destination via a communications network, the first and second locations being different

248. (New) The method of Claim 247, wherein for at least one of said location techniques of said first set, and for a different one of said location techniques of said second set there is a common predetermined interface at which said first and second location information are received.

249. (New) The method of Claim 247, wherein said steps of first and second determining use at least one common mobile station location related component for determining, respectively, said first output location data and said second output location data

250. (New) The method of Claim 247, wherein said steps of first and second transmitting includes outputting said first and second output location data via a common predetermined network interface.

251. (New) The method of Claim 247, wherein said first determining step includes accessing mobile station location output frequency information of said first output criteria.

252. (New) The method of Claim 247, wherein said first determining step includes determining a coarse location estimate of the first mobile station as a portion of said first output location data, wherein a subsequent location estimate of the first mobile station is an improvement thereof.

253. (New) The method of Claim 247, wherein at least one of said first determining and said first transmitting steps includes determining a particular protocol for outputting said first output location data on the communication network for transmission to the corresponding destination for the first location request.

254. (New) The method of Claim 247, wherein said first output criteria includes information for determining said representation of said first geographical range using a location of a known geographical feature different from the communication stations.

255. (New) The method of Claim 254, wherein the known geographical feature includes a roadway, and said determining step includes snapping to the roadway.

256. (New) The method of Claim 247, wherein said corresponding destination for said first location request is for a first application, and said corresponding destination for said second location request is for a second application, wherein said first and second applications, respectively, use said first and second output location data differently.

257. (New) The method of Claim 256, wherein said first and second applications are for corresponding different ones of the following: responding to emergency calls, tracking, routing, people and animal location including applications for confinement to or exclusion from certain areas, parolee surveillance, responding a mobile station user's request for the user's location.

258. (New) The method of Claim 256, wherein said first output criteria includes information for determining a first location granularity at which a location estimate of the first mobile station is transmitted in said first output location data, wherein said first location granularity is dependent upon said first application.

259. (New) The method of Claim 256, wherein said first output criteria includes information for determining a first representation for said first output location data, wherein said first representation is dependent upon said first application, and said second output criteria includes information for determining a second representation for said second output location data, wherein said second representation is dependent upon said second application.

260. (New) The method of Claim 247, wherein a first predetermined collection of computational components performs said steps of receiving, providing, first obtaining, first determining, second obtaining, second determining, first transmitting, and second transmitting, and wherein a second predetermined collection of computational components performs said steps of receiving, providing, first obtaining, first determining, second obtaining, second determining, first transmitting, and second transmitting;

wherein for at least one of said steps of receiving, providing, first obtaining, first determining, second obtaining, second determining, first transmitting, and second transmitting, there are different components in said first predetermined collection and said second predetermined collection for performing said at least one step, and said first predetermined collection transmits the first request to said second predetermined collection.

261. (New) The method of Claim 260, wherein said first predetermined collection includes a first location center, and said second predetermined collection includes a second location center.

262. (New) The method of Claim 247, wherein at least one of said steps of receiving, first obtaining, second obtaining, first transmitting, and second transmitting receives or transmits wireless location related information on TCP/IP network.

263. (New) The method of Claim 247, wherein said step of first obtaining includes receiving a first location estimate from a first of said location determining sources which performs an instance, I_1, of a first technique for estimating a location of the first mobile station using signal transmissions to the first mobile station from non-terrestrial transmitters, wherein said instance I_1 also uses wireless signals, S, between the first mobile station and at least one of the communication stations to improve at least one performance characteristic of said instance I_1 over a performance of I_1 without use of the wireless signals between the first mobile station and the at least one communication station.

264. (New) The method of Claim 263, wherein the instance I_1 uses first information for locating the first mobile station, wherein the first information is dependent upon signal timing measurements from the wireless signals S.

265. (New) The method of Claim 263, wherein the instance I_1 uses first information from the wireless signals S, wherein the first information is dependent upon a wireless coverage area of the at least one communication station.

266. (New) The method of Claim 247, further including a step of providing display information for displaying a representation of a location estimate L of the first mobile station, wherein said display information is for displaying a map of an area having the location estimate L, and for concurrently displaying information indicating an accuracy of the location estimate L.

267. (New) The method of Claim 266, wherein said display information is displayed at a mobile station M that has requested a location of the first mobile station.

268. (New) A method for locating a first and second wireless mobile stations using measurements of wireless signals, wherein at least one of: (i) said measurements, and (ii) said wireless signals are transmitted between the first mobile station and at least one of a plurality of terrestrial transceivers, and between the second mobile station and at least one of a plurality of terrestrial transceivers, wherein said transceivers are capable of at least wirelessly detecting a plurality of wireless transmitting mobile stations, including said first and second mobile stations, comprising:

providing access to first and second different mobile station location techniques, wherein each of said location techniques is capable of providing location information for each mobile station of at least some of said mobile stations when said location technique is supplied with corresponding data obtained from wireless signal measurements communicated between the mobile station and one or more of said plurality of transceivers, wherein for at least one location L of one of the mobile stations, said first location technique and said second location technique output, respectively, first and second position information related to the one mobile station being at L wherein neither of the first and second position information is dependent upon a change in the other;

first supplying said first location technique with first corresponding data obtained from wireless signal measurements communicated between one or more of: (a1) said first mobile station and one or more of said plurality of transceivers, and (a2) said second mobile station and one or more of said plurality of transceivers;

second supplying said second location technique with second corresponding data obtained from wireless signal measurements communicated between one or more of: (b1) said first mobile station and one or more of said plurality of transceivers, and (b2) said second mobile station and one or more of said plurality of transceivers;

first receiving from said first location technique, first location related information representing one or more of: a first range of locations for the first mobile station, and a second range of locations for the second mobile station;

second receiving from said second location technique, second location related information representing one or more of: a third range of locations for the first mobile station, and a fourth range of locations for the second mobile station;

determining resulting location information for each of the first and second mobile stations using at least one of: (c1) a first value obtained from said first location related information, and (c2) a second value obtained from said second location related information;

wherein there is at least one predetermined common location related component activated for determining the resulting location information for each of said first and second mobile stations, wherein:

(i) said common component is activated, for locating said first mobile station, after at least one step of said steps of first and second supplying, and

(ii) said common component is activated, for locating said second mobile station, after at least one step of said steps of first and second supplying;

providing said resulting location information for each of the first and second mobile stations for presentation, wherein said presentation for at least one of said first and second mobile stations is determined according to an expected accuracy of said resulting location information

269. (New) A method for locating a wireless mobile station, comprising:

repeatedly performing the following steps (A1) through (A3) for tracking the mobile station, wherein there is at least a first and a second mobile station location technique, each of the location techniques providing an instance of location information for a location of the mobile station to the step (A1) below at some time during said step of repeatedly performing;

wherein for at least one location L of the mobile station, said first mobile station location technique and said second mobile station location technique output location information instances having, respectively, first and second position information for the mobile station being at L, wherein neither of the first and second position information varies substantially as a result in a change in the other;

(A1) receiving an instance, I_1, of location information for the mobile station from at least one of the first and a second mobile station location techniques wherein I_1 includes position information for the mobile station;

(A2) determining at least one resulting instance of location information for said mobile station using at least one of: (a) a first value obtained from an instance of first location information received from said first location technique, and (b) a second value obtained from an instance of second location information received from said second location technique;

wherein said step of determining includes a step of determining a likely roadway upon which the mobile station is located;

(A3) outputting said resulting location information for display on a display device, wherein said resulting location information is displayed as at least one location of the mobile station on a map having roadways thereon.

270. (New) The method of Claim 269, wherein at least one occurrence of said step of outputting includes transmitting said resulting location information via a telephony network.

271. (New) The method of Claim 269, wherein said outputting step includes providing accuracy information indicating an accuracy of said resulting location information, wherein said accuracy information is displayed with said at least one location of the mobile station.

272. (New) The method of Claim 269, wherein for at least one location of the mobile station said step of determining uses both said first and second values.

273. (New) The method of Claim 269, wherein said first location technique includes a step of using wireless signals, S, between the first mobile station and at least one terrestrial transceiver to improve upon of said first location information over a performance of said first location technique without using the wireless signals between the first mobile station and the at least one terrestrial transceiver.

274. (New) The method of Claim 273, wherein said first location technique includes a step of using information dependent upon a wireless coverage area of the at least one transceiver for improving said first location information

275. (New) The method of Claim 274, wherein the at least one transceiver includes a base station for providing two way communication with the mobile station.

276. (New) A method for locating, from a plurality of wireless mobile stations, one of the wireless mobile stations using measurements of wireless signals, wherein at least one of: (i) said measurements and (ii) said wireless signals are transmitted between said one mobile station and at least one of a plurality of fixed location communication stations, each communication

station capable of at least one of receiving wireless signals from, and transmitting wireless signals to said one mobile station, comprising:

receiving, from each of at least first and second mobile station location estimators, corresponding first and second information related to a likely geographical approximations for a location of said one mobile station, wherein: (a) for determining a likely geographical approximation, GA_A, for a location, L_A, of a second of the mobile stations at a time T_A, said first location estimator generates GA_A without requiring a prior likely geographical location approximation generated by said second location estimator for locating the second mobile station at substantially the location L_A at substantially the time T_A, and, (b) for estimating a likely geographical approximation, GA_B, for a location, L_B, of a third one of the mobile stations at a time T_B, said second location estimator generates GA_B without requiring a prior likely geographical location approximation generated by said first location estimator for locating the third mobile station at the location L_B at substantially the time T_B;

determining a resulting location estimate of said one mobile station, wherein said step of determining includes at least one of the substeps (B1) through (B2) following:

(B1) when said first and second information include, respectively, first and second likely geographical approximations, combining said first and second likely geographical approximations so that said resulting location estimate is dependent on each of said first and second location likely geographical approximations; and

(B2) selecting one of said first and second information for receiving preference in determining said resulting location, wherein said selecting is dependent upon location related data in at least one of said first and second information.

277. (New) The method of Claim 276, further including a step of providing display information for: (a) displaying a representation of said resulting location estimate, wherein said display information is for displaying with a map of an area having the resulting location estimate, and (b) concurrently displaying information indicative of an accuracy of the resulting location estimate.

278. (New) A method for locating a wireless mobile station capable of wireless two way communication with a plurality of fixed location terrestrial stations, comprising:

providing access to a plurality of mobile station location estimating techniques, wherein said location techniques provide location information related to said mobile station when said location techniques are supplied with corresponding input information upon which their location estimates are dependent, and wherein the corresponding input information is at least partially derived from measurements of wireless signals transmitted from or received at the mobile station;

receiving, over time, a plurality of location estimates of the mobile station:

determining, a plurality of consecutive resulting location estimates for tracking the mobile station, wherein said step of determining includes steps (a) and (c) following:

(a) deriving, for at least one time during the tracking, a corresponding one of said resulting location estimates of the mobile station using one of said first one or more location estimates by said first location technique for a first location of the mobile station;

(b) deriving, for at least one time during the tracking, a corresponding one of said resulting location estimates of the mobile station using one of said second one or more location estimates by said second location technique for a second location of the mobile station;

(c) preferring a location estimate of said first location information over a location estimate of said second location information when both are available for substantially a same location of the mobile station.

279. (New) The method as claimed in Claim 278, wherein said step of determining includes:

establishing a priority between a location estimate of said first location information and a location estimate of said second location information.

280. (New) The method as claimed in Claim 279, wherein said step of establishing includes obtaining a confidence value for one or more of: (a) at least one of said location estimates for said first location information; and (b) at least one of said location estimates for said second location information;

wherein each said confidence value is indicative of a likelihood of the mobile station having a location represented by said corresponding location estimate for the confidence value.

281. (New) The method of Claim 278, further including a step of:

providing communication between the mobile station and another party via at least one of the terrestrial stations, wherein the communication travels through a telephony network.

282. (New) The method of Claim 278, further including the steps of:

requesting one or more of the resulting location estimates via signals transmitted by a commercial mobile radio service provider that wirelessly communicates with the mobile station;

transmitting, via a communication network, at least one location of the mobile station to one of: the mobile station, another mobile station, a police unit, a vehicle, and a party requesting the location of the mobile station.

283. (New) The method of Claim 278, wherein said determining step includes determining at least one of said resulting location estimates as a function of a position of a known geographical feature that is sufficiently close to one of the first or second location estimates so that the closeness is used to determine said more likely location estimate.

284. (New) The method as claimed in Claim 278, wherein said step of determining includes, for at least one of said resulting location estimates, determining one or more of: (a) a velocity of the mobile station, (b) an acceleration of the mobile station, and (c) one or more geographical features near said at least one resulting location estimate.

285. (New) A method for locating a mobile station using wireless signal measurements obtained from transmissions between said mobile station and a plurality of fixed location communication stations, wherein each of said communications stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile station, comprising:

providing access to first and second mobile station location evaluators, wherein said location evaluators are able to determine information related to one or more location estimates of said mobile station when said location evaluators are supplied with data having values obtained during wireless signal two way communication between said mobile station and the communication stations;

wherein for at least one location L of the mobile station, said first mobile station location evaluator and said second mobile station location evaluator output location information instances having, respectively, first and second position information for the mobile station being at L, wherein neither of the first and second position information substantially changes with a change in the other of the first and second position information;

first obtaining, from said first location evaluator, first location related information for identifying a location of the mobile station for at least one of the following situations: a tracking of the mobile station, and in response to a request for a location of the mobile station;

second obtaining, from said second location evaluator, second location related information for identifying a location of the mobile station for said same at least one situation;

determining additional location information of the mobile station dependent upon at least one of: (a) a first value obtained from said first location related information, and (b) a second value obtained from said second location related information;

wherein said determining step includes providing the additional location information with:

(i) data indicative of one of: an error and a likelihood of the mobile station being at a location represented by said additional location information; and

(ii) a timestamp indicative of when the resulting location information corresponds to a location of the mobile station.

286. (New) The method as claimed in Claim 285, wherein said mobile station is co-located with a processor for activating at least one of said location evaluators.

287. (New) The method of Claim 285, further including a step of transmitting said resulting location estimate on a communications network to a destination requesting the location of the mobile station.

288. (New) The method of Claim 285, further including a step of determining, using said resulting location information, output location information according to output criteria corresponding to an application requesting data related to a location of the mobile station.

289. (New) The method of Claim 288, wherein said output criteria includes at least some of:

(a) a transmission protocol;

(b) a granularity of by which a location estimate of the mobile station represented by said resulting location information is to be provided;

(c) a frequency with which repeated location estimates of the mobile station are to be output to the application;

(d) destination data for determining where said resulting location information is to be transmitted;

(e) an indication as to whether a location estimate of the mobile station is to be adjusted according to a known geographical feature different from the communication stations; and

(f) a desired representation of a location estimate of the mobile station represented by said resulting location information.

290. (New) A method for locating one or more mobile stations using wireless signal measurements obtained from transmissions between said mobile stations and a plurality of terrestrial communication stations, wherein each of said communication stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile stations, comprising:

receiving a location request for a location of a first of the mobile stations, wherein the first mobile station is capable of providing wireless telephony transmissions, and a substantially same collection of components are in electronic contact with one another for performing each of at least most wireless telephony transmissions from the first mobile station;

generating one or more messages, for information related to a location of said first mobile station, said messages for requesting activation of one or more mobile station location estimators such that when said location estimators are supplied with corresponding input data having values obtained from wireless signal measurements obtained via transmissions between said first mobile station and the communication stations, said one or more location estimators determine location related information for the first mobile station;

first obtaining, from at least two of said location estimators, first mobile station related location information obtained as a result of an available at least two instances of said corresponding input data;

determining a resulting location estimate of the first mobile station obtained from said first mobile station related location information;

wherein at least one of said steps of generating, first obtaining, and determining includes a substep of one of: (i) transmitting information to a destination via a communication network, and (ii) receiving information from a source via a communication network;

using said resulting location information, to determine output location information according to output criteria corresponding to an application requesting data related to a location of the mobile station, wherein said output criteria includes at least some of:

(a) a transmission protocol;
(b) a granularity of by which a location estimate of the mobile station represented by said resulting location information is to be provided;
(c) a frequency with which repeated location estimates of the mobile station are to be output to the application;
(d) destination data for determining where said resulting location information is to be transmitted;
(e) an indication as to whether a location estimate of the mobile station is to be adjusted according to a known geographical feature different from the communication stations; and
(f) a desired representation of a location estimate of the mobile station represented by said resulting location information.

291. (New) A method for locating a mobile station using wireless signal measurements obtained from transmissions between said mobile station and at least one of a plurality of terrestrial transceivers capable of wirelessly detecting said mobile station, comprising:

providing access to at least two of the location techniques;

determining whether an accessible first of the location techniques has its corresponding input available for determining a first location estimate of said mobile station;

determining a second location estimate of said mobile station by activating an accessible second of said location techniques different from said first location technique when the corresponding input for said second technique is available;

receiving at least one of said first and second location estimates;

obtaining resulting location information for transmitting on a communications network, wherein said resulting location information is obtained using at least one of said first location estimate and said second location estimate;

wherein when said mobile station is at a first location, an instance of at least said first location estimate is used in said obtaining step for obtaining a first corresponding instance of said resulting location information, and when said mobile station is at a second location, an instance of at least said second location estimate is used in said obtaining step for obtaining a second corresponding instance of said resulting location information; and

wherein for the first location, the corresponding performance of said obtaining step includes: (1) a step of improving upon said instance of at least said first location estimate, and (2) a step of providing information indicative of an accuracy of said first corresponding instance of said resulting location information.

292. (New) A mobile station location system, comprising:

a gating module for communicating with two or more mobile station location estimating sources for determining corresponding geographic extents for locations of a plurality of mobile stations, such that for each mobile station M of at least some of the mobile stations, when said one or more estimating sources are supplied with corresponding data obtained from measurements of wireless signals transmitted between the mobile station M, and at least one of (1) and (2) following:

(1) a plurality of communication stations capable of at least one of: wirelessly detecting said mobile stations, and being wirelessly detected by said mobile stations, and

(2) one or more non-terrestrial wireless signal transmitting stations,

then for said one or more location estimating sources supplied with their corresponding data, each such source outputs a corresponding geographic extent of a geographical location of the mobile station M;

wherein for a first of said mobile station location estimating sources, when estimating a location of one of the mobile stations, and for a second of said mobile station location estimating sources, and for at least one instance of locating one of the mobile stations, said first and second sources provide different geographic extents;

wherein said gating module communicates on a communications network with at least the first of the location estimating sources for providing said location system with said corresponding geographic extent for a location L of the mobile station M; and

a resulting estimator for determining a likely location estimate of the location L of the mobile station M using two or more of said corresponding geographic extents for the mobile station M, said resulting estimator activating at least one of: (i) a selector for giving preference, as

more indicative of the location L, to at least one geographic extent obtained from said corresponding geographic extents, and (ii) a combiner for combining said two or more corresponding geographic extents for obtaining said likely location estimate.

293. (New) The location system, as claimed in Claim 292, wherein one or more of said estimating sources are capable of being at least one of: added, replaced and deleted by transmissions on a communication network between a portion of said location system and a site remote from said portion.

294. (New) The location system as claimed in Claim 292, wherein one or more of:

(a) at least one of said one or more corresponding geographic extents, GE, has a corresponding value therewith indicative of a likelihood that the mobile station M resides in a geographical area represented by GE, and said combiner uses said corresponding value for obtaining said likely location estimate;

(b) said gating module activates a wireless transceiver for communicating with the plurality of communication stations;

(c) said plurality of communication stations includes base stations for wireless two way communication with said mobile stations;

(d) said non-terrestrial wireless signal transmitting stations include GPS satellites;

(e) said communications network includes a portion of the Internet;

(f) the mobile station M has an ability to communicate with other of the mobile stations as a base station;

(g) said selector includes a filter for reducing a dependence of said likely location estimate on one of the corresponding geographic extents;

(h) said resulting estimator is at least partially included in a mobile base station;

(i) said resulting estimator resides at a location center;

(j) said gating module resides at a location center;

(k) said gating module routes activation information to said two or more estimating sources; and

(l) said gating module resides at a mobile station.

295. (New) A mobile station location system, comprising:

a communications controller for selectively communicating with a plurality of mobile station location estimating sources for at least one of (1) and (2) following:

(1) activating a selected one or more of said mobile station location estimating sources; and

(2) receiving location related information for locating a plurality of mobile stations;

wherein for each mobile station M of at least some of the mobile stations, when one or more of said location estimating sources are supplied with corresponding data obtained from measurements of wireless signals transmitted between (i) and (ii) following:

(i) the mobile station M, and

(ii) at least one of: a network of communication stations cooperatively linked for use in locating the mobile stations, and one or more non-terrestrial wireless signal transmitting stations,

then each such source supplied with its corresponding data, outputs a corresponding location estimate of a geographical location of the mobile station M;

wherein for a first of said mobile station location estimating sources, when estimating a location of one of the mobile stations, said first source is dependent upon a result from a first component, and for a second of said mobile station location estimating sources, when estimating a location of one of the mobile stations, said second source is dependent upon a result from a different second component, wherein for at least one instance of locating one of the mobile stations, said first and second sources provide different location estimates;

an interface in communication with said controller, said interface for communicating on a communications network with at least one of said first and second location estimating sources for thereby at least one of (3) and (4) following:

(3) requesting activation of said at least one location estimating source, and

(4) receiving, from said at least one location estimating source, said corresponding location estimate of the mobile station M;

a resulting estimator for determining a likely location estimate of a location L of the mobile station M using two or more of said corresponding location estimates for the mobile station M at L, wherein said resulting estimator includes at least one of:

(i) a selector for giving preference, as more indicative of the location L, to at least one preferred location estimate obtained from said corresponding location estimates; and

(ii) a combiner for obtaining said likely location estimate as a function of said two or more of said corresponding location estimates.

Issue Classification	Application/Control No.	Applicant(s)/Patent under Reexamination	
	09/770,838	DUPRAY ET AL.	
	Examiner	Art Unit	
	Dao L. Phan	3662	

ISSUE CLASSIFICATION

ORIGINAL		CROSS REFERENCE(S)							
CLASS	SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)						
342	450	342	457						
INTERNATIONAL CLASSIFICATION									
G 0 1 S	3/02								
	/								
	/								
	/								
	/								

(Assistant Examiner) (Date)	(Primary Examiner) (Date) 4/19/07	Total Claims Allowed: 75	
(Legal Instruments Examiner) (Date)		O.G. Print Claim(s): 56	O.G. Print Fig.: 5

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	211	21	241	51	271		301		331		361		391
	212	22	242	52	272		302		332		362		392
	213	23	243	53	273		303		333		363		393
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12	232	42	262	72	292		322		352		382		412
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18	238	48	268		298		328		358		388		418
19	239	49	269		299		329		359		389		419
20	240	50	270		300		330		360		390		420

U.S. Patent and Trademark Office

Part of Paper No. 20070419

Issue Classification	Application/Control No.	Applicant(s)/Patent under Reexamination
	09/770,838	DUPRAY ET AL.
	Examiner	Art Unit
	Dao L. Phan	3662

ISSUE CLASSIFICATION

ORIGINAL		CROSS REFERENCE(S)							
CLASS	SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)						
342	450	342	457						
INTERNATIONAL CLASSIFICATION									
G 0 1 S	3 / 02								
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	/								
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(Assistant Examiner) (Date)	DAO PHAN PATENT EXAMINER 4/19/07	Total Claims Allowed: 75	
(Legal Instruments Examiner) (Date)	(Primary Examiner) (Date)	O.G. Print Claim(s) 56	O.G. Print Fig. 5

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
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	2		32		62		92		122		152		182
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	28		58		88		118		148		178		208
	29		59		89		119		149		179		209
	30		60		90		120		150		180		210

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Bib Data Sheet

CONFIRMATION NO. 8410

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
09/770,838	01/26/2001 RULE	342	3662	1003-1

APPLICANTS

Dennis J. Dupray, Golden, CO;
Charles L. Karr, Tuscaloosa, AL;

** CONTINUING DATA *************************

THIS APPLICATION IS A CON OF 09/194,367 11/24/1998
WHICH IS A 371 OF PCT/US97/15892 09/08/1997
WHICH CLAIMS BENEFIT OF 60/056,590 08/20/1997
WHICH CLAIMS BENEFIT OF 60/044,821 04/25/1997
WHICH CLAIMS BENEFIT OF 60/025,855 09/09/1996

** FOREIGN APPLICATIONS ********************

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	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☐ yes ☑ no 35 USC 119 (a-d) conditions met ☐ yes ☑ no ☑ Met after Allowance Verified and Acknowledged ____ Examiner's Signature ____ Initials	CO	62	96	5

ADDRESS

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden ,CO 80401

TITLE

A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

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Search Notes

Application/Control No.	Applicant(s)/Patent under Reexamination	
09/770,838	DUPRAY ET AL.	
Examiner	**Art Unit**	
Dao L. Phan	3662	

SEARCHED

Class	Subclass	Date	Examiner
342	357.01	3/6/2003	DP
	357.06		
	450		
	453		
	463-465		
	457		
455	456.2		
	456.6		
updated		8/23/2003	DP
updated		4/13/2004	DP
updated		6/7/2006	DP
updated		4/18/2007	DP

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner
PGPub text search-See interference search printout		6/7/2006	dp

SEARCH NOTES (INCLUDING SEARCH STRATEGY)

	DATE	EXMR
East text search (See search history printout)	6/7/2006	DP
updated	4/18/2007	dp

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	Group Art Unit: 3662
	)	
Dupray et al.	)	Confirmation No.: 8410
	)	
Serial No.: 09/770,838	)	Examiner: PHAN, DAO LINDA
	)	
Filed: January 26, 2001	)	SUPPLEMENTAL INFORMATION
	)	DISCLOSURE STATEMENT
Atty. File No.: 1003-1	)	
	)	Electronically Submitted
For: GATEWAY AND HYBRID	)	
SOLUTIONS FOR WIRELESS	)	
LOCATION	)	

Mail Stop Amendment
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Dear Sir:

The references cited on attached Form PTO-SB08 are being called to the attention of the Examiner.

☒ Copies of the cited non-patent and/or foreign references are enclosed herewith.

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☐ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English abstracts and in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☒ Examiner's attention is drawn to the following co-pending applications, copies of which have been or are being submitted:

Serial No. 10/262,413 filed 09-30-2002, now U.S. Patent Publication No. 2003/0222820 (Attorney's Ref. No. 1003-2);

Serial No. 10/262,338 filed 09-30-2002, now U.S. Patent Publication No. 2003/0146871 (Attorney's Ref. No. 1003-3);

Serial No. 11/739,097 filed 04-24-07 (Attorney's Ref. No. 1003-4);

Serial No. 11/069,441 filed 3-1-05 (Attorney's Ref. No. 1004-1-1);

Serial No. 09/176587 filed 10-21-1998 (Attorney's Ref. No. 1005);

Serial No. 10/297,449 filed 12-06-2002 (Attorney's Ref. No. 1010-PUS);

Serial No. 11/464,880 filed 08-14-06 (Attorney's Ref. No. 1010-1); and

Serial No. 10/337,807 filed 01-06-2003, now U.S. Patent Publication No. 2004/0198386 (Attorney's Ref. No. 1011).

☐ Other:____

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

It is respectfully requested that the cited information be made of record therein in the present application.

Respectfully submitted,

By: [signature]

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(303) 863-9700

Date: Aug. 1, 2007

Substitute for form 1449A/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application Number	09/770,838
	Filing Date	01-26-2001
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	PHAN, DAO LINDA
Sheet 1 of 1	Attorney Docket Number	1003-1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	5,045,852	09/03/91	Mitchell et al.	
	2	5,045,861	09/03/91	Duffett-Smith	
	3	5,233,541	08/03/93	Corwin et al.	
	4	5,373,456	12/13/94	Ferkinhoff et al.	
	5	5,402,524	03/28/95	Bauman et al.	
	6	5,513,243	04/30/96	Kage	
	7	5,581,490	12/03/96	Ferkinhoff et al.	
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	9	5,831,977	11/03/98	Dent	
	10	5,930,717	07/27/19	Yost et al.	
	11	5,938,721	08/17/99	Dussell et al.	
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	16	09/176587		DUPRAY (10-21-1998)	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	17	WO 96/20542	07/04/96	STANFORD TELECOMM INC		

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

Examiner Initials*	Cite No.[1]	
		"Amendment After Allowance, Application Serial No. 09/176,587 AMENDMENTS TO THE CLAIMS", filed April 3, 2007, 33 pages (Attorney's Ref. No. 1005)
		"AMENDMENT AND RESPONSE TO OFFICE ACTION DATED MAY 5, 2006 IN THE CLAIMS:", filed November 30, 2006, 27 pages (Attorney's Ref. No. 1003-3)

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

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(51) International Patent Classification 6 : H04B 15/00, H04K 1/00, H04L 27/30, H04J 3/12, G01S 13/00, H04Q 7/00, 9/00

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(74) Agent: ZEGEER, Jim; 801 North Pitt Street #108, Alexandria, VA 22314 (US).

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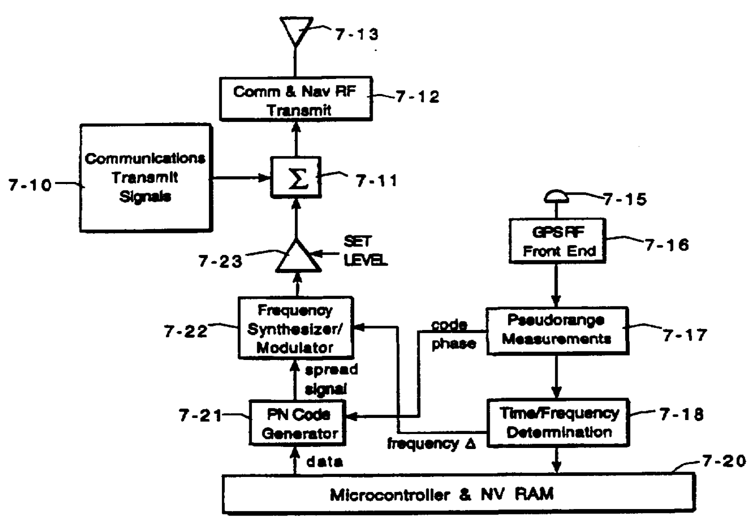
(54) Title: POSITION ENHANCED COMMUNICATION SYSTEM



(57) **Abstract**

A cellular telephone system (figure 1) having three or more cell sites with each cell site having a source of cellular communication signals (7-10) and an RF transmitter (7-12) and antenna (7-13) for broadcasting the cellular communication signals. A direct sequence spread spectrum waveform carrying navigation signals is embedded in the cellular communication signals, including controlling the signal strength of the navigation signals so that the combined energy of the navigation signals from all cell sites at any location is at least a predetermined energy level below the energy level of the cellular communication signals. Each cell site includes timing for timing the operation of a GPS receiver.

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Position enhanced communication system

BACKGROUND OF THE INVENTION:

Wireless communications are rapidly augmenting conventional telephone communications. In conventional telephone communications, emergency 911 service has been in existence for a number of years and has evolved and been upgraded over time. Currently, from most wired telephone systems, an "Enhanced 911" service is available. In Enhanced 911 service, the emergency center receiving the call automatically learns the phone number, location and identity of the calling party. Such information is necessary for rapidly dispatching the required help to the correct location, and for call-back to the party that reported the emergency, if required. Indeed, Enhanced 911 is so common, that there is an expectation and assumption by the public, that such service is available in the wireless world. However, at the current time, Enhanced 911 service does not exist for cellular telephony which is the most mature wireless communication system in the United States. At the current time, an emergency center that receives a call dialed from a cellular telephone, has no idea where the party is calling from and does not know the phone number or identity of the phone subscriber. Furthermore, there exists no infrastructure or standard for providing Enhanced 911 service in cellular and other wireless communications systems.

Determining the position of the calling terminal making a wireless call is a key requirement for providing Enhanced 911. A number of alternatives for determining position of a caller are based upon the calling terminal estimating its position with the support of auxiliary equipment and/or the use of broadcast RF beacons. Available options for position location at the calling terminal are as follows:

1. Broadcast Navigation RF Beacons: GPS and Loran are two examples.

2. Commercial Broadcasts as Navigation Beacon Surrogates: such as using the broadcasts of AM, FM or TV for determining position. (See, for example, U.S. Serial No. 08/203,257, and PCT Application No. PCT/US93/12179, incorporated herein by reference)

3. Base Station to Mobile/Portable Terminal Broadcasts as Navigation Beacon Surrogates: such as using the broadcasts from multiple cellular base stations.

4. Dead Reckoning and other forms of Inertial Navigation: such as using the speedometer output of a vehicle in combination with a gyroscope to detect turns.

Because of the variety of wireless environments and services, none of these options provides a universal solution for determining position of the calling terminal. For example, in the cellular world, there are two distinctly different environments for mobiles and portables. Mobile terminals are defined as those that are installed in and operate from vehicles. Thus the locations for the mobile environment are restricted to places that a vehicle may go. Portable terminals are defined as hand-held devices and so portables will be used anywhere that a person may go with or without a vehicle. Thus mobiles and portables are different insofar as the places that they are required to operate in. Mobiles must work primarily on streets and highways where there is often a clear view of the GPS constellation; and when there is not, such as in the "urban canyon," GPS position fixing is still possible, albeit on an interrupted basis. Portables however, will be used inside buildings, shopping malls, and parking garages where cellular communications signals penetrate, but GPS signals do not. Furthermore, mobiles (unlike portables) are not particularly constrained with respect to size and power; thus, the vehicle that hosts the mobile can support the power required for continuous position fixing; they can support the equipment needed for dead reckoning; and finally, they provide a platform on which to attach antennas (i.e., GPS) that must be mounted in a fixed orientation.

DESCRIPTION OF THE INVENTION:

The object of this invention is to provide a system with world-wide capability for position determination via broadcast of RF navigation signals.

The overall system comprises the following three elements: 1) the GPS system, 2) GPS-like signals broadcast at an alternative frequency, and 3) GPS-like RF signposts.

The first element of the system, GPS, provides world-wide positioning as long as the view to the GPS constellation is not obstructed. With GPS, a receiver determines its position by measuring the pseudorange of spread spectrum signals broadcast by the GPS satellites at 1575.42 MHz.

The second element is the novel concept embedding GPS-like signals within the communications bandwidth of a wireless communications systems. This is similar to the concept of GPS pseudolites that have been proposed for aviation navigation, but the navigation signals proposed here are not at GPS frequencies.

Rather they are at and share the same bandwidth with communications frequencies. The concept is flexible so that a variety of existing communications systems can have embedded navigation signals. Because of its widespread implementation, the US cellular telephone system is a particularly attractive environment for embedding navigation signals. However, the concept of embedded navigation signals applies to digital TDMA and CDMA cellular, GSM, and emerging systems in the PCS bands as well as those that operate in the ISM bands. The position determination supported by this second element serves as a supplement or replacement of the GPS system in any region or environment that is covered by that wireless communication system. This includes the urban canyon, but also indoor environments such as shopping malls and buildings which are serviceable by cellular telephone and other wireless communications systems. In this second element, a GPS-like receiver in the mobile/portable communications transceiver makes pseudorange measurements on the broadcast sources and calculates the position of the receiver from these measurements. The operation of this system is described below.

The third element is another novel concept that involves the use of GPS-like RF broadcasts that mark the location of the broadcast. The range of this broadcast is designed to be short (≈ 100 feet) so that the mere reception of this broadcast and reading the data location marker in the signal determines the position of the receiver to within 100 ft. These broadcast signals are referred to as RF Signposts. RF Signposts can be used indoors and can successfully convey address and floor of a building or locations in a shopping mall, etc., while ranging systems that are inherently corrupted by severe multipath in the indoor environment cannot.

DESCRIPTION OF THE DRAWINGS:

The above and other objects, advantages, and features of the invention will become more apparent when considered with the following specification and accompanying drawings wherein:

FIG. 1 is a block diagram of a cellular base station having incorporated therein a navigation signal generator,

FIG. 2 is a diagram depicting the overall system for seamless and comprehensive position locations,

FIG. 3 is a diagram illustrating a mobile terminal taking pseudorange measurements to three cellular telephone base stations,

FIG. 4a is a diagrammatic analysis of the impact of a spread spectrum navigation signal on the signal-to-noise ratio (SNR) of a conventional communications signal,

FIG. 4b is a diagrammatic analysis of the impact of a set of communication signals on the SNR of a navigation signal,

FIG. 5 is an illustration of a mobile terminal in a 7-cell cluster of a cellular communication system,

FIG. 6a is an analysis of the impact of navigation signals on the SNR of a communications signal with the mobile unit being located at Point E in Fig. 5,

FIG. 6b is an analysis of the impact of the communication signals on the SNR of a navigation signal when the mobile unit is located at Point E in fig. 5,

FIG. 6c is an analysis of the impact of a navigation signal from a far base station with the mobile unit at Point F in Fig. 5,

FIG. 7 is a block diagram of one configuration of a navigation signal generator embedded in a cellular base station,

FIG. 8a is a block diagram of a low power RF position signpost,

FIG. 8b is a diagrammatic layout of a large building in which the position signposts are distributed,

FIG. 8c is a diagrammatic layout of a large shopping mall or center where the RF position signposts are distributed at fixed locations,

FIG. 9 is a block diagram of one embodiment of a communication terminal with universal position determination capability.

DETAILED DESCRIPTION OF THE INVENTION:

GPS-like Signals Embedded Within Wireless Communications Systems

Application Serial No. 08/203,257 discloses the use of commercial radio and TV broadcast signals to supplement or even replace GPS positioning in environments where the GPS signals are frequently blocked, or do not penetrate at all. The present invention incorporates another alternative for supplementing or replacing GPS that involves adding a GPS-like navigation signal to the communications broadcasts from cellular and other wireless base station transmitters. As will be shown below, the navigation signal may simultaneously reside in the same frequency band that is used to carry the communications channels. As will be described herein, it is possible to set the navigation (location or position) signal low enough to have no interference impact on the communications, while at the same time, be high enough to be detected, tracked, and support a data rate of 50 bps. Like GPS, the proposed navigation signal is a direct sequence spread spectrum waveform with a chipping rate of 1.023 Mcps and thus occupies a bandwidth (null to null) of about 2 MHz. The chipping phase would be synchronized to a uniform time base and, preferably, is slaved to the GPS system (see fig. 7). The information payload of 50 bps would include such data as the position of the broadcast tower, time markers, and ancillary data to correct phase and frequency offsets of the signal.

The system concept is illustrated in Figure 3 which shows a mobile user MU enclosed or bounded within 3 base stations 10-1, 10-2, 10-3 of a cellular communications system. At any point in time, the mobile unit MU tracks the navigation signals from at least 3 base stations and measures the pseudorange to each of them. Measurements from three base stations are required for a 2D solution and if a 3D solution is desired, then measurements from 4 base stations are required. For the 2D case this may be understood as follows:

- 3 Measurements result in three equations that embody the range from the mobile to the base station; these three equations are:

$$PR_1 = \sqrt{(x_1 - x)^2 + (y_1 - y)^2} + c\Delta$$
$$PR_2 = \sqrt{(x_2 - x)^2 + (y_2 - y)^2} + c\Delta$$
$$PR_3 = \sqrt{(x_3 - x)^2 + (y_3 - y)^2} + c\Delta$$

- The PR_i are the values of the 3 pseudorange measurements, the x_i, y_i are the 2D coordinates of the 3 base stations, and c is the speed of light.
- Each equation shares 3 common unknowns: the x,y coordinates of the mobile, and the uncertainty in the time of measurement (Δ).

Thus the 3 equations are sufficient to solve the 3 unknowns that determine the position and time offset of the mobile. The algorithm for a 3D solution is a simple generalization of the 2D algorithm.

GPS-Like RF Signposts

Like GPS, the RF Signpost navigation signal of this invention is a direct sequence spread spectrum waveform with a chipping rate of 1.023 Mcps and thus occupies a bandwidth (null to null) of about 2 MHz. The chipping phase would not have to be synchronized with any time base so that the cost of an RF Signpost would be very low. As shown in Fig. 8a, the data source 8-1 supplied with position or location information (floor, shops, wing. etc. of a building, or walkway, shops, etc. and direction in a shopping mall) is stored in an EPROM 8-2 or other data storage device encoded 8-3 with a PN code 8-4 and phase modulator 8-5 on a carrier 8-6, and broadcast at very low power by antenna 8-7. The information payload of 50 bps would include, at a minimum, data that conveys the position of the signpost. The position data would include a signpost ID which would map to an address based position (e.g., 100 Simeon Way, 10th floor, suite #1024) and possibly also to a 3D coordinate position. The RF Signposts are of sufficiently low power so that they have a very limited range. The transmission of a Signpost ID would convey the fact that the mobile/portable terminal is within some 100 feet or so of the signpost. The frequency of the RF Signpost broadcast is flexible. In the indoors, the Signposts could actually be at the GPS frequency w/o causing interference to the signals broadcast by the GPS constellation. Signposts can also broadcast at the communications frequencies (of cellular and PCS systems) as well as at ISM frequencies. In addition, Signposts may also be broadcast in signal structures that are different from that of GPS.

Interference Analysis of Embedded Navigation Signals

This section illustrates how navigation signals may be embedded under the communications signals of a communications system without causing any significant mutual interference between the two signals. In Fig. 4, the analysis is shown for broadcasts from a single source. In Fig. 6, the interference analysis is expanded to include broadcasts from multiple base stations within a cellular system. In this discussion, the AMPS cellular telephone communications system is assumed, but the methodology and results are applicable to any similar communications system, both analog and digital. In fact, the invention will work whenever the following constraint can be obeyed:

$$\text{Spreading Gain} > SNR_C \bullet SNR_N$$

Where the spreading gain applies to the embedded SS navigation signal (=43 dB=100 Mcps/50 bps) and SNR_C and SNR_N are the desired signal to noise ratios for the communications and navigation signals, respectively.

Navigation and Communications Broadcasts from a Single Common Base Station

In order to support the required pseudorange measurements, the navigation signals must be broadcast at a level such that the signal to noise ratios (SNR) of the communications channels are not affected, but the SNR of the navigation signal is sufficient to support 50 bps. In this discussion, the noise term in the SNR is assumed to include interference terms as well as contribution from thermal noise. Below, an interference analysis between communications and navigation signals in a cellular communications system is described.

Consider a wireless cellular communications base station that broadcasts a number of communications channels that are separated by frequency. The communications broadcasts from this system are as follows:

- B_C = the bandwidth of the communications channels
- E_C = signal strength of a single communications with bandwidth B_C
- I_C = Interference to E_C from other communications channels of the system; this includes:

-adjacent channel interference from signals broadcast by the cell site base stations and from signals broadcast by other cell site base stations.

-co-channel interference from signals broadcast by other cell site base stations.

For a system in which the receiver noise density is given by N_0, the signal to noise for the communications signal is given by:

$$\left(\frac{S}{N}\right)_{Comm} = \frac{E_C}{I_C + N_o B_C}$$

In typical cellular environments, the communications signal to noise is typically 18 dB or greater in order to support good voice quality. This is illustrated in the signal level diagram in Figure 4a. Now imagine an additional navigation signal with an energy E_N that is spread across M communications channels. In such a case the signal to noise ratio of the communications signals are degraded slightly as follows:

$$\left(\frac{S}{N}\right)_{Comm} = \frac{E_C}{E_N/M + I_C + N_o B_C}$$

However, as indicated in Figure 4a, it is proposed that the level of E_N/M be set 10 dB below the level of I_C (or 28 dB below E_C) so that the impact of a navigation signal on the communications signal to noise ratio is negligible.

While, the impact of the navigation signal is negligible, the set magnitude of E_N is sufficiently high so that the signal to noise ratio of the navigation signal can support a 50 bps data rate. The navigation signal to noise may be derived by noting that the sum of the communications signal energy and interference ($E_C + I_C$) divided by the communications bandwidth (B_C) acts as an additional term to the noise spectral density. Thus the signal to noise density of the navigation signal to noise ratio is as follows:

$$\left(\frac{S}{N}\right)_{Nav} = \frac{E_N}{\left[(E_C + I_C)/B_C + N_o\right]B_N}$$

where B_N is the noise bandwidth associated with the 50 bps data rate of the navigation signal. As seen in Figure 4a, E_C dominates I_C so that the navigation SNR is very nearly approximated as follows:

$$\left(\frac{S}{N}\right)_{Nav} = \frac{E_N}{\left[E_C/B_C + N_o\right]B_N}$$

As illustrated, in Figure 4b, for the set of assumed parameters, this signal to noise ratio is 15dB and thus is easily able to support reliable data transfer. In addition, it is significant to note that the navigation signal is 15dB higher than the communications signals are above their respective thermal noise floors. Thus the navigation signals should have the same or better margin for building penetration as the communications signals.

Interference Among Broadcasts within a Cellular System

In Figure 5, the geometry and interference scenarios among broadcasts from a cluster of 7 adjacent base stations 5-1, 5-2, 5-3, 5-4, 5-5, 5-6, and 5-7 are illustrated. It is assumed that each base station uses roughly 1/7 of the allocated spectrum and that the channels used by each base station are distributed throughout the spectrum. This assumption is roughly consistent with channel assignment in the current AMPS cellular telephone system. Thus within the 2 MHz of the navigation signal, each base station transmits communications signals on 1/7 of the spectrum. The interference analysis is considered at two positions: E and F. The analysis at point E is a worst case for the interference impact of the navigation signals on the communications signals and it determines the relative level that the navigation signals must be set at. The analysis at point F is a worst case for the interference impact of the communications signals have on the navigation signal.

At point E which is midway between 3 base stations, there are 3 navigation signals of equal strength converging there. If we assume that all navigation signals share the same frequency, then these 3 signals interfere with a communications channel within the 2 MHz band. In this environment, the SNR of a communications signal is as follows:

$$\left(\frac{S}{N}\right)_{Comm,E} = \frac{E_C}{3E_N/M + I_C + N_o B_C}$$

If the strength of the navigation signals are set (as indicated by "set level" in Fig. 7) so that the combined interference from the 3 signals is 28dB below the energy in a communications channel, the navigation signals will not have any significant degrading impact on the communications. This is illustrated in Figure 6a.

In Figure 6b, the interference analysis at point E of the communications signals on the navigation signals is illustrated. In this case, we assume that the three surrounding base stations have communications channels that occupy 3/7 of the 2 MHz band. Thus the navigation SNR is as approximately expressed as follows:

$$\left(\frac{S}{N}\right)_{Nav,E} = \frac{E_N}{\left[3E_C/7B_C + N_o\right]B_N}$$

Then since, $3E_N$ is set 28dB below E_C, it follows that E_N is 29dB below (3/7)M E_C. With a spreading gain of 43dB, it follows that the SNR of the navigation signal is 14dB since the contributions to interference from other terms are negligible.

At point E, all the signals are equidistant from the base stations, so that there is no range loss differential to consider. However, when the mobile is at point F it is very close to base station #1 and the range loss differential between the signals broadcast by #1 vs the 6 adjacent base stations can be quite large. In this case, the energy of the communications signals broadcast from base station #1 are far stronger than the interfering navigation signals so that there is no significant interference impact of the navigation signals on the communications signals. Figure 6c shows the results of the interference analysis of the communications signals on the navigation signals when the mobile is at point F. In particular, this shows the analysis for receiving a navigation signal that is transmitted by one of the adjacent base stations that is relatively far away and therefore suffers a range loss. In this simplified analysis, the range loss differential is accounted for by adding a gain coefficient G on all the signals broadcast by base station #1. There are 3 sources of potentially significant interference to consider for a navigation signal broadcast by an adjacent base station:

1. The communications signals from the 6 adjacent base stations.
2. The communications signals from base station #1.

3. The navigation signal from base station #1.

The SNR of the navigation signal considering these interference sources are as follows:

$$\left(\frac{S}{N}\right)_{Nav,F} = \frac{E_N}{\left[\left(6E_C/7 + GE_C + GE_N/M\right)/B_C + N_o\right]B_N}$$

With respect to the first source, the adjacent stations are assumed to occupy 6/7 of the 2 MHz navigation signal bandwidth. Figure 6c indicates that the SNR between this and navigation signal and this source is 12.5dB.

With respect to the second interference source, it is seen that the SNR is about 20.5 dB-10 logG. This term is clearly problematic since it says that whenever G is as large as 10, the SNR is less than 10 dB and we cannot operate reliably. In typical cellular systems, the differential range losses are much larger than 10. This would mean that whenever the mobile was close to a base station, the navigation signals of the adjacent stations would be jammed and only the local navigation signal could be received. This interference situation can be significantly ameliorated if the local navigation signal broadcasts the channel numbers of the occupied communications frequencies. Then, the mobile receiver for the navigation signals could notch out the occupied frequencies, thereby greatly reducing the interference. The penalty for this action is a signal loss of 1/7 or about 0.7 dB. With such a loss, the 12.5 dB SNR with respect to the first interference source would be reduced to just below 12 dB.

With respect to the third interference source (not shown in Figure 6c), it noted that the navigation signal from base station #1 is 10 logG above a navigation signal from an adjacent base station. Considering the 43 dB spreading gain, the SNR of a weak navigation signal with respect to interference from a strong navigation signal is 43 dB-10logG. This leads to a good SNR even with G as large as 1000. This is a significant amount of differential gain variation which means that pseudorange measurements can be made to multiple base stations over most of the cellular area. The coverage can be further improved by addressing the problem of rear broadcasts interfering with a broadcast from a far base station. This can be accomplished in two ways: 1) multiple frequencies (3 at a minimum) can be for navigation signals and allocated so that no neighboring base stations broadcast at the same frequency, 2) navigation signals can be pulsed in coordination with adjacent base stations so that adjacent base stations do not broadcast simultaneously (e.g., in 3 second cycles in which 3 adjacent stations take turns with broadcasting of 1 second duration.

Referring now to Fig. 7, the base station includes a source 7-10 of conventional base station communication transmit signals which are supplied via summer 7-11 to conventional base station transmitter 7-12 and broadcast on base station antenna 7-13 in the usual manner for any given cellular telephone system. The present invention embeds the CDMA navigation beacon discussed above under the communication signals at the base station. In this embodiment, a GPS antenna 7-15 supplies GPS signals to the conventional GPS RF front end 7-16 and conventional pseudorange computations in 7-17 and time/frequency determinations 7-18 provided to microcontroller 7-20, which has a non-volatile RAM. Data for that base station (such as station identity, location, etc. corresponding in general to data transmitted from a GPS satellite) from microcontroLler 7-20 are overlaid or spread with the PN code 7-12 (whose phase is controlled by a signal based on the pseudorange measurements). The spread signal is modulated in modulator 7-22 (which incorporates a frequency synthesizer which receives a control signal from time frequency circuit 7-18 of the GPS portion of the circuit so that the accurate GPS clock is used as a common time base for all of the base stations. According to the invention, the strength of the navigation signal is set so that the combined interference from a predetermined number N of navigation signals at any point is at least a predetermined level below the energy in the communication channel. In the embodiment illustrated in Fig. 7, the level is set by control amplifier 7-23. The controlled signal level of the navigation (location or position) signal is summed in summer 7-11 with the conventional base station communication signals and then processed and broadcast in the usual manner.

Description of System Operation

With the 3 system elements described above, a mobile or portable communications terminal will be able to determine its position at any location and in virtually any environment. Figure 9 illustrates the logical block diagram of the most general terminal that would be used for position determination. The diplexer 9-21, amplifier 9-24S, 9-24R, modulator 9-25, demodulator 9-26 are conventional. Note that there are three potential RF paths into the terminal. Path A (from coupler 9-10, amplifier 9-11, and filter and downconverter 9-12) intercepts navigation signals that are embedded within the communication frequencies and pseudorange measurements made in 9-13 from which a position calculation 9-14 is made and provided to microcontroller 9-15, and utilization device 9-16, which may be a display (LCD or printed) a recorder, or a speaker. Path B includes GPS RF front end 9-17 which intercepts the navigation signals from the GPS satellites with an antenna and low-noise pre-amplifier in the RF front end. Path B could also receive transmissions of the RF Signposts as well, if on that frequency . Finally, path C uses an RF path at an alternative frequency (e.g., 900 MHz ISM) to receive, either GPS-like signals or other Signpost signals at that frequency. Note that all three paths, A, B, and C have separate front ends, but share the middle and end stages of the GPS receiver that:

1) acquires and tracks the signals, thereby making the pseudorange measurements, and
2) demodulates and interprets the received data, and calculates the terminal position.

In regions where there are no RF navigation signals other than GPS, the terminal will determine its position via the GPS constellation. The GPS receiver has an interface with communications terminal so that position can be sent via a control channel or assigned channel of the communication system.

When the terminal is in a region where the communications system provides embedded navigation signals, the terminal receives these signals via the same antenna 9-20 and diplexer 9-21 as for communication signals. Some of the received signal power split off by coupler 9-10 at the receiver front end for the processing of the navigation signals. After filtering and downconversion 9-12 to a common IF, the received signal is routed to the Pseudorange Measurement stage 9-13 of the GPS receiver. Typically, the strongest signal will be acquired and demodulated first. Sometimes, as discussed above, when a mobile/portable is near the base station, the communications broadcast will jam the navigation signals from more distant base stations. However, the navigation signal from the same base station will always be strong enough to be demodulated. This signal will have data that identifies the occupied communication channels of the nearby base station. With this information, the receiver will implement a notch filter within the 2 MHz band of the navigation signal that will effectively eliminate the interference of the strong communications signals. In this manner, the receiver will be capable of simultaneously measuring the pseudorange to multiple stations, even when the receiver may be quite near a base station.

Finally, when the portable phone passes by or is near an RF Signpost, the signal will be received and demodulated along path C. Sometimes, the position may be also determined from multiple RF signals. For example, at an indoor location with a region served by a cellular communications system with navigation signals, the receiver will typically determine a position via pseudorange measurements. However, if the building contains RF Signposts, the receiver will also have a position of the last Signpost seen. This is advantageous for two reasons:

1) Multipath in the indoor environment will typically prevent position sufficiently accurate to determine the floor level.
2) Even if altitude was determined with sufficient accuracy, there may not be a database that maps the altitude/lat/lon coordinates into the floor level of a building address.

As described above, the Signpost data will contain an ID and other information that will map to a building address, floor number, or even suite.

As a prelude to establishing a communication connection, the communications terminal in Figure 9 will make a positioning measurement as described. As part of the communications setup, the terminal will convey the position to the communications system (e.g., using the control/set-up channel in amps). Thus the communications system can route the call based on knowledge of position, and may also provide that position to the call destination. Once the call is connected, the communications terminal can also send the position to the call destination. With such position capabilities, the requirement of Enhanced 911 to know the position of a calling terminal is satisfied. These capabilities can also support the services of roadside assistance and fleet management via other special dialing codes. Finally, if positional information is embedded in all calls, this capability can also deter theft, fraud and abuse of wireless communications services.

The Invention Features the Following

1) The use of direct sequence spread spectrum (DSSS) waveform in a cellular coverage arrangement to provide terrestrial navigation to augment or replace GPS navigation.

2) The use of RF broadcasts (RF Signposts) that convey the location to a receiver using GPS-like or other digital RF waveform.

3) The reuse of communications frequencies of a cellular communications system to broadcast navigation beacons from the cell site base stations.

4) The level-setting technique for embedding the DSSS navigation beacon within the same band that is occupied by the communications frequencies so that the mutual interference between the communications signal and the navigation beacons are negligible.

5) The use of frequency notching within the navigation receiver to eliminate the interference caused by any narrow band communications broadcasts of the cellular communication system.

6) The use of navigation beacons at multiple frequencies to avoid near-far interference in a cellular array of navigation beacon. A 3 frequency system would be comprised of a center frequency and a frequency on either side offset by about 1 MHz (e.g. in the first null).

7) The use of time pulsing to avoid the near-far interference problem in an array of navigation beacons so that adjacent navigation beacons do not broadcast simultaneously, but

coordinated in a time-division multiplexed scheme.

8) The integrated system composed of GPS, navigation beacon broadcasts in a cellular coverage, and RF Signpost broadcasts, that provide seamless positioning worldwide in outdoor and indoor environments.

It will be appreciated that the CDMA navigation or position information embedded in the communication signals of the wireless communications system can be used separately without any GPS channels and without the RF signpost feature.

While the invention and preferred embodiments have been shown and described, it will be appreciated that various other embodiments, modifications and adaptations of the invention will be readily apparent to those skilled in the art.

WHAT IS CLAIMED IS:

CLAIMS

1. In a cellular telephone system having three or more cell sites with each cell site having a source of cellular communication signals and an RF transmitter and antenna for broadcasting said cellular communication signals, the improvement comprising:

means for embedding a direct sequence spread spectrum waveform carrying navigation signals in said cellular communication signals, including means for controlling the signal strength of said navigation signals so that the combined energy of said navigation signals from all said cell sites at any location is at least a predetermined energy level below the energy level of said cellular communication signals.

2. The cellular telephone system defined in claim 1 wherein the following constraint is applied:

Spreading Gain > $SNR_C \bullet SNR_N$

where the spreading gain applies to the embedded SS navigation signal (=43 dB-100 Mcps/50 bps) and SNR_C and SNR_N are the desired signal to noise ratios for the communications and navigation signals, respectively.

3. The cellular telephone system defined in claim 1 wherein said system is an AMPS cellular telephone communications system and said predetermined energy level is 28db.

4. The cellular telephone system defined in claim 1 or claim 2 or claim 3 wherein each said cell site includes timing means and means for timing the operation of said means for embedding, GPS receiver means for receiving and detecting GPS satellite signals, and means to derive control signals from said GPS satellite signals and controlling said timing means by said control signals.

5. The cellular telephone system defined in claim 1 including mobile cellular transceiver means having transmit channel and receive channel for voice and data communications, means coupled to said receive channel for extracting said embedded navigation signals and means to process the extracted navigation signals to determine the position of said mobile cellular transceiver means.

6. The cellular telephone system defined in claim 5 including a GPS receiver for producing GPS position information and a utilization device connected to selectively receive the position information from said extracted navigation signals and said GPS position information.

7. The cellular telephone system defined in claim 6 including a plurality of low power RF broadcast means, one each at a plurality of scattered geographic locations, each low powered RF broadcast means broadcasting a digital RF waveform of the format of said GPS satellite signal and means to modulate said digital RF waveform with location information identifying said geographic locations, respectively.

8. The cellular telephone system defined in claim 7 including further receiver means for receiving said digital RF waveform and deriving therefrom the geographic location information carried thereby.

9. An RF signpost system comprising a plurality of low powered RF broadcast stations, one each at a plurality of scattered geographic locations, each low powered RF broadcast station broadcasting a direct sequence spread spectrum digital RF waveform or other RF modulation format and means to modulate said digital RF waveform with location information identifying said geographic locations, respectively.

10. In a cellular array of navigation signal beacons, the method of avoiding near-far interference problems, comprising, pulsing the navigation signals from adjacent navigation signal beacons so that adjacent navigation beacons do not broadcast navigation signals simultaneously and coordinating the broadcasts of the navigation signal beacons in a time-division multiplexed manner.

11. In a cellular array of navigation signal beacons, the method of avoiding near-far interference, comprising, using multiple frequencies and time-division multiplexing and coordinating the use of said multiple frequencies and said time division multiplexing to assure avoidance of said near-far interference.

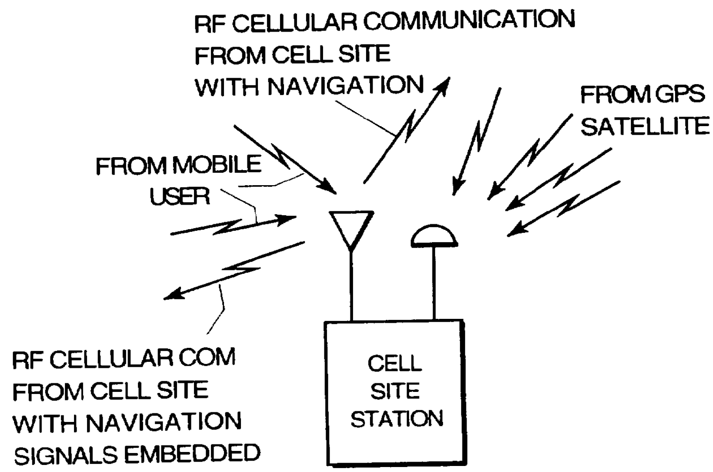
RF CELLULAR COMMUNICATION
FROM CELL SITE
WITH NAVIGATION
FROM GPS
SATELLITE
FROM MOBILE
USER
RF CELLULAR COM
FROM CELL SITE
WITH NAVIGATION
SIGNALS EMBEDDED
CELL
SITE
STATION

FIG. 1

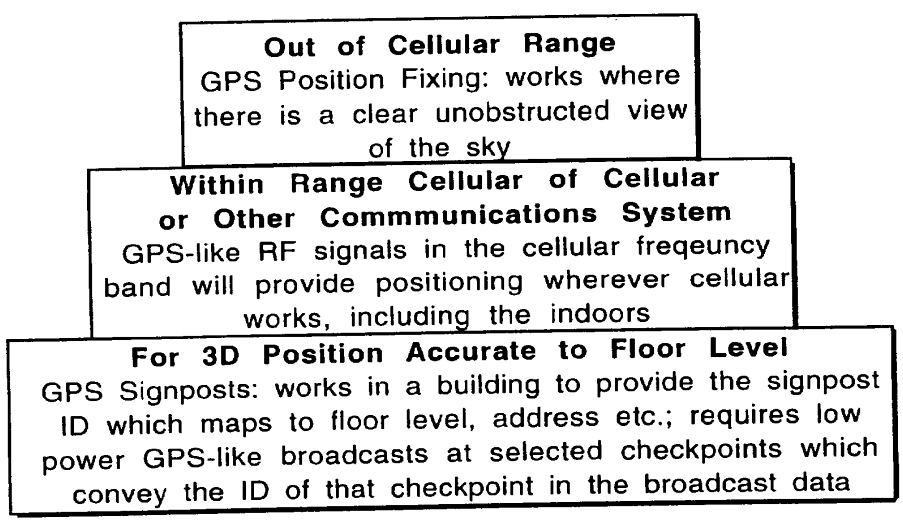
Out of Cellular Range
GPS Position Fixing: works where there is a clear unobstructed view of the sky
Within Range Cellular of Cellular or Other Commmunications System
GPS-like RF signals in the cellular freqeuncy band will provide positioning wherever cellular works, including the indoors
For 3D Position Accurate to Floor Level
GPS Signposts: works in a building to provide the signpost ID which maps to floor level, address etc.; requires low power GPS-like broadcasts at selected checkpoints which convey the ID of that checkpoint in the broadcast data

FIG. 2

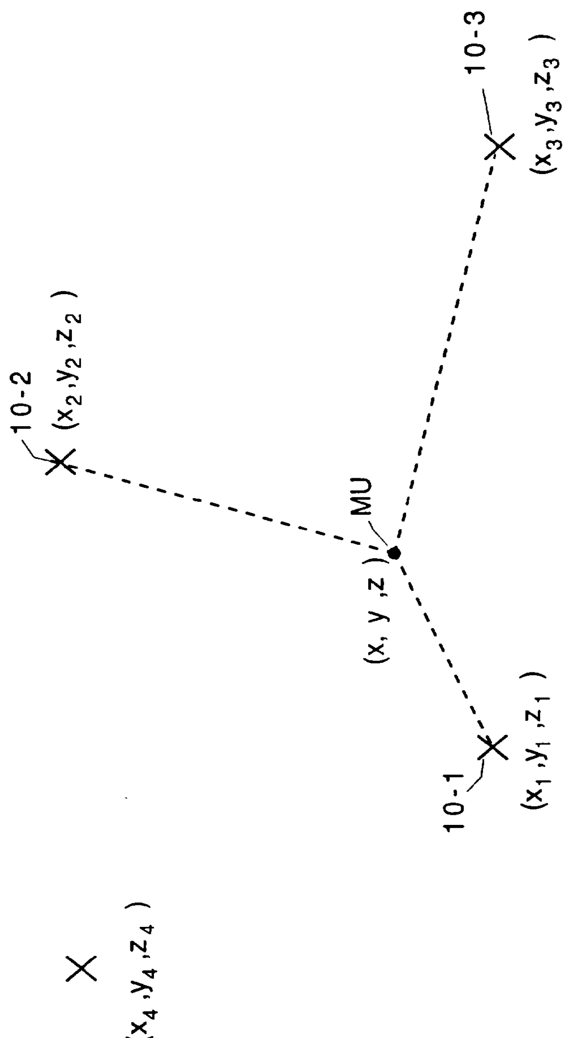

FIGURE 3

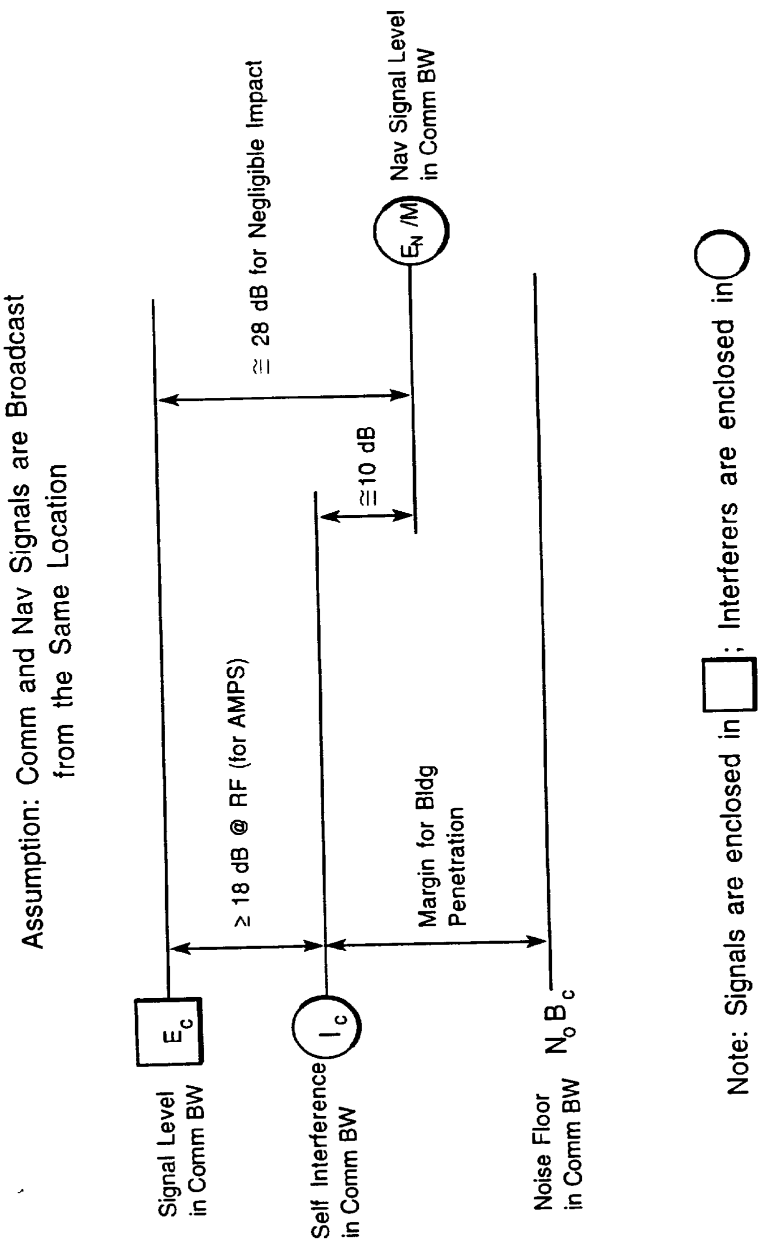
Assumption: Comm and Nav Signals are Broadcast from the Same Location
Signal Level in Comm BW
Ec
Self Interference in Comm BW
Ic
Noise Floor in Comm BW
NoBc
≥ 18 dB @ RF (for AMPS)
Margin for Bldg Penetration
≅10 dB
≅ 28 dB for Negligible Impact
EN /M
Nav Signal Level in Comm BW
Note: Signals are enclosed in ; Interferers are enclosed in

FIGURE 4A

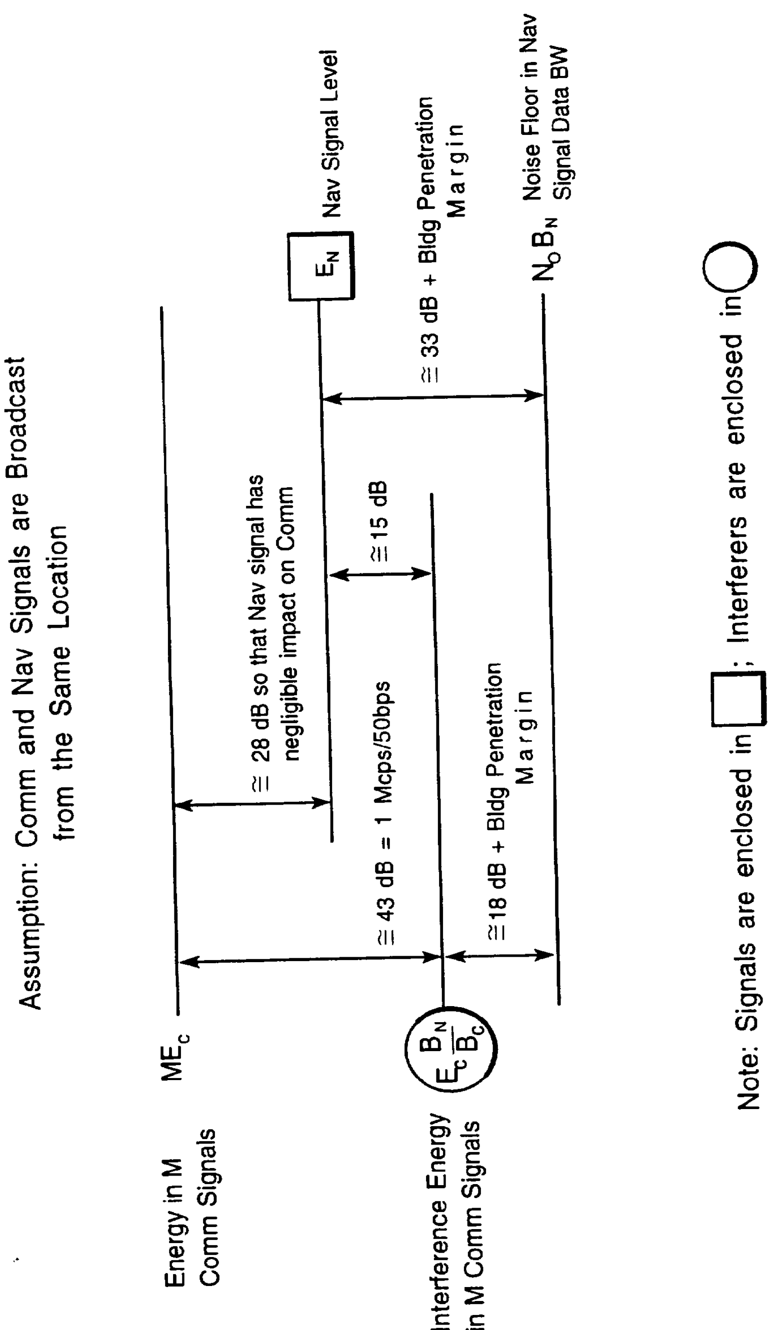
Assumption: Comm and Nav Signals are Broadcast from the Same Location
Energy in M Comm Signals
ME_c
Interference Energy in M Comm Signals
$E_c \frac{B_N}{B_c}$
E_N
Nav Signal Level
$N_o B_N$
Noise Floor in Nav Signal Data BW
≅ 28 dB so that Nav signal has negligible impact on Comm
≅ 43 dB = 1 Mcps/50bps
≅ 15 dB
≅ 18 dB + Bldg Penetration Margin
≅ 33 dB + Bldg Penetration Margin
Note: Signals are enclosed in □; Interferers are enclosed in ○

FIGURE 4B

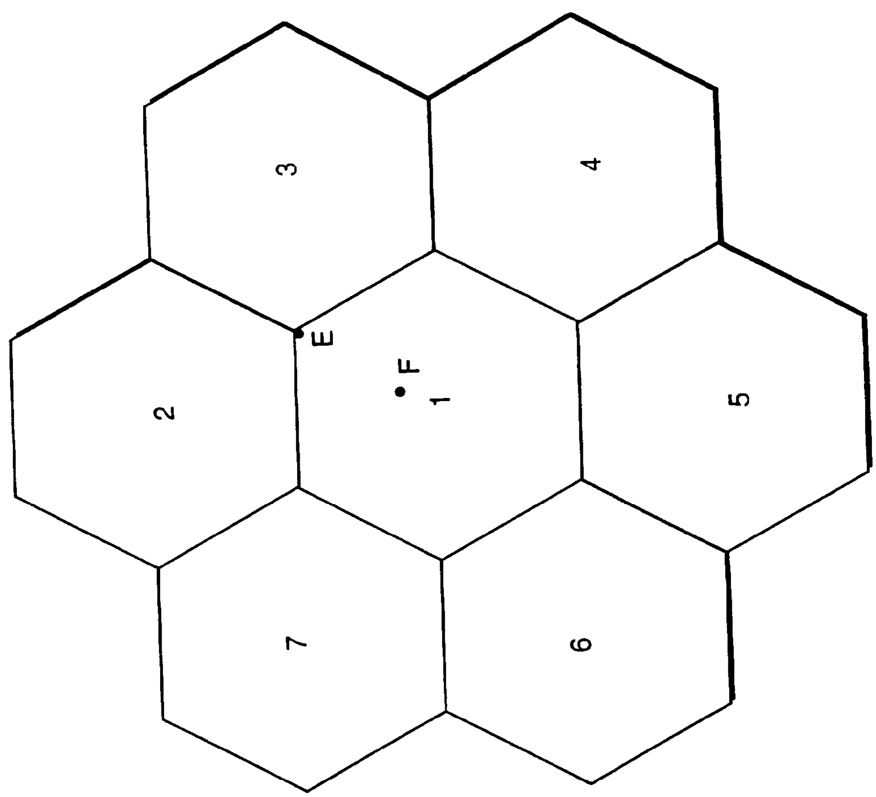

FIGURE 5

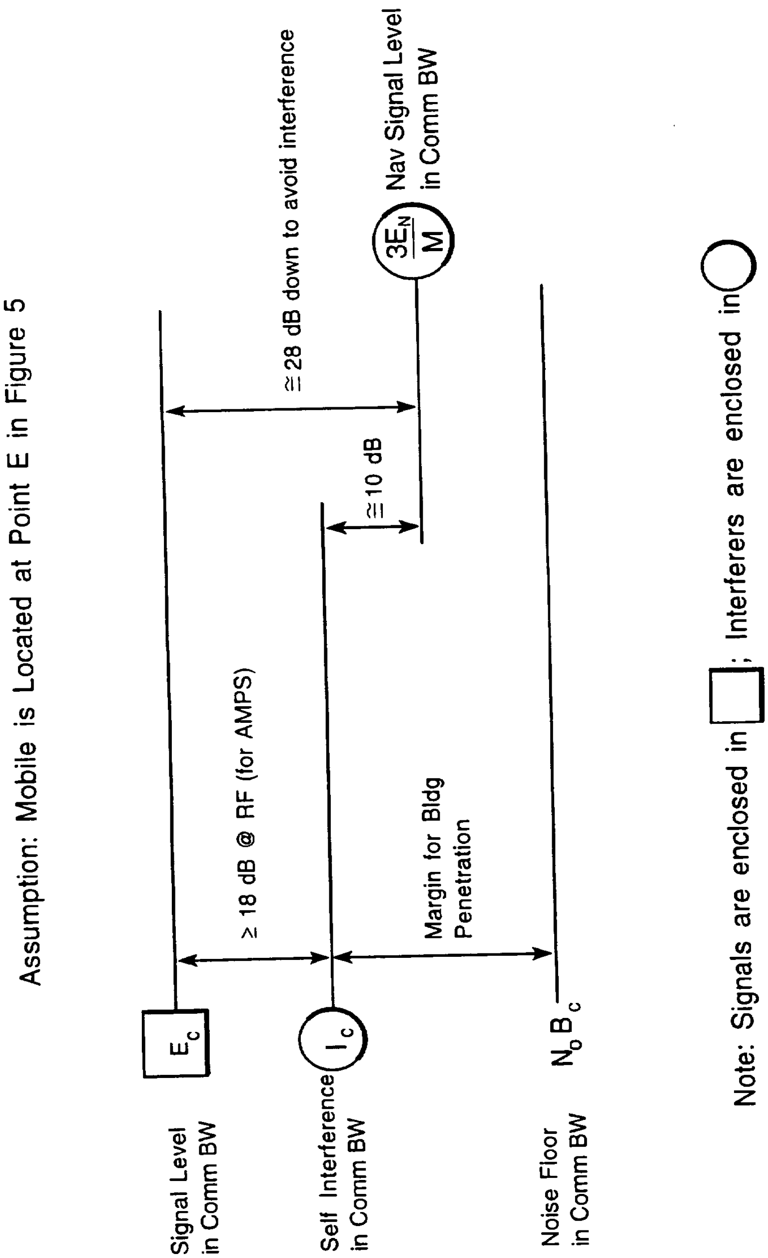
Assumption: Mobile is Located at Point E in Figure 5
Signal Level in Comm BW
E_c
Self Interference in Comm BW
I_c
Noise Floor in Comm BW
$N_o B_c$
≥ 18 dB @ RF (for AMPS)
Margin for Bldg Penetration
≅ 28 dB down to avoid interference
≅ 10 dB
$\frac{3E_N}{M}$
Nav Signal Level in Comm BW
Note: Signals are enclosed in □; Interferers are enclosed in ○

FIGURE 6A

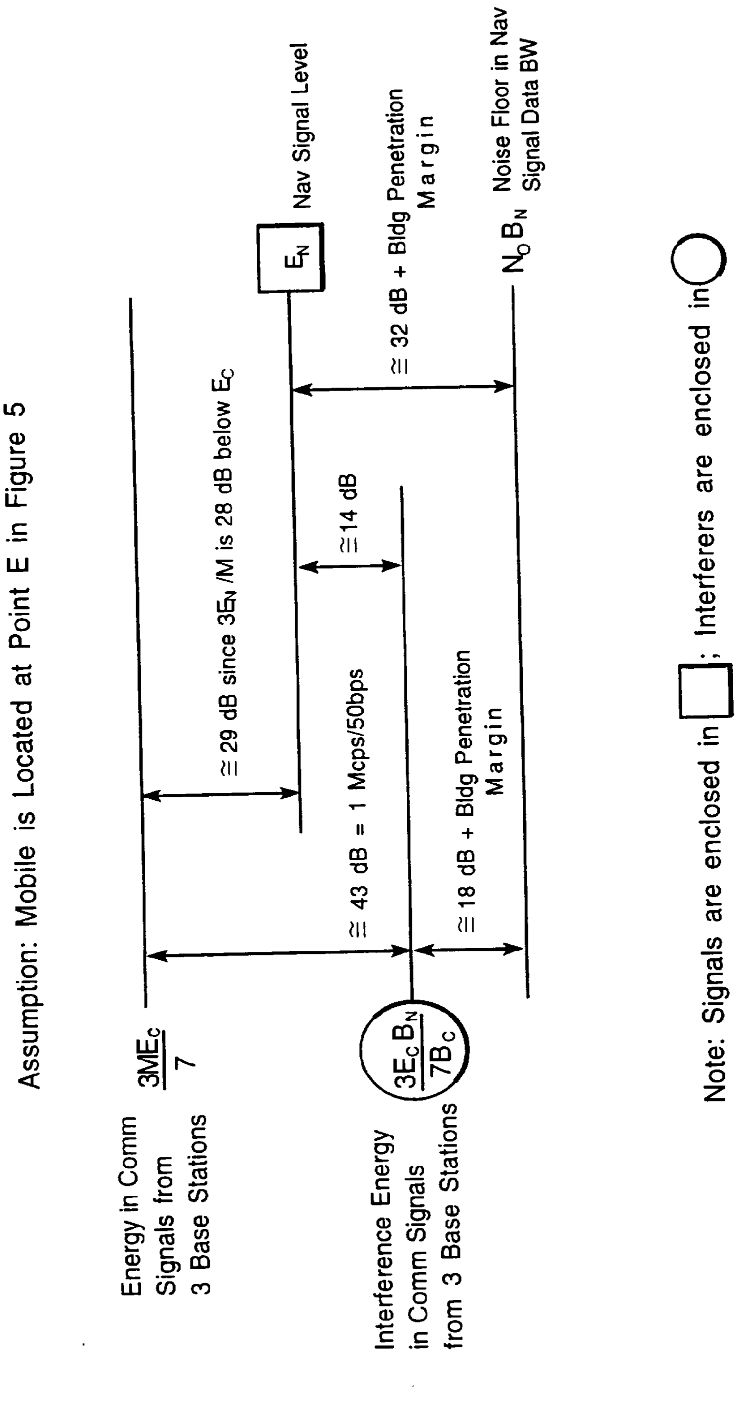
Assumption: Mobile is Located at Point E in Figure 5
Energy in Comm Signals from 3 Base Stations
$\frac{3ME_C}{7}$
Interference Energy in Comm Signals from 3 Base Stations
$\frac{3E_C B_N}{7B_C}$
≅ 29 dB since $3E_N/M$ is 28 dB below E_C
≅ 43 dB = 1 Mcps/50bps
≅14 dB
E_N
Nav Signal Level
≅ 18 dB + Bldg Penetration Margin
≅ 32 dB + Bldg Penetration Margin
$N_O B_N$
Noise Floor in Nav Signal Data BW
Note: Signals are enclosed in ☐; Interferers are enclosed in ○

FIGURE 6B

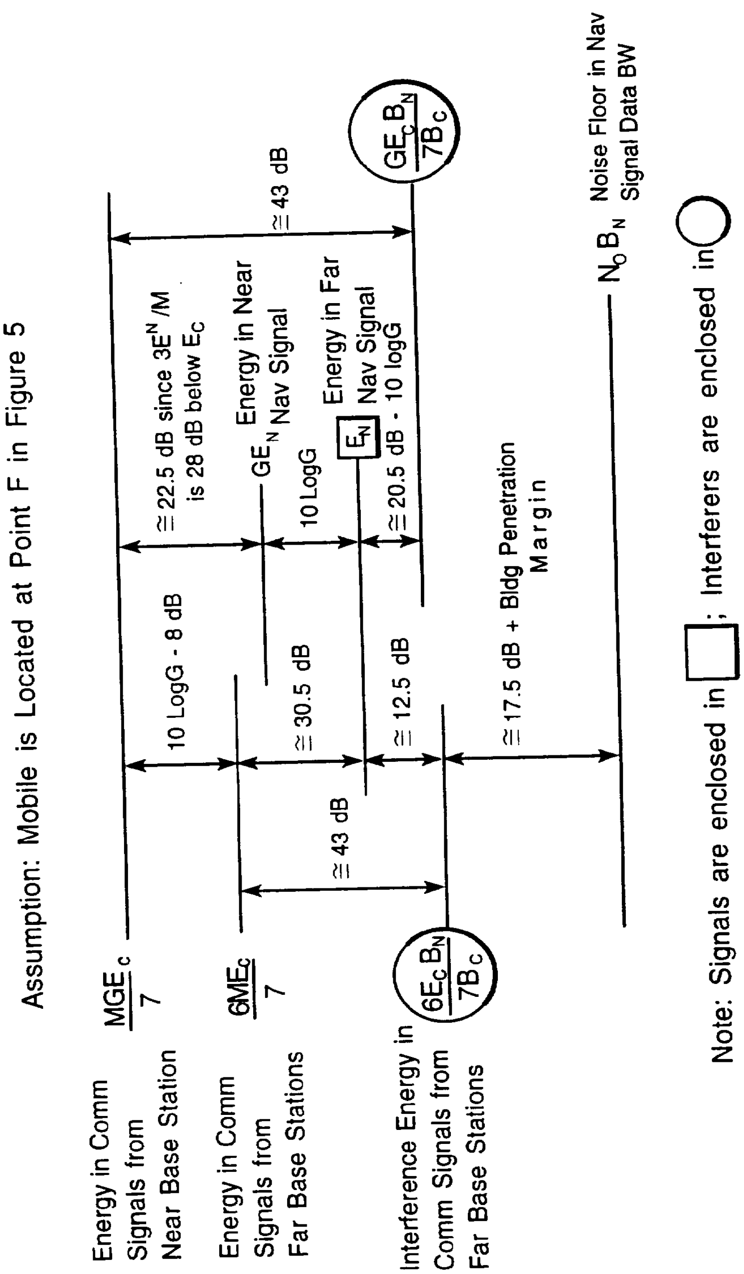
Assumption: Mobile is Located at Point F in Figure 5
Energy in Comm Signals from Near Base Station
$\frac{MGE_c}{7}$
Energy in Comm Signals from Far Base Stations
$\frac{6ME_c}{7}$
Interference Energy in Comm Signals from Far Base Stations
$\frac{6E_cB_N}{7B_c}$
≅ 43 dB
10 LogG - 8 dB
≅ 30.5 dB
≅ 12.5 dB
≅ 17.5 dB + Bldg Penetration Margin
≅ 22.5 dB since $3E^N/M$ is 28 dB below E_c
GE_N Energy in Near Nav Signal
10 LogG
E_N Energy in Far Nav Signal
≅ 20.5 dB - 10 logG
≅ 43 dB
$\frac{GE_cB_N}{7B_c}$
N_oB_N Noise Floor in Nav Signal Data BW
Note: Signals are enclosed in □; Interferers are enclosed in ○

FIGURE 6C

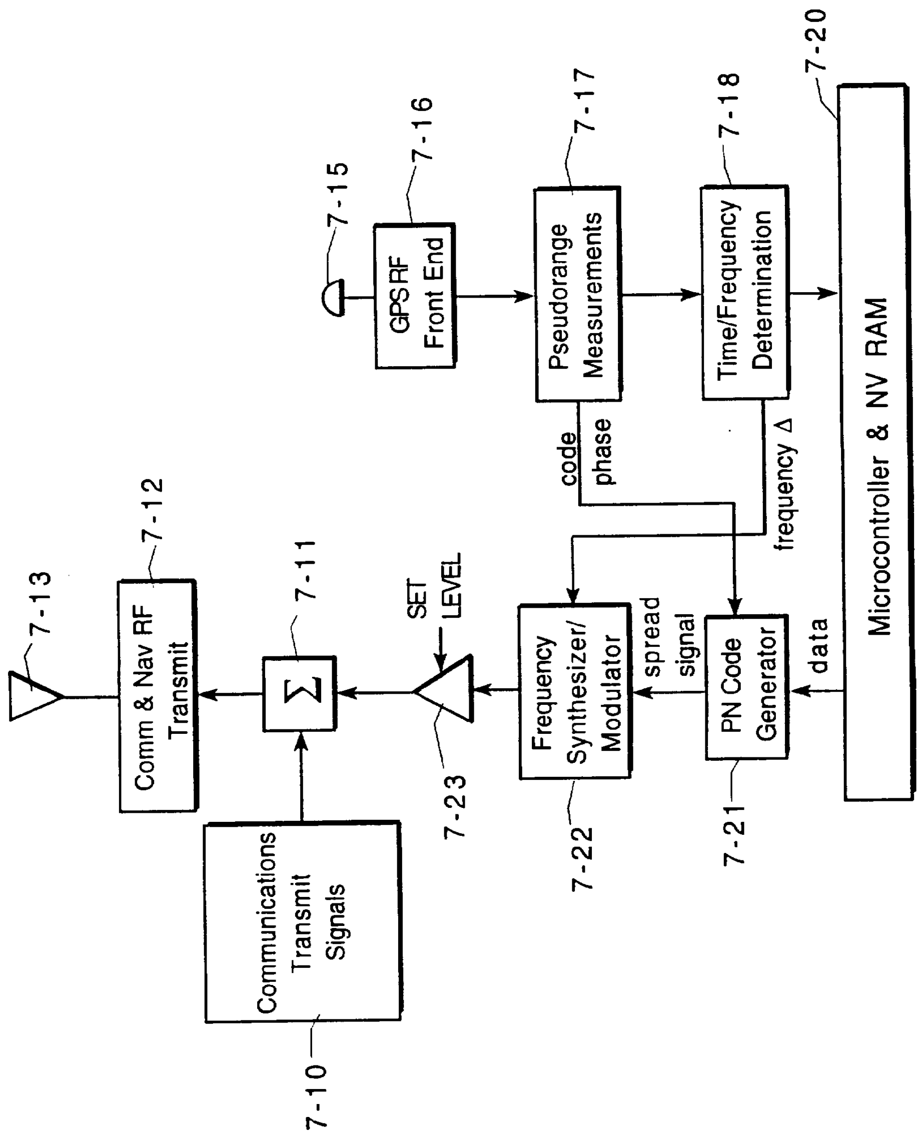
7-10
Communications Transmit Signals
7-11
Σ
7-12
Comm & Nav RF Transmit
7-13
SET LEVEL
7-23
Frequency Synthesizer/ Modulator
7-22
spread signal
PN Code Generator
7-21
data
7-15
GPS RF Front End
7-16
Pseudorange Measurements
7-17
code phase
Time/Frequency Determination
7-18
frequency Δ
Microcontroller & NV RAM
7-20

FIGURE 7

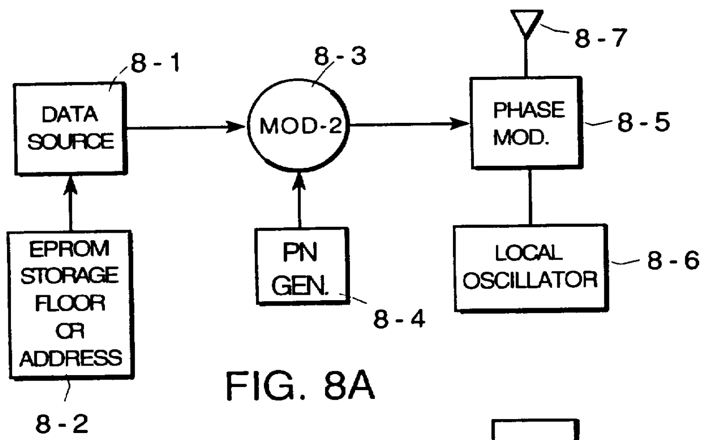

FIG. 8A

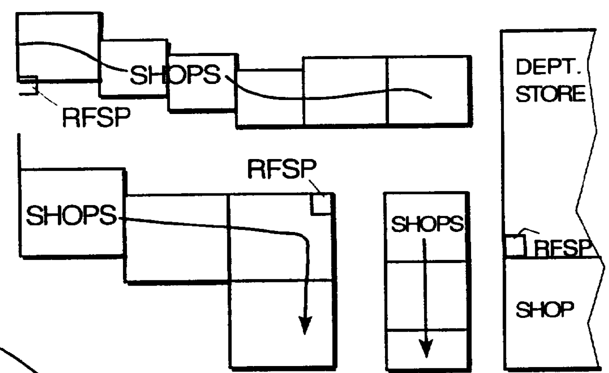

FIG. 8C

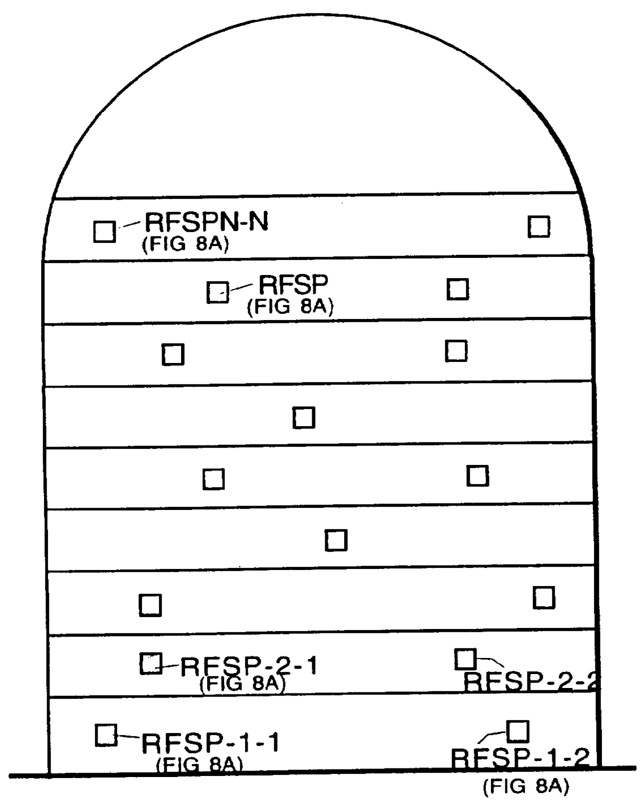

FIG. 8B

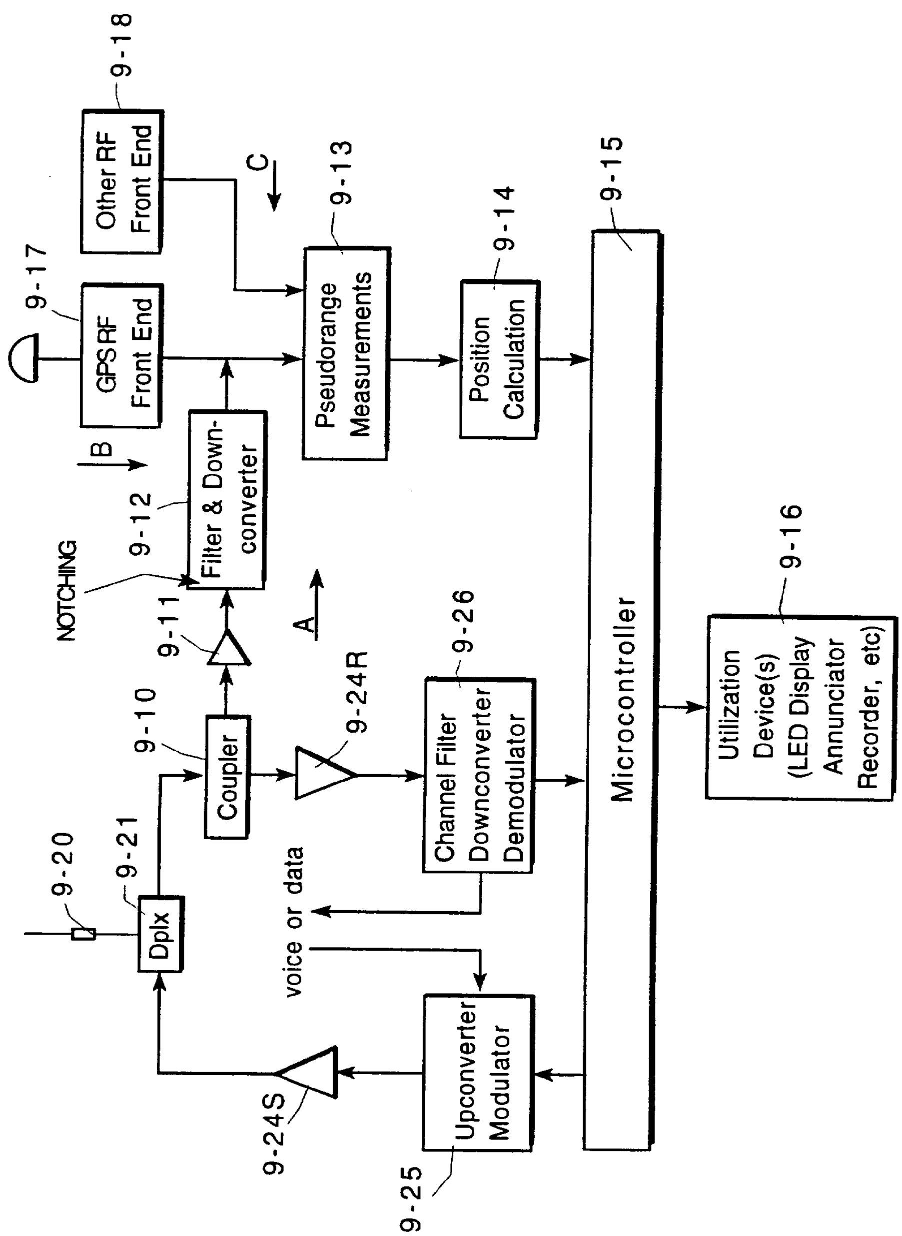
Other RF Front End
9-18
GPS RF Front End
9-17
C
9-13
Pseudorange Measurements
9-14
Position Calculation
9-15
Microcontroller
B
9-12
Filter & Down-converter
NOTCHING
9-11
A
9-10
Coupler
9-24R
9-26
Channel Filter Downconverter Demodulator
9-20
9-21
Dplx
voice or data
voice or data
Upconverter Modulator
9-24S
9-25
9-16
Utilization Device(s) (LED Display Annunciator Recorder, etc)

FIGURE 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/16019

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL : 375/200, 205, 206; 370/110.4; 342/57; 455/33.1
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 375/200, 205, 206; 370/110.4; 342/57, 58; 455/33.1, 38.3, 54.1, 56.1; 379/59, 63

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS search terms: signpost and geographic location; navigation? and (time division multiplex? or tdm?) and beacon; cellular and gps and (embed? or superimpos? or super impos?)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 4,232,317 (FREENY, Jr.) 04 November 1980, figure 1, abstract, column 1, lines 15-23 and column 2, lines 24-60.	9
A	US, A, 5,235,633 (DENNISON ET AL) 10 August 1993, figure 7, abstract, column 5, line 19 to column 6, line 12.	1-8
X	US, A, 4,914,651 (LUSIGNAN) 03 April 1990, figures 1 & 9 column 1, lines 34-62.	10-11
X	US, A, 5,319,374 (DESAI ET AL) 07 June 1994, figures 1 and 2, abstract, column 4, line 65 to column 5, line 23.	10-11

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 MARCH 1996	05 APR 1996
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer DON N. VO Telephone No. (703) 305-4885

Form PCT/ISA/210 (second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/16019

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

H04B 15/00; H04K 1/00; H04L 27/30; H04J 3/12; G01S 13/00; H04Q 7/00, 9/00

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

Group I, claim(s) 1-9, drawn to a cellular telephone system wherein the direct sequence spread spectrum waveform carrying navigational signals is embedded in the cellular communication signal to form the communicated signals.
Group II, claim(s) 10-11, drawn to a method of avoiding near-far interference problems in a cellular array of navigation signal beacons by using time division multiplexing.

The inventions listed as Groups I and II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:
Group I, claims 1-9, directs to a cellular telephone system in which a direct sequence spread spectrum waveform carrying navigational signals is embedded in the cellular communication signal to form the communicated signals. The energy level of the navigational signals is controlled to the level of at least a predetermined energy level below the energy level of said cellular communication signals.
Group II, claims 10-11, directs to a method of avoiding near-far interference problems in a cellular array of navigation signal beacons by using time division multiplexing.
Apparently, the special technical features of Groups I and II differ in modes of operation and their recognized divergent subject matter.

Electronic Acknowledgement Receipt

EFS ID:	2038038
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Correspondence Address:	Dennis J. Dupray, Ph.D. - 1801 Belvedere Street - Golden CO 80401 US 3038630223 -
Filer:	Dennis Jay Dupray./Debra Kesner
Filer Authorized By:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1
Receipt Date:	01-AUG-2007
Filing Date:	26-JAN-2001
Time Stamp:	19:00:18
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed	IDS_01.pdf	163589 e0f7afdc91333ecb3e60c88d834cd984e4e28417	no	3
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
2	Foreign Reference	WO9620542A1.pdf	1240826 710b3892ba4d44fc38ff655f48fb101dafddcd27	no	41
Warnings:					
Information:					
3	NPL Documents	Allowed_Claims_for_09176587.pdf	1370359 f11d5b2a9d53156421d85f18d8a6e5146e6222df	no	33
Warnings:					
Information:					
4	NPL Documents	Pending_Claims_For_10262338.pdf	1199477 b5d269d7268b4a886cb6f73de9abd39607c1f23b	no	27
Warnings:					
Information:					
		Total Files Size (in bytes):	3974251		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	)	Group Art Unit: 3662
	)	
Dupray et al.	)	Confirmation No.: 8410
	)	
Serial No.: 09/770,838	)	Examiner: PHAN, DAO LINDA
	)	
Filed: January 26, 2001	)	SUPPLEMENTAL INFORMATION
	)	DISCLOSURE STATEMENT
Atty. File No.: 1003-1	)	
	)	Electronically Submitted
For: GATEWAY AND HYBRID	)	
SOLUTIONS FOR WIRELESS	)	
LOCATION	)	

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The references cited on attached Form PTO-SB08 are being called to the attention of the Examiner.

☒ Copies of the cited non-patent and/or foreign references are enclosed herewith.

☐ Copies of the cited U.S. patents and/or patent applications are enclosed herewith.

☒ Copies of the cited U.S. patents/patent application publications are not enclosed in accordance with 37 C.F.R. § 1.98(a).

☐ Copies of the cited references are not enclosed, in accordance with 37 C.F.R. § 1.98(d), because the references were cited by or submitted to the U.S. Patent and Trademark Office in prior application Serial No. __________ filed ______________, which is relied upon for an earlier filing date under 35 U.S.C. § 120.

☐ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English abstracts and in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☒ Examiner's attention is drawn to the following co-pending applications, copies of which have been or are being submitted:

Serial No. 10/262,413 filed 09-30-2002, now U.S. Patent Publication No. 2003/0222820 (Attorney's Ref. No. 1003-2);

Serial No. 10/262,338 filed 09-30-2002, now U.S. Patent Publication No. 2003/0146871 (Attorney's Ref. No. 1003-3);

Serial No. 11/739,097 filed 04-24-07 (Attorney's Ref. No. 1003-4);

Serial No. 11/069,441 filed 3-1-05 (Attorney's Ref. No. 1004-1-1);

Serial No. 09/176587 filed 10-21-1998 (Attorney's Ref. No. 1005);

Serial No. 10/297,449 filed 12-06-2002 (Attorney's Ref. No. 1010-PUS);

Serial No. 11/464,880 filed 08-14-06 (Attorney's Ref. No. 1010-1); and

Serial No. 10/337,807 filed 01-06-2003, now U.S. Patent Publication No. 2004/0198386 (Attorney's Ref. No. 1011).

☐ Other:________________________________

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

It is respectfully requested that the cited information be made of record therein in the present application.

Respectfully submitted,

By: [signature]

Dennis J. Dupray
Registration No. 46299
1801 Belvedere Street
Golden CO 80401
(303) 863-9700

Date: Aug. 8, 2007

Substitute for form 1449A/PTO				*Complete if Known*	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	09/770,838
				Filing Date	01-26-2001
				First Named Inventor	Dupray
				Art Unit	3662
				Examiner Name	PHAN, DAO LINDA
Sheet	1	of	1	Attorney Docket Number	1003-1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	5625748	04/29/97	McDonough et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

Examiner Initials*	Cite No.[1]	
	2	"After Allowance Amendment under C.F.R. 1.312", filed July 10, 2007, for U.S. Patent Application No. 10/262,413, 23 pages (Attoreny's Ref. No. 1003-2)

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Electronic Acknowledgement Receipt

EFS ID:	2063592
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Correspondence Address:	Dennis J. Dupray, Ph.D. - 1801 Belvedere Street - Golden CO 80401 US 3038630223 -
Filer:	Dennis Jay Dupray./Debra Kesner
Filer Authorized By:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1
Receipt Date:	08-AUG-2007
Filing Date:	26-JAN-2001
Time Stamp:	18:58:15
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed	IDS_02.pdf	390265 8a7ca0c3926840bfc147b915297a9a73e5501591	no	3
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
2	NPL Documents	Allowed_Claims_for_1003-2.pdf	1018907 819274bb8ab634df2f3c188f51ebdd96e59c8982	no	23
Warnings:					
Information:					
		Total Files Size (in bytes):	1409172		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 05/23/2007

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

TITLE OF INVENTION: GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$700	$0	$700	~~$700~~ $0	08/23/2007

EXAMINER	ART UNIT	CLASS-SUBCLASS
PHAN, DAO LINDA	3662	342-450000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. Use of a Customer Number is required.

2. For printing on the patent front page, list
   (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
   1 ______
   2 ______
   3 ______

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: TracBeam LLC

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Golden, Colorado

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☐ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies ______

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 19-1970 (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)
- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature [signature] Date Aug. 23, 2007

Typed or printed name Dennis J. Dupray Registration No. ______

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION

In Re the Application of:

DUPRAY et al.

Serial No.: 09/770,838

Filed: January 26, 2001

Atty. File No.: 1003-1

For: "A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION"

Prior Group Art Unit: 3662

Prior Examiner: Dao Phan

AFTER ALLOWANCE AMENDMENT

MAIL STOP: Issue Fee
Commissioner for Patents P.O. Box 1450
Alexandria, VA. 22313-1450

Dear Sir/Madam:

Applicants file the present after allowance amendment to correct typographical errors, to clarify certain claims, to delete 8 dependent claims, and to add 10 new dependent claims.

If there are any questions regarding the present amendment, it is requested that the named Applicant hereinbelow (Dennis Dupray) be contacted at 303-863-2975. Note, it is believed that no fees are due with this transmittal beyond the amount for two dependent claims.

IN THE CLAIMS:

Claims 1 through 220 were previously cancelled.

221. (Currently Amended) A method for ~~use in a wireless network to~~ obtaining requested location information regarding a first of a plurality of ~~mobile~~ terrestrial wireless mobile stations using location information from ~~any of various~~ location estimating sources, and to provide the requested location information to an application using wireless location ~~application~~, ~~there being a plurality of~~ the location estimating sources, including a **first location estimating source** ~~for obtaining location information~~ and a **second location estimating source** ~~for obtaining location information~~, the first and second location estimating sources ~~for~~ providing information regarding locations of various of the mobile wireless stations ~~in the network~~, the method comprising the steps of:

first receiving a location request regarding [[a]] the first of said wireless mobile station[[s]] from ~~said first~~ the ~~wireless location~~ application, said location request seeking said requested location information;

first obtaining[[:]] a first location input obtained using an instance, I_1, of ~~said~~ location information from said first location estimating source, wherein I_1 is indicative of one or more locations of said first wireless mobile station, and

second obtaining a second location input obtained using an instance, I_2, of ~~said~~ location information provided from said second location estimating source, wherein I_2 is indicative of one or more locations of said first wireless mobile station;

wherein said first location estimating source employs a first location finding technology that provides I_1, and said second location estimating source employs a second location finding technology different than said first location finding technology that provides I_2; and

wherein said steps of first and second obtaining includes a step of providing said first and second location inputs in a common standardized format;

storing data in memory relating to said first location input and said second location input;

third obtaining said requested location information by selectively using portions of said data from said memory, wherein said requested location information is determined according to information indicative of a manner in which said ~~first wireless location~~ application prefers said requested location information; and

outputting said requested location information to said ~~first wireless location~~ application.

222. (Currently Amended) The method of Claim 221, wherein for locating a second of the mobile stations, there is a further step of requesting activation of each of one or more of said ~~plurality of~~ location estimating sources according to an availability of corresponding wireless signal measurements from the second mobile station for the one or more location estimating sources.

223. (Currently Amended) The method of Claim 221, further including, for locating a second of the mobile stations, a step of obtaining an instance of a third location input from a third of the ~~plurality of~~ location estimating sources different from said first and second location estimating sources.

224. (Currently Amended) The method of Claim [[221]] 223, further including, for locating one of the first and a second of the mobile stations, a step of obtaining an instance of a third location input by using a third location finding technology different from the first and second location finding technologies.

225. (Previously Presented) The method of Claim 224, further including providing said instance of said third location input in said standardized format.

226. (Currently Amended) The method of Claim 221, wherein said step of providing includes representing each of said first and second location inputs in a common data representation having a plurality of location attributes, including a common representation A_1 for representing a geographical position for the first mobile station, and one or more attributes related to one of: an error in data for A_1, a likelihood of the first mobile station being in the geographical extent represented by A_1, a timestamp related to the first mobile station being in the geographical extent represented by A_1, and descriptor information related to location processing performed by one of said first and second location estimating sources ~~resources in obtaining an instance of said location information for M~~.

227. (Previously Presented) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to an error in data for A_1.

228. (Previously Presented) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to a likelihood of the first mobile station being in the geographical extent represented by A_1.

229. (Previously Presented) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to a timestamp related to the first mobile station being in the geographical extent represented by A_1.

230. (Previously Presented) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes for descriptor information related to location processing performed by one of said location estimating sources in obtaining an instance of said location information for the first mobile station.

231. (Previously Presented) The method of Claim 226, wherein for locating a second of the mobile stations, further including a step of providing one or more location input instances of location information by one or more of said location estimating sources in said common data representation.

232. (Previously Presented) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of said wireless mobile stations including at least a location and a time.

233. (Previously Presented) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of the wireless mobile stations including one or more values indicative of an uncertainty regarding a location of the individual wireless mobile station.

234. (Previously Presented) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of said wireless mobile stations including one of a travel speed and a travel direction.

235. (Previously Presented) A method as set forth in claim 221, wherein said step of first obtaining comprises sending data for requesting activation of one of the first location estimating source and the second location estimating source to obtain the corresponding one of first and second location input.

236. (Previously Presented) A method as set forth in claim 221, wherein said step of third obtaining comprises determining additional location information including at least a wireless station identification and a location of the first wireless mobile station.

237. (Currently Amended) A method as set forth in claim 221, wherein said step of third obtaining comprises determining additional location information a including a time and an uncertainty or likelihood regarding location of the first mobile station.

238. (Previously Presented) A method as set forth in claim 221, wherein said step of third obtaining comprises providing additional location information including one of a speed of travel and direction of travel for the first wireless mobile station.

239. (Currently Amended) A method as set forth in claim 221, further comprising combining (a) and (b) following to make a location determination: (a) a first portion of said portions of said data, the first portion obtained using said first location input, with (b) a second portion of said portions of said data, the second portion obtained using said second location input ~~to make a location determination~~.

240. (Currently Amended) A method as set forth in claim 239, wherein said step of combining comprises obtaining a first set of information including first location information and first time information for said first wireless mobile station, obtaining a second set of information

including second location information and second time information for said first wireless mobile station, determining a time difference between said first and second sets of information, and adjusting one of said first and second sets of information based on said time difference.

241. (Currently Amended) A method as set forth in claim 240, wherein said adjusting includes ~~comprising~~ calculating one of a change in position and a value related to an uncertainty in position dependent on said time difference.

242. (Currently Amended) A method as set forth in claim 239, wherein said step of combining comprises obtaining a first set of position information including a position and first value related to an uncertainty, obtaining a second set of information including a position and second value related to an uncertainty and combining said first set and said second sets to yield a third set including a position and an uncertainty for said wireless station, wherein said third set includes a reduced uncertainty relative to said first and second sets.

243. (Currently Amended) A method as set forth in claim 239, wherein said first location finding technology includes ~~involves a first location finding controller for~~ receiving first location data from a first source and determining, using said first location data, one or more first geometric extents for a location of the first mobile station and a value related to an uncertainty of said one or more first geometric extents to thereby provide said first location input, and

wherein said second location finding technology ~~involves~~ includes obtaining second location data from a second source and determining, using said second location data, one or more second geometric extents for a location of the first mobile station and a value related to an uncertainty of said one or more second geometric extents to thereby provide said second location input, and

wherein the first source includes a non-terrestrial wireless transmitter above and not supported on the Earth's surface, and the second location data includes information related to a wireless signal time delay of transmissions between the first mobile station, and at least one terrestrial base station ~~said step of combining comprises obtaining said first data from said first source, obtaining said second data from said second source, and said step of combining further comprises using one of said first data and said second data to obtain derived location information~~.

244. (Currently Amended) A method as set forth in claim 221, further comprising the steps of:

obtaining tracking information regarding movement of said first wireless mobile station[[,]]; and

using said tracking information to derive location information.

245. (Currently Amended) A method for estimating, for each mobile station **M** of a plurality of mobile stations, an unknown terrestrial location[[,]] (L_M)[[,]] for **M** using wireless signal measurements obtained ~~from~~ via transmissions between said mobile station **M** and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations is substantially co-located with one or more of a transmitter and a receiver for wirelessly communicating with said mobile station **M**, comprising:

initiating a plurality of requests for information related to the location of said mobile station **M**, the requests provided to each of at least two mobile station location evaluators, wherein there is at least a first of the requests provided to a first of the location evaluators and a second of the requests, different from the first request, provided to a second of the location evaluators, such that when said location evaluators are supplied with corresponding input data having values obtained using wireless signal measurements obtained via two way wireless communication between said mobile station **M**, and the communication stations, each of said first and second location evaluators determine corresponding location information related to L_M, and

wherein for at least one location **L** of one of the mobile stations, said first location evaluator and said second location evaluator output, respectively, first and second position information related to the one mobile station being at **L** wherein neither of the first and second position information is dependent upon the other;

obtaining a first collection of location information of said mobile station **M**, wherein the first collection includes first location information from the first location evaluator, and second location information from the second location evaluator;

determining resulting information related to the location L_M of the mobile station **M**, wherein the resulting information is dependent on geographical information in each of the first and second location information; and

transmitting, to a predetermined destination via a communications network, the resulting information.

246. (Currently Amended) The method of Claim 245, further including the following steps:

second obtaining, from an additional one or more of the location evaluators, additional ~~a second~~ ~~collection of~~ location information using values obtained from wireless signal measurements for a time different from a time of the communications between the mobile station **M** and the communication stations for obtaining the first collection;

determining, as part of said resulting information, a resulting location estimate of the mobile station **M**, wherein said resulting location estimate is dependent upon a value obtained from said additional ~~second collection of~~ location information ~~estimates~~.

247. (Currently Amended) A method for locating mobile stations at one or more unknown terrestrial locations using wireless signal measurements obtained via ~~from~~ transmissions between said mobile stations and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile stations, comprising:

receiving, from a plurality of location requesting sources, a plurality of input requests for locations of the mobile stations, wherein for each of the input requests there is a corresponding destination for a responsive output;

for each of the input requests, providing one or more location requests for location information, related to a location of one of said mobile stations, to one or more mobile station location determining sources;

first obtaining, in response to a first of the location requests received from a first of the requesting sources, at least first location information of a first location of a first of said mobile stations, said first location information determined using a first set of one or more wireless location techniques;

first determining, using said first location information, first output location data according to a first output criteria for the corresponding destination for the first request, said first output location data including a representation identifying a first geographical ~~range~~ location of the first location;

second obtaining, in response to a second of the location requests received from a second of the requesting sources, at least second location information of a second location of a second of said mobile stations, said second location information determined using a second set of one or more wireless location techniques, wherein the second set determines the second location information by activating at least one ~~computational~~ location computing module for locating the second mobile station from at least a portion of the signal measurements, wherein the at least one location computing module ~~that~~ is not activated for determining the first location information;

second determining, using said second location information, second output location data according to a second output criteria for the corresponding destination for the second request, said second output location data including a representation identifying a second geographical ~~range~~ location of the second location;

wherein for at least one of said first and second output criteria, there is an output criteria for another of the location requests that is different from said at least one output criteria;

first transmitting said first output location data to its corresponding destination via a communications network; and

second transmitting said second output location data to its corresponding destination via a communications network, the first and second locations being different.

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248. (Previously Presented) The method of Claim 247, wherein for at least one of said location techniques of said first set, and for a different one of said location techniques of said second set there is a common predetermined interface at which said first and second location information are received.

249. (Previously Presented) The method of Claim 247, wherein said steps of first and second determining use at least one common mobile station location related component for determining, respectively, said first output location data and said second output location data

250. (Previously Presented) The method of Claim 247, wherein said steps of first and second transmitting includes outputting said first and second output location data via a common predetermined network interface.

251. (Previously Presented) The method of Claim 247, wherein said first determining step includes accessing mobile station location output frequency information of said first output criteria.

Please delete Claim 252.

253. (Previously Presented) The method of Claim 247, wherein at least one of said first determining and said first transmitting steps includes determining a particular protocol for outputting said first output location data on the communication network for transmission to the corresponding destination for the first location request.

254. (Currently Amended) The method of Claim 247, wherein said first output criteria includes information for determining said representation of said first geographical ~~range~~ location using a location of a known geographical feature different from the communication stations.

255. (Previously Amended) The method of Claim 254, wherein the known geographical feature includes a roadway, and said determining step includes snapping to the roadway.

256. (Currently Amended) The method of Claim 247, wherein said corresponding destination for said first location request is for a first application, and said corresponding destination for said second location request is for a second application, wherein said first and second applications, respectively, use said first and second output location data differently;

wherein said first and second applications are for corresponding different ones of the following: responding to emergency calls, tracking, routing, and animal location including applications for confinement to or exclusion from certain areas.

Please delete Claim 257.

258. (Currently Amended) The method of Claim [[256]] 247, wherein said corresponding destination for said first location request is for a first application, and said corresponding destination for said second location request is for a second application;

wherein said first output criteria includes information for determining a first location granularity at which a location estimate of the first mobile station is transmitted in said first output location data, wherein said first location granularity is dependent upon said first application.

259. (Currently Amended) The method of Claim [[256]] 247, wherein said corresponding destination for said first location request is for a first application, and said corresponding destination for said second location request is for a second application;

wherein said first output criteria includes information for determining a first representation for said first output location data, wherein said first representation is dependent upon said first application, and said second output criteria includes information for determining a second representation for said second output location data, wherein said second representation is dependent upon said second application.

Please delete Claims 260 and 261.

262. (Previously Presented) The method of Claim 247, wherein at least one of said steps of receiving, first obtaining, second obtaining, first transmitting, and second transmitting receives or transmits wireless location related information on TCP/IP network.

263. (Currently Amended) The method of Claim 247, wherein said step of first obtaining includes receiving a first location estimate from a first of said location determining sources which performs an instance, I_1, of a first technique for estimating a location of the first mobile station using signal transmissions to the first mobile station from non-terrestrial transmitters above and not supported on the Earth's surface, wherein said instance I_1 also uses wireless signals, S, between the first mobile station and at least one of the communication stations to improve at least one performance characteristic of said instance I_1 over a performance of I_1 without use of the wireless signals between the first mobile station and the at least one communication station.

264. (Previously Presented) The method of Claim 263, wherein the instance I_1 uses first information for locating the first mobile station, wherein the first information is dependent upon signal timing measurements from the wireless signals S.

265. (Previously Presented) The method of Claim 263, wherein the instance I_1 uses first information from the wireless signals S, wherein the first information is dependent upon a wireless coverage area of the at least one communication station.

266. (Previously Presented) The method of Claim 247, further including a step of providing display information for displaying a representation of a location estimate L of the first mobile station, wherein said display information is for displaying a map of an area having the location estimate L, and for concurrently displaying information indicating an accuracy of the location estimate L.

267. (Previously Presented) The method of Claim 266, wherein said display information is displayed at a mobile station M that has requested a location of the first mobile station.

268. (Currently Amended) A method for locating a first ~~and second~~ wireless mobile station[[s]] using measurements of wireless signals, wherein at least one of: (i) said measurements, and (ii) said wireless signals are transmitted between the first mobile station and at least one of a plurality of terrestrial transceivers, and for locating a second wireless mobile station using second measurements of second wireless signals, where at least one of: (1) said second measurements, and (2) said second wireless signals are transmitted between the second mobile station and at least one of [[a]] the plurality of terrestrial transceivers, wherein said transceivers are capable of at least wirelessly detecting a plurality of wireless transmitting mobile stations, including said first and second mobile stations, comprising:

providing access to first and second different mobile station location techniques, wherein each of said location techniques is capable of providing location information for each mobile station of at least some of said mobile stations when said location technique is supplied with corresponding data obtained from wireless signal measurements communicated between the mobile station and one or more of said plurality of transceivers, wherein for at least one location L of one of the mobile stations, said first location technique and said second location technique output, respectively, first and second position information related to the one mobile station being at L wherein neither of the first and second position information is dependent upon a change in the other;

first supplying said first location technique with first corresponding data obtained from wireless signal measurements communicated between one or more of: (a1) said first mobile station and one or more of said plurality of transceivers, and (a2) said second mobile station and one or more of said plurality of transceivers;

second supplying said second location technique with second corresponding data obtained from wireless signal measurements communicated between one or more of: (b1) said first mobile station and one or more of said plurality of transceivers, and (b2) said second mobile station and one or more of said plurality of transceivers;

first receiving from said first location technique, first location related information representing one or more of: a first range of locations for the first mobile station, and a second range of locations for the second mobile station;

second receiving from said second location technique, second location related information representing one or more of: a third range of locations for the first mobile station, and a fourth range of locations for the second mobile station;

determining resulting location information for each of the first and second mobile stations using at least one of: (c1) a first value obtained from said first location related information, and (c2) a second value obtained from said second location related information;

wherein there is at least one predetermined common location related component activated for determining the resulting location information for each of said first and second mobile stations, wherein:

(i) said common component is activated, for locating said first mobile station, after at least one step of said steps of first and second supplying, and

(ii) said common component is activated, for locating said second mobile station, after at least one step of said steps of first and second supplying;

providing said resulting location information for each of the first and second mobile stations for presentation, wherein said presentation for at least one of said first and second mobile stations is determined according to an expected accuracy of said resulting location information for the at least mobile station.

269. (Previously Presented) A method for locating a wireless mobile station, comprising:

repeatedly performing the following steps (A1) through (A3) for tracking the mobile station, wherein there is at least a first and a second mobile station location technique, each of the location techniques providing an instance of location information for a location of the mobile station to the step (A1) below at some time during said step of repeatedly performing;

wherein for at least one location L of the mobile station, said first mobile station location technique and said second mobile station location technique output location information instances having, respectively, first and second position information for the mobile station being at L, wherein neither of the first and second position information varies substantially as a result in a change in the other;

(A1) receiving an instance, I_1, of location information for the mobile station from at least one of the first and a second mobile station location techniques wherein I_1 includes position information for the mobile station;

(A2) determining at least one resulting instance of location information for said mobile station using at least one of: (a) a first value obtained from an instance of first location information received from said first location technique, and (b) a second value obtained from an instance of second location information received from said second location technique;

wherein said step of determining includes a step of determining a likely roadway upon which the mobile station is located;

(A3) outputting said resulting location information for display on a display device, wherein said resulting location information is displayed as at least one location of the mobile station on a map having roadways thereon.

270. (Previously Presented) The method of Claim 269, wherein at least one occurrence of said step of outputting includes transmitting said resulting location information via a telephony network.

271. (Previously Presented) The method of Claim 269, wherein said outputting step includes providing accuracy information indicating an accuracy of said resulting location information, wherein said accuracy information is displayed with said at least one location of the mobile station.

272. (Previously Presented) The method of Claim 269, wherein for at least one location of the mobile station said step of determining uses both said first and second values.

Please delete Claims 273 through 275.

276. (Currently Amended) A method for locating, from a plurality of wireless mobile stations, one of the wireless mobile stations using measurements of wireless signals, wherein at least one of: (i) said measurements and (ii) said wireless signals are transmitted

between said one mobile station and at least one of a plurality of fixed location communication stations, each communication station capable of at least one of receiving wireless signals from, and transmitting wireless signals to said one mobile station, comprising:

receiving, from each of at least first and second mobile station location estimators, corresponding first and second information related to [[a]] likely geographical approximations for a location of said one mobile station, wherein:

_______(a) for determining a likely geographical approximation, GA_A, for a location, L_A, of a second of the mobile stations at a time T_A, said first location estimator generates GA_A without requiring a prior likely geographical location approximation generated by said second location estimator for locating the second mobile station at substantially the location L_A at substantially the time T_A, and,

_______(b) for estimating a likely geographical approximation, GA_B, for a location, L_B, of a third one of the mobile stations at a time T_B, said second location estimator generates GA_B without requiring a prior likely geographical location approximation generated by said first location estimator for locating the third mobile station at the location L_B at substantially the time T_B;

determining a resulting location estimate of said one mobile station, wherein said step of determining includes at least one of the substeps (B1) through (B2) following:

(B1) when said first and second information include, respectively, first and second likely geographical approximations, combining said first and second likely geographical approximations so that said resulting location estimate is dependent on each of said first and second location likely geographical approximations; and

(B2) selecting one of said first and second information for receiving preference in determining said resulting location, wherein said selecting is dependent upon location related data in at least one of said first and second information.

277. (Previously Presented) The method of Claim 276, further including a step of providing display information for: (a) displaying a representation of said resulting location estimate, wherein said display information is for displaying with a map of an area having the resulting location estimate, and (b) concurrently displaying information indicative of an accuracy of the resulting location estimate.

278. (Currently Amended) A method for locating a wireless mobile station capable of wireless two way communication with a plurality of fixed location terrestrial stations, comprising:

providing access to a plurality of mobile station location estimating techniques, wherein each said location technique[[s]] provides location information ~~related to~~ having a location estimate of said mobile station when said location technique is ~~are~~ supplied with sufficient corresponding input information upon which ~~their~~ the location estimate is ~~are~~ dependent, and wherein the corresponding input information is at least partially derived from measurements of wireless signals transmitted from or received at the mobile station;

receiving, over time, a plurality of location estimates of the mobile station[[:]];

determining, a plurality of consecutive resulting location estimates for tracking the mobile station, wherein said step of determining includes steps (a) and (c) following:

(a) deriving, for at least one time during the tracking, a corresponding one of said resulting location estimates of the mobile station using one of said ~~first one or more~~ location estimates by said first location technique for ~~a first location of~~ locating the mobile station;

(b) deriving, for at least one time during the tracking, a corresponding one of said resulting location estimates of the mobile station using one of said ~~second one or more~~ location estimates by said second location technique for ~~a second location of~~ locating the mobile station;

(c) preferring a location estimate of said first location ~~information~~ technique over a location estimate of said second location ~~information~~ technique when both are available for substantially a same location of the mobile station.

279. (Currently Amended) The method as claimed in Claim 278, wherein said step of determining includes:

establishing a priority between a location estimate of said first location ~~information~~ technique and a location estimate of said second location ~~information~~ technique.

280. (Currently Amended) The method as claimed in Claim 279, wherein said step of establishing includes obtaining a confidence value for one or more of: (a) at least one of said

location estimates for said first location ~~information~~ technique; and (b) at least one of said location estimates for said second location ~~information~~ technique;

wherein each said confidence value is indicative of a likelihood of the mobile station having a location represented by said corresponding location estimate for the confidence value.

Please delete Claim 281.

282. (Currently Amended) The method of Claim 278, further including the steps of:

requesting one or more of the resulting location estimates via signals transmitted on the Internet ~~by a commercial mobile radio service provider~~ ~~that wirelessly communicates with the mobile station;~~

~~transmitting, via a communication network, at least one location of the mobile station to one of: the mobile station, another mobile station, a police unit, a vehicle, and a party requesting the location of the mobile station~~.

283. (Previously Presented) The method of Claim 278, wherein said determining step includes determining at least one of said resulting location estimates as a function of a position of a known geographical feature that is sufficiently close to one of the first or second location estimates so that the closeness is used to determine said more likely location estimate.

284. (Previously Presented) The method as claimed in Claim 278, wherein said step of determining includes, for at least one of said resulting location estimates, determining one or more of: (a) a velocity of the mobile station, (b) an acceleration of the mobile station, and (c) one or more geographical features near said at least one resulting location estimate.

285. (Currently Amended) A method for locating a mobile station using wireless signal measurements obtained from transmissions between said mobile station and a plurality of fixed location communication stations, wherein each of said communications stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile station, comprising:

providing access to first and second mobile station location evaluators, wherein said location evaluators are able to determine information related to one or more location estimates of said mobile station when said location evaluators are supplied with data having values obtained during wireless signal two way communication between said mobile station and the communication stations;

wherein for at least one location L of the mobile station, said first mobile station location evaluator and said second mobile station location evaluator output location information instances having, respectively, first and second position information for the mobile station being at L, wherein neither of the first and second position information substantially changes with a change in the other of the first and second position information;

first obtaining, from said first location evaluator, first location related information for identifying a location of the mobile station for at least one of the following situations: a tracking of the mobile station, and in response to a request for a location of the mobile station;

second obtaining, from said second location evaluator, second location related information for identifying a location of the mobile station for said same at least one situation;

determining ~~additional~~ resulting location information of the mobile station dependent upon at least one of: (a) a first value obtained from said first location related information, and (b) a second value obtained from said second location related information;

wherein said determining step includes providing the ~~additional~~ resulting location information with:

(i) data indicative of one of: an error and a likelihood of the mobile station being at a location represented by said ~~additional~~ resulting location information; and

(ii) a timestamp indicative of when the resulting location information corresponds to a location of the mobile station.

286. (Currently Amended) The method as claimed in Claim 285, wherein said mobile station is co-located with a processor for activating at least one of said location evaluators, said processor receives signals from a non-terrestrial wireless transmitter above and not supported on the Earth's surface.

287. (Previously Presented) The method of Claim 285, further including a step of transmitting said resulting location estimate on a communications network to a destination requesting the location of the mobile station.

288. (Previously Presented) The method of Claim 285, further including a step of determining, using said resulting location information, output location information according to

output criteria corresponding to an application requesting data related to a location of the mobile station.

289. (Previously Presented) The method of Claim 288, wherein said output criteria includes at least some of:

(a) a transmission protocol;

(b) a granularity of by which a location estimate of the mobile station represented by said resulting location information is to be provided;

(c) a frequency with which repeated location estimates of the mobile station are to be output to the application;

(d) destination data for determining where said resulting location information is to be transmitted;

(e) an indication as to whether a location estimate of the mobile station is to be adjusted according to a known geographical feature different from the communication stations; and

(f) a desired representation of a location estimate of the mobile station represented by said resulting location information.

290. (Currently Amended) A method for locating one or more mobile stations using wireless signal measurements obtained from transmissions between said mobile stations and a plurality of terrestrial communication stations, wherein each of said communication stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile stations, comprising:

receiving a location request for a location of a first of the mobile stations, wherein the first mobile station is capable of providing wireless telephony transmissions, and the first mobile station includes a substantially same collection of components that are in electronic contact with one another for performing each of at least most wireless telephony transmissions from the first mobile station;

generating one or more messages, for information related to a location of said first mobile station, said messages for requesting activation of one or more mobile station location estimators such that when said location estimators are supplied with corresponding input data having values obtained from wireless signal measurements obtained via transmissions between said first mobile station and the communication stations, said one or more location estimators determine location related information for the first mobile station;

first obtaining, from at least two of said location estimators, first mobile station related location information obtained as a result of an available at least two instances of said corresponding input data;

determining a resulting location estimate of the first mobile station obtained from said first mobile station related location information;

wherein at least one of said steps of generating, first obtaining, and determining includes a substep of one of: (i) transmitting information to a destination via a communication network, and (ii) receiving information from a source via a communication network;

_______using said resulting location information, to determine output location information according to output criteria corresponding to an application requesting data related to a location of the mobile station, wherein said output criteria includes at least some of:

(a) a transmission protocol;
(b) a granularity of by which a location estimate of the mobile station represented by said resulting location information is to be provided;
(c) a frequency with which repeated location estimates of the mobile station are to be output to the application;
(d) destination data for determining where said resulting location information is to be transmitted;
(e) an indication as to whether a location estimate of the mobile station is to be adjusted according to a known geographical feature different from the communication stations; and
(f) a desired representation of a location estimate of the mobile station represented by said resulting location information.

291. (Currently Amended) A method for locating a mobile station using wireless signal measurements obtained from transmissions between said mobile station and at least one of a plurality of terrestrial transceivers capable of wirelessly detecting said mobile station, comprising:

providing access to at least two ~~of the~~ location techniques;

determining whether an accessible first of the location techniques has its corresponding input available for determining a first location estimate of said mobile station;

determining a second location estimate of said mobile station by activating an accessible second of said location techniques different from said first location technique when the corresponding input for said second technique is available;

receiving at least one of said first and second location estimates;

obtaining resulting location information for transmitting on a communications network, wherein said resulting location information is obtained using at least one of said first location estimate and said second location estimate;

wherein when said mobile station is at a first location, an instance of at least said first location estimate is used in said obtaining step for obtaining a first corresponding instance of said resulting location information, and when said mobile station is at a second location, an instance of at least said second location estimate is used in said obtaining step for obtaining a second corresponding instance of said resulting location information; and

wherein for the first location, ~~the corresponding performance of~~ said obtaining step includes: (1) a step of improving upon said instance of at least said first location estimate, and (2) a step of providing information indicative of an accuracy of said first corresponding instance of said resulting location information.

292. (Currently Amended) A mobile station location system, comprising:

a gating module for communicating with two or more mobile station location estimating sources for determining corresponding geographic extents for locations of a plurality of mobile stations, such that for each mobile station **M** of at least some of the mobile stations, when ~~said~~ one or more of the estimating sources are supplied with corresponding data obtained from measurements of wireless signals transmitted between the mobile station **M**, and at least one of (1) and (2) following:

(1) a plurality of communication stations capable of at least one of: wirelessly detecting said mobile stations, and being wirelessly detected by said mobile stations, and

(2) one or more non-terrestrial wireless signal transmitting stations,

then for said one or more location estimating sources supplied with their corresponding data, each such source outputs a corresponding geographic extent of a geographical location of the mobile station **M**;

wherein for a first of said mobile station location estimating sources~~, when estimating a location of one of the mobile stations~~, and for a second of said mobile station location estimating sources, ~~and~~ for at least one instance of locating one of the mobile stations, said first and second sources can provide if activated, respectively, first and second different corresponding geographic extents for the one mobile station;

wherein the first corresponding geographic extent is not dependent upon the second corresponding geographic extent,and the second geographic extent is not dependent upon the first geographic extent;

wherein said gating module communicates on a communications network with at least the first of the location estimating sources for providing said location system with said corresponding geographic extent for a location L of the mobile station **M**; and

a resulting estimator for determining a likely location estimate of the location L of the mobile station **M** using two or more of said corresponding geographic extents for the mobile station **M**, said resulting estimator activating at least one of: (i) a selector for giving preference, as more indicative of the location L, to at least one geographic extent obtained from said corresponding geographic extents, and (ii) a combiner for combining said two or more corresponding geographic extents for obtaining said likely location estimate.

293. (Previously Presented) The location system, as claimed in Claim 292, wherein one or more of said estimating sources are capable of being at least one of: added, replaced and deleted by transmissions on a communication network between a portion of said location system and a site remote from said portion.

294. (Currently Amended) The location system as claimed in Claim 292, wherein ~~one~~ two or more of:

(a) at least one of said one or more corresponding geographic extents, GE, has a corresponding value therewith indicative of a likelihood that the mobile station **M** resides in a geographical area represented by GE, and said combiner uses said corresponding value for obtaining said likely location estimate;

~~(b) said gating module activates a wireless transceiver for communicating with the plurality of communication stations;~~

~~(c) said plurality of communication stations includes base stations for wireless two way communication with said mobile stations;~~

(<u>b</u>[[d]]) said non-terrestrial wireless signal transmitting stations include GPS satellites;

(<u>c</u>[[e]]) said communications network includes a portion of the Internet;

(<u>d</u>[[f]]) the mobile station **M** has an ability to communicate with other of the mobile stations as a base station;

(<u>e</u>[[g]]) said selector includes a filter for reducing a dependence of said likely location estimate on one of the corresponding geographic extents;

(<u>f</u>[[h]]) said resulting estimator is at least partially included in a mobile base station; <u>and</u>

~~(i) said resulting estimator resides at a location center;~~

~~(j) said gating module resides at a location center;~~

(<u>g</u>[[k]]) said gating module routes activation information to said two or more estimating sources~~; and~~

~~(l) said gating module resides at a mobile station~~.

295. (Currently Amended) A mobile station location system, comprising:

a communications controller for selectively communicating with a plurality of mobile station location estimating sources for at least one of (1) and (2) following:

(1) activating a selected one or more of said mobile station location estimating sources; and

(2) receiving location related information for locating a plurality of mobile stations;

wherein for each mobile station **M** of at least some of the mobile stations, when one or more of said location estimating sources are supplied with corresponding data obtained from measurements of wireless signals transmitted between (i) and (ii) following:

(i) the mobile station **M**, and

(ii) at least one of: a network of communication stations cooperatively linked for use in locating the mobile stations, and one or more non-terrestrial wireless signal transmitting stations,

then each such source supplied with its corresponding data, outputs a corresponding location estimate of a geographical location of the mobile station **M**;

wherein for a first of said mobile station location estimating sources, when estimating a location L_1 of one of the mobile stations, said first source is dependent upon a result from a first location computing component for computing the location L_1, and for a second of said mobile station location estimating sources, when estimating a location L_2 of one of the mobile stations, said second source is dependent upon a result from a different second location computing component, wherein the first source is not dependent upon on an output from the second location computing component when estimating the mobile at the location L_1, and the second location computing component is not dependent upon an output from the first location computing component when estimating the mobile at the location L_2;

wherein for at least one instance of locating one of the mobile stations, said first and second sources can provide, if activated, different location estimates;

an interface in communication with said controller, said interface for communicating on a communications network with at least one of said first and second location estimating sources for thereby at least one of (3) and (4) following:

(3) requesting activation of said at least one location estimating source, and

(4) receiving, from said at least one location estimating source, said corresponding location estimate of the mobile station **M**;

a resulting estimator for determining a likely location estimate of a location L of the mobile station **M** using two or more of said corresponding location estimates for the mobile station **M** at L, wherein said resulting estimator includes at least one of:

(i) a selector for giving preference, as more indicative of the location L, to at least one preferred location estimate obtained from said corresponding location estimates; and

(ii) a combiner for obtaining said likely location estimate as a function of said two or more of said corresponding location estimates.

296. (New) The method of Claim 221, wherein said common standardized format defines a plurality of location related data fields, each field having a common data representation for both of said first and second location inputs, said fields for including: (a) information indicative of one of: an error, and a confidence of the first mobile station being in a corresponding location estimate of the first mobile station, and (b) time related information indicative of when the first mobile station is in the corresponding location estimate.

297. (New) The method of Claim 221, wherein said common standardized format defines a plurality of location related data fields, each field having a common data representation for both

of said first and second location inputs, said fields for including information for identifying a corresponding one of the first and second location estimating sources.

298. (New) The method of Claim 221, wherein said common standardized format defines a plurality of location related data fields, each field having a common data representation for both of said first and second location inputs, said fields for including descriptor having information indicative of location related processing performed by a corresponding one of the first and second location estimating sources.

299. (New) The method of Claim 221, wherein said data includes first data for said first location input, and second data for said second location input, and said step of third obtaining includes a step of providing a preference to the first data over the second data when determining said requested information.

300. (New) The method of Claim 245, wherein at least one of the wireless signal measurements for obtaining at least one of the values of the corresponding input data for the first location evaluator is such that this at least one wireless signal measuremt is for a wireless signal having its source as a non-terrestrial wireless transmitter above and not supported on the Earth's surface.

301. (New) The method of Claim 247, wherein for locating at least one of the first and second mobile stations, the corresponding one of the first and second sets for performing the locating uses data form wireless signal measurements (S) obtained via transmissions between the at least one mobile station and a plurality of fixed location terrestrial communication stations, wherein at least one of the wireless signal measuremts of S is for a wireless signal having its source as a non-terrestrial wireless transmitter above and not supported on the Earth's surface.

302. (New) The method of Claim 269, wherein said first location technique uses a measurement of a wireless signal, S, to the mobile station and from at least one non-terrestrial transceiver above and not supported on the Earth's surface, and said second location technique uses a measurement of a wireless signal transmission, T, between the first mobile station and at least one terrestrial transceiver to improve upon of said first location.

303. (New) The method of Claim 302, wherein said second location technique includes a step of using information dependent upon a wireless coverage area of the at least one transceiver for improving said first location information

304. (New) The method of Claim 303, wherein the at least one transceiver includes a base station for providing two way communication with the mobile station.

305. (New) The method of Claim 290, wherein said output criteria includes at least two of: (a), (b), (c) and (e).

Remarks

Claim Amendments

Applicants request entry of the claim amendments provided herein. Applicants provide hereinbelow a description of each amended claim. Note that the undersigned Applicant has reviewed the Reasons for allowance that the Examiner provided with the Notice of Allowance of the present application having a mailing date of March 11, 2003, and it appears that the claim language referred to by the Examiner in providing the Reasons for Allowance remains substantially unchanged in the presently amended claims.

Claim 221 has been amended to simplify the claim language. The amendment to the preamble may change the claim scope somewhat. However, the preamble now better reflects the steps of this claim. Additionally the amendments to the body of this claim provide appropriate antecedent bases for terms of the claim as well as provide grammatical consistency. Note that the term "wireless location application" has been changed to – application using wireless location – since it is believed that the latter term is more appropriate. It is believed that Applicant's have not departed from the novelty recited in the present claim.

Claim 222 has been amended to provide proper antecedent basis to the claim language.

Claim 223 has been amended to provide consistency with Claim 221 upon which it depends.

Claim 224 has been amended to provide proper antecedent basis to the claim language by making this dependent upon Claim 223.

Claim 226 has been amended to insert a period at the end of the claim.

Claim 237 has been amended by adding "or likelihood" as an additional condition instead of (or in addition to) "uncertainty".

Claim 239 has been amended to provide proper antecedent basis to the claim language, and to clarify the claim.

Claim 240 has been amended to provide proper antecedent basis to the claim language.

Claim 241 has been amended to correct the grammar thereof.

Claim 242 has been amended to correct a typographical error.

Claim 243 has been amended to recite a different aspect of the invention. Applicants could have added the wording of this claim as a new claim. This claim is allowable due to its dependence upon allowable Claim 221.

Claim 244 has been amended to provide proper antecedent basis to the claim language, and correct grammar errors.

Claim 245 has been amended to recite the word "via" rather of "from" in the preamble. Note that this change is consistent with the wording in the initiating step of this claim. Additionally, some commas have been changed to parentheses so that the grammatical structure of the preamble is easier to follow. It is believed these amendments do not make the present unpatentable.

Claim 246 has been amended to recite "additional location information" instead of –a second collection of location information--. This claim is at least patentable due to its dependence upon patentable Claim 245.

Claim 247 has been amended to recite "via" instead of "from" as in Claim 245. Also, the word "range" has been changed to "location", since it is believed "location" is a broader term. Additional limitations have been added to further clarify the "module" that is activated for the "second set" of one or more wireless location techniques. It is believed that the present claim remains patentable, although it scope has changed somewhat.

Claim 254 has been amended to be consistent with the amendment of Claim 247.

Claim 256 has been amended to include many of the limitations of Claim 257 which has been deleted.

Claim 258 has been amended to include a portion of Claim 256 so that the present claim can now depend directly from Claim 247.

Claim 259 has been amended similarly to Claim 258.

Claim 263 has been amended to better describe the "non-terrestrial transmitters".

Claim 268 has been amended to clarify the claim. In particular, the claim preamble is now clearer.

Claim 276 has been amended to remove an extraneous "a", and some formatting of the claim has been changed.

Claim 278 has been amended to provide proper antecedent basis for claim terms. Additionally, the present claim included errors wherein in "location information related to" in providing step should be –location information having a location estimate of--. Moreover, in (c) of the claim "first location information" should be –first location technique", and "second location information" should be –second location technique--.

Claim 282 has been amended to recite that signals for requesting resulting location estimates are transmitted on the Internet. To Applicant's knowledge, no prior art cites such a limitation in combination with the limitations of Claim 278. Accordingly, it is believed that the present claim is patentable at least due to its dependence upon patentable claim 278.

Claim 285 has been amended to provide proper antecedent basis for claim terms. In particular, the term "resulting location information" had no antecedent basis.

Claim 286 has been amended to recite an additional limitation. Accordingly, it is believed to be patentable.

Claim 290 has been amended to clarify the claim. The intended claim scope has not changed.

Claim 291 has been amended to correct antecedent basis errors in that there was no antecedent basis for "the location techniques" in the providing step, there was no antecedent basis for "the corresponding performance of said obtaining step" in the last "wherein" clause of the claim.

Claim 292 has been amended to better clarify the claim. In particular, additional limitations have been added to the claim to clarify the intent of the claim. For example, it is intended that the first and second location estimating sources be "independent" of one another at least in the sense that for at least one location of one of the mobile stations, the first and second location estimating sources would provide different corresponding geographic extents for locating a mobile station. However, Applicants believe it is additionally prudent in the present claim to further limit the processing performed by the first and second location estimating sources so that neither of their corresponding output geographic extents are dependent upon the other.

Additionally, the phrase "when estimating a location of one of the mobile stations" did not appear to contribute to the clarity of the claim, and did not appear to add any additional limitation. So accordingly the phrase was deleted.

Claim 294 has been amended to narrow the scope of the claim. Accordingly, this claim is believed allowable.

Claim 295 has been amended in a manner similar to Claim 292. Accordingly, it is believed that this claim is no broader than its non-amended version.

NEW CLAIMS

New dependent claims 296 through 305 are provided herein. Since each new claim is dependent upon an allowable claim. It is believed that these new claims are also allowable.

Applicants request entry of all the amendments provided herewith, and reconsideration of the present application. It is believed that all pending claims are patentable. Thus, it is requested that the Examiner contact the Applicant named below by phone if the Examiner determines that one or more of the claims are not patentable. No other fees are believed due with this transmittal since any fees were paid with the original submittal of these claims.

Applicants have added 10 new dependent claims and have cancelled 8 claims herein. Accordingly, Applicants are paying two dependent claims concurrently with entry of this amendment. No other fees are believed due.

Note that if additional fees are due, then the Applicant respectfully requests notification of the Applicant named below so that any additional fees can be timely paid.

Respectfully submitted,

By: /Dennis J. Dupray/

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, Colorado 80401
(303) 863-2975

Date: Aug. 23, 2007

PATENT APPLICATION

In Re the Application of:

DUPRAY et al.

Serial No.: 09/770,838

Filed: January 26, 2001

Atty. File No.: 1003-1

For: "A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION"

Prior Group Art Unit: 3662

Prior Examiner: Dao Phan

RESPONSE TO EXAMINER'S REASONS FOR ALLOWANCE

MAIL STOP: Issue Fee
Commissioner for Patents P.O. Box 1450
Alexandria, VA. 22313-1450

Dear Sir/Madam:

Dear Examiner:

Applicant's representative acknowledges with appreciation the Examiner's Statement of Reasons for Allowance. Applicant notes, however, that such statement of reasons for allowance appears to reflect only some of the patentable features of some of the independent claims. In particular, the Examiner indicated the reasons for allowance are based on the Examiner finding:

> 'the examiner found no teaching in the prior art that would render obvious the claimed mobile station location system and method for use in a wireless network including the steps of "wherein the first location estimating source employs a first location finding technology, wherein the steps of first and second obtaining includes a step of providing the first and second location inputs in a common standardized format, and third obtaining the requested location information by selectively using portions of the data from the memory", claim 221, "initialing a plurality of requests for information

related to the location of the mobile station M", claim 245, "where the first obtaining steps results from an activation of at least two different wireless location technique, first determining, using the first location information, first output location data according to a first output criteria, second obtaining, in response to a second of the location requests received from a second of the requesting sources, at least second location information of a second location of a second of the mobile stations, and second determining, using the second location information, second output location data according to a second output criteria", claim 247, "providing access to first and second different mobile station location technique, wherein there is at least on predetermined common location related component activated for determining the resulting location information, and providing the resulting location information for each of the first and second mobile stations for presentation", claim 268, "repeatedly performing the following steps (Al) through (A3) for tracking the mobile station as claimed", claim 269, "receiving, from each of at least first and second mobile station location estimators" , claim 276, "providing access to a plurality of mobile station location estimating techniques", claim 278, "determining additional location information of the mobile station", claim 285, "generating one or more messages, for information related to a location of the first mobile station", claim 290, "determining a second location estimate of the mobile station by activating an accessible second of the location techniques, wherein when the mobile is at a first location, an instance of at least the first location estimate is used in obtaining step for obtaining a first corresponding instance of the resulting location information", claim 291, "a gating module for communicating with two or more mobile station location estimating sources for determining corresponding geographic extents for locations of a plurality of mobile stations, and a resulting estimator for determining a likely location estimate of the location L of the mobile station M", claim 292, "wherein for a first of the mobile station location estimating sources, when estimating a location of one of the mobile station, and a resulting estimator for determining a likely location estimate of a location L of the mobile station M", claim 295.

However, it is respectfully submitted that there are believed to be additional reasons for allowance due to, e.g., the amendments to the claims since the Examiner formulated the above reasons for allowance. As such, Applicant's representative hereby states that for all allowed claims whether or not explicitly identified by the Examiner in the Reasons for Allowance, it is believed the Examiner's reasons for allowance is that the features as set forth in such claims define an invention that is free of the prior art and that complies with all 35 U.S.C. §112 requirements.

Accordingly, the patentability of each of the pending claims is assumed to be based upon the features as set forth in the pending claims, and that such claims meet all criteria for patentability under 35 U.S.C. §101, §102, §103 and §112.

Moreover, as is clear from MPEP 1302.14,

> "The statement [of reasons for allowance] is not intended to necessarily state all the reasons for allowance or all the details why claims are allowed and should not be written to specifically or impliedly state that all the reasons for allowance are set forth."

Thus, the Examiner is not required to state all reasons for allowance.

If the Examiner disagrees with any of Applicant's above statements, it is requested that the Examiner contact the undersigned as soon as possible. It will be assumed that Applicant's above statements are accurate and complete otherwise.

Respectfully submitted,

By: /Dennis J. Dupray/
Dennis J. Dupray
Registration No. 46,299
1801 Belvedere St.
Golden, Colorado 80202-5141
Phone: 303-863-2975

Date: Aug. 23, 2007

.

Electronic Patent Application Fee Transmittal

Application Number:	09770838
Filing Date:	26-Jan-2001
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Filer:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1

Filed as Small Entity

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Claims in excess of 20	2202	2	25	50
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**50**

Electronic Acknowledgement Receipt	
EFS ID:	2119516
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Correspondence Address:	Dennis J. Dupray, Ph.D. - 1801 Belvedere Street - Golden CO 80401 US 3038630223 -
Filer:	Dennis Jay Dupray.
Filer Authorized By:	
Attorney Docket Number:	1003-1
Receipt Date:	23-AUG-2007
Filing Date:	26-JAN-2001
Time Stamp:	22:52:57
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	$50
RAM confirmation Number	3350

Deposit Account	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/Message Digest	Multi Part /.zip	Pages (if appl.)
1	Post Allowance Communication - Incoming	Ltr_RE_Previously_Paid_Issue_Fees.pdf	622227 0adb9a3d51f85742dad7cb6b8a976312cc3bed71	no	7
Warnings:					
Information:					
2	Issue Fee Payment (PTO-85B)	Signed_Issue_Fee_Transmittal_Form.pdf	201432 ed6a8e5e241f6b886a771375548fd6f1a8227341	no	1
Warnings:					
Information:					
3		Amendment_After_Allowance.pdf	198631 179b70c52c09bdc01a9f8a28c72cfe6061eeb834	yes	30

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment after Notice of Allowance (Rule 312)	1	1
Claims	2	26
Applicant Arguments/Remarks Made in an Amendment	27	30

Document Number	Document Description	File Name	File Size(Bytes)/Message Digest	Multi Part /.zip	Pages (if appl.)
Warnings:					
Information:					
4	Post Allowance Communication - Incoming	Response_to_Reasons_for_Allowance.pdf	112963 eda941d22aa61b3b4b550d7f02f1c9fc1d691ac7	no	3
Warnings:					
Information:					
5	Fee Worksheet (PTO-06)	fee-info.pdf	8138 fb6c521315394e86b4e6e711061da4ed546c01ee	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1143391		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT APPLICATION

In Re the Application of:

DUPRAY et al.

Serial No.: 09/770,838

Filed: January 26, 2001

Atty. File No.: 1003-1

For: "A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION"

Prior Group Art Unit: 3662

Prior Examiner: Dao Phan

PREVIOUS PAYMENT OF PUBLICATION AND ISSUE FEES

MAIL STOP: Issue Fee
Commissioner for Patents P.O. Box 1450
Alexandria, VA. 22313-1450

Dear Sir/Madam:

In a filing for the present application on April 28, 2007 for the present application, both the issue fee and the publication fee were paid as indicated by the Electronic Patent Application Fee Transmittal, and Electronic Acknowledgement Receipt provided herewith. Accordingly, it is believed that all fees have been paid, and that contrary to what is indicated on the Issue Fee Transmital (a copy is also provided herewith), it is believed that **no fees are due** with the filing of the Fee(s) Transmittal.

In the event that additional fees are due, please debit deposit account 19-1970. However, it is requested that the undersigned be contacted in this event.

Respectfully submitted,

By: /Dennis J. Dupray/

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, Colorado 80401
(303) 863-2975

Date: Aug. 23, 2007

Electronic Patent Application Fee Transmittal

Application Number:	09770838
Filing Date:	26-Jan-2001
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Filer:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1

Filed as Small Entity

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	2501	1	700	700
Publication fee for republication	1505	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1000**

Electronic Acknowledgement Receipt	
EFS ID:	1726282
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Correspondence Address:	Dennis J. Dupray, Ph.D. - 1801 Belvedere Street - Golden CO 80401 US 3038630223 -
Filer:	Dennis Jay Dupray.
Filer Authorized By:	
Attorney Docket Number:	1003-1
Receipt Date:	28-APR-2007
Filing Date:	26-JAN-2001
Time Stamp:	16:03:16
Application Type:	Utility

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	$1000
RAM confirmation Number	1622

Deposit Account	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part /.zip	Pages (if appl.)
1	Post Allowance Communication - Incoming	Renewed_Petition_Revival.pdf	84571	no	2
Warnings:					
Information:					
2	Issue Fee Payment (PTO-85B)	Issue_Fee_Transmittal.pdf	99187	no	1
Warnings:					
Information:					
3	Fee Worksheet (PTO-06)	fee-info.pdf	8258	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	192016		

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: **Mail** **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 05/23/2007

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

TITLE OF INVENTION: GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$700	$0	$700	$700	08/23/2007

EXAMINER	ART UNIT	CLASS-SUBCLASS
PHAN, DAO LINDA	3662	342-450000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. Use of a Customer **Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 __________
2 __________
3 __________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

- ☐ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies __________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number __________ (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)

- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature __________ Date __________

Typed or printed name __________ Registration No. __________

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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OIPE IAP — AUG 2 4 2007 — PATENT & TRADEMARK OFFICE

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 05/23/2007

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

08/24/2007 SSANDAR1 00000003 09770838
01 FC:2501 700.00 OP

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

TITLE OF INVENTION: GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$700	$0	$700	~~$700~~ $0	08/23/2007

EXAMINER	ART UNIT	CLASS-SUBCLASS
PHAN, DAO LINDA	3662	342-450000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. Use of a Customer Number is required.

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 ________
2 ________
3 ________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: TracBeam LLC
(B) RESIDENCE: (CITY and STATE OR COUNTRY): Golden, Colorado

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☐ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies ________

4b. Payment of Fee(s): (Please first reapply any previously paid issue fee shown above)
☐ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 19-1970 (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)
☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature [signature] Date Aug. 23, 2007

Typed or printed name Dennis J. Dupray Registration No. ________

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Adjustment date: 08/24/2007 SSANDAR1
00000003 09770838
01 FC:2501 -700.00 OP

Application Serial No.: 09/770,838
Document: "After Allowance Amendment"

PATENT APPLICATION

In Re the Application of:

DUPRAY et al.

Serial No.: 09/770,838

Filed: January 26, 2001

Atty. File No.: 1003-1

For: "A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION"

Prior Group Art Unit: 3662

Prior Examiner: Dao Phan

AFTER ALLOWANCE AMENDMENT

MAIL STOP: Issue Fee
Commissioner for Patents P.O. Box 1450
Alexandria, VA. 22313-1450

Dear Sir/Madam:

Applicants file the present after allowance amendment to correct typographical errors, to clarify certain claims, to delete 8 dependent claims, and to add 10 new dependent claims.

If there are any questions regarding the present amendment, it is requested that the named Applicant hereinbelow (Dennis Dupray) be contacted at 303-863-2975. Note, it is believed that no fees are due with this transmittal beyond the amount for two dependent claims.

08/24/2007 INTEFSW 00003350 09770838
01 FC:2202 50.00 OP

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

7590 10/10/2007

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

EXAMINER	
PHAN, DAO LINDA	

ART UNIT	PAPER NUMBER
3662	

MAIL DATE	DELIVERY MODE
10/10/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

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APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR / PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
09770838			

EXAMINER	
ART UNIT	PAPER

DATE MAILED:

NOTICE OF NON-COMPLIANT INFORMATION DISCLOSURE STATEMENT

An Information Disclosure Statement (IDS) filed 8/1/07 in the above-identified application fails to meet the requirements of 37 CFR 1.97(d) for the reason(s) specified below. Accordingly, the IDS will be placed in the file, but the information referred to therein has not been considered.

The IDS is not compliant with 37 CFR 1.97(d) because:

- ☐ The IDS lacks a statement as specified in 37 CFR 1.97(e).
- ☑ The IDS lacks the fee set forth in 37 CFR 1.17(p).
- ☐ The IDS was filed after the issue fee was paid. Applicant may wish to consider filing a petition to withdraw the application from issue under 37 CFR 1.313(c) to have the IDS considered. See MPEP 1308.

CB
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

7590 10/10/2007

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

EXAMINER	
PHAN, DAO LINDA	

ART UNIT	PAPER NUMBER
3662	

MAIL DATE	DELIVERY MODE
10/10/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

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APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR / PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
09770838			

EXAMINER	
ART UNIT	PAPER
	[redacted]

DATE MAILED:

NOTICE OF NON-COMPLIANT INFORMATION DISCLOSURE STATEMENT

An Information Disclosure Statement (IDS) filed 8/8/07 in the above-identified application fails to meet the requirements of 37 CFR 1.97(d) for the reason(s) specified below. Accordingly, the IDS will be placed in the file, but the information referred to therein has not been considered.

The IDS is not compliant with 37 CFR 1.97(d) because:

- ☐ The IDS lacks a statement as specified in 37 CFR 1.97(e).
- ☑ The IDS lacks the fee set forth in 37 CFR 1.17(p).
- ☐ The IDS was filed after the issue fee was paid. Applicant may wish to consider filing a petition to withdraw the application from issue under 37 CFR 1.313(c) to have the IDS considered. See MPEP 1308.

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PTO/SB/81 (01-06)
Approved for use through 12/31/2008. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

POWER OF ATTORNEY and CORRESPONDENCE ADDRESS INDICATION FORM

Application Number	09/770,838
Filing Date	01-26-2001
First Named Inventor	DUPRAY
Title	MULTIPLE EVALUATORS FOR...
Art Unit	3662
Examiner Name	PHAN, DAO LINDA
Attorney Docket Number	1003-1

I hereby revoke all previous powers of attorney given in the above-identified application.

I hereby appoint:

☑ Practitioners associated with the Customer Number: 62914

OR

☐ Practitioner(s) named below:

Name	Registration Number

as my/our attorney(s) or agent(s) to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith.

Please recognize or change the correspondence address for the above-identified application to:

☑ The address associated with the above-mentioned Customer Number:

OR

☐ The address associated with Customer Number:

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Address					
City		State		Zip	
Country					
Telephone		Email			

I am the:

☐ Applicant/Inventor.

☑ Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96)

SIGNATURE of Applicant or Assignee of Record

Signature	[signature]	Date	Feb. 14, 2008
Name	Dennis J. Dupray	Telephone	(303) 273-0167
Title and Company	Managing Partner, TRACBEAM, LLC		

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

☑ *Total of 1 forms are submitted.

Electronic Acknowledgement Receipt	
EFS ID:	2881530
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Correspondence Address:	Dennis J. Dupray, Ph.D. - 1801 Belvedere Street - Golden CO 80401 US 3038632975 -
Filer:	Dennis Jay Dupray./Debra Kesner
Filer Authorized By:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1
Receipt Date:	19-FEB-2008
Filing Date:	26-JAN-2001
Time Stamp:	18:41:01
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	POA_Signed.pdf	119789 9e3d9d3a46c1d5370369c9c50f0dec3feff9e78c	no	1
Warnings:					
Information:					
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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
09/770,838	01/26/2001	Dennis J. Dupray	1003-1

CONFIRMATION NO. 8410

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

POA ACCEPTANCE LETTER

OC000000028447056

Date Mailed: 02/22/2008

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 02/19/2008.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/tcaldwell/

Office of Initial Patent Examination (571) 272-4000 or 1-800-PTO-9199

PTO/SB/08a (05-07)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	Phan, Dao Linda
	Attorney Docket Number	1003-1

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		09770838
	Filing Date		2001-01-26
	First Named Inventor	Dupray	
	Art Unit		3662
	Examiner Name	Phan, Dao Linda	
	Attorney Docket Number		1003-1

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Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	Phan, Dao Linda
	Attorney Docket Number	1003-1

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Dennis J. Dupray/	Date (YYYY-MM-DD)	2008-03-08
Name/Print	Dennis J. Dupray	Registration Number	

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04Q 7/20	A1	(11) International Publication Number: WO 95/34177 (43) International Publication Date: 14 December 1995 (14.12.95)

(21) International Application Number: PCT/US95/07251

(22) International Filing Date: 7 June 1995 (07.06.95)

(30) Priority Data:
08/225,341 7 June 1994 (07.06.94) US

(71) Applicant *(for all designated States except US)*: CELSAT AMERICA, INC. [US/US]; Suite 220, 3460 Torrance Boulevard, Torrance, CA 90503 (US).

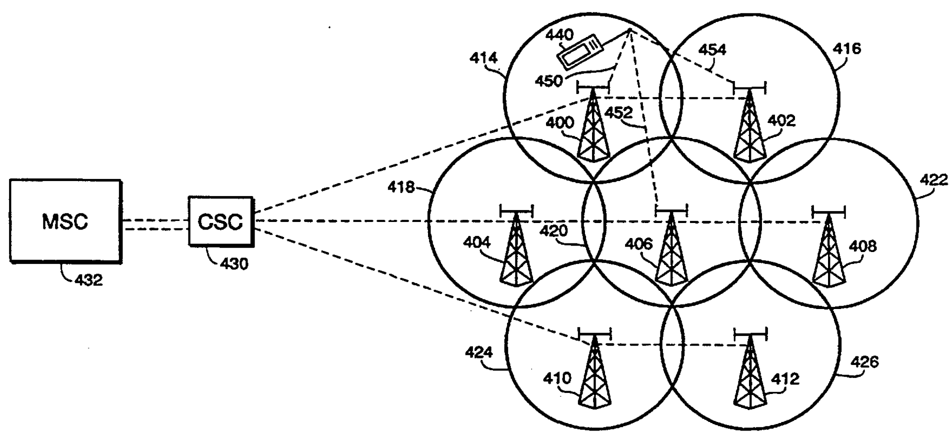
(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: OTTEN, David, D. [US/US]; 532 South Gertruda, Redondo Beach, CA 90277 (US).

(74) Agent: DRUMMOND, William, H.; Drummond & Duckworth, Suite 500, 4590 MacArthur Boulevard, Newport Beach, CA 92660 (US).

(81) Designated States: CA, CN, JP, RU, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: FRAUD DETECTION IN A CELLULAR COMMUNICATIONS SYSTEM



(57) Abstract

Apparatus and methods for operating a wireless communications system provided for reducing the use of the system by unauthorized users by establishing the geographical location of a selected user (440), comparing this location with the known locations of authorized users and denying service to the selected user if the selected user's location does not correspond to the known location of authorized users.

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FRAUD DETECTION IN A CELLULAR COMMUNICATIONS SYSTEM

BACKGROUND

This invention relates to improvements in mobile wireless communication systems.

In another respect, the invention relates to communication systems such as a cellular mobile communications system having integrated satellite and ground nodes.

More particularly, the invention pertains to mobile wireless communications systems which can locate and/or disable the communications equipment of a fraudulent user of the system.

The cellular communications industry has grown at a fast pace in the United States and even faster in some other countries. In the cellular communications industry alone, it is estimated that the number of mobile subscribers will increase on a world-wide level by an order of magnitude within the next ten years. In order to meet the world's ever-increasing demand for mobile communications, numerous diverse systems have been devised. For example, mobile communications system such as Specialized Mobile Radio (SMR), the planned Personal Communications Service (PCS) and existing cellular radio are primarily aimed at providing mobile telephone service to automotive users in developed metropolitan areas. For remote area users, airborne users, and marine users, AIRFONE and INMARSAT services exist but coverage is incomplete and/or service is relatively expensive. Mobile radio satellite systems in an advanced planning stage will probably provide improved direct-broadcast voice channels to mobile subscribers in remote areas but still at significantly higher cost in comparison to existing ground cellular service. The ground cellular and planned satellite technologies complement one another in geographical coverage in that the ground cellular communications service provides voice and data telephone service in relatively developed urban and suburban areas but not in sparsely populated areas, while the planned earth orbiting satellites will serve the sparsely populated areas.

In the case where one band of frequencies is preferable over others and that one band alone is to be used for mobile communications, efficient communications systems are necessary to assure that the number of users desiring to use the band can be accommodated. For example, there is presently widespread agreement on the choice of L-band as the technically preferred frequency band for the satellite-to-mobile link in mobile communications systems.

To meet the world's demand for additional mobile communications capabilities, more communications systems will need to be employed. An additional technology that is anticipated to find widespread application in mobile wireless communications systems is the spread spectrum communications technique. The spread spectrum communications technique is a technology that has found widespread use in military applications which must meet requirements for security, minimized likelihood of signal detection, and minimum susceptibility to external interference or jamming. In a spread spectrum system, the data modulated carrier signal is further modulated by a relatively wide-band, pseudo-random "spreading" signal so that the transmitted bandwidth is much greater than the bandwidth or rate of the information to be transmitted. Commonly the "spreading" signal is generated by a pseudo-random deterministic digital logic algorithm which is duplicated at the receiver.

By further modulating the received signal by the same spreading waveform, the received signal is remapped into the original information bandwidth to reproduce the desired signal. Because a receiver is responsive only to a signal that was spread using the same unique spreading code, a uniquely addressable channel is possible. Also, the power spectral density is low and without the unique spreading code, the signal is very difficult to detect, much less decode, so privacy is enhanced and interference with the signals of other services is reduced. The spread spectrum signal has strong immunity to multipath fading, interference from other users of the same system, and interference from other systems.

Unfortunately, accompanying the rapid growth of mobile communications technology has been corresponding growth in the fraudulent procurement of mobile communications. Already, signal theft, also known as "pirating," or "cellular fraud," is a major problem in current cellular systems.

Cellular fraud is a serious problem in the cellular industry, not only in the United States but worldwide. In 1994 cellular fraud accounted for $500M of lost revenue in the United States and $1 billion worldwide. Currently, every month an additional 50,000 cellular telephone numbers are stolen and illegally used in the United States. Cellular fraud is thus equivalent to 2.5% of the total annual revenue of the United States cellular industry for 1994 ($20 billion) and it is rising every year. Some cellular carriers in the largest United States cities have been hit extremely hard by fraud, including one large US carrier who lost $40M in one three month period, when 600 cellular phones were illegally activated, without being detected by the operator. Internationally, some cellular operators in less developed countries have experienced fraud as high as 30%

on their networks, because they have not installed adequate credit checking controls or fraud prevention procedures.

The United States Secret Service considers the stealing of cellular telephone numbers as counterfeiting (Title 18, Section 1029) and as such, it is a Federal offense with penalties rising as high as a fine of $100,000 and 20 years imprisonment. Organized criminals including drug dealers and gangs, car thieves and armed robbers use counterfeit cellular phones widely because cellular phones provide the criminal with communications mobility as well as anonymity. Thus the police often find that when they catch organized criminals, counterfeit phones are also recovered. In the last two years, over 500 suspects have been arrested for counterfeiting cellular phones and thousands of stolen phones have been recovered by the United States Secret Service and Federal Bureau of Investigation. Notwithstanding, the number of counterfeit phones is growing rapidly.

Pirating can be accomplished in several manners. In particular, there are three basic classifications of cellular fraud described herein as "Access Fraud", "Subscription Fraud" and "Stolen Phone Fraud." Essentially all types of cellular access fraud involve the perpetrators or "Bandits" making cellular calls on counterfeit cellular phones, whose electronic identity has been illegally modified to resemble that of another valid or non-existent subscriber's cellular phone.

In order for a subscriber to make a call on his home cellular network, his subscriber unit's cellular phone number/electronic serial number (ESN) combination must correspond exactly with the phone and electronic serial and numbers stored in the cellular operator's cellular telephone exchange. If the numbers do not correspond, then the cellular system will not complete the subscribers call.

Access fraud is the unauthorized use of cellular service through changing of a cellular phone's unique Electronic Serial Number (ESN) and/or the subscriber's phone number or Mobile Identification Number (MIN). Presently, pirates manage to acquire the authorization code intended to restrict system use to the authorized customers for whom it was intended. A mobile user unit is then altered to incorporate the stolen authorization code enabling the altered pirate user unit to transmit and receive signals of the communications system in the same manner as the lawful subscriber of the cellular system to whom had been originally appointed the authorization code. In this manner, it is extremely common for a fraudulent user to unlawfully use the communications system charging all communications to an innocent subscriber.

Further, access fraud has several variants including the most common, tumbling ESN/MIN & Counterfeiting (Cloning). Tumbling ESN/MIN involves the modification of a mobile unit's unique ESN/MIN combination. The phone is modified such that the ESN/MIN identity for a pseudo "roamer" is changed whether randomly or sequentially after every call to that of another roaming subscriber's unit. A roamer is a cellular subscriber who uses his cellular phone in another market, i.e., a New York "Nynex Mobile" subscriber who visits Chicago and makes and receives calls on his phone using the local "Ameritech Mobile" network.

The constant alteration of the counterfeit phone's ESN and/or MIN allows the bandit to evade the detection and "shut down" of that phone. This is because, in the less sophisticated cellular systems, there is no way of telling whether the roamer caller is a valid roamer subscriber or not and so tumbling fraud cannot be immediately detected. This authentication is known as "Pre-Call Subscriber ESN/MIN validation".

Cloning, or counterfeiting, occurs when the bandit obtains valid subscriber's ESN/MIN combinations, usually by monitoring ("scanning") cellular radio transmission "over the air" using special cellular radio signaling data receivers and decoders. The bandit then programs these ESN/MIN's into his phone, thus appearing to the cellular operator as a valid subscriber. the bandit continues to place illegal calls on his cellular phones until detected. This detection often occurs only after the valid subscriber calls up the cellular operator's Customer Car department to complain that his monthly bill contains calls which he did not make. At this time the counterfeited ESN/MIN combination is denied service. Additionally, the valid subscriber is also denied service and must have his MIN (cellular telephone number) changed in order to have his service restored causing additional inconvenience.

"Subscription fraud" occurs when a subscriber signs up for service with fraudulent identification, without any intention of paying for the service. An example of subscription fraud occurs when a bandit subscriber fraudulently uses the credit card number, social security number, state drivers license, or other means of identification, of another in an effort to obtain the use of a cellular communications system. The bandit then uses the system without paying until the bills have mounted to the point that their authorization is discontinued by the cellular provider. This cycle is then repeated using the identification of another innocent individual. Unfortunately, this type of cellular fraud is particularly widespread and costly, incurring millions of dollars of losses to both the cellular industry and those innocent individuals whose means of identification has been purloined.

Simply, "stolen phone" fraud occurs when a legitimate phone is stolen and used before it can be denied service. The pirate merely steals a user unit already including the authorization code of a subscriber. Unfortunately, by the very nature of the cellular units being lightweight, readily concealable and mobile has created a low risk, high profit market for theft. Further, a subscriber, often believing that they have merely misplaced their user unit, will often wait weeks or even months before realizing that their user unit has been stolen. Accordingly, the subscriber often does not notify their mobile communications provider to cease cellular services until thousands of dollars worth of cellular communications have been pirated. The pirate does not pay the fees due to the service provider and the costs are transferred either to the subscriber of the stolen authorization code or to the users of the system as a whole.

Unfortunately, due to the threat of cellular fraud, many cellular operators now limit the ability of cellular subscribers to use their cellular phones to make long distance and international calls, particularly residential and roaming subscribers. This limits the revenue opportunities for the cellular operator. If cellular fraud could be more easily detected and combated, then cellular operators could lift these calling restrictions, increasing the utility of the phones to the subscribers and raising the average monthly revenue for the operators.

In an effort to eliminate cellular fraud, numerous fraud detection techniques have been attempted. The first of these, "call pattern analysis" entails the review of a subscribers cellular velocity, volume, duration, destination, and initial bill credit limit. Special software in a billing server analyzes a very large number of call detail records (e.g., 3 month's worth) from the cellular telephone exchange to look for anomalies and changes in patterns of: 1) call origination location with respect to time, e.g., to look for phones with the same MIN/ESN being used at the same time in two different places (also known as "Velocity"); 2) call volume, e.g., the subscriber starts to use very high volumes of airtime minutes when their previous volume was low; 3) call duration, which may indicate that the phone is being used as a "free long distance pipeline" for calls forwarded to that MIN; 4) call destination, e.g., if a subscriber starts making large numbers of international calls when the previous international activity was low; 5) call time, e.g., the subscriber starts using high volumes of nighttime minutes whereas previously all the usage was during the day. The same software is also programmed to detect very high calling volumes in the initial few days and weeks after the services is activated when no pattern data is available. This often detects when a subscriber has no intention of paying the bill.

An additional fraudulent detection means has been called "Dual Call Set-Up Logs." Special software in the cellular telephone exchange identifies any situation with an alarm log when two subscriber units with identical MIN/ESN combinations attempt to have simultaneous phone calls on the same cellular switch.

Some cellular systems include the fraudulent detection means "Dual Phone Page Responses." When a cellular phone number is dialled and two units respond to the "page" on different cellsites and different frequencies at the same time. The switch identifies that two separate and distinct mobiles with the same MIN/ESN combination have the responded to a page and issues an alarm log that a fraudulent user is using the system.

"Tumbling ESN Analysis" is a fraud detection system where the cellular telephone exchange looks for patterns in MIN/ESN combinations as well as patterns in MIN/ESN combination tumbling and issues an alarm log if tumbling is detected.

A somewhat ingenious system for detecting cellular fraud, though hardware intensive and somewhat expensive, is "Subscriber Unit Fingerprinting." Special receivers at each base station, characterize the FM transmission of each cellular telephone, e.g., the exact FM deviation, carrier frequency, data modulation frequency, etc. on the call set-up channels of the network. If cellular telephones with identical ESN/MIN combinations and different radio characteristics are identified, a cloned unit is detected.

In addition to detecting a cellular fraud realtime, increased analysis of presently provided information has been employed to reduce cellular fraud. For example, subscribers are asked to examine their monthly bill and document those calls that appear on their bills which they did not make. Subscribers are then asked to call the cellular operators' billing department to get the fraudulent calls removed, their bill adjusted and their ESN/MIN changed. Further, cellular companies have started to install the latest in Inter-System PRV (Positive Roamer Validation). PRV signaling equipment and SS-7 data links are now used to validate the identity and credit worthiness of roamers (those cellular users not operating in their subscriber territory) on the cellular network. Additionally, the cellular industry has taken to improved verification of credit information, address, identity checking, and roamer activity. Real time links to the credit bureaus for improved credit risk management has been initiated, as well as the calling of a subscriber's home or office to verify his billing address a few days after service has commenced.

Notwithstanding the cellular industry's extensive effort to stop the spread of cellular fraud, in the past, such pirates have been amazingly successful both in terms of speedy delivery to their markets and the magnitude of the stolen signals. In the coming decade, as the demand for cellular communications increases, signal theft is anticipated to increase at a rate at least comparable with increase of cellular communications.

Accordingly, their is a need to reduce the debt losses to the cellular industry, including direct losses from uncollected airtime revenues, increased expenses from interconnect charges from the need to hire extra staff to handle fraud problems on legitimate customers phones and monthly bills.

Further, their is a need to reduce the ability for organized criminals to operate using cellular phones.

Additionally, their is a need to reduce the inconvenience to legitimate cellular subscribers from wrong phone bills, strange incoming phone calls and the need to get their phone reprogrammed to a "clean" number.

For the foregoing reasons, there is a need to reduce or eliminate fraudulent use of a wireless system by improved detection and location of the fraudulent user. It would be desirable to verify if system users were authorized by virtue of their position.

Accordingly, it would be desirable if the cellular system would cease the transmission of signals to users determined to be fraudulent.

Additionally, it would be desirable to provide a cellular system that would provide for the apprehension of fraudulent users once their position had been determined.

SUMMARY OF THE INVENTION

The invention provides improvements in wireless communications systems. While various aspects of the invention will be explained by reference, for example, to a cellular communications system using spread spectrum waveforms, it will be apparent to those skilled in the art that these techniques are applicable to similar forms of wireless communications systems, such as, for example, Specialized Mobile Radio (SMR), the planned Personal Communications Service (PCS) and existing cellular radio systems.

The present invention is directed to improvements in such wireless communications systems, for example, a cellular communications system using spread spectrum waveforms. The spread spectrum system makes possible the use of very low rate, highly redundant coding without loss of capacity to accommodate a large number of users within the allocated bandwidth. Further, though not limited to such, the present invention is directed to a cellular communications using Code Division Multiple Access (CDMA) which is anticipated to have achieved world wide use in the coming decade.

Briefly, in one aspect, a wireless communication system of the present invention is directed to a wireless communications system which includes node means and a plurality of user units, each said user unit including a means for establishing selective communication between the node means and the user unit. Such a system is improved by establishing the geographical location of a selected user. The geographical location of the selected user is compared to known locations of authorized users to determine if the communication system is being "pirated" and communication signals being fraudulently stolen. Once determination has been made that the selected user is an unauthorized recipient of the communications services, the cellular system can disrupt the communication services by numerous means. For example, in one embodiment of the present invention, the communication system disrupts communications services by simply ceasing the receipt or transmission of signals to the unauthorized selected user. In an additional embodiment, the nodal unit of the communications systems transmits a signal to the selected user instructing the user unit to disable itself. Though not intended to be limited thereto, this may be accomplished by scrambling the internal software of a user unit, instructing the user unit to destroy its internal circuitry or to blow an internal fuse.

In still another embodiment of the operation of the communications system, the determination of the geographical location of an unauthorized fraudulent user of the communication system provides means by which the pirate may be apprehended and arrested. Once the position of the pirate is known, the information is forwarded to the police or other law enforcement agency such as the Federal Communications Commission (FCC). The law enforcement agency then proceeds to the geographic location, where the user unit is impounded and the pirate user is arrested. In this manner, not only is fraudulent use of the system reduced due to the arrest of those "pirating" the system, but those contemplating cellular theft are deterred from such actions due to the high risk of being apprehended.

As stated above, the present invention utilizes the knowledge of a users position to first verify the legitimate, authorized user units. The remaining units operating on that code are clearly identified as non-paying pirate users by having a different position. The communication system then operates to deny service to the selected user if the selected user's location does not correspond to one of the known locations of authorized users.

Preferably, the system includes means for determining the position of a selected user unit by providing a timing signal to the selected user unit from the node, providing a timing response signal from the selected user unit from the node, providing a time response signal from the selected user unit in response to each timing signal, receiving the timing response signal by the node, measuring the response time of the user unit to the timing signal based on receipt of the timing response signal, and determining the position of the user unit based on the round trip time of transmission of the timing signal and receipt of the timing response signal.

In a more detailed aspect of the invention, the position means comprises means for measuring the response times of the user unit to respective timing signals transmitted by at least two nodes and for determining the position of the selected user unit based on the round trip times from each timing signal transmitting surface node.

In yet another aspect, the position means comprises means for determining the position of the selected user unit by measuring at a plurality of nodes the response time of the user unit to a timing signal transmitted by at least one of the nodes and determining the position of the selected user unit based on the times of receipt by the nodes of the timing response signal from the user unit.

In another aspect, the position means may store *a priori* information about the selected user unit and may determine the position of the selected user unit by providing a timing signal to the user unit from a node, measuring the response time of the user unit to the timing signal at the node, and determining the position of the user unit based on such measurement and on the *a priori* information. Additionally, the position means also determines in which cell a selected user unit is and indicates the location of the cell.

Other aspects and advantages of the invention will become apparent from the following detailed description and the accompanying drawings, illustrating by way of example the features of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1(a)-(c) are diagrams showing an overview of the principal elements of typical communications systems which embody the principles of the invention;

FIG. 2 is a diagram of the frequency sub-bands of the frequency band allocation for a mobile system, e.g., a cellular system;

FIG. 3 is a block diagram of a satellite link system showing the user unit and satellite node control center;

FIG. 4 is a block diagram of one embodiment of a satellite signal processing in the system in FIG. 5;

FIG. 5 is a functional block diagram of a user transceiver;

FIG. 6 depicts the interrelationship of the cellular structure of the ground nodes, cellsite controller (CSC), and mobile switching center (MSC) of a typical system; and

FIG. 7 depicts an internal circuit of a user unit capable of being remotely operated to prevent further use of the user unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As is shown in the exemplary drawings, the invention is embodied in a mobile system, e.g., a cellular communications system utilizing integrated satellite and ground nodes both of which use the same modulation, coding, and spreading structure and both responding to an identical user unit.

Signal theft or "pirating" is a major problem in current cellular and TV receive only (TVRO) systems, and will probably affect additional future communications systems. Pirates manage to learn a code intended to restrict the system use to the authorized customers for whom it was intended, and then to alter users units such that they become pirate units which operate using the stolen code. Thus, unlawful use of the system is accomplished and the pirate user does not pay the fees due to the service provider. In the past, such pirates have been amazingly successful at their unlawful trade, both in terms of speedy delivery to their markets and the value of stolen signals. Such piracy continues on a large scale today not only in cellular communications systems but also other communications systems such as satellite television systems where satellite television transmissions are pirated.

This invention utilizes the knowledge of a users position, obtained as described above, first to verify the legitimate, authorized users unit. The remaining units operating on that code are clearly identified as non paying or pirate users by virtue of having a different position. In one embodiment, this information is used to apprehend the pirates.

In an alternate embodiment, the pirated unit can be disabled. There are two embodiments for disabling the pirated unit, each being effective under different circumstances. The first involves simply not providing service. The second involves commanding the disablement of the pirated unit by means including commanding that fuses to be blown within the circuitry and commanding the destruction of the user circuitry.

Referring now to FIG. 1(a), an overview of a typical communications system 10 is presented showing the functional inter-relationships of the major elements. The disclosed communication system is for example only and may be embodied in various forms. The system network control center 12 directs the top level allocation of calls to satellite and ground regional resources throughout the system. It also is used to coordinate system-wide operations, to keep track of user locations, to perform optimum allocation of system resources to each call, dispatch facility command codes, and monitor and supervise overall system health. The regional node control centers 14, one of which is shown, are connected to the system network control center 12 and direct the allocation of calls to ground nodes within a major metropolitan region. The regional node control center 14 provides access to and from fixed land communication lines, such as commercial telephone systems known as the public switched telephone network (PSTN). The ground nodes 16 under direction of the respective regional node control center 14 receive calls over the fixed land line network, encode them, spread them according to the unique spreading code assigned to each designated user, combine them into a composite signal, modulate that composite signal onto the transmission carrier, and broadcast them over the cellular region covered.

Satellite node control centers 18 are also connected to the system network control center 12 via status and control land lines and similarly handle calls designated for satellite links such as from PSTN, encode them, spread them according to the unique spreading codes assigned to the designated users, and multiplex them with other similarly directed calls into an uplink trunk, which is beamed up to the designated satellite 20. Satellite nodes 20 receive the uplink trunks, frequency demultiplex the calls intended for different satellite cells, frequency translate and direct each to its appropriate cell transmitter and cell beam, and broadcast the composite of all such similarly directed calls down to the intended satellite cellular area. As used herein, "backhaul" means the link between a satellite 20 and a satellite node control center 18. In one embodiment, it is a K-band frequency while the link between the satellite 20 and the user unit 22 uses an L-band or an S-band frequency.

As used herein, a "node" is a communication site or a communication relay site capable of direct one or two-way radio communication with users. Nodes may include moving or stationary surface sites or airborne or satellite sites.

User units 22 respond to signals of either satellite or ground node origin, receive the outbound composite signal, separate out the signal intended for that user by despreading using the user's assigned unique spreading code, de-modulate, and decode the information and deliver the call to the user. Such user units 22 may be mobile or may be fixed in position. Gateways 24 provide direct trunks that is, groups of channels, between satellite and the ground public switched telephone system or private trunk users. For example, a gateway may comprise a dedicated satellite terminal for use by a large company or other entity. In the embodiment of FIG. 1, the gateway 24 is also connected to that system network controller 12.

All of the above-discussed centers, nodes, units and gateways are full duplex transmit/receive performing the corresponding inbound (user to system) link functions as well in the inverse manner to the outbound (system to user) link functions just described.

FIGs. 1(b) and 1(c) represent systems with space only and ground only nodes. Certain aspects of this invention relate to these two systems as well as the "hybrid" system previously described.

Referring now to FIG. 2, the allocated frequency band 26 of a communications system is shown. The allocated frequency band 26 is divided into 2 main sub-bands, an outgoing sub-band 25 and an incoming sub-band 27. Additionally the main sub-bands are themselves divided into further sub-bands which are designated as follows:

OG: Outbound Ground 28 (ground node to user)
OS: Outbound Satellite 30 (satellite node to user)
OC: Outbound Calling and Command 32 (node to user)
IG: Inbound Ground 34 (user to ground node)
IS: Inbound Satellite 36 (user to satellite node)
IC: Inbound Calling and Tracking 38 (user to node)

All users in all cells use the entire designated sub-band for the described function. Unlike existing ground or satellite mobile systems, there is no necessity for frequency division by cells; all cells may use these same basic six sub-bands. This arrangement results in a higher frequency reuse factor as is discussed in more detail below.

In one embodiment of the cellular system, a mobile user's unit 22 will send an occasional burst of an identification signal in the IC sub-band either in response to a poll or autonomously. This may occur when the unit 22 is in standby mode. This identification signal is tracked by the regional node control center 14 as long as the unit is within that respective region, otherwise the signal will be tracked by the satellite node or nodes. In another embodiment, this identification signal is tracked by all ground and satellite nodes capable of receiving it. This information is forwarded to the network control center 12 via status and command lines. By this means, the applicable regional node control center 14 and the system network control center 12 remain constantly aware of the cellular location and link options for each active user 22. An intra-regional call to or from a mobile user 22 will generally be handled solely by the respective regional node control center 14. Inter-regional calls are assigned to satellite or ground regional system resources by the system network control center 12 based on the location of the parties to the call, signal quality on the various link options, resource availability and best utilization of resources.

A user 22 in standby mode constantly monitors the common outbound calling frequency sub-band OC 32 for calling signals addressed to him by means of his unique spreading code. Such calls may be originated from either ground or satellite nodes. Recognition of his unique call code initiates the user unit 22 ring function. When the user goes "off-hook", e.g., by lifting the handset from its cradle, a return signal is broadcast from the user unit 22 to any receiving node in the user calling frequency sub-band IC 38. This initiates a handshaking sequence between the calling node and the user unit which instructs the user unit whether to transition to either satellite, or ground frequency sub-bands, OS 30 and IS 36 or OG 28 and IG 34.

A mobile user wishing to place a call simply takes his unit 22 off hook and dials the number of the desired party, confirms the number and "sends" the call. Thereby an incoming call sequence is initiated in the IC sub-band 38. This call is generally heard by several ground and satellite nodes which forward call and signal quality reports to the appropriate system network control center 12 which in turn designates the call handling to a particular satellite node 20 or regional node control center 14. The call handling element then initiates a handshaking function with the calling unit over the OC 32 and IC 38 sub-bands, leading finally to transition to the appropriate satellite or ground sub-bands for communication.

The combined satellite/ground nodes system provides a hierarchical geographical cellular structure. Thus within a dense metropolitan area, each satellite cell may further contain as many as 100 or more ground cells, which ground cells would normally carry the bulk of the traffic originated therein. The number of users of the ground nodes 16 is anticipated to exceed the number of users of the satellite nodes 20 where ground cells exist within satellite cells. Because all of these ground node users would otherwise interfere as background noise with the intended user-satellite links, in one embodiment the frequency band allocation may be separated into separate segments for the ground element and the space element as has been discussed in connection with FIG. 2. This combined, hybrid service can be provided in a manner that is smoothly transparent to the user. Calls will be allocated among all available ground and satellite resources in the most efficient manner by the system network control center 12.

Referring now to FIG. 3, a block diagram is shown of a typical user unit 22 to satellite 20 to satellite node control 18 communication and the processing involved in the user unit 22 and the satellite node control 18. In placing a call for example, the handset 64 is lifted and the telephone number entered by the user. After confirming a display of the number dialed, the user pushes a "send" button, thus initiating a call request signal. This signal is processed through the transmitter processing circuitry 66 which includes spreading the signal using a calling spread code. The signal is radiated by the omni-directional antenna 68 and received by the satellite 20 through its narrow beamwidth antenna 62. The satellite processes the received signal as will be described below and sends the backhaul to the satellite node control center 18 by way of its backhaul antenna 70. On receive, the antenna 68 of the user unit 22 receives the signal and the receiver processor 72 processes the signal. Processing by the user unit 22 will be described in more detail below in reference to FIG. 5.

The satellite node control center 18 receives the signal at its antenna 71, applies it to a circulator 73, amplifies 74, frequency demultiplexes 76 the signal separating off the composite signal which includes the signal from the user shown in FIG. 3, splits it 78 off to one of a bank of code correlators, each of which comprises a mixer 80 for removing the spreading and identification codes, an AGC amplifier 82, the FECC demodulator 84, a demultiplexer 86 and finally a voice encoder/decoder (CODEC) 88 for converting digital voice information into an analog voice signal. The voice signal is then routed to the appropriate land line, such as a commercial telephone system. Transmission by the satellite node control center 18 is essentially the reverse of the above described reception operation.

Referring now to FIG. 4, the satellite transponder 90 of FIG. 3 is shown in block diagram form. A circulator/diplexer 92 receives the uplink signal and applies it to an L-band or S-band amplifier 94 as appropriate. The signals from the M satellite cells within a "cluster" are frequency multiplexed 96 into a single composite K-band backhaul signal occupying M times the bandwidth of an individual L-/S-band mobile link channel. The composite signal is then split 98 into N parts, separately amplified 100, and beamed through a second circulator 102 to N separate satellite ground cells. This general configuration supports a number of particular configurations various of which may be best adapted to one or another situation depending on system optimization which for example may include considerations related to regional land line long distance rate structure, frequency allocation and subscriber population. Thus, for a low density rural area, one may utilize an M-to-1 (M>1, N=1) cluster configuration of M contiguous cells served by a single common satellite ground node with M limited by available bandwidth. In order to provide high-value, long distance service between metropolitan area, already or best covered for local calling by ground cellular technology, an M-to-M configuration would provide an "inter-metropolitan bus" which would tie together all occupants of such M satellite cells as if in a single local calling region. To illustrate, the same cells (for example, Seattle, Los Angeles, Omaha and others) comprising the cluster of M user cells on the left side of FIG. 4, are each served by corresponding backhaul beams on the right side of FIG. 4.

Referring now to FIG. 5, a functional block diagram of a typical user unit 22 is shown. The user unit 22 comprises a small, light-weight, low-cost, mobile transceiver handset with a small, non-directional antenna 68. The single antenna 68 provides both transmit and receive functions by the use of a circulator/diplexer 104 or other means. It is fully portable and whether stationary or in motion, permits access to a wide range of communication services from one telephone with one call number. It is anticipated that user units will transmit and receive on frequencies in the 1-3 GHz band but can operate in other bands as well.

The user unit 22 shown in FIG. 5 comprises a transmitter section 106 and a receiver station 108. For the transmission of a voice communication, a microphone couples the voice signal to a voice encode 110 which performs analog to digital encoding using one of the various modern speech coding technologies well known to those skilled in the art. The digital voice signal is combined with local status data, and/or other data, facsimile, or video data forming a composite bit stream in digital multiplexer 112. The resulting digital bit stream proceeds sequentially through forward error encoder 114, symbol or bit interleaver 116, symbol or bit, phase, and/or amplitude modulator 118, narrow band IF amplifier 120, wideband multiplier or spreader 122, wide band IF amplifier 124, wide band mixer 126, and final power amplifier 128. Oscillators or equivalent synthesizers derive the bit or baud frequency 130, pseudo-random noise or "chip" frequency 132, and carrier frequency 134. The PRN generator 136 comprises deterministic logic generating a pseudo-random digital bit stream capable of being replicated at the remote receiver. The ring generator 138 on command generates a short pseudo-random sequence functionally equivalent to a "ring".

The transceiver receive function 108 demodulation operations mirror the corresponding transmit modulation functions in the transmitter section 106. The signal is received by the non-directional antenna 68 and conducted to the circulator 104. An amplifier 142 amplifies the received signal for mixing to an IF at mixer 144. The IF signal is amplified 146 and multiplied or despread 148 and then IF amplified 150 again. The IF signal then is conducted to a bit or symbol detector 152 which decides the polarity or value of each channel bit or symbol, a bit or symbol de-interleaver 154 and then to a forward error decoder 156, the composite bit stream from the FEC decoder 156 is then split into its several voice, data, and command components in the de-multiplexer 158. Finally a voice decoder 160 performs digital to analog converting and results in a voice signal for communication to the user by a speaker or other means. Local oscillator 162 provides the first mixer 144 LO and the bit or symbol detector 152 timing. A PRN oscillator 164 and PRN generator 166 provide the deterministic logic of the spread signal for despreading purposes. The baud or bit clock oscillator 168 drives the bit in the bit detector 152, forward error decoder 156 and the voice decoder 160.

The bit or symbol interleaver 116 and de-interleaver 154 provide a type of coded time diversity reception which provides an effective power gain against multipath fading to be expected for mobile users. Its function is to spread or diffuse the effect of short burst of channel bit or symbol errors so that they can more readily be corrected by the error correction code.

As an alternative mode of operation, provision is made for direct data or facsimile or other digital data input 170 to the transmitter chain and output 172 form the receiver chain.

A command decoder 174 and command logic element 176 are coupled to the forward error decoder 156 for receiving commands or information. By means of special coding techniques known to those skilled in the art, the non-voice signal output at the forward error decoder 156 may be ignored by the voice decoder 160 but used by the command decoder 174. An example of the special coding techniques are illustrated in FIG. 5 by the MUX 112 and DEMUX 158.

As shown, acquisition, control and tracking circuitry 178 are provided in the receiver section 108 for the three receive side functional oscillators 162, 164, 168 to acquire and track the phase of their counterpart oscillators in the received signal. Means for so doing are well known to those skilled in the art.

Referring again to FIG. 5, an arrangement is provided for generating call requests and detecting ring signals. The ring generator 138 generates a ring signal based on the user's code for calling out with the user unit 22. For receiving a call, the ring signal is detected in a fixed matched filter 198 matched to a short pulse sequence which carries the user's unique code. By this means each user can be selectively called. As an option, the ring detect and call request signals may be utilized in poll/response mode to provide tracking information on each active or standby mode user. Course tracking information, adequate for management of the call routing functions is provided by comparison of signal quality as received at various modes.

With reference also to FIG. 6, for the precision location option, the user response signal time is accurately locked to the time of receipt of the polling or timing signal, to a fraction of a PRN chip width. Measurement of the round trip poll/response time from two or more nodes or time differences of arrival at several nodes provides the basic measurement that enable solution and provision of precise user position. Ground and satellite transmitters and receivers duplicate the functions summarized above for the user units. Given *a priori* information, for example as to the route plan of a vehicle, a single round trip poll/response time measurement from a single node can yield valuable user position information.

The command logic 176 is further coupled to the receiver AGC 180, the matched filter ring detector (RD) 198, the acquisition and tracking circuitry 178, the transmit local oscillator (LO) 162 and the ring generator (RG) 138 to command various modes of operation.

A preferred communication system includes the use of spread spectrum multiple access so that adjacent cells are not required to use different frequency bands. All ground-user links utilize the same two frequency sub-bands (OG 28, IG 34) and all satellite-user links use the same two frequency sub-bands (OS 30, IS 36). This obviates an otherwise complex and restrictive frequency coordination problem of ensuring that frequencies are not reused within cells closer than some minimum distance to one another (as in the FM approach), and yet provides for a hierarchial set of cell sizes to accommodate areas of significantly different subscriber densities.

The economic feasibility of a mobile telephone system is related to the number of users that can be supported. Two significant limits on the number of users supported are bandwidth utilization efficiency and power efficiency. In regard to bandwidth utilization efficiency, in either the ground based cellular or mobile satellite elements, radio frequency spectrum allocation is a severely limited commodity. Measures incorporated in the invention to maximize bandwidth utilization efficiency include the use of code division multiple access (CDMA) technology which provides an important spectral utilization efficiency gain and higher spatial frequency reuse factor made possible by the user of smaller satellite antenna beams. In regard to power efficiency, which is a major factor for the satellite-mobile links, the satellite transmitter source power per user is minimized by the use of forward-error-correcting coding, which in turn is enabled by the above use of spread spectrum code division multiple access (SS/CDMA) technology and by the use of relatively high antenna gain on the satellite. CDMA and forward-error-correction coding are known to those skilled in the art and no further details are given here.

One aspect of the invention is directed to accurate position determination of individual users of the cellular communications system.

With reference to FIG. 6, a cellular system is disclosed having a plurality of cellular nodes, 400, 402, 404, 406, 408, 410, and 412, respectively, forming cellular sectors 414, 416, 418, 420, 422, 424, and 426, respectively. Controlling receipt and transmission of signals is the cellsite controller (CSC) 430 and the mobile switching center (MSC) 432. It is anticipated for the cellular system to include a plurality of user units. However, a single user unit 440 is shown for example only.

For precision location of the user, the user response signal time is accurately locked to the time of receipt of the polling or timing signal, to a fraction of a PRN chip width. The distance between an individual node and a user may then be determined by providing a timing signal to the selected user unit from at least one node, providing a timing response signal from the selected user unit in response to each timing signal, receiving the timing response signal by at least one node, and measuring the response time of the user unit to the timing signal. The position of the user unit can then be determined based on the round trip time of transmission of the timing signal and receipt of the timing response signal from a plurality of nodes. Measurement of the round trip poll/response time from two or more nodes or time differences of arrival at several nodes provides the basic measurement that enables solution and provision of precise user position. For example, round trip poll/response times from nodes 400, 402, and 406 to user unit 440 provides the measurement of distances 450, 452, and 454. Through simple analysis, or alternatively, use of a Kalman filter, the central cellsite controller can determine the location of the user unit.

In another aspect of the invention, given *a priori* information, for example, as to the route plan of a vehicle, a single round trip poll/response time measurement from a single node can yield valuable user position information. The position means may store *a priori* information about the selected user unit and may determine the position of the selected user unit by providing a timing signal to the user unit from a node, measuring the response time of the user unit to the timing signal at the node, and determining the position of the user unit based on such measurement and on the *a priori* information. An example of *a priori* information includes the sought to be travelled route of a user. By knowing the route of a selected user and the distance from a node, determined by application of the present invention, the central controller can determine the position of a selected user.

In another embodiment of position determination including the use of *a priori* information, the position of the user unit can be determined by distance determination from only two nodes. For example, the distances 452 and 454 of user unit 440 from nodes 402 and 406 combined the *a priori* information that the user unit is located cell sector 414 provides the necessary information to accurately determine the location of user unit 440. This *a priori* information may be determined by knowledge of the user unit's last known location or by analysis of the signal quality of the user unit's transmissions by cell nodes 400, 402, 404 and 406 to determine the user unit's location to be in cell sector 414. In another embodiment, once the user unit's location and present cell cite has been determined utilizing the three node trigonometric analysis described above, the cell site controller may switch to two node position determination thereby reducing computer computations.

Ideally suited for position determination is the use of code division multiple access (CDMA) technology which provides an important spectral utilization efficiency gain and higher spatial frequency reuse factor made possible by the use of smaller satellite antenna beams. In regard to power efficiency, which is a major factor for the satellite-mobile links, the satellite transmitter source power per user is minimized by the use of forward-error-correcting coding, which in turn is enabled by the above use of spread spectrum code division multiple access (SS/CDMA) technology and by the use of relatively high antenna gain on the satellite. CDMA and forward-error-correction coding are known to those skilled in the art and no further details are given here.

In addition, the Code Division Multiplex system has the following important advantages in the present system. Blank time when some of the channels are not in use reduces the average interference background. In other words, the system overloads and underloads gracefully. The system inherently provides flexibility of base band rates; as opposed to FDM systems, signals having different baseband rates can be multiplexed together on an ad-hoc basis without complex preplanned and restrictive sub-band allocation plans. Not all users need the same baseband rate. Satellite antenna sidelobe control problems are significantly reduced. Numerical studies of out-of-cell interference factors show that secondary lobe responses may effectively be ignored. Co-code reassignment (that is reuse of the same spreading code) is feasible with just one beam separation. However, because there are effectively (i.e. including phasing as a means of providing independent codes) an unlimited number of channel codes, the requirements on space division are eased; there is no need to reuse the same channel access i.e., spreading code.

Accurate position determination can be obtained through two-dimensional multi-lateration. Each CDMA mobile user unit's transmitted spreading code is synchronized to the epoch of reception of the pilot signal from its current control site, whether ground or satellite node. The normal mode of operation will be two-dimensional, i.e., based upon two receptions, at ground or satellite nodes of the user response code. In conjunction with *a priori* information inherent in a topographic database, e.g., altitude of the surface of the earth, position accuracy to within a fraction of a kilometer can be provided.

In a CDMA system, means for determining the position of a mobile user relative to a multiplicity of known system nodes, either fixed on the ground or at known positions in space, is largely incidental to the function of transmitting and/or receiving the CDMA signal at multiple sites. The receiving function requires synchronization of the epoch of a local spread code generator to that of the received spread code, so that having achieved code synchronization, one inherently has a measure of the delay time and hence the range of the signal. Various references describe how this information can be used in several different geometrical configurations to provide the delay measurements necessary to provide hyperbolic, elliptical, spherical or hybrid multi-lateration position determination. By any of these means the mobile position can either be determined by the network controller or by the mobile user and relayed to the network controller.

An additional aspect of the present invention is the determination of a fraudulent user by analysis of the position of a user in the system. The position of all users is periodically determined by the network controller. In one aspect of the invention, the controller is programmed to search for the same user ID appearing at locations which could not possibly be reached by the same user. A determination by the cellsite controller indicating that two or more units utilizing the same ESN/MIN, though not operating contemporaneously, have been operating in locations which could have been reached by a single user unit establishes that there are one or more pirated units in use.

In one embodiment, the computer software keeps track of each user's position in the system and the time period and location between uses of the system.

An algorithm determines whether any two or more uses could not have been made by a single user. For example only, algorithm (A) may equal the distance between the location of the last known transmission and present transmission divided by the time differences between the last positions.

$$A = \frac{\text{(distance of previous and present uses)}}{\text{(time period between transmissions)}}$$

If the result exceeds, say, 100 MPH for any pair of transmissions, one or more separate users of the same ID code are indicated. Only one will be a valid user, the others will be "Bandits" (typically there will be many such "Bandits"). To determine the legitimate user, the user nearest the home address of the valid subscriber will be queried to determine whether or not that caller is a valid subscriber. The query can be either human to human, or machine to machine. If the first such queried party is legitimate, he is assigned a new ESN/MIN combination, and the prior code is placed in a category recognized by the network controller as invalid. All the bandit users are then operating using an invalid code, and the next steps will be determined by the current service owner's policy and will include (a) causing the Bandits to be pursued for theft, (b) causing the bandit units to be disables or (c) ceasing service to these units as discussed below.

If the first such queried party is not legitimate the next party will be queried until the valid party is determined. If the distance between tracks is greater than 100 miles, then all users are queried, again beginning with the user nearest to the home address of the legitimate party, until the legitimate user is found. All other users are then Bandits, and are treated as below.

In an alternative embodiment, the cellsite controller initiates separate algorithms dependent upon the distance between transmissions. For example, the constant "A" in the equation:

$$A = \frac{\text{(distance of previous and present uses)}}{\text{(time period between transmissions)}}$$

may be altered where the distance between the previous use and the present use of the cellular system is greater than 100 miles. In this manner, the cellular system is capable of compensating for those instances where a legitimate subscriber has travelled by plane to a new location. Further, a series of algorithms may be employed depending upon the various distances between transmissions and different periods between transmissions to account for common user habits and local topography, e.g. urban vs. rural travel. Such algorithms and the methods for creating such are known to those skilled in the art and no further details are given here.

An additional aspect of the present invention is that once a unit has been determined to be a fraudulently operated unit, (a) the bandit is pursued for theft, (b) the bandit unit is caused to be disabled or (c) service to the user unit is ceased. In a first embodiment, the cellular system merely ceases to provide service to anyone using the ESN/MIN combination determined to have been pirated.

The counterfeited ESN/MIN combination is denied service and the bandit is no longer capable engaging the cellular system without obtaining an alternative authorized ESN/MIN combination. Additionally, the valid subscriber is also denied service and must have his MIN (cellular telephone number) changed in order to have his service restored.

In an alternative embodiment, the cellsite controller transmits a remote erasure or alteration signal from the Cellular Node to the bandit user unit to erase or alter the mobile phone's operating software.

If fraud has been detected by the cellular system on a particular MIN/ESN combination, then the cellular node sends a pre-determined registration or call origination page message to the counterfeited phone. This pre-determined message instructs the phone to activate a self-destructing software algorithm which erases, scrambles or otherwise alters the phone's stored operating program in E^2PROM as well as the phone's Electronic Serial Number, Mobile Identification Number, Station Class Mark, etc., so that it is now rendered completely useless to the counterfeiter.

If the phone is in a call mode when the cellular switch wishes to deactivate it, then the "self-destruct algorithm" could also be activated by having the cellular node send either a pre-determined dual tone multiple frequency (DTMF) or Forward Voice Channel signaling message to it. This program and memory altering algorithm could be stored in the phone as a hidden "virus" which is activated only upon a certain code being transmitted to the phone, but otherwise is not easily detectable in the phone's software. For example, the hidden "virus" may be disguised as another piece of the phone's normal operating code. In this form of counterfeiting countermeasure, the unit is disabled remotely rendering the keyboard and display inactive, such that none of the keys operate on the mobile unit's keypad and signals can be neither transmitted nor received. Alternatively, the user unit displays an error message indicating to the subscriber that he needs to get his unit examined by an authorized service center. In order to get the unit operating again the counterfeiter would need to replace the unit's software at an authorized dealer or service center making possible the impounding of the counterfeit unit and the apprehension of the bandit.

In another embodiment, once a cellular ESN/MIN has been identified by the cellular operator as being counterfeit, the MIN is place into a "customer group" which routes all its outgoing calls to a recorded message, instructing the authorized subscriber to have his unit re-programmed at an authorized dealer. Once the real subscriber has had his identity verified and his user unit reprogrammed, the ESN/MIN combination is deactivated from the cellular system, so that the counterfeit unit is unable to make calls.

In an additional embodiment, the cell site controller sends a disablement signal, operating to physically damage one or more critical components of the user unit. For example, the user unit is disabled by having one or more of its components destroyed by commanding an increase of current in a certain path which blows a fuse or critical component. With reference to FIG. 7, an electronic switch 464 is commanded to be closed by a signal transmitted from the cellular node. The voltage differential between Vcc 466 and 0v 468 provides a current that is switched from the circuit path through resistor 462 to a short through electrical switch 464. The current passing through critical component 460 is thereby increased to a level where the component, such as a fuse, is damaged. Thus, once the counterfeiting of a user unit is detected, the switch is closed by remote control and the critical phone component is destroyed by the increased current flowing through it. The phone is rendered inoperable and has to be repaired by the authorized service center. An attempted repair of the damaged user unit also makes possible the impounding of the counterfeit unit and the apprehension of the bandit.

In still another embodiment, the determination of the geographical location of an unauthorized user provides means by which the pirate may be apprehended and arrested. Once the position of the pirate is known, the information is forwarded to the police or other law enforcement agency such as the Federal Communications Commission (FCC). The law enforcement agency then proceeds to the geographic location of the bandit where the user unit is impounded and the bandit is arrested.

By virtue of the above discussed design factors the system in accordance with the invention provides a flexible capability of providing the following services: high quality, high rate voice and data service; facsimile (the standard group 3 as well as the high speed group 4); two way messaging, i.e. data interchange between mobile terminals at variable rates; paging rural residential telephone; private wireless exchange; automatic position determination and reporting to within several hundred feet, in conjunction with fraudulent detection of unauthorized users and the prevention thereof.

By virtue of the above discussed design factors the system in accordance with the invention provides a flexible capability of providing the following additional special services: high quality, high rate voice and data service; facsimile (the standard group 3 as well as the high speed group 4); two way messaging, i.e., data interchange between mobile terminals at variable rates; automatic position determination and reporting to within several hundred feet; paging rural residential telephone; and private wireless exchange.

It is anticipated that a satellite will utilize geostationary orbits but is not restricted to such. The invention permits operating in other orbits as well. The system network control center 12 is designed to normally make the choice of which satellite or ground node a user will communicate with. In another embodiment, as an option, the user can request his choice between satellite link or direct ground based link depending on which provides clearer communications at the time or request his choice based on other communication requirements.

While a satellite node has been described above, it is not intended that this be the only means of providing above-ground service. In the case where a satellite has failed or is unable to provide the desired level of service for other reasons, for example, the satellite has been jammed by a hostile entity, an aircraft or other super-surface vehicle may be commissioned to provide the satellite functions described above. The "surface" nodes described above may be located on the ground or in water bodies on the surface of the earth. Additionally, while users have been shown and described as being located in automobiles, other users may exist. For example a satellite may be a user of the system for communicating signals, just as a ship at sea may or a user on foot.

While several particular forms of the invention have been illustrated and described, it will be apparent that various modifications can be made without departing from the spirit and scope of the invention. For example, the present invention is not meant to be limited to cellular mobile communications systems but is intended to include additional communication systems, such as satellite or nodal television systems such as the recently marketed "Direct TV" system. Accordingly, it is not intended that the invention be limited, except by the appended claims.

Having described the invention in such terms as to enable those skilled in the art to make and use it, and having identified the presently preferred best modes thereof, I claim:

1. A communications system having a plurality of user units and at least one cellular node so as to establish at least one cell, the cellular communications system comprising:

a) position determination means for establishing the geographical location of a selected user;

b) logic means for comparing the location of said selected user with the known locations of authorized users; and

c) fraudulent detection means for determining whether said selected user is a fraudulent user of the communications system.

2. The communications system of claim 1, further comprises:

a) disablement means for denying service to said selected user if said selected user is a fraudulent user of the communications system.

3. The communications system of claim 2, wherein:

a) said disablement means includes a commanding means for sending a signal to said user unit to disable operation of said user unit.

4. The communications system of claim 3, wherein:

a) said commanding means is capable of destroying critical components in the user unit.

5. The communications system of claim 1, wherein:

a) said position means for determining the geographic location of a selected user unit is determined by providing a timing signal to the user unit from one or more nodes, providing a timing response signal from the selected user unit in response to each timing signal, receiving the timing response signal by at least one node, measuring the response time of the user unit to each timing signal, and determining the position of the user unit based on such measurements.

6. In the operation of a communications system, which system includes node means, and a plurality of user units, each said user unit including means for establishing selective communication between the node means and the user unit, the improvement for reducing use of said system by an unauthorized user, comprising:

a) establishing the geographical location of a selected user;

b) comparing the location of said selected user with the known locations of authorized users; and

c) determining whether said selected user is a fraudulent user based upon the comparison of the location of said selected user with the known locations of authorized users.

7. In the operation of a system of claim 6, further comprising:

a) denying service to said selected user if said selected user's location does not correspond to one of said known locations.

8. In the operation of a system of claim 6, further comprising:

a) apprehending said selected user.

9. In the operation of a system of claim 6, further comprising:

a) disabling said user unit.

10. In the operation of a system of claim 9, further comprising:

a) destroying a critical component in said user unit.

11. In the operation of a system of claim 6, wherein establishing the geographical location of a selected user further comprises:

a) providing a timing signal to said selected user unit from at least one node;

b) providing a timing response signal from the selected user unit in response to the timing signal;

c) receiving the timing response signal by at least one node;

d) measuring the response time of the user unit to the timing signal based on receipt of the timing response signal; and

e) determining the position of the user unit based on the round trip time of transmission of the timing signal and receipt of the timing response signal.

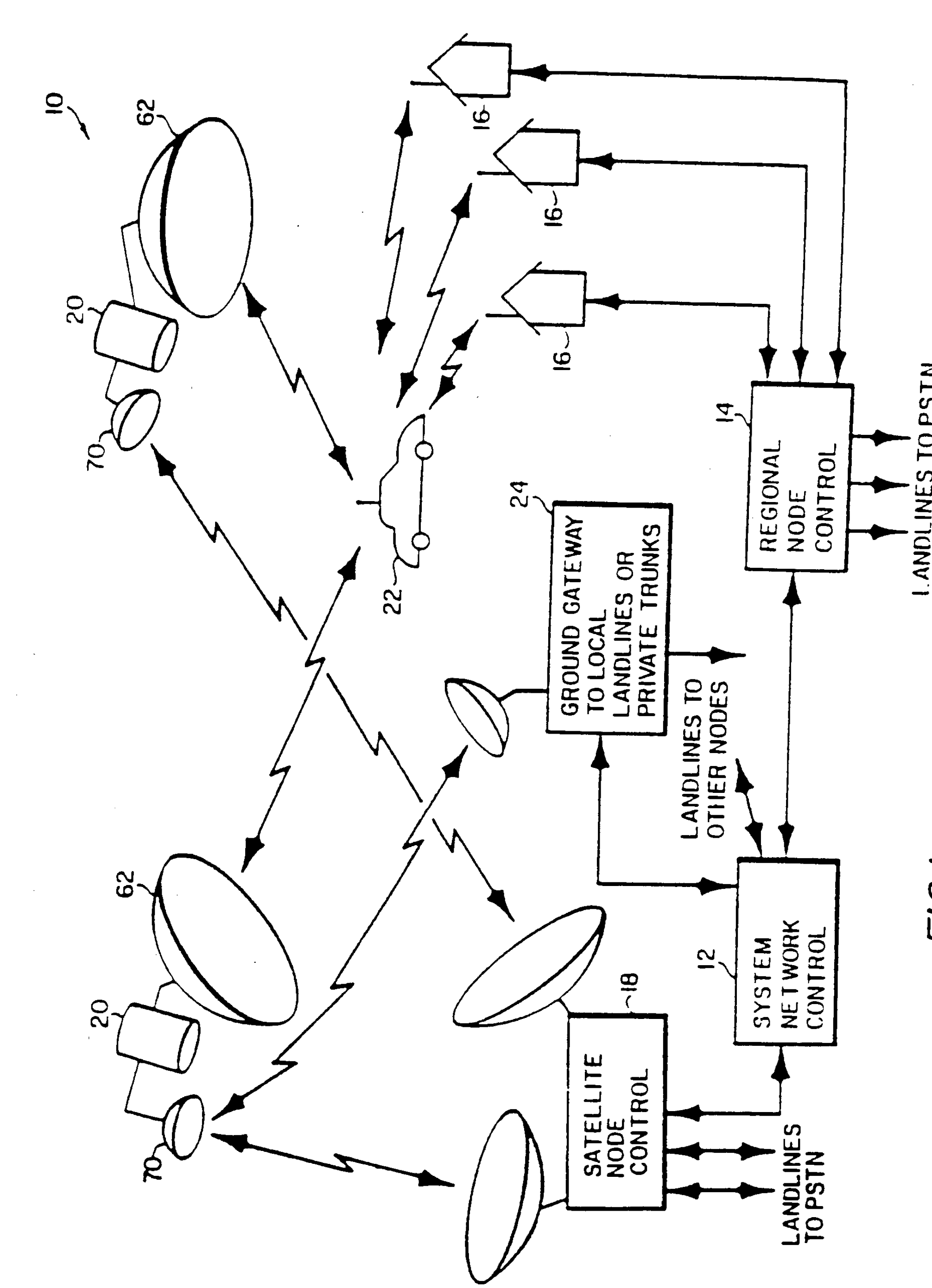

10
62
20
70
16
22
24
GROUND GATEWAY TO LOCAL LANDLINES OR PRIVATE TRUNKS
14
REGIONAL NODE CONTROL
LANDLINES TO PSTN
LANDLINES TO OTHER NODES
12
SYSTEM NETWORK CONTROL
18
SATELLITE NODE CONTROL
LANDLINES TO PSTN

FIG.1(a)

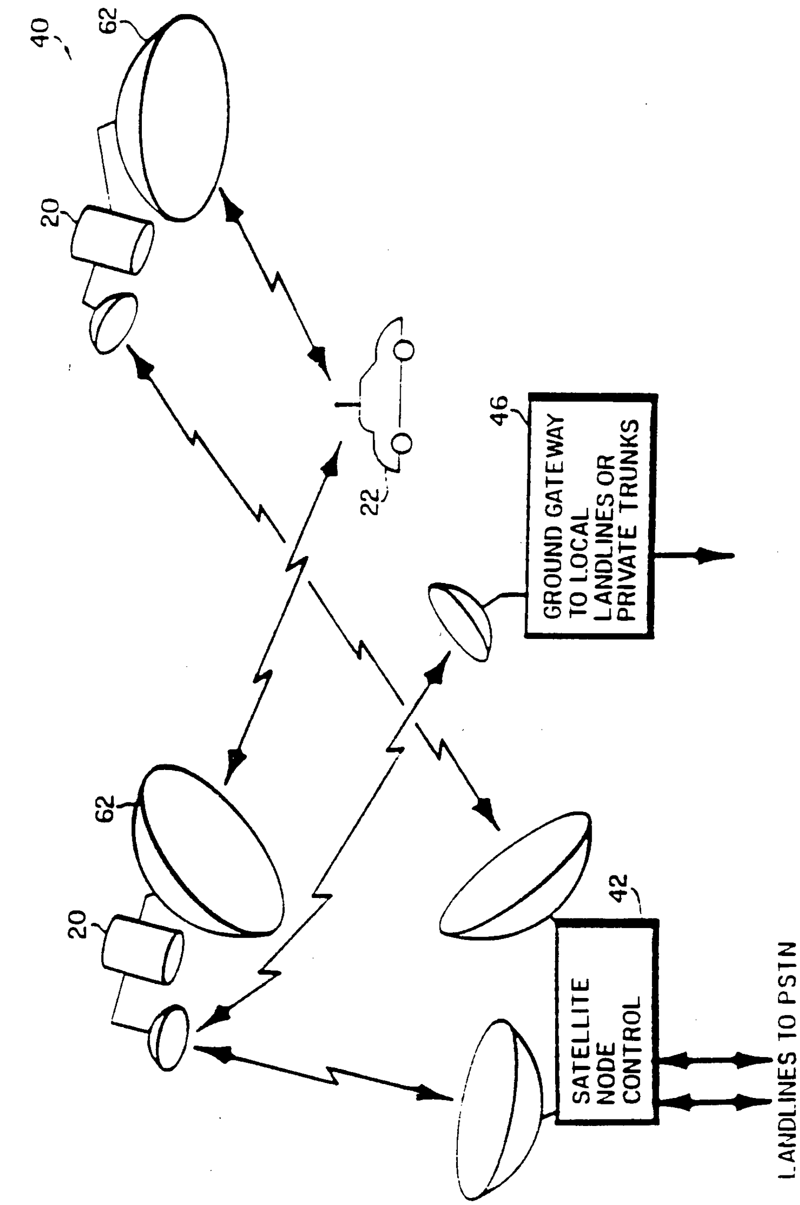


FIG. 1(b)

RECTIFIED SHEET (RULE 91)

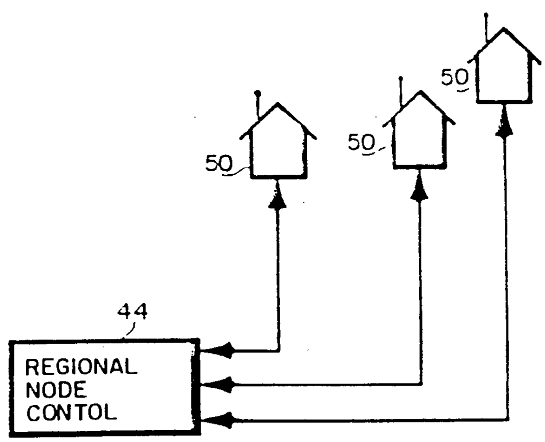


FIG. 1(c)

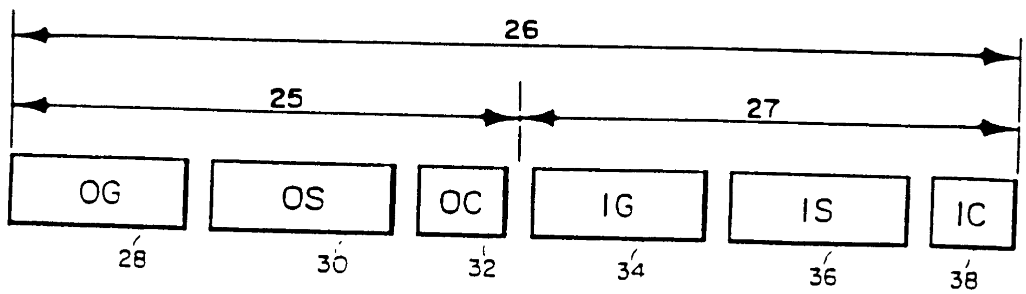


FIG. 2

RECTIFIED SHEET (RULE 91)

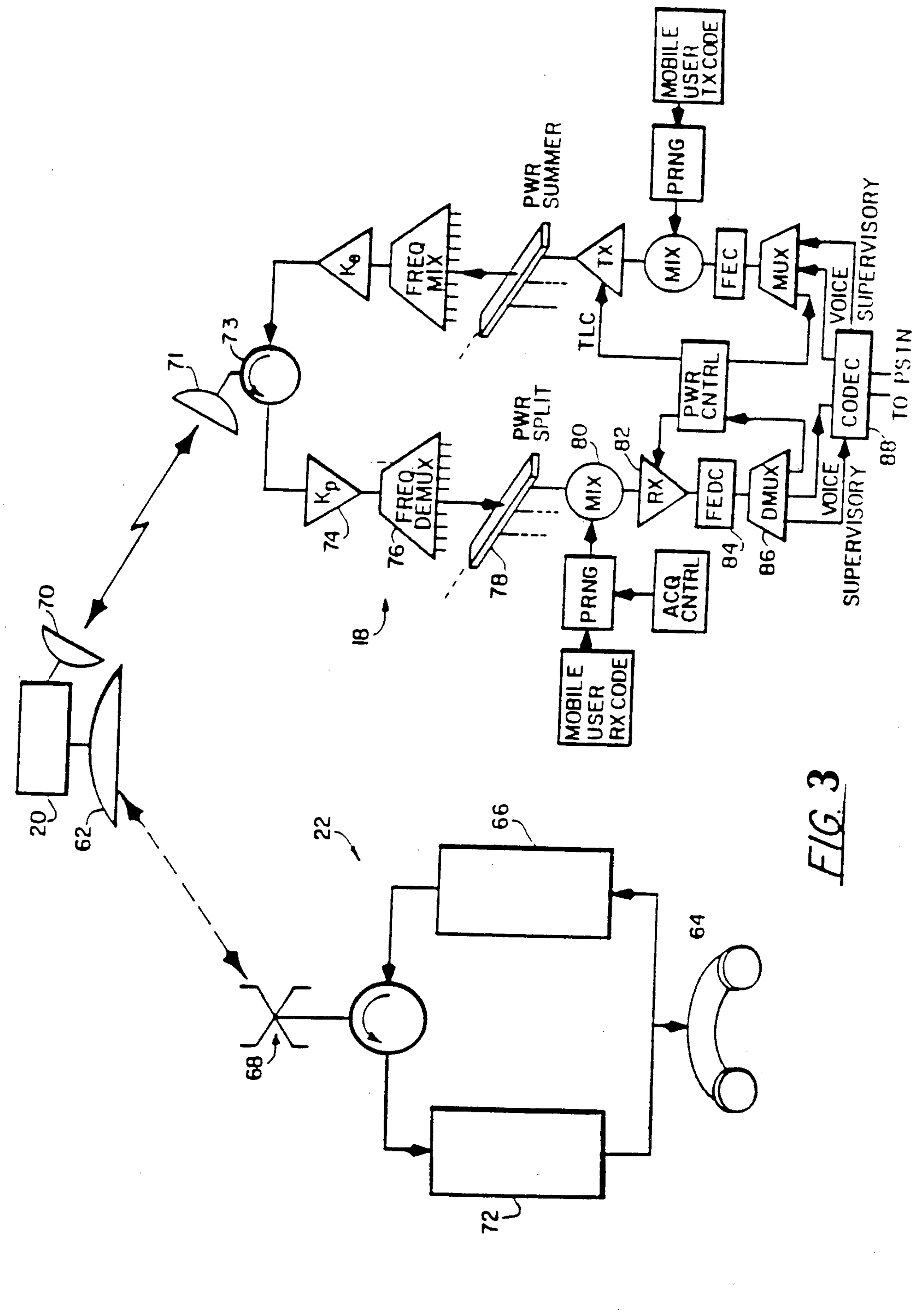


FIG. 3

RECTIFIED SHEET (RULE 91)

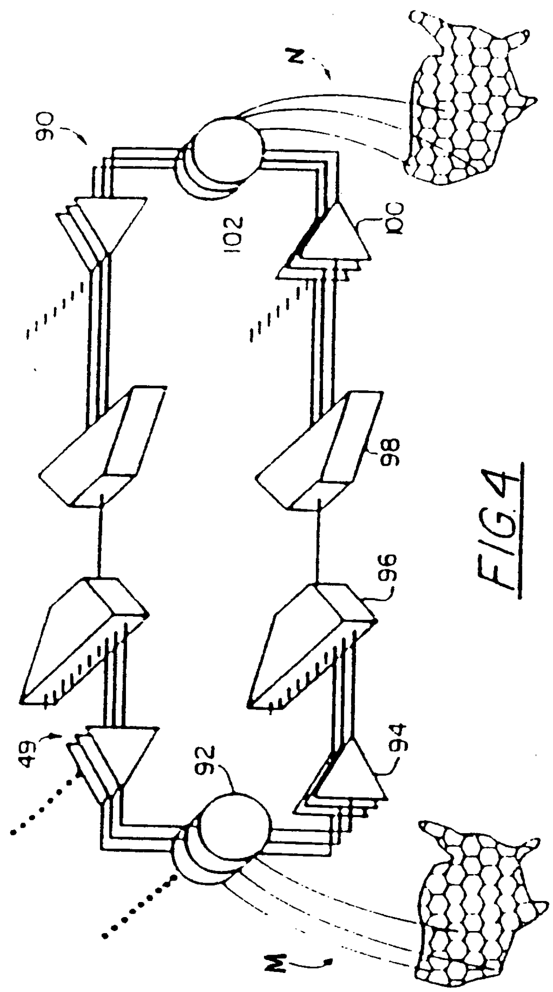
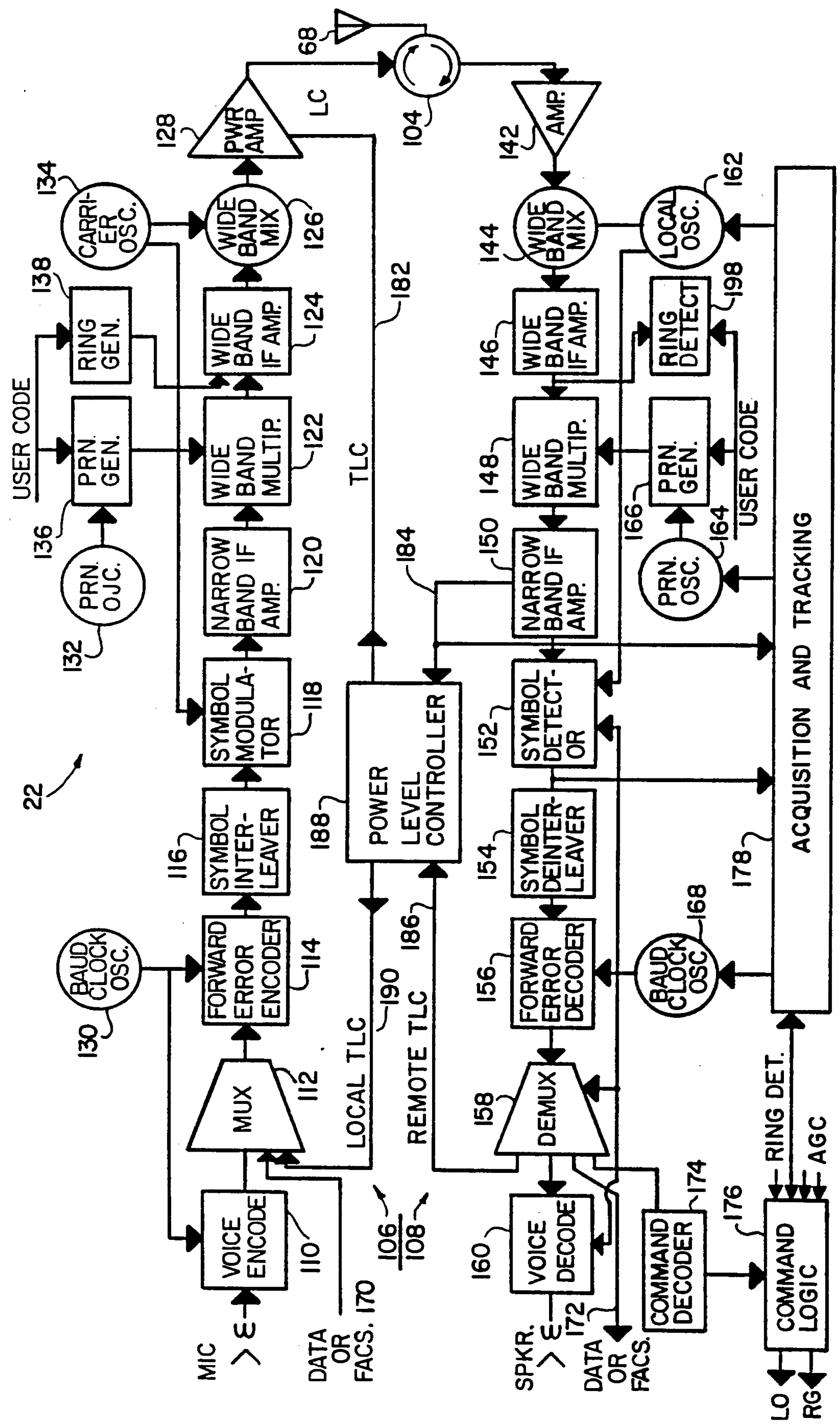


FIG 4

RECTIFIED SHEET (RULE 91)

FIG. 5



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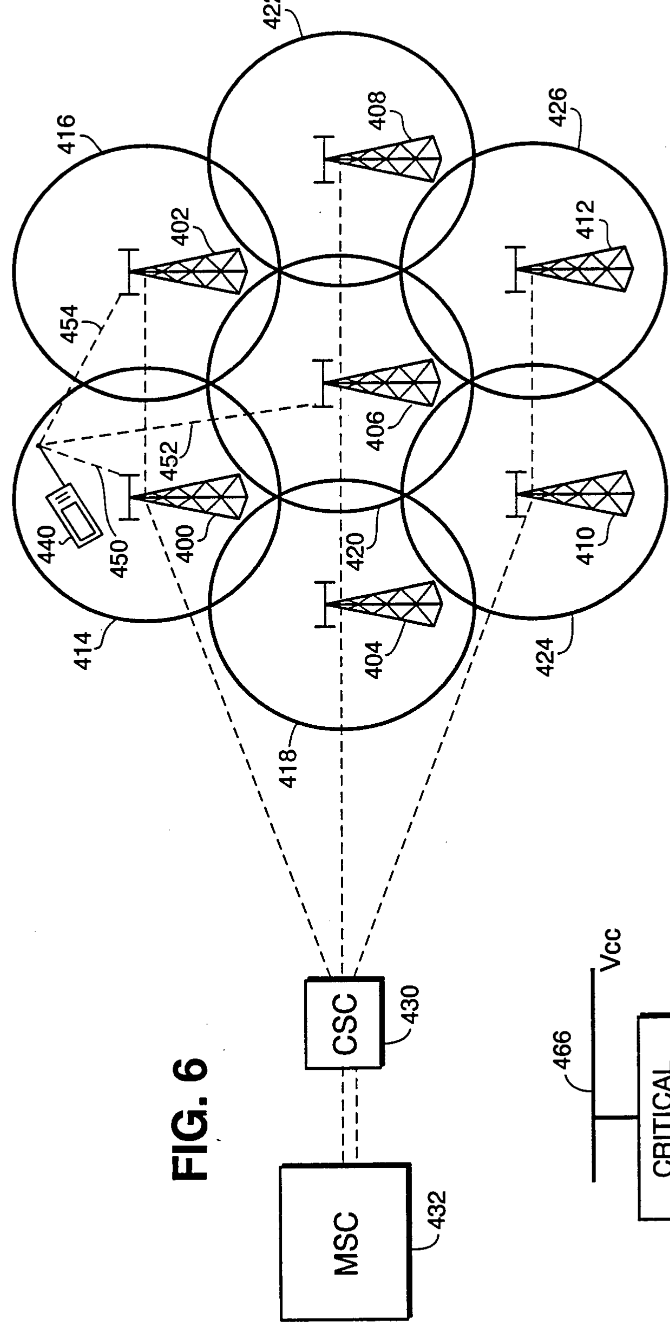

FIG. 6

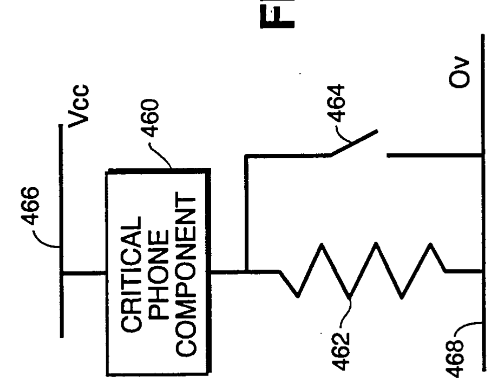

FIG. 7

RECTIFIED SHEET (RULE 91)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/07251

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04Q 7/20
US CL :455/33.1, 54.1, 67.1; 379/59
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P ------- Y,P	US, A, 5,335,265 (COOPER ET AL) 02 August 1994, abstract, col. 1, lines 51-58, col. 2, lines 6-26, col. 5, lines 8-14, col. 8, lines 26-68, col. 9, lines 1-14.	1-4, 6-10 --------------- 5, 11
Y	US, A, 4,278,975 (KIMURA ET AL) 14 July 1981, col. 4, lines 3-12.	5, 11
X,P ------- Y,P	US, A, 5,345,595 (JOHNSON ET AL) 06 September 1994, col. 3, lines 42-68, col. 13, lines 45-55.	1, 6 --------------- 2-5, 7-11
Y,P	US, A, 5,420,910 (RUDOKAS ET AL) 30 May 1995, col. 2, lines 13-41.	2-4, 7-10

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
08 AUGUST 1995

Date of mailing of the international search report
01 SEP 1995

Name and mailing address of the ISA/US
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Facsimile No. (703) [illegible]05-3230

Authorized officer
NGUYEN VO
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Form PCT/ISA/210 (second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/07251

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	US, A, 5,335,278 (MATCHETT ET AL) 02 August 1994, col. 1-4.	1-11
A	US, A, 5,309,501 (KOZIK ET AL) 03 May 1994, col. 1-2.	1-11

Form PCT/ISA/210 (continuation of second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/07251

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

455/33.1, 54.1, 67.1, 33.2, 33.3, 33.4, 49.1, 54.2, 56.1, 67.6, 68, 88; 379/59, 60, 62; 340/988, 989, 991; 342/46, 118, 357, 450, 458, 463; 364/443, 449, 460, 561

Form PCT/ISA/210 (extra sheet)(July 1992)★

Electronic Acknowledgement Receipt	
EFS ID:	2944030
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Correspondence Address:	Dennis J. Dupray, Ph.D. - 1801 Belvedere Street - Golden CO 80401 US 3038632975 -
Filer:	Dennis Jay Dupray.
Filer Authorized By:	
Attorney Docket Number:	1003-1
Receipt Date:	04-MAR-2008
Filing Date:	26-JAN-2001
Time Stamp:	00:07:45
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed	US_IDS_Form__SB_08a.pdf	789251 3f1b4ad5e4bb455fadfbe177b249307ec9f7df93	no	4
Warnings:					
Information:					
2	Foreign Reference	WO09534177A1.pdf	2144079 214008240e3f22737ed42cfbbd7bd1173c07a738	no	75
Warnings:					
Information:					
		Total Files Size (in bytes):	2933330		

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<u>New Applications Under 35 U.S.C. 111</u>
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If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

7590 03/05/2008

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

EXAMINER	
PHAN, DAO LINDA	

ART UNIT	PAPER NUMBER
3662	

MAIL DATE	DELIVERY MODE
03/05/2008	PAPER

NOTICE OF NON-COMPLIANT INFORMATION DISCLOSURE STATEMENT

An Information Disclosure Statement (IDS) filed 3-4-08 in the above-identified application fails to meet the requirements of 37 CFR 1.97(d) for the reason(s) specified below. Accordingly, the IDS will be placed in the file, but the information referred to therein has not been considered.

The IDS is not compliant with 37 CFR 1.97(d) because:

- ☐ The IDS lacks a statement as specified in 37 CFR 1.97(e).
- ☐ The IDS lacks the fee set forth in 37 CFR 1.17(p).
- ☑ The IDS was filed after the issue fee was paid. Applicant may wish to consider filing a petition to withdraw the application from issue under 37 CFR 1.313(c) to have the IDS considered. See MPEP 1308.

Timothy Caldwell

571-272-4200 or 1-888-786-0101
Application Assistance Unit
Office of Data Management

FORM PTOM327-B (Rev. 02/08)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	) Group Art Unit: 3662
	)
DUPRAY et. al.	) Examiner: Phan Dao, Linda
	)
Serial No.: 09/770,838	) Art Unit: 3662
	)
Filed: Jan. 26, 2001	) **PETITION UNDER 37 CFR § 1.313**
	) **TO WITHDRAW APPLICATION**
Atty. File No.: 1003-1	) **FROM ISSUE**
	)
For: "A GATEWAY AND HYBRID	)
SOLUTIONS FOR	)
WIRELESS LOCATION"	)

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

It is respectfully petitioned that the above-identified application be withdrawn from issue under 37 CFR 1.313 based on the discovery of new prior art references. A Request for Continued Examination (RCE) is being filed concurrently with this petition. An Information Disclosure Statement is concurrently filed herewith under 37 CFR § 1.114 to permit the USPTO to consider the new references as set forth in MPEP 609 subpart B(4). Because this withdrawal from issue is not the fault of the USPTO, the petition fee of $130.00 in connection with this Petition pursuant to Section 1.17(h).

Respectfully submitted,
SHERIDAN ROSS P.C.

By: /Dennis J. Dupray/
Dennis J. Dupray, Ph.D.
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1801 Belvedere Dr.
Golden, Colorado 80401
(303) 863-2975

Dated: Mar. 16, 2008

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	09770838	Filing Date	2001-01-26	Docket Number (if applicable)	1003-1	Art Unit	3662
First Named Inventor	Dupray			Examiner Name	Phan, Dao Linda		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on ______
- ☐ Other ______

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- ☐ Amendment/Reply
- ☒ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other ______

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months ______ (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other ______

FEES

☐ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No ______

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☐ Patent Practitioner Signature
☒ Applicant Signature

Applicant Signature			
Applicant 1			Remove
Signature	/Dennis J. Dupray/	Date (YYYY-MM-DD)	2008-03-16
Name	Dennis J. Dupray		
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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	Phan, Dao Linda
	Attorney Docket Number	1003-1

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
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	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	Phan, Dao Linda
	Attorney Docket Number	1003-1

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

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☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature		Date (YYYY-MM-DD)	
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Published
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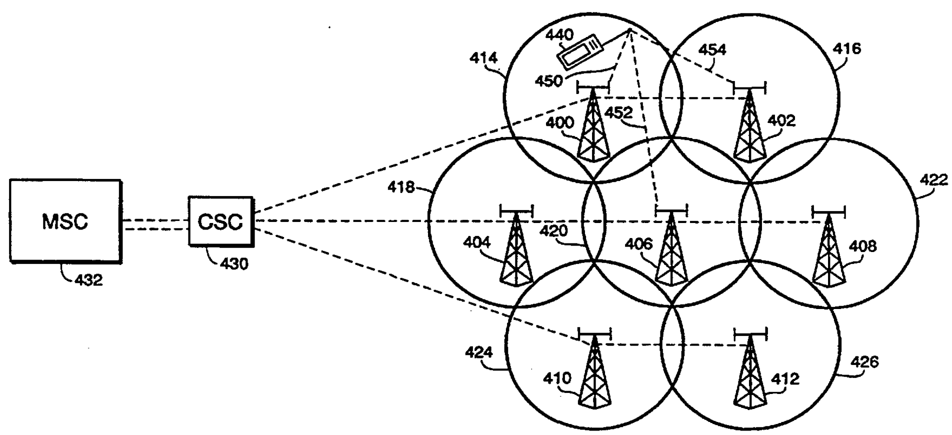
(54) Title: FRAUD DETECTION IN A CELLULAR COMMUNICATIONS SYSTEM



(57) Abstract

Apparatus and methods for operating a wireless communications system provided for reducing the use of the system by unauthorized users by establishing the geographical location of a selected user (440), comparing this location with the known locations of authorized users and denying service to the selected user if the selected user's location does not correspond to the known location of authorized users.

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FRAUD DETECTION IN A CELLULAR COMMUNICATIONS SYSTEM

BACKGROUND

This invention relates to improvements in mobile wireless communication systems.

In another respect, the invention relates to communication systems such as a cellular mobile communications system having integrated satellite and ground nodes.

More particularly, the invention pertains to mobile wireless communications systems which can locate and/or disable the communications equipment of a fraudulent user of the system.

The cellular communications industry has grown at a fast pace in the United States and even faster in some other countries. In the cellular communications industry alone, it is estimated that the number of mobile subscribers will increase on a world-wide level by an order of magnitude within the next ten years. In order to meet the world's ever-increasing demand for mobile communications, numerous diverse systems have been devised. For example, mobile communications system such as Specialized Mobile Radio (SMR), the planned Personal Communications Service (PCS) and existing cellular radio are primarily aimed at providing mobile telephone service to automotive users in developed metropolitan areas. For remote area users, airborne users, and marine users, AIRFONE and INMARSAT services exist but coverage is incomplete and/or service is relatively expensive. Mobile radio satellite systems in an advanced planning stage will probably provide improved direct-broadcast voice channels to mobile subscribers in remote areas but still at significantly higher cost in comparison to existing ground cellular service. The ground cellular and planned satellite technologies complement one another in geographical coverage in that the ground cellular communications service provides voice and data telephone service in relatively developed urban and suburban areas but not in sparsely populated areas, while the planned earth orbiting satellites will serve the sparsely populated areas.

In the case where one band of frequencies is preferable over others and that one band alone is to be used for mobile communications, efficient communications systems are necessary to assure that the number of users desiring to use the band can be accommodated. For example, there is presently widespread agreement on the choice of L-band as the technically preferred frequency band for the satellite-to-mobile link in mobile communications systems.

To meet the world's demand for additional mobile communications capabilities, more communications systems will need to be employed. An additional technology that is anticipated to find widespread application in mobile wireless communications systems is the spread spectrum communications technique. The spread spectrum communications technique is a technology that has found widespread use in military applications which must meet requirements for security, minimized likelihood of signal detection, and minimum susceptibility to external interference or jamming. In a spread spectrum system, the data modulated carrier signal is further modulated by a relatively wide-band, pseudo-random "spreading" signal so that the transmitted bandwidth is much greater than the bandwidth or rate of the information to be transmitted. Commonly the "spreading" signal is generated by a pseudo-random deterministic digital logic algorithm which is duplicated at the receiver.

By further modulating the received signal by the same spreading waveform, the received signal is remapped into the original information bandwidth to reproduce the desired signal. Because a receiver is responsive only to a signal that was spread using the same unique spreading code, a uniquely addressable channel is possible. Also, the power spectral density is low and without the unique spreading code, the signal is very difficult to detect, much less decode, so privacy is enhanced and interference with the signals of other services is reduced. The spread spectrum signal has strong immunity to multipath fading, interference from other users of the same system, and interference from other systems.

Unfortunately, accompanying the rapid growth of mobile communications technology has been corresponding growth in the fraudulent procurement of mobile communications. Already, signal theft, also known as "pirating," or "cellular fraud," is a major problem in current cellular systems.

Cellular fraud is a serious problem in the cellular industry, not only in the United States but worldwide. In 1994 cellular fraud accounted for $500M of lost revenue in the United States and $1 billion worldwide. Currently, every month an additional 50,000 cellular telephone numbers are stolen and illegally used in the United States. Cellular fraud is thus equivalent to 2.5% of the total annual revenue of the United States cellular industry for 1994 ($20 billion) and it is rising every year. Some cellular carriers in the largest United States cities have been hit extremely hard by fraud, including one large US carrier who lost $40M in one three month period, when 600 cellular phones were illegally activated, without being detected by the operator. Internationally, some cellular operators in less developed countries have experienced fraud as high as 30%

on their networks, because they have not installed adequate credit checking controls or fraud prevention procedures.

The United States Secret Service considers the stealing of cellular telephone numbers as counterfeiting (Title 18, Section 1029) and as such, it is a Federal offense with penalties rising as high as a fine of $100,000 and 20 years imprisonment. Organized criminals including drug dealers and gangs, car thieves and armed robbers use counterfeit cellular phones widely because cellular phones provide the criminal with communications mobility as well as anonymity. Thus the police often find that when they catch organized criminals, counterfeit phones are also recovered. In the last two years, over 500 suspects have been arrested for counterfeiting cellular phones and thousands of stolen phones have been recovered by the United States Secret Service and Federal Bureau of Investigation. Notwithstanding, the number of counterfeit phones is growing rapidly.

Pirating can be accomplished in several manners. In particular, there are three basic classifications of cellular fraud described herein as "Access Fraud", "Subscription Fraud" and "Stolen Phone Fraud." Essentially all types of cellular access fraud involve the perpetrators or "Bandits" making cellular calls on counterfeit cellular phones, whose electronic identity has been illegally modified to resemble that of another valid or non-existent subscriber's cellular phone.

In order for a subscriber to make a call on his home cellular network, his subscriber unit's cellular phone number/electronic serial number (ESN) combination must correspond exactly with the phone and electronic serial and numbers stored in the cellular operator's cellular telephone exchange. If the numbers do not correspond, then the cellular system will not complete the subscribers call.

Access fraud is the unauthorized use of cellular service through changing of a cellular phone's unique Electronic Serial Number (ESN) and/or the subscriber's phone number or Mobile Identification Number (MIN). Presently, pirates manage to acquire the authorization code intended to restrict system use to the authorized customers for whom it was intended. A mobile user unit is then altered to incorporate the stolen authorization code enabling the altered pirate user unit to transmit and receive signals of the communications system in the same manner as the lawful subscriber of the cellular system to whom had been originally appointed the authorization code. In this manner, it is extremely common for a fraudulent user to unlawfully use the communications system charging all communications to an innocent subscriber.

Further, access fraud has several variants including the most common, tumbling ESN/MIN & Counterfeiting (Cloning). Tumbling ESN/MIN involves the modification of a mobile unit's unique ESN/MIN combination. The phone is modified such that the ESN/MIN identity for a pseudo "roamer" is changed whether randomly or sequentially after every call to that of another roaming subscriber's unit. A roamer is a cellular subscriber who uses his cellular phone in another market, i.e., a New York "Nynex Mobile" subscriber who visits Chicago and makes and receives calls on his phone using the local "Ameritech Mobile" network.

The constant alteration of the counterfeit phone's ESN and/or MIN allows the bandit to evade the detection and "shut down" of that phone. This is because, in the less sophisticated cellular systems, there is no way of telling whether the roamer caller is a valid roamer subscriber or not and so tumbling fraud cannot be immediately detected. This authentication is known as "Pre-Call Subscriber ESN/MIN validation".

Cloning, or counterfeiting, occurs when the bandit obtains valid subscriber's ESN/MIN combinations, usually by monitoring ("scanning") cellular radio transmission "over the air" using special cellular radio signaling data receivers and decoders. The bandit then programs these ESN/MIN's into his phone, thus appearing to the cellular operator as a valid subscriber. the bandit continues to place illegal calls on his cellular phones until detected. This detection often occurs only after the valid subscriber calls up the cellular operator's Customer Car department to complain that his monthly bill contains calls which he did not make. At this time the counterfeited ESN/MIN combination is denied service. Additionally, the valid subscriber is also denied service and must have his MIN (cellular telephone number) changed in order to have his service restored causing additional inconvenience.

"Subscription fraud" occurs when a subscriber signs up for service with fraudulent identification, without any intention of paying for the service. An example of subscription fraud occurs when a bandit subscriber fraudulently uses the credit card number, social security number, state drivers license, or other means of identification, of another in an effort to obtain the use of a cellular communications system. The bandit then uses the system without paying until the bills have mounted to the point that their authorization is discontinued by the cellular provider. This cycle is then repeated using the identification of another innocent individual. Unfortunately, this type of cellular fraud is particularly widespread and costly, incurring millions of dollars of losses to both the cellular industry and those innocent individuals whose means of identification has been purloined.

Simply, "stolen phone" fraud occurs when a legitimate phone is stolen and used before it can be denied service. The pirate merely steals a user unit already including the authorization code of a subscriber. Unfortunately, by the very nature of the cellular units being lightweight, readily concealable and mobile has created a low risk, high profit market for theft. Further, a subscriber, often believing that they have merely misplaced their user unit, will often wait weeks or even months before realizing that their user unit has been stolen. Accordingly, the subscriber often does not notify their mobile communications provider to cease cellular services until thousands of dollars worth of cellular communications have been pirated. The pirate does not pay the fees due to the service provider and the costs are transferred either to the subscriber of the stolen authorization code or to the users of the system as a whole.

Unfortunately, due to the threat of cellular fraud, many cellular operators now limit the ability of cellular subscribers to use their cellular phones to make long distance and international calls, particularly residential and roaming subscribers. This limits the revenue opportunities for the cellular operator. If cellular fraud could be more easily detected and combated, then cellular operators could lift these calling restrictions, increasing the utility of the phones to the subscribers and raising the average monthly revenue for the operators.

In an effort to eliminate cellular fraud, numerous fraud detection techniques have been attempted. The first of these, "call pattern analysis" entails the review of a subscribers cellular velocity, volume, duration, destination, and initial bill credit limit. Special software in a billing server analyzes a very large number of call detail records (e.g., 3 month's worth) from the cellular telephone exchange to look for anomalies and changes in patterns of: 1) call origination location with respect to time, e.g., to look for phones with the same MIN/ESN being used at the same time in two different places (also known as "Velocity"); 2) call volume, e.g., the subscriber starts to use very high volumes of airtime minutes when their previous volume was low; 3) call duration, which may indicate that the phone is being used as a "free long distance pipeline" for calls forwarded to that MIN; 4) call destination, e.g., if a subscriber starts making large numbers of international calls when the previous international activity was low; 5) call time, e.g., the subscriber starts using high volumes of nighttime minutes whereas previously all the usage was during the day. The same software is also programmed to detect very high calling volumes in the initial few days and weeks after the services is activated when no pattern data is available. This often detects when a subscriber has no intention of paying the bill.

An additional fraudulent detection means has been called "Dual Call Set-Up Logs." Special software in the cellular telephone exchange identifies any situation with an alarm log when two subscriber units with identical MIN/ESN combinations attempt to have simultaneous phone calls on the same cellular switch.

Some cellular systems include the fraudulent detection means "Dual Phone Page Responses." When a cellular phone number is dialled and two units respond to the "page" on different cellsites and different frequencies at the same time. The switch identifies that two separate and distinct mobiles with the same MIN/ESN combination have the responded to a page and issues an alarm log that a fraudulent user is using the system.

"Tumbling ESN Analysis" is a fraud detection system where the cellular telephone exchange looks for patterns in MIN/ESN combinations as well as patterns in MIN/ESN combination tumbling and issues an alarm log if tumbling is detected.

A somewhat ingenious system for detecting cellular fraud, though hardware intensive and somewhat expensive, is "Subscriber Unit Fingerprinting." Special receivers at each base station, characterize the FM transmission of each cellular telephone, e.g., the exact FM deviation, carrier frequency, data modulation frequency, etc. on the call set-up channels of the network. If cellular telephones with identical ESN/MIN combinations and different radio characteristics are identified, a cloned unit is detected.

In addition to detecting a cellular fraud realtime, increased analysis of presently provided information has been employed to reduce cellular fraud. For example, subscribers are asked to examine their monthly bill and document those calls that appear on their bills which they did not make. Subscribers are then asked to call the cellular operators' billing department to get the fraudulent calls removed, their bill adjusted and their ESN/MIN changed. Further, cellular companies have started to install the latest in Inter-System PRV (Positive Roamer Validation). PRV signaling equipment and SS-7 data links are now used to validate the identity and credit worthiness of roamers (those cellular users not operating in their subscriber territory) on the cellular network. Additionally, the cellular industry has taken to improved verification of credit information, address, identity checking, and roamer activity. Real time links to the credit bureaus for improved credit risk management has been initiated, as well as the calling of a subscriber's home or office to verify his billing address a few days after service has commenced.

Notwithstanding the cellular industry's extensive effort to stop the spread of cellular fraud, in the past, such pirates have been amazingly successful both in terms of speedy delivery to their markets and the magnitude of the stolen signals. In the coming decade, as the demand for cellular communications increases, signal theft is anticipated to increase at a rate at least comparable with increase of cellular communications.

Accordingly, their is a need to reduce the debt losses to the cellular industry, including direct losses from uncollected airtime revenues, increased expenses from interconnect charges from the need to hire extra staff to handle fraud problems on legitimate customers phones and monthly bills.

Further, their is a need to reduce the ability for organized criminals to operate using cellular phones.

Additionally, their is a need to reduce the inconvenience to legitimate cellular subscribers from wrong phone bills, strange incoming phone calls and the need to get their phone reprogrammed to a "clean" number.

For the foregoing reasons, there is a need to reduce or eliminate fraudulent use of a wireless system by improved detection and location of the fraudulent user. It would be desirable to verify if system users were authorized by virtue of their position.

Accordingly, it would be desirable if the cellular system would cease the transmission of signals to users determined to be fraudulent.

Additionally, it would be desirable to provide a cellular system that would provide for the apprehension of fraudulent users once their position had been determined.

SUMMARY OF THE INVENTION

The invention provides improvements in wireless communications systems. While various aspects of the invention will be explained by reference, for example, to a cellular communications system using spread spectrum waveforms, it will be apparent to those skilled in the art that these techniques are applicable to similar forms of wireless communications systems, such as, for example, Specialized Mobile Radio (SMR), the planned Personal Communications Service (PCS) and existing cellular radio systems.

The present invention is directed to improvements in such wireless communications systems, for example, a cellular communications system using spread spectrum waveforms. The spread spectrum system makes possible the use of very low rate, highly redundant coding without loss of capacity to accommodate a large number of users within the allocated bandwidth. Further, though not limited to such, the present invention is directed to a cellular communications using Code Division Multiple Access (CDMA) which is anticipated to have achieved world wide use in the coming decade.

Briefly, in one aspect, a wireless communication system of the present invention is directed to a wireless communications system which includes node means and a plurality of user units, each said user unit including a means for establishing selective communication between the node means and the user unit. Such a system is improved by establishing the geographical location of a selected user. The geographical location of the selected user is compared to known locations of authorized users to determine if the communication system is being "pirated" and communication signals being fraudulently stolen. Once determination has been made that the selected user is an unauthorized recipient of the communications services, the cellular system can disrupt the communication services by numerous means. For example, in one embodiment of the present invention, the communication system disrupts communications services by simply ceasing the receipt or transmission of signals to the unauthorized selected user. In an additional embodiment, the nodal unit of the communications systems transmits a signal to the selected user instructing the user unit to disable itself. Though not intended to be limited thereto, this may be accomplished by scrambling the internal software of a user unit, instructing the user unit to destroy its internal circuitry or to blow an internal fuse.

In still another embodiment of the operation of the communications system, the determination of the geographical location of an unauthorized fraudulent user of the communication system provides means by which the pirate may be apprehended and arrested. Once the position of the pirate is known, the information is forwarded to the police or other law enforcement agency such as the Federal Communications Commission (FCC). The law enforcement agency then proceeds to the geographic location, where the user unit is impounded and the pirate user is arrested. In this manner, not only is fraudulent use of the system reduced due to the arrest of those "pirating" the system, but those contemplating cellular theft are deterred from such actions due to the high risk of being apprehended.

As stated above, the present invention utilizes the knowledge of a users position to first verify the legitimate, authorized user units. The remaining units operating on that code are clearly identified as non-paying pirate users by having a different position. The communication system then operates to deny service to the selected user if the selected user's location does not correspond to one of the known locations of authorized users.

Preferably, the system includes means for determining the position of a selected user unit by providing a timing signal to the selected user unit from the node, providing a timing response signal from the selected user unit from the node, providing a time response signal from the selected user unit in response to each timing signal, receiving the timing response signal by the node, measuring the response time of the user unit to the timing signal based on receipt of the timing response signal, and determining the position of the user unit based on the round trip time of transmission of the timing signal and receipt of the timing response signal.

In a more detailed aspect of the invention, the position means comprises means for measuring the response times of the user unit to respective timing signals transmitted by at least two nodes and for determining the position of the selected user unit based on the round trip times from each timing signal transmitting surface node.

In yet another aspect, the position means comprises means for determining the position of the selected user unit by measuring at a plurality of nodes the response time of the user unit to a timing signal transmitted by at least one of the nodes and determining the position of the selected user unit based on the times of receipt by the nodes of the timing response signal from the user unit.

In another aspect, the position means may store *a priori* information about the selected user unit and may determine the position of the selected user unit by providing a timing signal to the user unit from a node, measuring the response time of the user unit to the timing signal at the node, and determining the position of the user unit based on such measurement and on the *a priori* information. Additionally, the position means also determines in which cell a selected user unit is and indicates the location of the cell.

Other aspects and advantages of the invention will become apparent from the following detailed description and the accompanying drawings, illustrating by way of example the features of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1(a)-(c) are diagrams showing an overview of the principal elements of typical communications systems which embody the principles of the invention;

FIG. 2 is a diagram of the frequency sub-bands of the frequency band allocation for a mobile system, e.g., a cellular system;

FIG. 3 is a block diagram of a satellite link system showing the user unit and satellite node control center;

FIG. 4 is a block diagram of one embodiment of a satellite signal processing in the system in FIG. 5;

FIG. 5 is a functional block diagram of a user transceiver;

FIG. 6 depicts the interrelationship of the cellular structure of the ground nodes, cellsite controller (CSC), and mobile switching center (MSC) of a typical system; and

FIG. 7 depicts an internal circuit of a user unit capable of being remotely operated to prevent further use of the user unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As is shown in the exemplary drawings, the invention is embodied in a mobile system, e.g., a cellular communications system utilizing integrated satellite and ground nodes both of which use the same modulation, coding, and spreading structure and both responding to an identical user unit.

Signal theft or "pirating" is a major problem in current cellular and TV receive only (TVRO) systems, and will probably affect additional future communications systems. Pirates manage to learn a code intended to restrict the system use to the authorized customers for whom it was intended, and then to alter users units such that they become pirate units which operate using the stolen code. Thus, unlawful use of the system is accomplished and the pirate user does not pay the fees due to the service provider. In the past, such pirates have been amazingly successful at their unlawful trade, both in terms of speedy delivery to their markets and the value of stolen signals. Such piracy continues on a large scale today not only in cellular communications systems but also other communications systems such as satellite television systems where satellite television transmissions are pirated.

This invention utilizes the knowledge of a users position, obtained as described above, first to verify the legitimate, authorized users unit. The remaining units operating on that code are clearly identified as non paying or pirate users by virtue of having a different position. In one embodiment, this information is used to apprehend the pirates.

In an alternate embodiment, the pirated unit can be disabled. There are two embodiments for disabling the pirated unit, each being effective under different circumstances. The first involves simply not providing service. The second involves commanding the disablement of the pirated unit by means including commanding that fuses to be blown within the circuitry and commanding the destruction of the user circuitry.

Referring now to FIG. 1(a), an overview of a typical communications system 10 is presented showing the functional inter-relationships of the major elements. The disclosed communication system is for example only and may be embodied in various forms. The system network control center 12 directs the top level allocation of calls to satellite and ground regional resources throughout the system. It also is used to coordinate system-wide operations, to keep track of user locations, to perform optimum allocation of system resources to each call, dispatch facility command codes, and monitor and supervise overall system health. The regional node control centers 14, one of which is shown, are connected to the system network control center 12 and direct the allocation of calls to ground nodes within a major metropolitan region. The regional node control center 14 provides access to and from fixed land communication lines, such as commercial telephone systems known as the public switched telephone network (PSTN). The ground nodes 16 under direction of the respective regional node control center 14 receive calls over the fixed land line network, encode them, spread them according to the unique spreading code assigned to each designated user, combine them into a composite signal, modulate that composite signal onto the transmission carrier, and broadcast them over the cellular region covered.

Satellite node control centers 18 are also connected to the system network control center 12 via status and control land lines and similarly handle calls designated for satellite links such as from PSTN, encode them, spread them according to the unique spreading codes assigned to the designated users, and multiplex them with other similarly directed calls into an uplink trunk, which is beamed up to the designated satellite 20. Satellite nodes 20 receive the uplink trunks, frequency demultiplex the calls intended for different satellite cells, frequency translate and direct each to its appropriate cell transmitter and cell beam, and broadcast the composite of all such similarly directed calls down to the intended satellite cellular area. As used herein, "backhaul" means the link between a satellite 20 and a satellite node control center 18. In one embodiment, it is a K-band frequency while the link between the satellite 20 and the user unit 22 uses an L-band or an S-band frequency.

As used herein, a "node" is a communication site or a communication relay site capable of direct one or two-way radio communication with users. Nodes may include moving or stationary surface sites or airborne or satellite sites.

User units 22 respond to signals of either satellite or ground node origin, receive the outbound composite signal, separate out the signal intended for that user by despreading using the user's assigned unique spreading code, de-modulate, and decode the information and deliver the call to the user. Such user units 22 may be mobile or may be fixed in position. Gateways 24 provide direct trunks that is, groups of channels, between satellite and the ground public switched telephone system or private trunk users. For example, a gateway may comprise a dedicated satellite terminal for use by a large company or other entity. In the embodiment of FIG. 1, the gateway 24 is also connected to that system network controller 12.

All of the above-discussed centers, nodes, units and gateways are full duplex transmit/receive performing the corresponding inbound (user to system) link functions as well in the inverse manner to the outbound (system to user) link functions just described.

FIGs. 1(b) and 1(c) represent systems with space only and ground only nodes. Certain aspects of this invention relate to these two systems as well as the "hybrid" system previously described.

Referring now to FIG. 2, the allocated frequency band 26 of a communications system is shown. The allocated frequency band 26 is divided into 2 main sub-bands, an outgoing sub-band 25 and an incoming sub-band 27. Additionally the main sub-bands are themselves divided into further sub-bands which are designated as follows:

OG: Outbound Ground 28 (ground node to user)
OS: Outbound Satellite 30 (satellite node to user)
OC: Outbound Calling and Command 32 (node to user)
IG: Inbound Ground 34 (user to ground node)
IS: Inbound Satellite 36 (user to satellite node)
IC: Inbound Calling and Tracking 38 (user to node)

All users in all cells use the entire designated sub-band for the described function. Unlike existing ground or satellite mobile systems, there is no necessity for frequency division by cells; all cells may use these same basic six sub-bands. This arrangement results in a higher frequency reuse factor as is discussed in more detail below.

In one embodiment of the cellular system, a mobile user's unit 22 will send an occasional burst of an identification signal in the IC sub-band either in response to a poll or autonomously. This may occur when the unit 22 is in standby mode. This identification signal is tracked by the regional node control center 14 as long as the unit is within that respective region, otherwise the signal will be tracked by the satellite node or nodes. In another embodiment, this identification signal is tracked by all ground and satellite nodes capable of receiving it. This information is forwarded to the network control center 12 via status and command lines. By this means, the applicable regional node control center 14 and the system network control center 12 remain constantly aware of the cellular location and link options for each active user 22. An intra-regional call to or from a mobile user 22 will generally be handled solely by the respective regional node control center 14. Inter-regional calls are assigned to satellite or ground regional system resources by the system network control center 12 based on the location of the parties to the call, signal quality on the various link options, resource availability and best utilization of resources.

A user 22 in standby mode constantly monitors the common outbound calling frequency sub-band OC 32 for calling signals addressed to him by means of his unique spreading code. Such calls may be originated from either ground or satellite nodes. Recognition of his unique call code initiates the user unit 22 ring function. When the user goes "off-hook", e.g., by lifting the handset from its cradle, a return signal is broadcast from the user unit 22 to any receiving node in the user calling frequency sub-band IC 38. This initiates a handshaking sequence between the calling node and the user unit which instructs the user unit whether to transition to either satellite, or ground frequency sub-bands, OS 30 and IS 36 or OG 28 and IG 34.

A mobile user wishing to place a call simply takes his unit 22 off hook and dials the number of the desired party, confirms the number and "sends" the call. Thereby an incoming call sequence is initiated in the IC sub-band 38. This call is generally heard by several ground and satellite nodes which forward call and signal quality reports to the appropriate system network control center 12 which in turn designates the call handling to a particular satellite node 20 or regional node control center 14. The call handling element then initiates a handshaking function with the calling unit over the OC 32 and IC 38 sub-bands, leading finally to transition to the appropriate satellite or ground sub-bands for communication.

The combined satellite/ground nodes system provides a hierarchical geographical cellular structure. Thus within a dense metropolitan area, each satellite cell may further contain as many as 100 or more ground cells, which ground cells would normally carry the bulk of the traffic originated therein. The number of users of the ground nodes 16 is anticipated to exceed the number of users of the satellite nodes 20 where ground cells exist within satellite cells. Because all of these ground node users would otherwise interfere as background noise with the intended user-satellite links, in one embodiment the frequency band allocation may be separated into separate segments for the ground element and the space element as has been discussed in connection with FIG. 2. This combined, hybrid service can be provided in a manner that is smoothly transparent to the user. Calls will be allocated among all available ground and satellite resources in the most efficient manner by the system network control center 12.

Referring now to FIG. 3, a block diagram is shown of a typical user unit 22 to satellite 20 to satellite node control 18 communication and the processing involved in the user unit 22 and the satellite node control 18. In placing a call for example, the handset 64 is lifted and the telephone number entered by the user. After confirming a display of the number dialed, the user pushes a "send" button, thus initiating a call request signal. This signal is processed through the transmitter processing circuitry 66 which includes spreading the signal using a calling spread code. The signal is radiated by the omni-directional antenna 68 and received by the satellite 20 through its narrow beamwidth antenna 62. The satellite processes the received signal as will be described below and sends the backhaul to the satellite node control center 18 by way of its backhaul antenna 70. On receive, the antenna 68 of the user unit 22 receives the signal and the receiver processor 72 processes the signal. Processing by the user unit 22 will be described in more detail below in reference to FIG. 5.

The satellite node control center 18 receives the signal at its antenna 71, applies it to a circulator 73, amplifies 74, frequency demultiplexes 76 the signal separating off the composite signal which includes the signal from the user shown in FIG. 3, splits it 78 off to one of a bank of code correlators, each of which comprises a mixer 80 for removing the spreading and identification codes, an AGC amplifier 82, the FECC demodulator 84, a demultiplexer 86 and finally a voice encoder/decoder (CODEC) 88 for converting digital voice information into an analog voice signal. The voice signal is then routed to the appropriate land line, such as a commercial telephone system. Transmission by the satellite node control center 18 is essentially the reverse of the above described reception operation.

Referring now to FIG. 4, the satellite transponder 90 of FIG. 3 is shown in block diagram form. A circulator/diplexer 92 receives the uplink signal and applies it to an L-band or S-band amplifier 94 as appropriate. The signals from the M satellite cells within a "cluster" are frequency multiplexed 96 into a single composite K-band backhaul signal occupying M times the bandwidth of an individual L-/S-band mobile link channel. The composite signal is then split 98 into N parts, separately amplified 100, and beamed through a second circulator 102 to N separate satellite ground cells. This general configuration supports a number of particular configurations various of which may be best adapted to one or another situation depending on system optimization which for example may include considerations related to regional land line long distance rate structure, frequency allocation and subscriber population. Thus, for a low density rural area, one may utilize an M-to-1 (M>1, N=1) cluster configuration of M contiguous cells served by a single common satellite ground node with M limited by available bandwidth. In order to provide high-value, long distance service between metropolitan area, already or best covered for local calling by ground cellular technology, an M-to-M configuration would provide an "inter-metropolitan bus" which would tie together all occupants of such M satellite cells as if in a single local calling region. To illustrate, the same cells (for example, Seattle, Los Angeles, Omaha and others) comprising the cluster of M user cells on the left side of FIG. 4, are each served by corresponding backhaul beams on the right side of FIG. 4.

Referring now to FIG. 5, a functional block diagram of a typical user unit 22 is shown. The user unit 22 comprises a small, light-weight, low-cost, mobile transceiver handset with a small, non-directional antenna 68. The single antenna 68 provides both transmit and receive functions by the use of a circulator/diplexer 104 or other means. It is fully portable and whether stationary or in motion, permits access to a wide range of communication services from one telephone with one call number. It is anticipated that user units will transmit and receive on frequencies in the 1-3 GHz band but can operate in other bands as well.

The user unit 22 shown in FIG. 5 comprises a transmitter section 106 and a receiver station 108. For the transmission of a voice communication, a microphone couples the voice signal to a voice encode 110 which performs analog to digital encoding using one of the various modern speech coding technologies well known to those skilled in the art. The digital voice signal is combined with local status data, and/or other data, facsimile, or video data forming a composite bit stream in digital multiplexer 112. The resulting digital bit stream proceeds sequentially through forward error encoder 114, symbol or bit interleaver 116, symbol or bit, phase, and/or amplitude modulator 118, narrow band IF amplifier 120, wideband multiplier or spreader 122, wide band IF amplifier 124, wide band mixer 126, and final power amplifier 128. Oscillators or equivalent synthesizers derive the bit or baud frequency 130, pseudo-random noise or "chip" frequency 132, and carrier frequency 134. The PRN generator 136 comprises deterministic logic generating a pseudo-random digital bit stream capable of being replicated at the remote receiver. The ring generator 138 on command generates a short pseudo-random sequence functionally equivalent to a "ring".

The transceiver receive function 108 demodulation operations mirror the corresponding transmit modulation functions in the transmitter section 106. The signal is received by the non-directional antenna 68 and conducted to the circulator 104. An amplifier 142 amplifies the received signal for mixing to an IF at mixer 144. The IF signal is amplified 146 and multiplied or despread 148 and then IF amplified 150 again. The IF signal then is conducted to a bit or symbol detector 152 which decides the polarity or value of each channel bit or symbol, a bit or symbol de-interleaver 154 and then to a forward error decoder 156, the composite bit stream from the FEC decoder 156 is then split into its several voice, data, and command components in the de-multiplexer 158. Finally a voice decoder 160 performs digital to analog converting and results in a voice signal for communication to the user by a speaker or other means. Local oscillator 162 provides the first mixer 144 LO and the bit or symbol detector 152 timing. A PRN oscillator 164 and PRN generator 166 provide the deterministic logic of the spread signal for despreading purposes. The baud or bit clock oscillator 168 drives the bit in the bit detector 152, forward error decoder 156 and the voice decoder 160.

The bit or symbol interleaver 116 and de-interleaver 154 provide a type of coded time diversity reception which provides an effective power gain against multipath fading to be expected for mobile users. Its function is to spread or diffuse the effect of short burst of channel bit or symbol errors so that they can more readily be corrected by the error correction code.

As an alternative mode of operation, provision is made for direct data or facsimile or other digital data input 170 to the transmitter chain and output 172 form the receiver chain.

A command decoder 174 and command logic element 176 are coupled to the forward error decoder 156 for receiving commands or information. By means of special coding techniques known to those skilled in the art, the non-voice signal output at the forward error decoder 156 may be ignored by the voice decoder 160 but used by the command decoder 174. An example of the special coding techniques are illustrated in FIG. 5 by the MUX 112 and DEMUX 158.

As shown, acquisition, control and tracking circuitry 178 are provided in the receiver section 108 for the three receive side functional oscillators 162, 164, 168 to acquire and track the phase of their counterpart oscillators in the received signal. Means for so doing are well known to those skilled in the art.

Referring again to FIG. 5, an arrangement is provided for generating call requests and detecting ring signals. The ring generator 138 generates a ring signal based on the user's code for calling out with the user unit 22. For receiving a call, the ring signal is detected in a fixed matched filter 198 matched to a short pulse sequence which carries the user's unique code. By this means each user can be selectively called. As an option, the ring detect and call request signals may be utilized in poll/response mode to provide tracking information on each active or standby mode user. Course tracking information, adequate for management of the call routing functions is provided by comparison of signal quality as received at various modes.

With reference also to FIG. 6, for the precision location option, the user response signal time is accurately locked to the time of receipt of the polling or timing signal, to a fraction of a PRN chip width. Measurement of the round trip poll/response time from two or more nodes or time differences of arrival at several nodes provides the basic measurement that enable solution and provision of precise user position. Ground and satellite transmitters and receivers duplicate the functions summarized above for the user units. Given *a priori* information, for example as to the route plan of a vehicle, a single round trip poll/response time measurement from a single node can yield valuable user position information.

The command logic 176 is further coupled to the receiver AGC 180, the matched filter ring detector (RD) 198, the acquisition and tracking circuitry 178, the transmit local oscillator (LO) 162 and the ring generator (RG) 138 to command various modes of operation.

A preferred communication system includes the use of spread spectrum multiple access so that adjacent cells are not required to use different frequency bands. All ground-user links utilize the same two frequency sub-bands (OG 28, IG 34) and all satellite-user links use the same two frequency sub-bands (OS 30, IS 36). This obviates an otherwise complex and restrictive frequency coordination problem of ensuring that frequencies are not reused within cells closer than some minimum distance to one another (as in the FM approach), and yet provides for a hierarchial set of cell sizes to accommodate areas of significantly different subscriber densities.

The economic feasibility of a mobile telephone system is related to the number of users that can be supported. Two significant limits on the number of users supported are bandwidth utilization efficiency and power efficiency. In regard to bandwidth utilization efficiency, in either the ground based cellular or mobile satellite elements, radio frequency spectrum allocation is a severely limited commodity. Measures incorporated in the invention to maximize bandwidth utilization efficiency include the use of code division multiple access (CDMA) technology which provides an important spectral utilization efficiency gain and higher spatial frequency reuse factor made possible by the user of smaller satellite antenna beams. In regard to power efficiency, which is a major factor for the satellite-mobile links, the satellite transmitter source power per user is minimized by the use of forward-error-correcting coding, which in turn is enabled by the above use of spread spectrum code division multiple access (SS/CDMA) technology and by the use of relatively high antenna gain on the satellite. CDMA and forward-error-correction coding are known to those skilled in the art and no further details are given here.

One aspect of the invention is directed to accurate position determination of individual users of the cellular communications system.

With reference to FIG. 6, a cellular system is disclosed having a plurality of cellular nodes, 400, 402, 404, 406, 408, 410, and 412, respectively, forming cellular sectors 414, 416, 418, 420, 422, 424, and 426, respectively. Controlling receipt and transmission of signals is the cellsite controller (CSC) 430 and the mobile switching center (MSC) 432. It is anticipated for the cellular system to include a plurality of user units. However, a single user unit 440 is shown for example only.

For precision location of the user, the user response signal time is accurately locked to the time of receipt of the polling or timing signal, to a fraction of a PRN chip width. The distance between an individual node and a user may then be determined by providing a timing signal to the selected user unit from at least one node, providing a timing response signal from the selected user unit in response to each timing signal, receiving the timing response signal by at least one node, and measuring the response time of the user unit to the timing signal. The position of the user unit can then be determined based on the round trip time of transmission of the timing signal and receipt of the timing response signal from a plurality of nodes. Measurement of the round trip poll/response time from two or more nodes or time differences of arrival at several nodes provides the basic measurement that enables solution and provision of precise user position. For example, round trip poll/response times from nodes 400, 402, and 406 to user unit 440 provides the measurement of distances 450, 452, and 454. Through simple analysis, or alternatively, use of a Kalman filter, the central cellsite controller can determine the location of the user unit.

In another aspect of the invention, given *a priori* information, for example, as to the route plan of a vehicle, a single round trip poll/response time measurement from a single node can yield valuable user position information. The position means may store *a priori* information about the selected user unit and may determine the position of the selected user unit by providing a timing signal to the user unit from a node, measuring the response time of the user unit to the timing signal at the node, and determining the position of the user unit based on such measurement and on the *a priori* information. An example of *a priori* information includes the sought to be travelled route of a user. By knowing the route of a selected user and the distance from a node, determined by application of the present invention, the central controller can determine the position of a selected user.

In another embodiment of position determination including the use of *a priori* information, the position of the user unit can be determined by distance determination from only two nodes. For example, the distances 452 and 454 of user unit 440 from nodes 402 and 406 combined the *a priori* information that the user unit is located cell sector 414 provides the necessary information to accurately determine the location of user unit 440. This *a priori* information may be determined by knowledge of the user unit's last known location or by analysis of the signal quality of the user unit's transmissions by cell nodes 400, 402, 404 and 406 to determine the user unit's location to be in cell sector 414. In another embodiment, once the user unit's location and present cell cite has been determined utilizing the three node trigonometric analysis described above, the cell site controller may switch to two node position determination thereby reducing computer computations.

Ideally suited for position determination is the use of code division multiple access (CDMA) technology which provides an important spectral utilization efficiency gain and higher spatial frequency reuse factor made possible by the use of smaller satellite antenna beams. In regard to power efficiency, which is a major factor for the satellite-mobile links, the satellite transmitter source power per user is minimized by the use of forward-error-correcting coding, which in turn is enabled by the above use of spread spectrum code division multiple access (SS/CDMA) technology and by the use of relatively high antenna gain on the satellite. CDMA and forward-error-correction coding are known to those skilled in the art and no further details are given here.

In addition, the Code Division Multiplex system has the following important advantages in the present system. Blank time when some of the channels are not in use reduces the average interference background. In other words, the system overloads and underloads gracefully. The system inherently provides flexibility of base band rates; as opposed to FDM systems, signals having different baseband rates can be multiplexed together on an ad-hoc basis without complex preplanned and restrictive sub-band allocation plans. Not all users need the same baseband rate. Satellite antenna sidelobe control problems are significantly reduced. Numerical studies of out-of-cell interference factors show that secondary lobe responses may effectively be ignored. Co-code reassignment (that is reuse of the same spreading code) is feasible with just one beam separation. However, because there are effectively (i.e. including phasing as a means of providing independent codes) an unlimited number of channel codes, the requirements on space division are eased; there is no need to reuse the same channel access i.e., spreading code.

Accurate position determination can be obtained through two-dimensional multi-lateration. Each CDMA mobile user unit's transmitted spreading code is synchronized to the epoch of reception of the pilot signal from its current control site, whether ground or satellite node. The normal mode of operation will be two-dimensional, i.e., based upon two receptions, at ground or satellite nodes of the user response code. In conjunction with *a priori* information inherent in a topographic database, e.g., altitude of the surface of the earth, position accuracy to within a fraction of a kilometer can be provided.

In a CDMA system, means for determining the position of a mobile user relative to a multiplicity of known system nodes, either fixed on the ground or at known positions in space, is largely incidental to the function of transmitting and/or receiving the CDMA signal at multiple sites. The receiving function requires synchronization of the epoch of a local spread code generator to that of the received spread code, so that having achieved code synchronization, one inherently has a measure of the delay time and hence the range of the signal. Various references describe how this information can be used in several different geometrical configurations to provide the delay measurements necessary to provide hyperbolic, elliptical, spherical or hybrid multi-lateration position determination. By any of these means the mobile position can either be determined by the network controller or by the mobile user and relayed to the network controller.

An additional aspect of the present invention is the determination of a fraudulent user by analysis of the position of a user in the system. The position of all users is periodically determined by the network controller. In one aspect of the invention, the controller is programmed to search for the same user ID appearing at locations which could not possibly be reached by the same user. A determination by the cellsite controller indicating that two or more units utilizing the same ESN/MIN, though not operating contemporaneously, have been operating in locations which could have been reached by a single user unit establishes that there are one or more pirated units in use.

In one embodiment, the computer software keeps track of each user's position in the system and the time period and location between uses of the system.

An algorithm determines whether any two or more uses could not have been made by a single user. For example only, algorithm (A) may equal the distance between the location of the last known transmission and present transmission divided by the time differences between the last positions.

$$A = \frac{\text{(distance of previous and present uses)}}{\text{(time period between transmissions)}}$$

If the result exceeds, say, 100 MPH for any pair of transmissions, one or more separate users of the same ID code are indicated. Only one will be a valid user, the others will be "Bandits" (typically there will be many such "Bandits"). To determine the legitimate user, the user nearest the home address of the valid subscriber will be queried to determine whether or not that caller is a valid subscriber. The query can be either human to human, or machine to machine. If the first such queried party is legitimate, he is assigned a new ESN/MIN combination, and the prior code is placed in a category recognized by the network controller as invalid. All the bandit users are then operating using an invalid code, and the next steps will be determined by the current service owner's policy and will include (a) causing the Bandits to be pursued for theft, (b) causing the bandit units to be disables or (c) ceasing service to these units as discussed below.

If the first such queried party is not legitimate the next party will be queried until the valid party is determined. If the distance between tracks is greater than 100 miles, then all users are queried, again beginning with the user nearest to the home address of the legitimate party, until the legitimate user is found. All other users are then Bandits, and are treated as below.

In an alternative embodiment, the cellsite controller initiates separate algorithms dependent upon the distance between transmissions. For example, the constant "A" in the equation:

$$A = \frac{\text{(distance of previous and present uses)}}{\text{(time period between transmissions)}}$$

may be altered where the distance between the previous use and the present use of the cellular system is greater than 100 miles. In this manner, the cellular system is capable of compensating for those instances where a legitimate subscriber has travelled by plane to a new location. Further, a series of algorithms may be employed depending upon the various distances between transmissions and different periods between transmissions to account for common user habits and local topography, e.g. urban vs. rural travel. Such algorithms and the methods for creating such are known to those skilled in the art and no further details are given here.

An additional aspect of the present invention is that once a unit has been determined to be a fraudulently operated unit, (a) the bandit is pursued for theft, (b) the bandit unit is caused to be disabled or (c) service to the user unit is ceased. In a first embodiment, the cellular system merely ceases to provide service to anyone using the ESN/MIN combination determined to have been pirated.

The counterfeited ESN/MIN combination is denied service and the bandit is no longer capable engaging the cellular system without obtaining an alternative authorized ESN/MIN combination. Additionally, the valid subscriber is also denied service and must have his MIN (cellular telephone number) changed in order to have his service restored.

In an alternative embodiment, the cellsite controller transmits a remote erasure or alteration signal from the Cellular Node to the bandit user unit to erase or alter the mobile phone's operating software.

If fraud has been detected by the cellular system on a particular MIN/ESN combination, then the cellular node sends a pre-determined registration or call origination page message to the counterfeited phone. This pre-determined message instructs the phone to activate a self-destructing software algorithm which erases, scrambles or otherwise alters the phone's stored operating program in E^2PROM as well as the phone's Electronic Serial Number, Mobile Identification Number, Station Class Mark, etc., so that it is now rendered completely useless to the counterfeiter.

If the phone is in a call mode when the cellular switch wishes to deactivate it, then the "self-destruct algorithm" could also be activated by having the cellular node send either a pre-determined dual tone multiple frequency (DTMF) or Forward Voice Channel signaling message to it. This program and memory altering algorithm could be stored in the phone as a hidden "virus" which is activated only upon a certain code being transmitted to the phone, but otherwise is not easily detectable in the phone's software. For example, the hidden "virus" may be disguised as another piece of the phone's normal operating code. In this form of counterfeiting countermeasure, the unit is disabled remotely rendering the keyboard and display inactive, such that none of the keys operate on the mobile unit's keypad and signals can be neither transmitted nor received. Alternatively, the user unit displays an error message indicating to the subscriber that he needs to get his unit examined by an authorized service center. In order to get the unit operating again the counterfeiter would need to replace the unit's software at an authorized dealer or service center making possible the impounding of the counterfeit unit and the apprehension of the bandit.

In another embodiment, once a cellular ESN/MIN has been identified by the cellular operator as being counterfeit, the MIN is place into a "customer group" which routes all its outgoing calls to a recorded message, instructing the authorized subscriber to have his unit re-programmed at an authorized dealer. Once the real subscriber has had his identity verified and his user unit reprogrammed, the ESN/MIN combination is deactivated from the cellular system, so that the counterfeit unit is unable to make calls.

In an additional embodiment, the cell site controller sends a disablement signal, operating to physically damage one or more critical components of the user unit. For example, the user unit is disabled by having one or more of its components destroyed by commanding an increase of current in a certain path which blows a fuse or critical component. With reference to FIG. 7, an electronic switch 464 is commanded to be closed by a signal transmitted from the cellular node. The voltage differential between Vcc 466 and 0v 468 provides a current that is switched from the circuit path through resistor 462 to a short through electrical switch 464. The current passing through critical component 460 is thereby increased to a level where the component, such as a fuse, is damaged. Thus, once the counterfeiting of a user unit is detected, the switch is closed by remote control and the critical phone component is destroyed by the increased current flowing through it. The phone is rendered inoperable and has to be repaired by the authorized service center. An attempted repair of the damaged user unit also makes possible the impounding of the counterfeit unit and the apprehension of the bandit.

In still another embodiment, the determination of the geographical location of an unauthorized user provides means by which the pirate may be apprehended and arrested. Once the position of the pirate is known, the information is forwarded to the police or other law enforcement agency such as the Federal Communications Commission (FCC). The law enforcement agency then proceeds to the geographic location of the bandit where the user unit is impounded and the bandit is arrested.

By virtue of the above discussed design factors the system in accordance with the invention provides a flexible capability of providing the following services: high quality, high rate voice and data service; facsimile (the standard group 3 as well as the high speed group 4); two way messaging, i.e. data interchange between mobile terminals at variable rates; paging rural residential telephone; private wireless exchange; automatic position determination and reporting to within several hundred feet, in conjunction with fraudulent detection of unauthorized users and the prevention thereof.

By virtue of the above discussed design factors the system in accordance with the invention provides a flexible capability of providing the following additional special services: high quality, high rate voice and data service; facsimile (the standard group 3 as well as the high speed group 4); two way messaging, i.e., data interchange between mobile terminals at variable rates; automatic position determination and reporting to within several hundred feet; paging rural residential telephone; and private wireless exchange.

It is anticipated that a satellite will utilize geostationary orbits but is not restricted to such. The invention permits operating in other orbits as well. The system network control center 12 is designed to normally make the choice of which satellite or ground node a user will communicate with. In another embodiment, as an option, the user can request his choice between satellite link or direct ground based link depending on which provides clearer communications at the time or request his choice based on other communication requirements.

While a satellite node has been described above, it is not intended that this be the only means of providing above-ground service. In the case where a satellite has failed or is unable to provide the desired level of service for other reasons, for example, the satellite has been jammed by a hostile entity, an aircraft or other super-surface vehicle may be commissioned to provide the satellite functions described above. The "surface" nodes described above may be located on the ground or in water bodies on the surface of the earth. Additionally, while users have been shown and described as being located in automobiles, other users may exist. For example a satellite may be a user of the system for communicating signals, just as a ship at sea may or a user on foot.

While several particular forms of the invention have been illustrated and described, it will be apparent that various modifications can be made without departing from the spirit and scope of the invention. For example, the present invention is not meant to be limited to cellular mobile communications systems but is intended to include additional communication systems, such as satellite or nodal television systems such as the recently marketed "Direct TV" system. Accordingly, it is not intended that the invention be limited, except by the appended claims.

Having described the invention in such terms as to enable those skilled in the art to make and use it, and having identified the presently preferred best modes thereof, I claim:

1. A communications system having a plurality of user units and at least one cellular node so as to establish at least one cell, the cellular communications system comprising:

a) position determination means for establishing the geographical location of a selected user;

b) logic means for comparing the location of said selected user with the known locations of authorized users; and

c) fraudulent detection means for determining whether said selected user is a fraudulent user of the communications system.

2. The communications system of claim 1, further comprises:

a) disablement means for denying service to said selected user if said selected user is a fraudulent user of the communications system.

3. The communications system of claim 2, wherein:

a) said disablement means includes a commanding means for sending a signal to said user unit to disable operation of said user unit.

4. The communications system of claim 3, wherein:

a) said commanding means is capable of destroying critical components in the user unit.

5. The communications system of claim 1, wherein:

a) said position means for determining the geographic location of a selected user unit is determined by providing a timing signal to the user unit from one or more nodes, providing a timing response signal from the selected user unit in response to each timing signal, receiving the timing response signal by at least one node, measuring the response time of the user unit to each timing signal, and determining the position of the user unit based on such measurements.

6. In the operation of a communications system, which system includes node means, and a plurality of user units, each said user unit including means for establishing selective communication between the node means and the user unit, the improvement for reducing use of said system by an unauthorized user, comprising:

a) establishing the geographical location of a selected user;

b) comparing the location of said selected user with the known locations of authorized users; and

c) determining whether said selected user is a fraudulent user based upon the comparison of the location of said selected user with the known locations of authorized users.

7. In the operation of a system of claim 6, further comprising:

a) denying service to said selected user if said selected user's location does not correspond to one of said known locations.

8. In the operation of a system of claim 6, further comprising:

a) apprehending said selected user.

9. In the operation of a system of claim 6, further comprising:

a) disabling said user unit.

10. In the operation of a system of claim 9, further comprising:

a) destroying a critical component in said user unit.

11. In the operation of a system of claim 6, wherein establishing the geographical location of a selected user further comprises:

a) providing a timing signal to said selected user unit from at least one node;

b) providing a timing response signal from the selected user unit in response to the timing signal;

c) receiving the timing response signal by at least one node;

d) measuring the response time of the user unit to the timing signal based on receipt of the timing response signal; and

e) determining the position of the user unit based on the round trip time of transmission of the timing signal and receipt of the timing response signal.

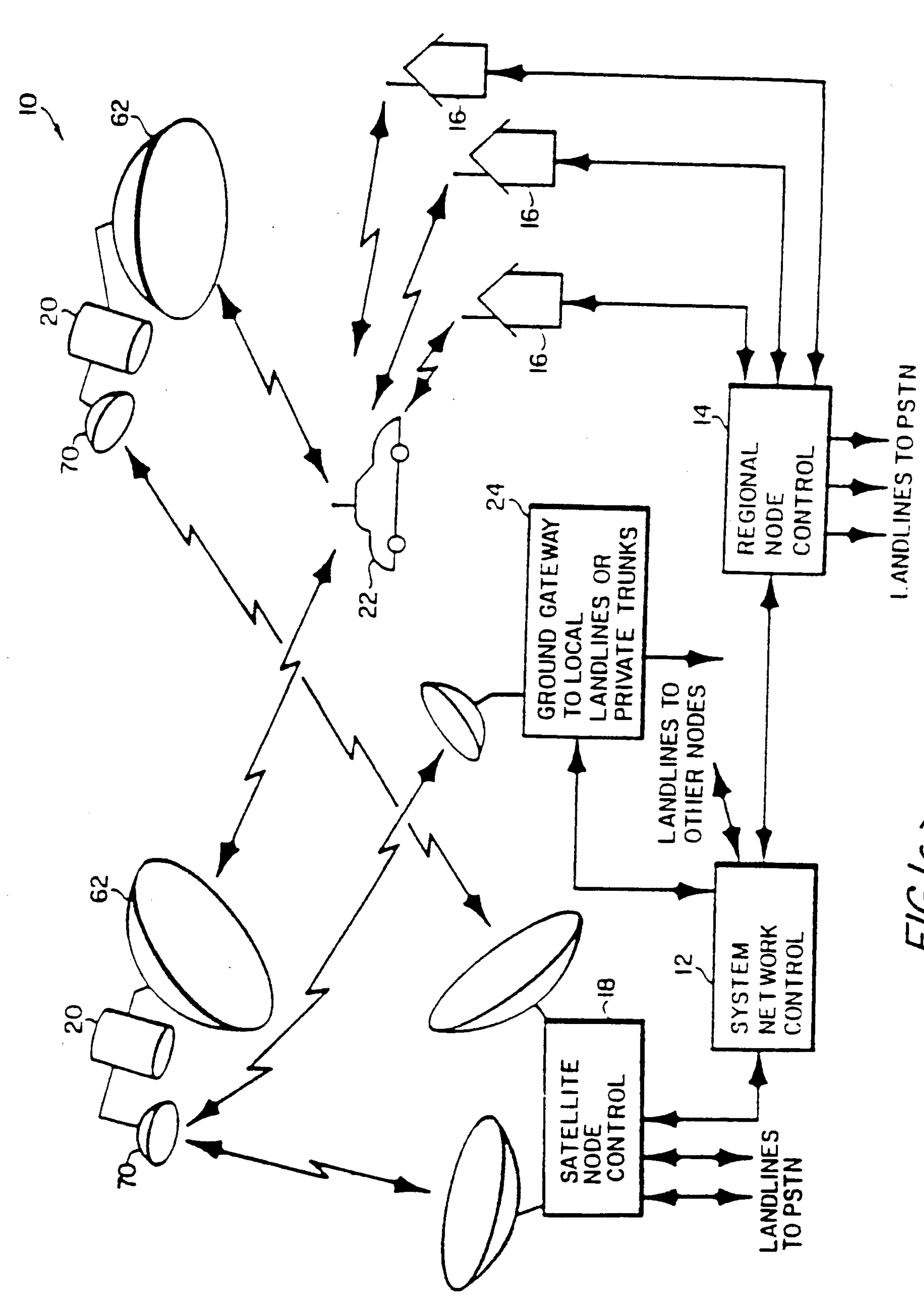

10
62
20
70
16
16
16
22
24
GROUND GATEWAY TO LOCAL LANDLINES OR PRIVATE TRUNKS
14
REGIONAL NODE CONTROL
LANDLINES TO PSTN
LANDLINES TO OTHER NODES
62
20
70
18
SATELLITE NODE CONTROL
12
SYSTEM NETWORK CONTROL
LANDLINES TO PSTN

FIG. 1(a)

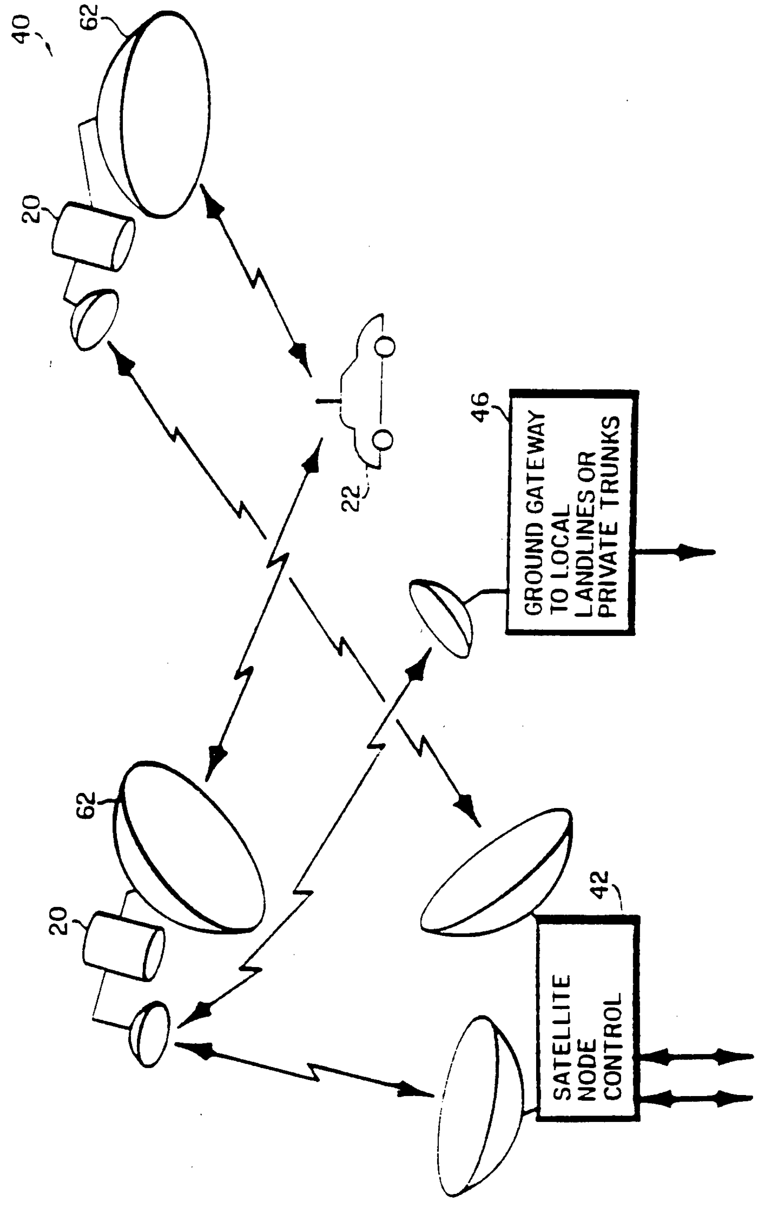


FIG. 1(b)

RECTIFIED SHEET (RULE 91)

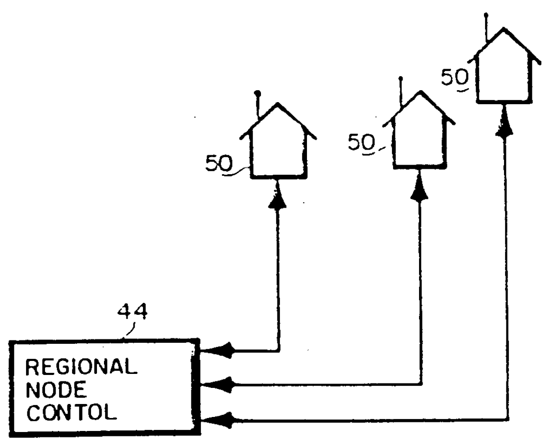


FIG. 1(c)

RECTIFIED SHEET (RULE 91)

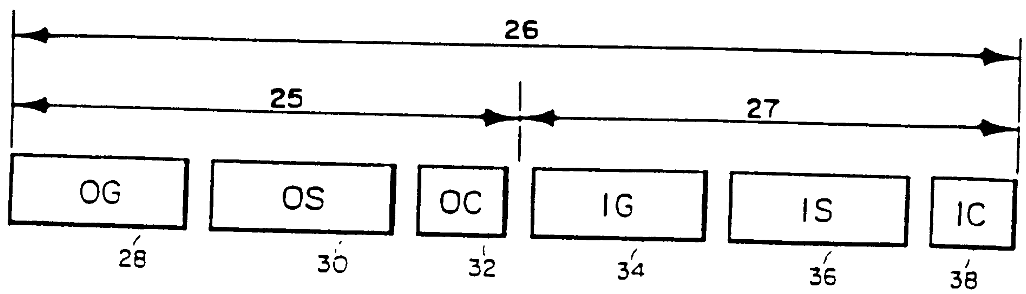


FIG. 2

RECTIFIED SHEET (RULE 91)

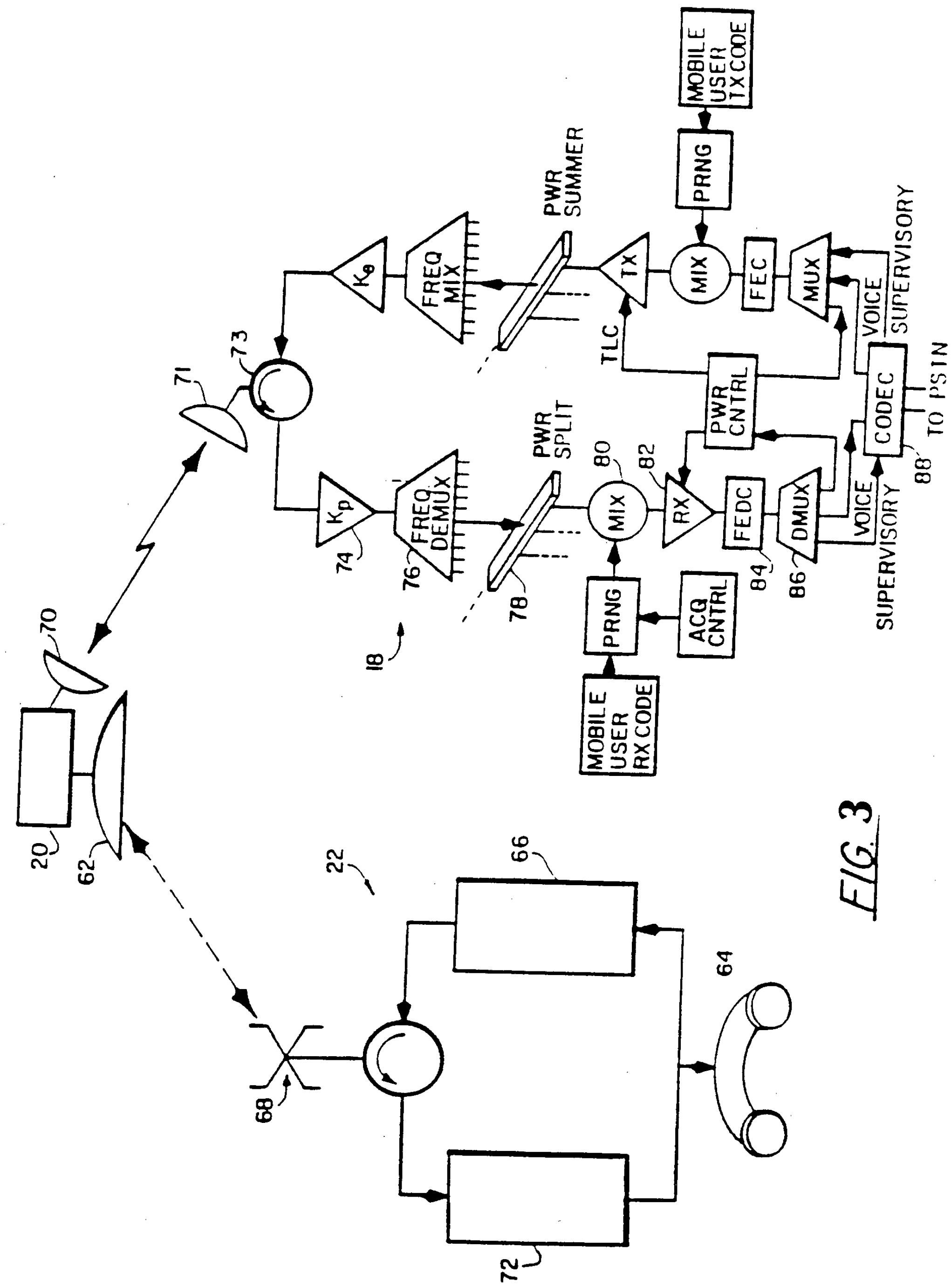


FIG. 3

RECTIFIED SHEET (RULE 91)

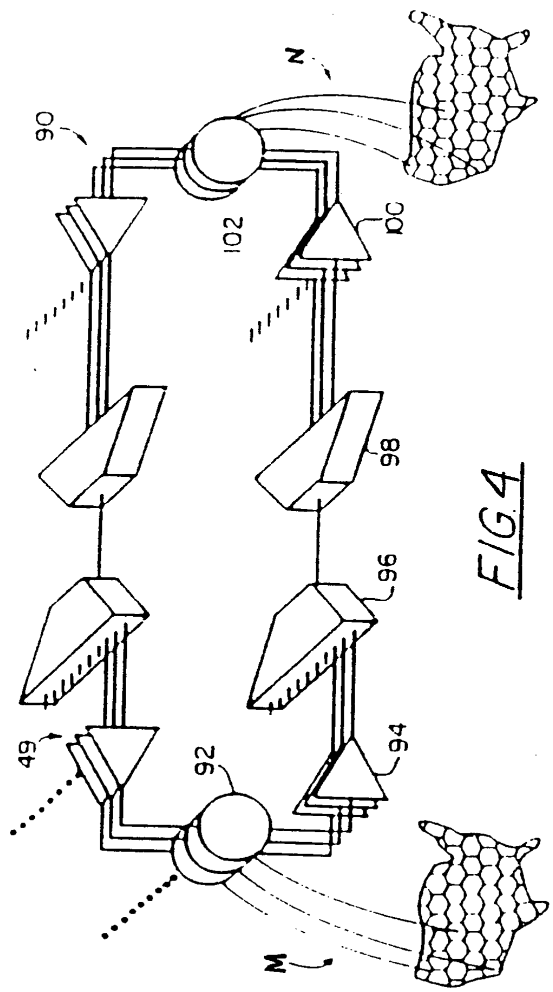
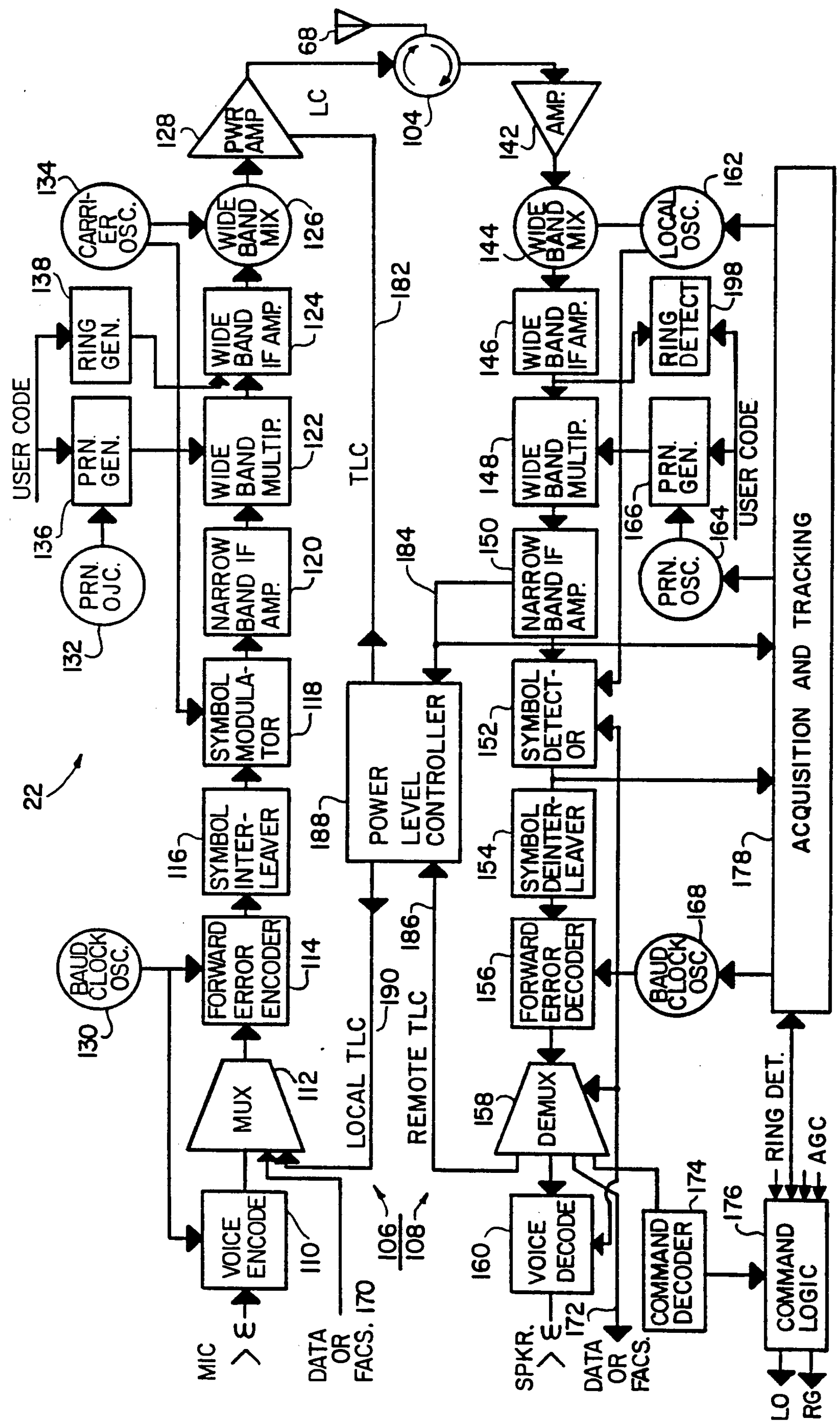


FIG.4

RECTIFIED SHEET (RULE 91)

FIG. 5



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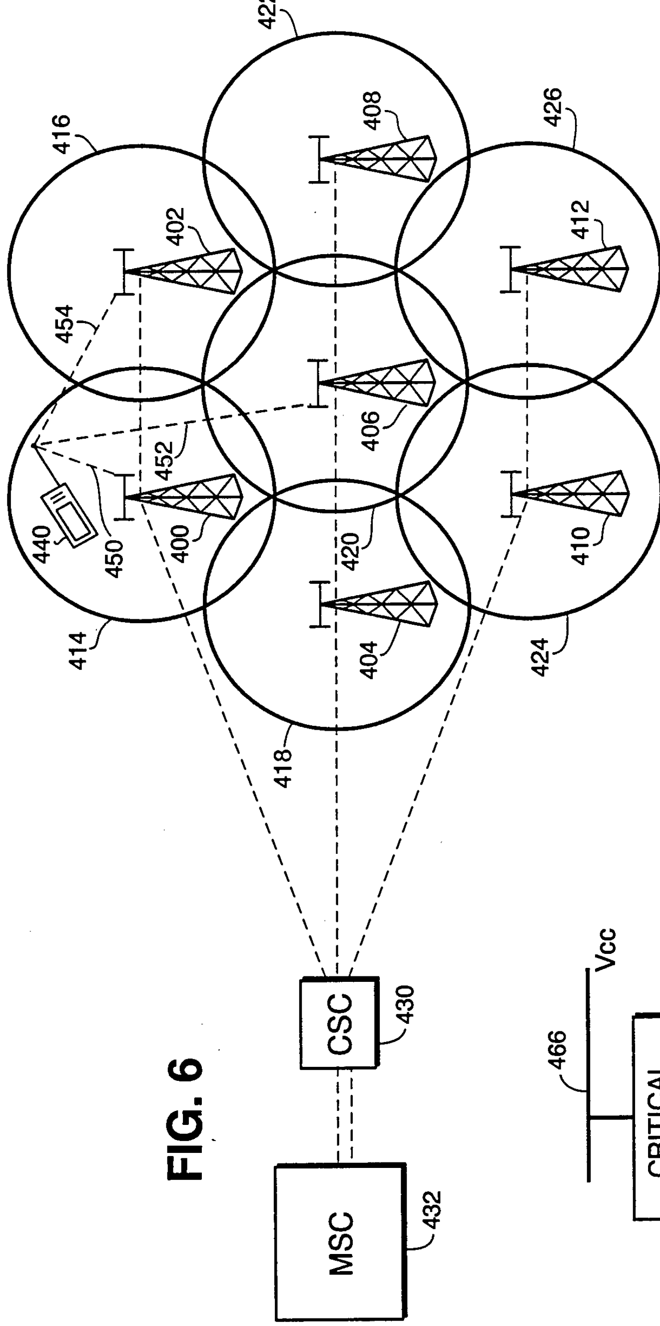

FIG. 6

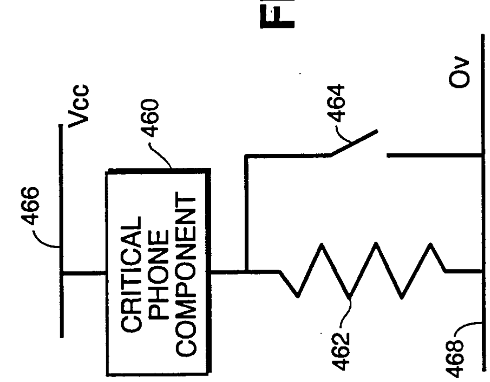

FIG. 7

RECTIFIED SHEET (RULE 91)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/07251

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04Q 7/20
US CL :455/33.1, 54.1, 67.1; 379/59
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P ------- Y,P	US, A, 5,335,265 (COOPER ET AL) 02 August 1994, abstract, col. 1, lines 51-58, col. 2, lines 6-26, col. 5, lines 8-14, col. 8, lines 26-68, col. 9, lines 1-14.	1-4, 6-10 --------------- 5, 11
Y	US, A, 4,278,975 (KIMURA ET AL) 14 July 1981, col. 4, lines 3-12.	5, 11
X,P ------- Y,P	US, A, 5,345,595 (JOHNSON ET AL) 06 September 1994, col. 3, lines 42-68, col. 13, lines 45-55.	1, 6 --------------- 2-5, 7-11
Y,P	US, A, 5,420,910 (RUDOKAS ET AL) 30 May 1995, col. 2, lines 13-41.	2-4, 7-10

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 08 AUGUST 1995	Date of mailing of the international search report 01 SEP 1995
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20[illegible] Facsimile No. (703) [illegible]05-3230	Authorized officer NGUYEN VO Joni Hill Telephone No. (703) 308-6728

Form PCT/ISA/210 (second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/07251

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	US, A, 5,335,278 (MATCHETT ET AL) 02 August 1994, col. 1-4.	1-11
A	US, A, 5,309,501 (KOZIK ET AL) 03 May 1994, col. 1-2.	1-11

Form PCT/ISA/210 (continuation of second sheet)(July 1992)★

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

455/33.1, 54.1, 67.1, 33.2, 33.3, 33.4, 49.1, 54.2, 56.1, 67.6, 68, 88; 379/59, 60, 62; 340/988, 989, 991; 342/46, 118, 357, 450, 458, 463; 364/443, 449, 460, 561

Electronic Patent Application Fee Transmittal

Application Number:	09770838
Filing Date:	26-Jan-2001
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Filer:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1

Filed as Small Entity

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Petition fee- 37 CFR 1.17(h) (Group III)	1464	1	130	130
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for continued examination	2801	1	405	405
		Total in USD ($)		**535**

Electronic Acknowledgement Receipt

EFS ID:	3006168
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Correspondence Address:	Dennis J. Dupray, Ph.D. - 1801 Belvedere Street - Golden CO 80401 US 3038632975 -
Filer:	Dennis Jay Dupray.
Filer Authorized By:	
Attorney Docket Number:	1003-1
Receipt Date:	16-MAR-2008
Filing Date:	26-JAN-2001
Time Stamp:	20:55:59
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$535

RAM confirmation Number	5575
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Petition to Withdraw from Issue	Petition-to-Withdraw.pdf	78197 c86dd3296a73416d2220b016695646a627ed1d40	no	1
Warnings:					
Information:					
2	Request for Continued Examination (RCE)	RCE_sb0030e_fill.pdf	626203 25209fe9522923a3426c2a1a863ca471c861d2f8	no	3
Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Filed	US_IDS_Form__SB_08a.pdf	574528 fbe0266461b8f6c504127ba959aba56719b1f60f	no	4
Warnings:					
Information:					
4	Foreign Reference	WO09534177_Otten.pdf	2144079 214008240e3f22737ed42cfbbd7bd1173c07a738	no	75
Warnings:					
Information:					
5	Fee Worksheet (PTO-06)	fee-info.pdf	8316 f786059d349d15d3ee3c274d06068b8a41318437	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	3431323		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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DENNIS J. DUPRAY, PH.D.
1801 BELVEDERE STREET
GOLDEN, CO 80401

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MAR 17 2008
OFFICE OF PETITIONS

In re Application of
DUPRAY, et al.
Application No. 09/770,838
Filed: January 26, 2001
Attorney Docket No. **1003-1**

: DECISION GRANTING PETITION
: UNDER 37 CFR 1.313(c)(2)

This is a decision on the petition under 37 CFR 1.313(c)(2), filed March 16, 2008, to withdraw the above-identified application from issue after payment of the issue fee.

The petition is **GRANTED**.

The above-identified application is withdrawn from issue for consideration of a submission under 37 CFR 1.114 (request for continued examination). *See* 37 CFR 1.313(c)(2).

Petitioner is advised that the issue fee paid on August 23, 2007 cannot be refunded. If, however, this application is again allowed, petitioner may request that it be applied towards the issue fee required by the new Notice of Allowance.[1]

Telephone inquiries should be directed to the undersigned at (571) 272-7253.

This application is being referred to Technology Center AU 3662 for processing of the request for continued examination under 37 CFR 1.114 and for consideration of the concurrently filed information disclosure statement.

Monica A. Graves
Petitions Examiner
Office of Petitions

[1] *The request to apply the issue fee to the new Notice may be satisfied by completing and returning the new Part B – Fee(s) Transmittal Form (along with any balance due at the time of submission). Petitioner is advised that the Issue Fee Transmittal Form must be completed and timely submitted to avoid abandonment of the application.*

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:	) Group Art Unit: 3662
Dupray et al.	) Confirmation No.: 8410
Serial No.: 09/770,838	) Examiner: PHAN, DAO LINDA
Filed: January 26, 2001	) SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT
Atty. File No.: 1003-1	) Electronically Submitted
For: GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION	)

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The references cited on attached Form PTO-SB08 are being called to the attention of the Examiner.

☒ Copies of the cited non-patent and/or foreign references are enclosed herewith.

☐ Copies of the cited U.S. patents and/or patent applications are enclosed herewith.

☒ Copies of the cited U.S. patents/patent application publications are not enclosed in accordance with 37 C.F.R. § 1.98(a).

☐ Copies of the cited references are not enclosed, in accordance with 37 C.F.R. § 1.98(d), because the references were cited by or submitted to the U.S. Patent and Trademark Office in prior application Serial No. __________ filed _______________, which is relied upon for an earlier filing date under 35 U.S.C. § 120.

☐ To the best of applicants' belief, the pertinence of the foreign-language references are believed to be summarized in the attached English abstracts and in the figures, although applicants do not necessarily vouch for the accuracy of the translation.

☒ Examiner's attention is drawn to the following co-pending applications, copies of which have been or are being submitted:

Serial No. 09/194,367 filed 11-24-1998, now U.S. Patent Publication No. 2001/0022558 (Attorney's Ref. No. 1003-PUS);

Serial No. 10/262,338 filed 09-30-2002, now U.S. Patent Publication No. 2003/0222820 (Attorney's Ref. No. 1003-3);

Serial No. 11/739,097 filed 04-24-07 (Attorney's Ref. No. 1003-4);

Serial No. 11/746,753 filed 05-10-2007 (Attorney's Ref. No. 1003-5);

Serial No. 12/014,092 filed 01-14-08 (Attorney's Ref. No. 1003-6);

Serial No. 11/069,441 filed 3-1-05 (Attorney's Ref. No. 1004-1-1);

Serial No. 10/297,449 filed 12-06-2002 (Attorney's Ref. No. 1010-PUS);

Serial No. 11/464,880 filed 08-14-06 (Attorney's Ref. No. 1010-1);

Serial No. 12/021,222 filed 01-28-2008 (Attorney's Ref. No. 1010-3); and

Serial No. 11/838,213 filed 08-13-2007 (Attorney's Ref. No. 1011-1)

☐ Other:____________________

Submission of the above information is not intended as an admission that any item is citable under the statutes or rules to support a rejection, that any item disclosed represents analogous art, or that those skilled in the art would refer to or recognize the pertinence of any reference without the benefit of hindsight, nor should an inference be drawn as to the pertinence of the references based on the order in which they are presented. Submission of this statement should not be taken as an indication that a search has been conducted, or that no better art exists.

It is respectfully requested that the cited information be expressly considered during the prosecution of this application and the references made of record therein.

FEES

☒	**37 CFR 1.97(b)**: No fee is believed due in connection with this submission, because the information disclosure statement submitted herewith is satisfies one of the following conditions ("X" indicates satisfaction): ☐ Within three months of the filing date of a national application other than a continued prosecution application under 37 CFR 1.53(d), or ☐ Within three months of the date of entry into the national stage of an international application as set forth in 37 CFR 1.491 or ☐ Before the mailing date of a first Office Action on the merits, or ☒ Before the mailing of a first Office action after the filing of a request for continued examination under 37 CFR 1.114. Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970.
☐	**37 CFR 1.97(c)**: The information disclosure statement transmitted herewith is being filed after all the above conditions (37 CFR 1.97(b)), but before the mailing date of one of the following conditions: (1) a final action under 37 C.F.R. 1.113 or (2) a notice of allowance under 37 C.F.R. 1.311, or (3) an action that otherwise closes prosecution in the application. This Information Disclosure Statement is accompanied by: ☐ A Certification (below) as specified by 37 C.F.R. 1.97(e). Although no fee is believed due, if any fee is deemed due in connection with this submission, please charge such fee to Deposit Account 19-1970. OR ☐ Please charge Deposit Account 19-1970 in the amount of $180.00 for the fee set forth in 37 C.F.R. 1.17(p) for submission of an information disclosure statement. Please credit any overpayment or charge any underpayment to Deposit Account 19-1970.
☐	**37 CFR 1.97(d)**: This Information Disclosure Statement is being submitted after the period specified in 37 CFR 1.97(c). ☐ This information Disclosure Statement includes a Certification (below) as specified by 37 C.F.R. 1.97(e) AND ☐ Applicants hereby requests consideration of the reference(s) disclosed herein. Please charge Deposit Account 19-1970 in the amount of $180.00 under 37 C.F.R. 1.17(p). Please credit any overpayment or charge any underpayment to Deposit Account 19-1970. Election to pay the fee should not be taken as an indication that applicant(s) cannot execute a certification.

Certification (37 C.F.R. 1.97(e))
(Applicable only if checked)

☐ The undersigned certifies that:

☐ Each item of information contained in this information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(1).

☐ A copy of the communication from the foreign patent office is enclosed.

OR

☐ No item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned after making reasonable inquiry, no item of information contained in this Information Disclosure Statement was known to any individual designated in 37 C.F.R. 1.56(c) more than three months prior to the filing of this statement. 37 C.F.R. 1.97(e)(2).

Respectfully submitted,

By: [signature]

Dennis J. Dupray
Registration No. 46299
1801 Belvedere Street
Golden CO 80401
(303) 863-9700

Date: MAR. 24, 2008

Substitute for form 1449A/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	09/770,838
				Filing Date	01-26-2001
				First Named Inventor	Dupray
				Art Unit	3662
				Examiner Name	PHAN, DAO LINDA
Sheet	1	of	1	Attorney Docket Number	1003-1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	5,394,158	02/28/95	Chia	
	2	5,416,712	05/16/95	Geier et al.	
	3	5,627,547	05/06/97	Ramaswamy et al.	
	4	5,815,417	09/29/98	Orr et al.	
	5	5,864,313	01/26/99	Speck et al.	
	6	6,301,463	10/09/01	Dao et al.	
	7	6,385,541	05/07/02	Blumberg et al.	
	8	6,834,195	12/21/04	Brandenberg et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)

Examiner Initials*	Cite No.[1]	
	9	Mynatt et. al., "Designing Audio Aura", published in CHI '98 Conference Proceedings, publication yr. 1998

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

Electronic Acknowledgement Receipt	
EFS ID:	3050974
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Correspondence Address:	Dennis J. Dupray, Ph.D. - 1801 Belvedere Street - Golden CO 80401 US 3038632975 -
Filer:	Dennis Jay Dupray./Debra Kesner
Filer Authorized By:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1
Receipt Date:	25-MAR-2008
Filing Date:	26-JAN-2001
Time Stamp:	18:56:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1		IDS_03.pdf	399103 c8e8e58b0ae83947015d5f79d9f1b459e47dae6e	yes	5

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Information Disclosure Statement Letter	1	4
Information Disclosure Statement (IDS) Filed	5	5

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
2	NPL Documents	Mynatt_Designing_Audio_Aura.pdf	1798622 cefd33ea1e028b651ba4eab56641579b48f9c33d	no	8

Warnings:

Information:

Total Files Size (in bytes):	2197725

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

7590 06/13/2008

Dennis J. Dupray, Ph.D.
1801 Belvedere Street
Golden, CO 80401

EXAMINER	
PHAN, DAO LINDA	

ART UNIT	PAPER NUMBER
3662	

MAIL DATE	DELIVERY MODE
06/13/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No. 09/770,838	Applicant(s) DUPRAY ET AL.	
	Examiner Dao L. Phan	Art Unit 3662	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 2 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *16 March 2008*.

2a)☐ This action is **FINAL**. 2b)☐ This action is non-final.

3)☒ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *221-251,253-256,258,259,262-272,276-280,282-305* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☒ Claim(s) *221-251,253-256,258,259,262-272,276-280,282-285 and 287-305* is/are allowed.

6)☐ Claim(s) _____ is/are rejected.

7)☒ Claim(s) *286* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *3/16/2008 &3/25/2008*.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

1. A copy of PCT/IS95/07251 cited in PTO-SB08 filed on 2/21/2008 has not been received.

2. Claim 286 is objected to because of the following informalities: the text of currently amended claim 286 must be presented with markings to show changes relative to immediate prior version. Appropriate correction is required.

3. Claims 221-251, 253-256, 258-259, 262-272, 276-280, 282-285, 287-305 are allowed.

4. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dao L. Phan whose telephone number is (571)272-6976. The examiner can normally be reached on M-F 9:00-5:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Thomas Tarcza can be reached on (571)272-6979. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

/Dao L. Phan/
Primary Examiner, Art Unit 3662

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	Phan, Dao Linda
	Attorney Docket Number	1003-1

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
/DP/	1	5969673		1999-10-19	Bickley	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	~~1~~	~~PCT/IS95/07251~~	~~US~~		~~1995-12-14~~	~~Otten~~		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	09770838
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	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	Phan, Dao Linda
	Attorney Docket Number	1003-1

	1		☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/Dao Phan/	Date Considered	06/09/2008

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

Substitute for form 1449A/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application Number	09/770,838
	Filing Date	01-26-2001
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	PHAN, DAO LINDA
Sheet 1 of 1	Attorney Docket Number	1003-1

U.S. PATENT DOCUMENTS					
Examiner Initials*	Cite No.[1]	Document Number Number-kind Code [2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee of Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
/DP/	1	5,394,158	02/28/95	Chia	
	2	5,416,712	05/16/95	Geier et al.	
	3	5,627,547	05/06/97	Ramaswamy et al.	
	4	5,815,417	09/29/98	Orr et al.	
	5	5,864,313	01/26/99	Speck et al.	
	6	6,301,463	10/09/01	Dao et al.	
	7	6,385,541	05/07/02	Blumberg et al.	
/DP/	8	6,834,195	12/21/04	Brandenberg et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]; Number[4]; Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

OTHER ART (Including Author, Title, Date, Pertinent Pages, etc.)		
Examiner Initials*	Cite No.[1]	
/DP/	9	Mynatt et. al., "Designing Audio Aura", published in CHI '98 Conference Proceedings, publication yr. 1998

Examiner Signature	/Dao Phan/	Date Considered	06/09/2008

*EXAMINER: Initial if reference is considered, whether or not citation is in conformance and not considered. Include copy of this form with next communication to applicant.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	PHAN, DAO LINDA
	Attorney Docket Number	1003-1

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	5202829		1993-04-13	Geier	
	2	5343209		1994-08-30	Sennott et al.	
	3	5555286		1996-09-10	Tendler	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	95/03598	WO		1995-02-02	WESBY, Philip, Bernard		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	PHAN, DAO LINDA
	Attorney Docket Number	1003-1

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1		☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	PHAN, DAO LINDA
	Attorney Docket Number	1003-1

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Dennis J. Dupray/	Date (YYYY-MM-DD)	2008-10-10
Name/Print	Dennis J. Dupray	Registration Number	46299

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
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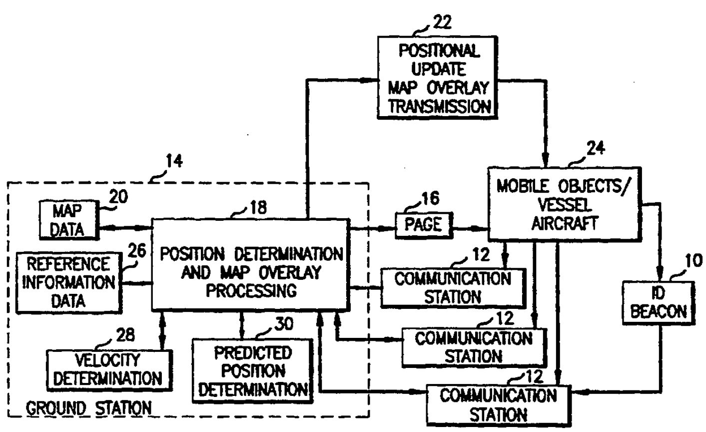

(57) Abstract

An earth based locating and map dissemination system wherein the locations of mobile objects in a monitored area are identified and then broadcast throughout the monitored area. Each mobile object being tracked in the monitored area carries a unique ID code device. A master ground station in a monitored area contains apparatus for paging each of the unique ID codes in the given area. The positions of each of the mobile objects carrying a unique ID code device may be determined by a bearing determination or a time delay determination based on the response to the paged signal. Alternatively, the page signal response may include the location coordinates of the mobile object as determined by a navigational system carried by the mobile object. The master ground station collects the position information for all of the mobile objects in the given area and then transmits those positions in a file throughout the given area. The position file information is coordinate encoded so that it may be superposed on a map of the area. In addition to the position files, the master ground station can transmit reference information that is also coordinate encoded. Further in addition to the position file, velocities of the mobile objects can be determined and distributed along with as predicted positions of the mobile objects based on their present position and velocity.

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LOCATING/MAP DISSEMINATION SYSTEM

BACKGROUND OF THE INVENTION

The present invention is directed to a system for disseminating map information providing the locations of mobile objects within a given monitored area.

In navigating through a harbor, around an airport or through a municipal street network a mobile object such as a boat, airplane or car can be greatly assisted by a map, particularly one that includes the locations of other mobile objects in the same vicinity. Systems are available for identifying the location of one's own mobile object. Other systems exist which provide a relative positioning of other objects relative to one's own moving object. Many of these systems however, are quite expensive and not available to individuals with private boats, cars or planes.

The present invention builds upon an earlier invention by the present inventor disclosed in U.S. Patent Number 5,051,741. In the earlier patent, the inventor discloses a locating system in which mobile objects carry transponders, the location of which is determined by paging a given area and monitoring the responses within a network of communication stations. The network of stations is set up so that the location of a mobile object can be generally determined within a triangular sector formed by three of the communication stations.

SUMMARY OF THE INVENTION

The present invention is directed to an earth-based locating and information dissemination system. In the given area served by the system, mobile objects each carry a unique ID code device. Each of these devices is paged throughout the given area. The position of the unique ID code devices is determined by their responses to their page. The position information is compiled for all the mobile objects in the area into a form that can be superposed on a map image. In addition to the position of the mobile objects, the system may also provide the velocity of the objects and other reference information stored in association with various locations on the map image. For systems covering contiguous areas it is recommended that each system transmit its location information over a different frequency or make use of a different transmission protocol.

The mobile objects carry a receiver and a display device. A computing device connected to the receiver superposes the location information onto a map image for display on the display device.

The present invention can advantageously provide map and location information on all of the mobile objects in a given area and deliver that information to all of the mobile objects in the given area. The position information is transmitted in a file that can be used for display on a map of a given area. The locating function of the present invention is advantageously centralized so that each mobile object need not purchase an expensive locating system to make use of this navigational aid. Other objects and advantages will become apparent during the following description of the presently preferred embodiments of the invention taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a conceptual block diagram of the overall locating and map dissemination system of the present invention.

Fig. 2 is a schematic block diagram of a communication station of Fig. 1.

Fig. 3 is a schematic block diagram of a ground station shown in Fig. 1.

Fig. 4 is a schematic block diagram of a mobile receiver and processor for use in the mobile objects shown in Fig. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, Fig. 1 provides a signal processing schematic of the position locating map dissemination system of the present invention. The system of Fig. 1 operates over a given area. Mobile objects 24 tracked by the system are each provided with a unique ID code. The system needs to be made aware of unique ID codes for all mobile objects 24 to be monitored in the given area. To this end, in a harbor or airport environment, each craft is provided with an ID beacon transmitter 10. Each mobile craft transmits its own unique ID continuously until deactivated by the system when the system has confirmed the entrance of the mobile object into the monitored given area. Preferably, the ID beacon is transmitted on a number of different frequencies sequentially at differing intervals of time. This helps to avoid data collisions with the other objects entering the area. Out of the several frequencies, it is hoped that at least one will be unique from the other mobile objects entering the monitored area so as to permit clear reception.

Communication stations 12 are distributed about the monitored area to provide the system with the ability to receive signals from anywhere in the monitored area. Any communication station 12 receiving a coherent signal on one of the ID beacon frequencies relays this information to a master ground-station 14 when addressed during an address cycle. The master station 14 pages all of the unique ID codes in the given area. When a mobile object receives a page with its unique ID code for the first time, it deactivates the ID code beacon as it is no longer needed in that area. The ID beacon transmissions are deactivated to more quickly open up frequencies for clear reception of the ID beacons.

Instead of transmitting ID code beacons, a cellular phone link may be used to call the master station of a given area to provide the ID code upon entering the given area. A processor in the mobile object can be programmed to automatically dial the appropriate cell phone number and automatically communicate its ID code upon entering a given area monitored by a system of the invention. In a land-based system, mobile vehicles will often remain within a given area or contiguous monitored areas. The ground station 14 is provided with communication links to all ground stations in contiguous areas. The ground station 14 communicates the ID code of a mobile object to the ground station in the contiguous area into which the mobile object enters as it leaves its present given area. Thus, ID code beacon transmission may not be necessary in strictly land-based systems that are thoroughly covered by contiguous systems.

In an airport environment, the map dissemination system may be able to take advantage of the airport radar system. In response to a radar pulse, aircraft onboard systems return a coded reply. This reply could serve the function of an ID beacon by identifying a unique ID code.

Whatever method is used, the ID codes are provided to the master ground station 14. The codes are all added to the list of ID codes of all of the mobile objects in the given area. The ground station cyclically pages each of the ID codes in its list. The unique ID codes may be paged sequentially through the list, or alternatively, an algorithm may be executed for paging faster moving mobile objects more often than the non-moving and slower moving objects. Pages 16 are sent out over the one paging frequency assigned for use within the given area. Each mobile object is equipped with a transponder for responding to pages containing the unique ID code for that object. The transponder receives and processes signals received on any of four paging frequencies. By making four paging frequencies available, adjoining areas can each use one of the four frequencies without using the same frequency as an adjoining area.

The network of communication stations 12 may be arranged in a honeycomb pattern of triangles as disclosed in the applicant's previous U.S. Patent No. 5,051,741. The complete disclosure of U.S. Patent No. 5,051,741 is hereby incorporated by reference herein. Such an arrangement is set up such that the response from a transponder will most likely only be received by three of the communication stations. This will quickly locate the mobile object responding to the page to within a triangular sector outlined by the three receiving communication stations. In the present system, a more specific location for each mobile object is desired. The ground station and associated system may use any of the position determining methods 18 described below. These will work even if more than three stations receive the response to the page.

In order to obtain a more specific location for the mobile object, a comparison may be made based on the time delay before each of the communication stations receive the identification response from the transponder on a mobile object. Instead of time delay, the system may instead make use of phase comparison to obtain a specific location for the mobile object. Another method of position determination on the other hand, makes use of a bearing determination device. A simple example of a bearing determination device is a goniometer. The goniometer is a cross loop aerial that provides bearing information at each of the communication stations. The bearing determination devices are used at each communication station to get a bearing for the responding device. By reviewing the bearing information from two or more communication stations it is possible to identify a rather accurate position for the responding vessel.

An additional alternative for determining the position of the mobile object is for the mobile object itself to provide its own coordinate location. Some mobile objects may have the benefit of a sophisticated navigational system such as the Navstar Global Positioning System (GPS). These systems may be used to obtain the coordinates for a mobile object. The mobile object may add the coordinate information to its response to the page. Thus, only a single communication station 12 need receive the response for the ground station system to learn the position of such a mobile object.

The ground station 14 cyclically interrogates each of the communication stations 12 to determine the positional information for each of the mobile objects in the given area. The information obtained from the communication stations is used in the ground station 14 to determine position coordinates for the mobile object. In the case of aircraft, three dimensional coordinates may be desired and determined by the system. Triangulation using three stations will provide a 3D coordinate fix relative to the three stations' positions. Bearing determination aerials determine direction implicitly and will thus provide 3D coordinates. Time and phase comparisons will only cause ambiguities in altitude in the instance that an aircraft is flying through the plane determined by the receiving antennas of the communication station. In general, knowing their actual positions will almost always exclude the erroneous suggestion that the aircraft is underground.

Map data 20 is available in a computer file to the ground station 14. The map data 20 is static and represents a geographical representation of the given area covered by the ground station 14. The ground station could operate in accordance with the present invention without the map data, if assurance could be provided that each of the mobile objects in the given area has ready access to the map data. This ready access may be provided through CD ROMs, for example. Preferably, each mobile object will have onboard access to total map image information. As such, the processing requirements are significantly reduced as compared to a system that would need to receive and process static map information upon entering each new given area. The alternative less preferred method is to have the map data file transmitted throughout the given area on a separate frequency.

The ground station 14 broadcasts throughout the given area a file 22 with the position information of all the mobile objects in the given area. The file information 22 is arranged so that at the receiving mobile object, the position file can be combined with the map file to provide a display that contains representations of each of the mobile objects on the geographic map image in their specified locations as determined at the ground station 14.

In addition to graphic map data, the ground station 14 may be provided with reference information data 26. The reference information in the data file is associated with various locations on the geographic map. The reference data may include various overlays for superposition on the geographic map, each overlay displaying one or more characteristics. In a seaport environment such characteristics may include water depths. Also the file may include information such as where one could obtain gasoline or identification of available moorings and perhaps the prices therefore. Display screen software in the mobile objects provides the user with access to the various reference information. The reference information could be accessed as a complete overlay or alternatively as a response to an inquiry directed at a particular location. This is made possible since the reference information is provided in its file in association with the various locations on the geographic map. In a ground based highway location system or street location system for a city, the reference information may provide such information as where one could buy milk, where the local movie theaters are or where to buy gas. Another source of reference data may be from the mobile objects 24 themselves. For example, in an airport environment the airplane may respond to a page by providing a data file that includes various flight systems data. This data may then be made available from the ground station through data files that relate the information to the location of the mobile object.

Additional processing information may be determined by the ground station 14. Since position information is continually being monitored for all of the mobile objects in the given area, the ground station 14 has information on the change in position over a period of time. Thus, a velocity determination 28 of the various mobile objects may be made in the ground station. This velocity information may be provided in the data file and transmitted throughout the given area to all of the mobile objects. Even further processing may take advantage of the velocity and position information to make a predicted position determination 30. By reviewing where each mobile object is heading and the velocity with which it is moving, the ground station may be able to provide a positional map of where the mobile objects in the given area are expected to be after a specified time delay.

We shall now review the individual components of the system in more detail. The communication stations 12 are spread in a network over the given area. The area density of the communication stations is determined by reception conditions. Existence of steel structures or other shielding obstacles in the area may increase the number of required communication stations. It is preferred that at least three communication stations be within receiving distance of any transponder in the given area. Map dissemination systems for different environments should operate at different frequencies so that a marine application for a city river would not be visible to a land-based motor vehicle application.

In Fig. 2, the contents of a communication station 12 are illustrated. A communication station may include ID beacon identification capability for determining the unique ID codes of mobile objects as they enter the given area. The communication station includes a number of receivers, illustrated by transmit/receive unit 42, tuned to different frequencies which pick up the ID beacon data from an antenna 40. ID beacon data is extracted from received signals through a modem 44. Not every communication station 12 needs ID beacon determination capability. It is sufficient, for example, to supply only the communications stations whose reception areas extend to the perimeter of the given area with the ID beacon determination modules. Mobile objects entering an area, particularly in the marine environment, would be required to carry ID beacons. These would issue ID beacon signals consecutively over a plurality of access frequencies. The ID beacon signals are repeated periodically until deactivated by onboard circuitry reacting to a page signal. Once the ground station begins sending page signals with the ID code of a mobile object, that object's ID beacon is deactivated.

The communication station 12 includes a CPU 48 and signal analyzer 50 to identify the ID code in an ID beacon signal. An input/output device 46 provides the ID beacon data from the modem 44 to the CPU 48. Each of the ID codes determined to have been provided by a mobile object from a given area by the CPU 48 is sent to the ground station using a conventional communication technique. Using Fig. 2 to provide a simplified explanation, the CPU 48 provides the ID code data file to the input/output device 46. The data file is added to a carrier signal in the modem 44 for transmission through the transmitter/receiver 42 from the antenna 40. Requests for data from the ground station to the communication station are received through the antenna 40 and transmitter/receiver 42. Modem 44 extracts the data from the reception and inputs it through I/O device 46 to the CPU 48.

Communication stations 12 are provided in a network that can be used to determine the positions of the mobile objects over the given area. The honeycomb triangular network of U.S. Patent No. 5,051,741 may be used for distributing the communication stations. However, with the use of a bearing determination device 58 at the communication stations, not as many would be needed and three communication stations might even be sufficient to cover an entire given area. The receiver 42 is tuned into all operational page response frequencies to pick up the response signals from the transponders in the mobile objects. For networks using the time delay method, the communication stations simply provide a time that a page response was received and return that time representing the receipt of the page response for an ID code to the master station.

In accordance with one embodiment of the invention, the communication stations are provided with a bearing determination device such as a goniometer 62. The goniometer is a cross-loop aerial that receives signals in a manner that allows for determination of the direction from which the signals came. This is used to determine the direction from which a page response was issued. These signals are provided through a receiver 60 to the bearing determination device 58. The bearing of the incoming page response signals are determined and delivered on a signal to a demodulator 164. The direction data is then input through the input/output device 46. The data is then made available to the CPU 48. The information may then be transmitted to the ground station by transmission through the antenna 40. At the ground station the various bearing determinations obtained from the plurality of communication stations may be combined to obtain the coordinates of the paged mobile object. The computer system at the communication station 12 is equipped with a data storage device 54 and additional system control software 52. The page response signal from the mobile object may in certain circumstances include coordinate information when the mobile object contains its own coordinate determining system. The entire page response is provided into the CPU 48 and can be analyzed by the system control software 52 for forming an appropriate file for transmission to the ground station. The communication station may also include a video display unit 64 to facilitate on site testing of the station.

A master ground station shown in Fig. 3 controls the operation of the system for each given area. The ground station communicates with the communication stations. These communications can be carried out through an antenna 70 and a transceiver 72. Alternatively, standard cellular phone links or land lines could be used for these communications between the ground station and communication stations. A modem 74 and an input/output device 76 provide an interface between the transceiver 72 and a CPU 78 in the ground station. The ground station receives from the communication stations all of the unique ID codes for all mobile objects in the given area. The ground station keeps a list of all of the unique ID codes in the given area and cyclically proceeds through the list paging the given area with each of the unique ID codes. A page signal may include one or more ID codes. A page signal may also include an interrogation request asking the mobile object being paged to return certain information. Before a page, the ground station may alert the communication stations as to the ID code or codes that are about to be paged. In other words, the communication stations are primed. In the marine environment, however, priming is not required for all communication stations. Because the water vessels move relatively slowly, only the communication stations in the vicinity of the water vessel need to be primed.

For a page, the unique ID code is provided by the CPU through the input/output device 76 to a modulator 80. The ID code page signal is sent through transceiver 72 over the antenna 70 or, alternatively, through standard cellular phone links. Responses to the page signal are picked up by one or more of the communication stations. These responses are returned to the ground station through the antenna 70 and transceiver 72 or the alternatives. The ground station continuously polls all of the communication stations for received responses from paged mobile objects and the ID codes of newly arrived mobile objects.

The response data gathered in response to the page signal are used to compile a position file with the locations of all the mobile objects in the given area. Some of the responses will be from mobile objects that have their own navigation systems and thus may directly provide their coordinates as data. For those that do not have the navigation capability on board, the responses received by the communication stations are used by the ground station to determine the position of the mobile object. The system control software 86 includes programs for determining position from the responses received by the communication stations. The particular program that is used is going to depend on the equipment used at the communication stations. Two examples already given are the use of a bearing determination device at each of the stations or the use of time delay measurements to derive or determine the precise location of each of the mobile objects.

The system control software 86 prepares the position file so that it is arranged in terms that can be easily superposed on a map image of the given area. The map file stored onboard is arranged as coordinate coded geographic data. The locations for each of the mobile objects is coordinate coded in the position file. Identifying information for each of the mobile objects is provided along with its location. Identification information provides the type of objects such as the type of boat or size of the boat. The information may be more specific so as to identify specifically the mobile object with an identifier that can be displayed on the screen and made useful for the observer. The CPU 78 provides the position information file through the input/output device 76 for transmission over the given area. The position file is made continually available. Its rate of change depends upon the rate of change of the dynamic information. Land vehicle traffic may change within a few minutes and thus processing and modifying the dynamic file should be in accordance with this. At airports, the update ought to be more rapid, perhaps after every paging cycle. In general, the rate of change should provide information updates at a rate that addresses the environment being served.

In addition to the position file, the ground station may be used to determine the velocities of the mobile objects and/or predicted positions of the mobile objects. These additional files may be broadcast over the given area as is done with the position file. The predicted positions may be used to trigger an alarm if two mobile objects are predicted to come within less than a predetermined distance of one another.

A keyboard 96 and a video display unit 98 are provided at the ground station so that an operator can monitor the operation of the system. Map data for the given area and reference information data 26 are stored in data storage device 20. The reference information is associated with locations on the map image. The reference information is semi-static, changing occasionally. The reference information is transmitted continually, making it always available throughout the given area. The reference information is selectively displayed at the onboard system of a mobile object.

Referring now to Fig. 4, the onboard system carried by each of the mobile objects for receiving and processing the position and map information is now to be described in detail. When a mobile object enters an area being serviced by a locating/map dissemination system of the present invention for the first time, it is necessary for the system to learn the unique ID code for the transponder on the mobile object. The unique ID code data is stored onboard in a data storage device 112. A CPU 114 accesses the unique ID code data and provides it through an input/output device 116. The input/output device 116 provides the data through a modulator 118 to a transmitter 120. The modulator 118 and transmitter 120 are controlled to send the unique ID code data on several specified frequencies. The use of several access frequencies is for minimizing common frequencies. For example, if two boats entered a monitored harbor from open sea, each having four ID access frequencies, it is likely that at least one of those frequencies will be distinct from those being transmitted by the other boat. The communication stations will determine through signal analysis which ID access frequencies are unique so that the ID codes can be detected.

The transmitter 120 sends out through aerial 122 the ID code data over the several different frequencies. Alternatively, particularly in the marine and air environments, the ID code data may be sent over a cell phone link. The transmissions are transmitted periodically at different time intervals and are issued continuously until some external signal deactivates the transmissions. When an ID communication station determines a unique ID code it transmits the ID information to the ground master station. It is presently contemplated that once the master station issues a page with the unique ID code, the page will deactivate the ID code transmissions. It is desirable to have the transmissions of the ID data codes deactivated so as to minimize data collisions. The use of the ID code beacon in the present invention is most suitable for the marine environment. Aircraft are normally equipped with radar triggered ID code transmitters which should suffice. On land, vehicles will normally be moving from one monitored area to another and the master stations can transfer the ID code between themselves.

The onboard system on each of the mobile objects acts as a transponder. Aerial 122 picks up page signals, position file transmissions and reference file transmissions. A page signal received from the ground station is processed through a receiver 124. Receiver 124 includes four tuned receiving circuits so that a page signal can be received in any monitored area. Each monitored area uses one of the four paging frequencies for broadcasting page signals. The received signal is provided to a demodulator 126. The demodulated page signal is provided through an input/output device 128 to a CPU 114. The input/output device 116 and the input/output device 128 may be separate or may be a single device. The CPU 114 compares the received signal with the ID codes stored in the data storage device 112. A transponding operation is performed by comparing the incoming signal with its own ID code. A page signal will only be received upon positive identification of its own ID code. Other page signals are rejected. If the received page signal matches the unique ID code of the onboard system the CPU 114 will send a page response for transmission through input/output device 116, modulator 118, transmitter 128 and aerial 122. The frequency of the page response is determined by the frequency on which the page signal was received. Each of the four paging frequencies corresponds to one of four response frequencies. The page response is compiled in the CPU 114. The page response includes a fixed portion with an identification data file including the ID code to identify the mobile object. The page response may also be compiled with a variable portion with several parameters relating to the mobile object. Such parameters may include altitude, distress signals, "vehicle parked" signal, fuel level, or other such signals.

The response is completed within a predetermined time interval. The end of the ID transmission will be an end of message code so that any slight variation in transmission time will be accounted for by the receiver. The timing or direction of the page response may be used by the system to determine the position of the mobile object. Alternatively, some mobile objects may come equipped with a coordinate determining system 134 of its own. The coordinate determining system 134 may be a global positioning system (GPS) or other navigational system. For mobile objects that have the coordinate determining system 134 their ID page response may be compiled to include in the variable portion the coordinates for the mobile object.

The receiver 124 in Fig. 4, in addition to representing the tuned circuits for the paging frequencies, may also represent four tuned circuits for receiving the position file from the master ground station of a monitored area. Alternatively, a variably tuned circuit can be set to the appropriate position file frequency corresponding to the paging frequency received by the mobile object. When a mobile object is near two or more monitored areas, it may be desirable to receive position file data from all of the two or more monitored areas. Moreover, rather than using different frequencies to distinguish from among the position files of adjacent monitored areas, a single frequency can be used for position files and adjacent areas can use different transmission protocols to identify and distinguish its position file from that sent out by a master ground station in an adjacent monitored area.

A position file containing the coordinates of all the mobile objects in the given area is transmitted throughout the given area periodically. The position file data is passed through demodulator 126 to the input/output device 128 to the CPU 114. Here the information is recognized as a position coordinate file. System control software 136 is used to decode the position coordinate file and meld it with the map data stored in data storage device 112 to create a map image that includes each of the mobile objects in the given area located on the map in its position as learned from the position coordinate file. For this, the software may use CD-ROM GIS map software. The system control software 136 may also include touch screen software, pull down menus, mouse driver, cursors, and other software for accomplishing the objects of the invention, said software being readily available or well within the ordinary skill of computer programmers to write.

The onboard system is equipped with a display unit 138 for displaying the map and the mobile objects in their respective positions. In the harbor application various icons may be used on the display to illustrate the type of vessel that is located in any given position. Other identifying information such as a name may be provided alongside the icon representing a mobile object. The system software 136 may also include programs for changing the portion of the map image that is shown on the display unit. The onboard display unit may display the map information at different magnifications. This is made possible by storing the map image as a polygon encoded image. The software should also be provided with the ability to move the picture around rotating it as desired. Advantageously, the display unit can locate that part of the map through which the mobile object is traveling in the center of the display screen. The display unit 138 may advantageously be provided with a touch screen 139. Such a display device permits a user to access information by touching a location on the screen to request further information regarding that location. Alternatively the display may be provided by a head-up display 144 in which the operation of the mobile object sees the display projected in front. This permits the display to be seen without diverting attention too far from the forward direction of the mobile object.

A reference information file also keyed to the various positions on a map image may also be transmitted throughout the given area on a separate frequency by the ground station. On unique frequency for the reference information can be selected for use by all monitored areas because the information is semi-static. Alternatively, four frequencies each corresponding to one of the paging frequencies, may be distributed among the monitored areas. Receiver 124 may be provided with the additional receiving capacity to tune into the reference information frequency or frequencies. The onboard system can store the reference information in the data storage device 112. Informational questions can be made regarding a given area through the keyboard 140 or the touch screen 139. If an answer is available, the reference information file in the data storage device 112 can report the answer to the video display unit 138. The reference information may be stored in association with a code to identify data type. For example, water depth may be one data type and tidal information may be another. The onboard system may choose to display any one or more of the reference data types superposed on the displayed map image. Text generated by the reference data is displayed horizontally on the screen in the vicinity of the associated geographic location. The system software controls the display so that the text remains horizontal even if the polygon encoded map is rotated on the display. The information about a particular location may also be quickly accessed by this onboard system. With the touch screen display 138, a user can touch a particular location and obtain a menu of information available regarding that location which can then be quickly accessed by touching an appropriate box displayed on the touch screen 138.

A data acquisition system 142 is connected between the mobile object's onboard controls and the onboard mapping system. This permits information such as speed, altitude, fuel level and other such data to be used and included in the page response signal. This information would be for use by an operator at the ground station. In exceptional cases, such as to announce emergencies, the information could be inserted into a position file that is transmitted throughout the given area.

When given areas are adjacent to one another accommodation needs to be made to avoid interference of the two systems. Preferably, each system operates on different frequencies. Alternatively each system operates with a different transmission protocol. The system for each given area will provide map information for that given area only. A mobile object in an overlapping region of two areas could receive and map out the two areas. Because all map information and reference information is coordinate encoded, there is no processing problem at all in showing any part of the combined map image.

The present invention may be used in a variety of environments. It may be used in an airport monitoring the locations of planes and other vehicles on the ground. It may be used in harbors and restricted waterways to identify the locations of vessels on the water. The map information may be further provided with depth information to assist a vessel in navigating through the harbor. The system may be used on land to provide street map information for any given area. It should be understood that the present disclosure is for the purpose of illustration only and does not include all modifications or improvements which may fall within the scope of the appended claims.

I CLAIM:

1. An earth based information system for mobile objects, each carrying a unique ID code device, comprising:

means for paging each of the unique ID code devices present within a given area;

means for determining a position for each of the unique ID code devices within the given area; and

means for transmitting to the mobile objects the positions of all of the mobile objects corresponding to the paged unique ID code devices.

2. The information system of claim 1 wherein said transmitting means transmits the position of all of said plurality of mobile objects in a data file arranged for combination with a map file to enable display of a superposed image of any of said mobile objects positioned on a map.

3. The information system of claim 2 further comprising a memory device for supplying a data file containing information for recreating a static map image of the given area.

4. The information system of claim 3 further comprising means for transmitting data files of reference information individually associated with locations on the static map image.

5. The information system of claim 1 further comprising means for determining velocity of each of the mobile objects within the given area.

6. The information system of claim 5 further comprising means for determining predicted positions of all of the mobile objects in a predetermined time from present based upon the position and velocity of all of the mobile

objects and means for transmitting data files containing the predicted positions.

7. The information system of claim 1 wherein said means for determining position comprises means for receiving navigation coordinates from individual ones of said mobile objects.

8. The information system of claim 1 wherein said paging means comprises means for paging the given area with one of a plurality of unique codes, wherein the unique ID code devices each comprise a transponder responsive to one of said unique codes and wherein said means for determining position calculates position of a mobile object from the response of the transponder in said mobile object to a page with its respective unique code.

9. The information system of claim 8 further comprising means for providing said paging means with the unique codes of the mobile objects in the given area.

10. The information system of claim 1 further comprising a display means in each of said mobile objects for receiving the positions of all of the mobile objects within the given area.

11. An earth based information system for mobile objects, each carrying a unique ID code device, comprising:

a plurality of locating systems each including:

means for paging each of the unique ID code devices present within a given area serviced by said locating system;

means for determining a position for each of the unique ID code devices within the given area serviced by said locating system; and

means for transmitting the positions of all of the mobile objects corresponding to the paged unique ID code devices in the given area serviced by said locating system, such that a receiver located in more than one of the given areas can distinguish among the transmissions from the locating systems.

12. The information system of claim 11 wherein said transmitting means for each locating system serving given areas that are adjacent one another transmits the positions of the mobile objects in its respective given area over a frequency different from a frequency used by the transmitting means of each other locating system serving an adjacent given area.

13. The information system of claim 11 wherein said transmitting means for each locating system serving given areas that are adjacent one another transmits the positions of the mobile objects in its respective given area using a transmission protocol different from a transmission protocol used by the transmitting means of each other locating system serving an adjacent given area.

14. An earth based information system for mobile objects comprising:

a plurality of transponders, each mobile object carrying one of said transponders;

means for repeatedly paging each of a plurality of mobile objects present within a given area;

means for determining a position for each of the plurality of mobile objects within the given area;

means for transmitting the positions of the mobile objects in the given area throughout at least the given area;

receiver means, carried on at least one of said mobile objects in the given area, for receiving the positions of the plurality of mobile objects in the given area; and means, connected to said receiver means, for superposing the positions of any of the mobile objects in the given area onto a map image.

15. The information system of claim 14 wherein said means for determining position comprises means for receiving navigation coordinates from individual ones of said mobile objects.

16. The information system of claim 14 wherein said paging means comprises means for paging the given area with each of a plurality of unique codes and wherein each of said transponders is responsive to one of said unique codes and wherein said means for determining position comprises means for calculating position of a mobile object from the response of said transponder carried by said mobile object to a page including its respective unique code.

17. The information system of claim 16 wherein said transponders each include means for transmitting an identification data file in response to detection of its respective unique code.

18. An earth based information system for tracking mobile objects over a given area comprising:

a master station remote from said mobile objects, said master station including:

means for paging each of said mobile objects present within the given area using a unique ID code for each mobile object;

means for determining position coordinates for each of said mobile objects within the given area and for creating a file with the coordinates of said mobile objects; and

means for broadcasting the file with the coordinates of said mobile objects.

19. The information system of claim 18 further comprising means, located on a mobile object, for receiving the file with the position coordinates of said mobile objects and means, connected to said receiving means, for creating a map image of the given area that includes representations of said mobile objects located on the map image in accordance with the position coordinates determined by said position coordinates determining means.

20. The information system of claim 19 wherein said master station further includes means for broadcasting data files including encoded information associated with geographic coordinates for selective superposition onto the map image.

21. The information system of claim 20 further comprising selection means, located on a mobile object, for displaying selected information received from said broadcasting means superposed over the map image and a geographic map of the given area.

22. The information system of claim 21 wherein said selection means comprises a display screen on which selections are made by touching said screen.

23. The information system of claim 18 further comprising a plurality of transponders, each aboard one of said mobile objects.

24. The information system of claim 23 wherein each of said transponders includes means for responding to a page from said paging means with a fixed identification data signal.

25. The information system of claim 24 wherein each of said transponders further includes means for responding to a page with a variable information signal.

26. The information system of claim 18 wherein said means for determining coordinates comprises means for receiving navigation coordinates from individual ones of said mobile objects.

27. The information system of claim 18 further comprising means for identifying the unique ID code of each mobile object in the given area and providing the unique ID codes to said master station.

28. The information system of claim 18 wherein said master station further comprises means for identifying two mobile objects heading to within a predetermined minimum distance of one another and issuing an alarm in response thereto.

29. A method for disseminating mapping and position information to a plurality of mobile objects, each carrying a unique ID code device, in a given area, said method comprising:

paging each of the unique ID code devices present within the given area;

receiving a response from a unique ID code device paged with its unique ID;

determining a position for each of the unique ID code devices within the given area; and

transmitting to the mobile objects the positions of all of the mobile objects corresponding to the paged ID code devices present within the given area.

30. The method of claim 29 wherein said step of determining position comprises receiving navigation coordinates from unique ID code devices when they respond to a page.

31. The method of claim 29 wherein said step of determining position comprises calculating a position for a

unique ID code device based upon how much time elapsed between the step of paging the unique ID code device and the step of receiving a response from the unique ID code device.

32. The method of claim 29 further comprising the step of superposing representations of any of the mobile objects on a map image of at least a portion of the given area in accordance with the determined positions for the unique ID code devices carried by said any of the mobile objects.

33. A mapping system carried by a primary mobile object comprising:

means for receiving a paging signal including an ID code;

means for determining if the ID code of the paging signal received by said receiving means is equal to a predetermined unique ID code;

means for compiling a data file including information pertaining to the mobile object;

a transmitter for sending a response containing the data file when said determining means determines the ID code of the paging signal equals the predetermined unique ID code;

memory means for storing a data file representing a geographic map image;

display means;

means for receiving position information files with the data file representing a geographic map image to produce a map image for said display means that includes representations of mobile objects positioned on the map image according to the position information files.

34. The mapping system of claim 33 further comprising means for identifying the primary mobile object in the position information files so as to select and orient an appropriate portion of the geographic map image for use by

said combining means to produce the map image for said display means.

35. The mapping system of claim 33 wherein said display means comprises a touch screen which inputs commands in response to a person touching the screen.

36. The mapping system of claim 33 further comprising means for decoding position information files.

37. The mapping system of claim 33 further comprising means for determining navigational coordinates of the primary mobile object and providing the navigational coordinates to said compiling means.

38. The mapping system of claim 33 further comprising means for accessing information pertinent to a location in response to an input pointing to the location on the display means.

39. The mapping system of claim 33 further comprising magnification means for adjusting how large a portion of the map image is displayed on said display means.

40. The mapping system of claim 33 wherein said display means comprises a head-up display.

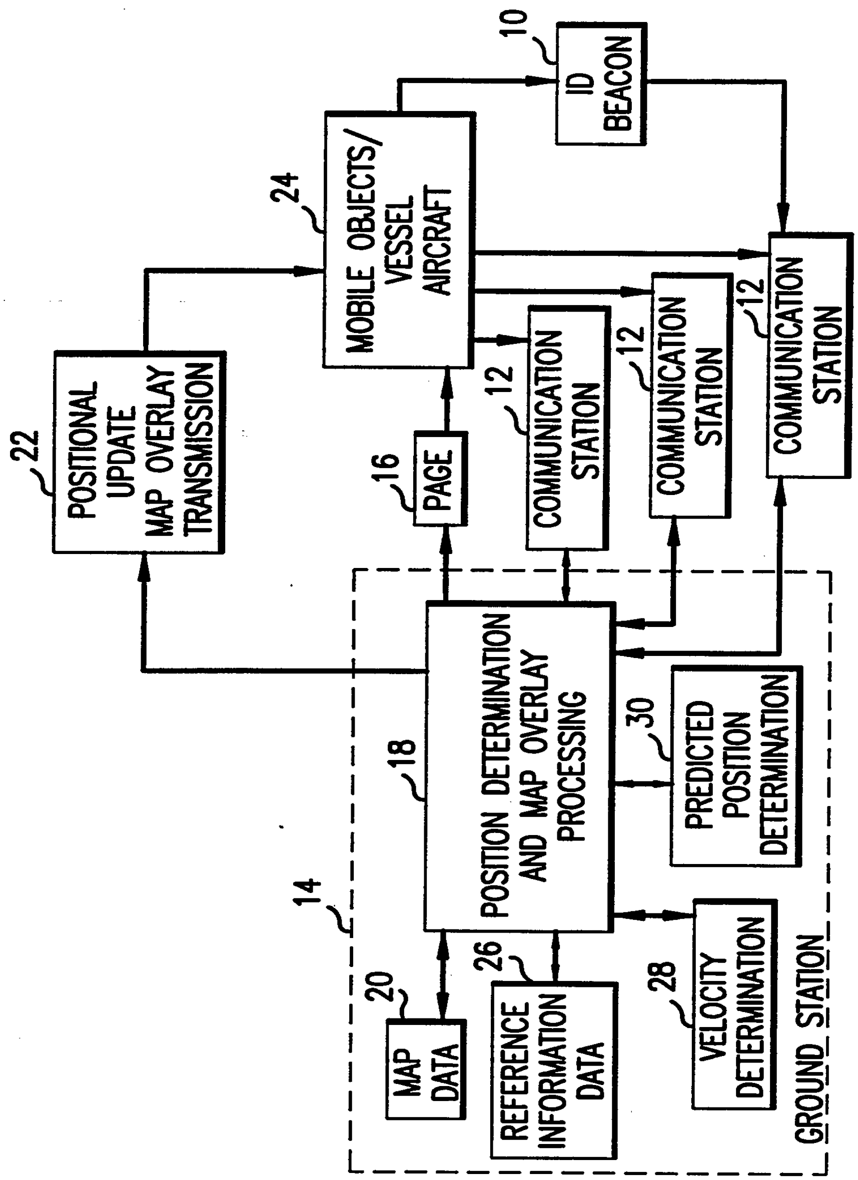

POSITIONAL UPDATE MAP OVERLAY TRANSMISSION
22
MOBILE OBJECTS/ VESSEL AIRCRAFT
24
ID BEACON
10
PAGE
16
COMMUNICATION STATION
12
COMMUNICATION STATION
12
COMMUNICATION STATION
12
POSITION DETERMINATION AND MAP OVERLAY PROCESSING
18
PREDICTED POSITION DETERMINATION
30
14
MAP DATA
20
REFERENCE INFORMATION DATA
26
VELOCITY DETERMINATION
28
GROUND STATION

FIG.1

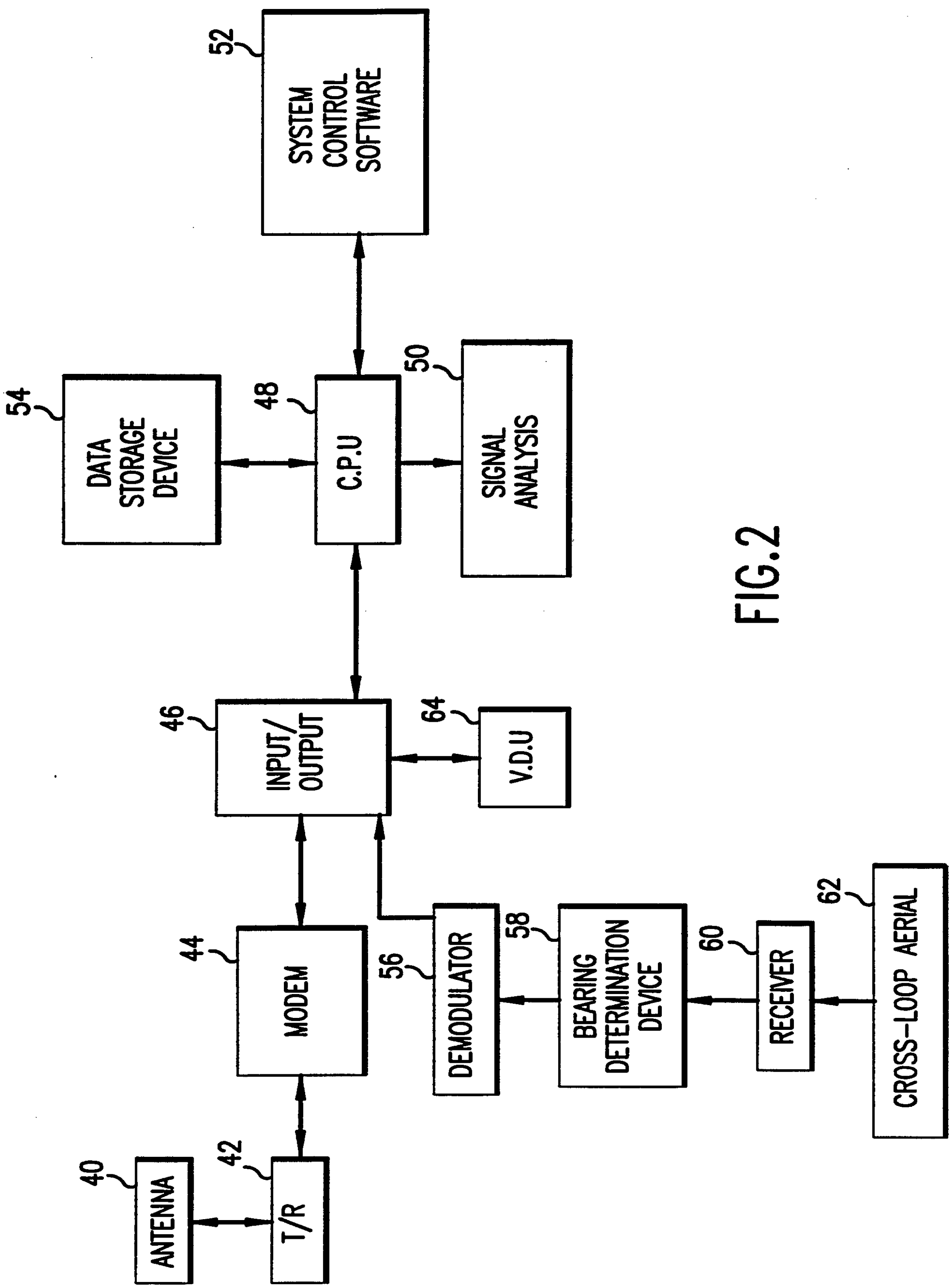
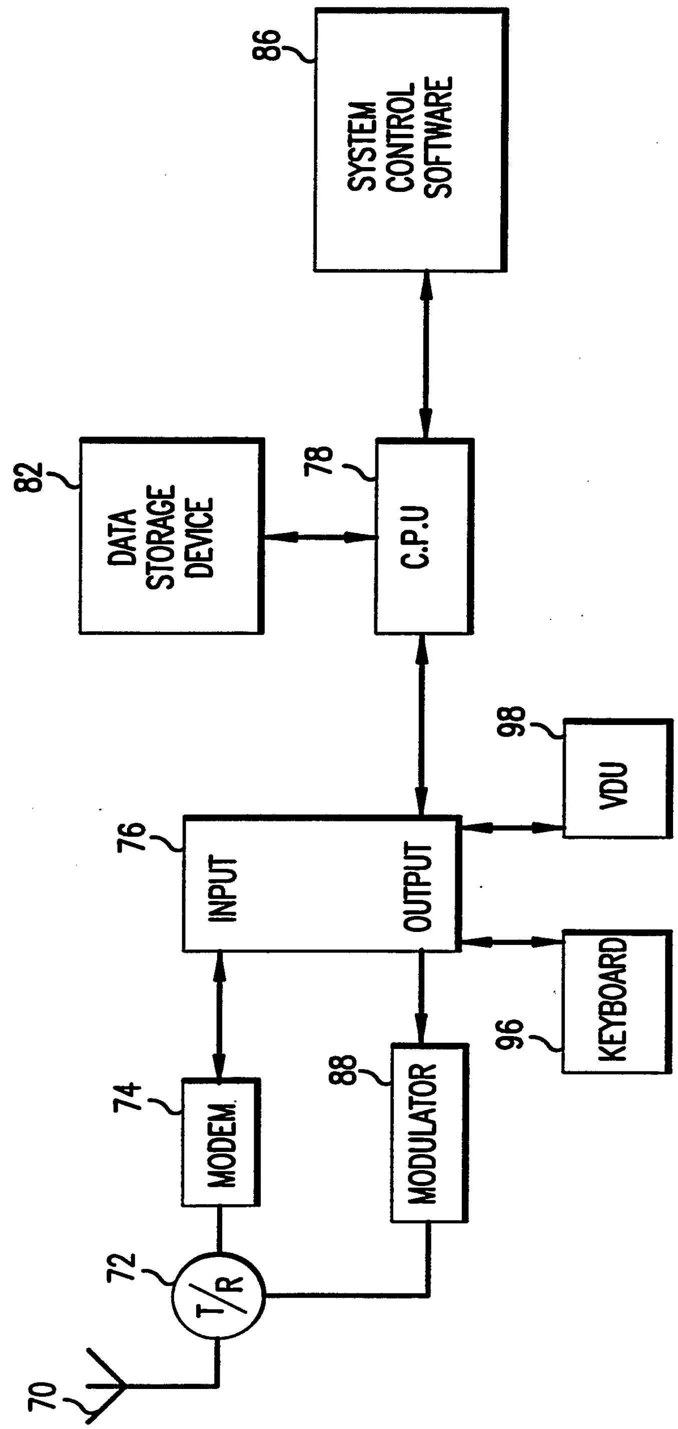

SYSTEM CONTROL SOFTWARE
52
DATA STORAGE DEVICE
54
C.P.U
48
SIGNAL ANALYSIS
50
INPUT/ OUTPUT
46
V.D.U
64
MODEM
44
DEMODULATOR
56
BEARING DETERMINATION DEVICE
58
RECEIVER
60
CROSS-LOOP AERIAL
62
ANTENNA
40
T/R
42

FIG.2



86
SYSTEM CONTROL SOFTWARE
82
DATA STORAGE DEVICE
78
C.P.U
98
VDU
76
INPUT
OUTPUT
96
KEYBOARD
74
MODEM
88
MODULATOR
72
T/R
70

FIG.3

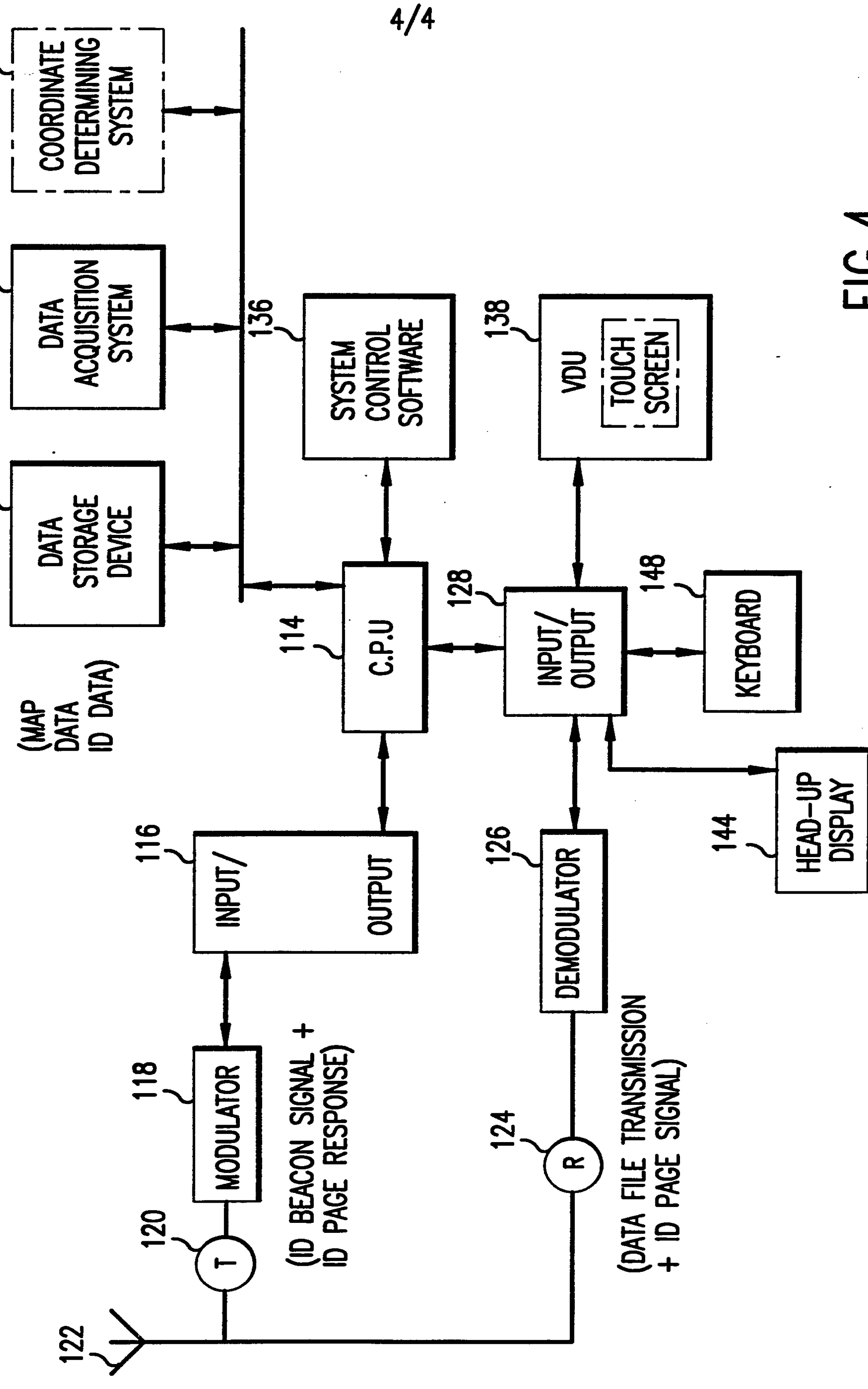

134
COORDINATE DETERMINING SYSTEM
142
DATA ACQUISITION SYSTEM
112
DATA STORAGE DEVICE
(MAP DATA ID DATA)
136
SYSTEM CONTROL SOFTWARE
138
VDU
TOUCH SCREEN
114
C.P.U
128
INPUT/ OUTPUT
148
KEYBOARD
144
HEAD-UP DISPLAY
116
INPUT/ OUTPUT
126
DEMODULATOR
118
MODULATOR
120
T
122
124
R
(ID BEACON SIGNAL + ID PAGE RESPONSE)
(DATA FILE TRANSMISSION + ID PAGE SIGNAL)

FIG.4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 94/01512

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G08G5/04 G08G3/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G08G G01S H04Q G08B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,5 051 741 (WESBY) 24 September 1991 cited in the application see claims	1-40
Y	US,A,5 111 400 (YODER) 5 May 1992 see the whole document	1-40
Y	EP,A,0 516 501 (SEXTANT AVIONIQUE) 2 December 1992 see the whole document	22,35
A	FR,A,2 601 168 (LMT RADIO PROFESSIONNELLE) 8 January 1988 see the whole document	1-7,14, 15
A	EP,A,0 484 918 (HUGHES AIRCRAFT COMPANY) 13 May 1992 see abstract	11-13

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
27 October 1994	09.11.94

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2, NL - 2280 HV Rijswijk, Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Reekmans, M

Form PCT/ISA/210 (second sheet) (July 1992)

IN"TERNATIONAL SEARCH REPORT

Inte...ional Application No
PCT/GB 94/01512

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,4 835 537 (MANION) 30 May 1989 see the whole document ---	1-7,11, 14,15
A	EP,A,0 514 826 (TELEFUNKEN SYSTEMTECHNIK AG) 25 November 1992 see the whole document ---	1-7,14, 15
A	DE,A,34 00 602 (PRAKLA-SEISMOS GMBH) 18 July 1985 -----	

1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 94/01512

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A-5051741	24-09-91	CA-A-	2079112	29-09-91
		EP-A-	0522040	13-01-93
		WO-A-	9114952	03-10-91
US-A-5111400	05-05-92	NONE		
EP-A-0516501	02-12-92	FR-A-	2677149	04-12-92
		US-A-	5340061	23-08-94
FR-A-2601168	08-01-88	EP-A,B	0273953	13-07-88
		WO-A-	8800379	14-01-88
		JP-T-	1501177	20-04-89
		US-A-	5307074	26-04-94
EP-A-0484918	13-05-92	US-A-	5218618	08-06-93
		CA-A-	2054361	08-05-92
		JP-A-	4267638	24-09-92
US-A-4835537	30-05-89	NONE		
EP-A-0514826	25-11-92	DE-A-	4116667	26-11-92
		DE-A-	4223118	20-01-94
DE-A-3400602	18-07-85	EP-A,B	0154018	11-09-85

Form PCT/ISA/210 (patent family annex) (July 1992)

Electronic Patent Application Fee Transmittal

Application Number:	09770838
Filing Date:	26-Jan-2001
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Filer:	Dennis Jay Dupray./Debra Kesner
Attorney Docket Number:	1003-1

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt

EFS ID:	4133687
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Customer Number:	62914
Filer:	Dennis Jay Dupray./Debra Kesner
Filer Authorized By:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1
Receipt Date:	17-OCT-2008
Filing Date:	26-JAN-2001
Time Stamp:	14:32:14
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$180
RAM confirmation Number	8374
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Information Disclosure Statement (IDS) Filed (SB/08)	IDS_04.pdf	779749 d4bc84e1a49557a6a803933865746b09247583d6	no	4
Warnings:					
Information:					
2	Foreign Reference	WO95003598.pdf	1590562 feba356d83e277ce9b4f1fff6358cb55dcbf6f55	no	36
Warnings:					
Information:					
3	Fee Worksheet (PTO-06)	fee-info.pdf	30348 5aa1dfa5dde064e18e810a432c8b5275a1763713	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	2400659	

PATENT APPLICATION

In Re the Application of:	
DUPRAY et al.	Prior Group Art Unit: 3662
Serial No.: 09/770,838	Prior Examiner: Dao Phan
Filed: January 26, 2001	**AMENDMENT AND RESPONSE**
Atty. File No.: 1003-1	
For: "A GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION"	

MAIL STOP: Issue Fee
Commissioner for Patents P.O. Box 1450
Alexandria, VA. 22313-1450

Dear Sir/Madam:

Applicants file the present amendment and response to address the Office Action having a mailing date of June 13, 2008.

If there are any questions regarding the present amendment, it is requested that the named Applicant hereinbelow (Dennis Dupray) be contacted at 303-863-2975. Note, it is believed that no fees are due with this transmittal beyond the amount for a three month extension of time.

IN THE CLAIMS:

Claims 1 through 220 were previously cancelled.

221. (Previously Presented) A method for obtaining requested location information regarding a first of a plurality of terrestrial wireless mobile stations using location information from location estimating sources, and to provide the requested location information to an application using wireless location, the location estimating sources, including a first location estimating source and a second location estimating source, the first and second location estimating sources providing information regarding locations of various of the mobile wireless stations, the method comprising the steps of:

first receiving a location request regarding the first of said wireless mobile station from the application, said location request seeking said requested location information;

first obtaining a first location input obtained using an instance, I_1, of location information from said first location estimating source, wherein I_1 is indicative of one or more locations of said first wireless mobile station, and

second obtaining a second location input obtained using an instance, I_2, of location information provided from said second location estimating source, wherein I_2 is indicative of one or more locations of said first wireless mobile station;

wherein said first location estimating source employs a first location finding technology that provides I_1, and said second location estimating source employs a second location finding technology different than said first location finding technology that provides I_2; and

wherein said steps of first and second obtaining includes a step of providing said first and second location inputs in a common standardized format;

storing data in memory relating to said first location input and said second location input;

third obtaining said requested location information by selectively using portions of said data from said memory, wherein said requested location information is determined according to information indicative of a manner in which said application prefers said requested location information; and

outputting said requested location information to said application.

222. (Previously Presented) The method of Claim 221, wherein for locating a second of the mobile stations, there is a further step of requesting activation of each of one or more of said location estimating sources according to an availability of corresponding wireless signal measurements from the second mobile station for the one or more location estimating sources.

223. (Previously Presented) The method of Claim 221, further including, for locating a second of the mobile stations, a step of obtaining an instance of a third location input from a third of the location estimating sources different from said first and second location estimating sources.

224. (Previously Presented) The method of Claim 223, further including, for locating one of the first and a second of the mobile stations, a step of obtaining an instance of a third location input by using a third location finding technology different from the first and second location finding technologies.

225. (Previously Presented) The method of Claim 224, further including providing said instance of said third location input in said standardized format.

226. (Previously Presented) The method of Claim 221, wherein said step of providing includes representing each of said first and second location inputs in a common data representation having a plurality of location attributes, including a common representation A_1 for representing a geographical position for the first mobile station, and one or more attributes related to one of: an error in data for A_1, a likelihood of the first mobile station being in the geographical extent represented by A_1, a timestamp related to the first mobile station being in the geographical extent represented by A_1, and descriptor information related to location processing performed by one of said first and second location estimating sources.

227. (Previously Presented) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to an error in data for A_1.

228. (Previously Presented) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to a likelihood of the first mobile station being in the geographical extent represented by A_1.

229. (Previously Presented) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes related to a timestamp related to the first mobile station being in the geographical extent represented by A_1.

230. (Previously Presented) The method of Claim 226, wherein said step of providing includes a common representation for representing one or more of said location attributes for descriptor information related to location processing performed by one of said location estimating sources in obtaining an instance of said location information for the first mobile station.

231. (Previously Presented) The method of Claim 226, wherein for locating a second of the mobile stations, further including a step of providing one or more location input instances of location information by one or more of said location estimating sources in said common data representation.

232. (Previously Presented) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of said wireless mobile stations including at least a location and a time.

233. (Previously Presented) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of the wireless mobile stations including one or more values indicative of an uncertainty regarding a location of the individual wireless mobile station.

234. (Previously Presented) A method as set forth in claim 221, wherein said step of storing comprises storing information for individual ones of said wireless mobile stations including one of a travel speed and a travel direction.

235. (Previously Presented) A method as set forth in claim 221, wherein said step of first obtaining comprises sending data for requesting activation of one of the first location estimating source and the second location estimating source to obtain the corresponding one of first and second location input.

236. (Previously Presented) A method as set forth in claim 221, wherein said step of third obtaining comprises determining additional location information including at least a wireless station identification and a location of the first wireless mobile station.

237. (Previously Presented) A method as set forth in claim 221, wherein said step of third obtaining comprises determining additional location information a including a time and an uncertainty or likelihood regarding location of the first mobile station.

238. (Previously Presented) A method as set forth in claim 221, wherein said step of third obtaining comprises providing additional location information including one of a speed of travel and direction of travel for the first wireless mobile station.

239. (Previously Presented) A method as set forth in claim 221, further comprising combining (a) and (b) following to make a location determination: (a) a first portion of said portions of said data, the first portion obtained using said first location input, with (b) a second portion of said portions of said data, the second portion obtained using said second location input.

240. (Previously Presented) A method as set forth in claim 239, wherein said step of combining comprises obtaining a first set of information including first location information and first time information for said first wireless mobile station, obtaining a second set of information including second location information and second time information for said first wireless mobile station, determining a time difference between said first and second sets of information, and adjusting one of said first and second sets of information based on said time difference.

241. (Previously Presented) A method as set forth in claim 240, wherein said adjusting includes calculating one of a change in position and a value related to an uncertainty in position dependent on said time difference.

242. (Previously Presented) A method as set forth in claim 239, wherein said step of combining comprises obtaining a first set of position information including a position and first value related to an uncertainty, obtaining a second set of information including a position and second value related to an uncertainty and combining said first set and said second sets to yield a third set including a position and an uncertainty for said wireless station, wherein said third set includes a reduced uncertainty relative to said first and second sets.

243. (Previously Presented) A method as set forth in claim 239, wherein said first location finding technology includes receiving first location data from a first source and determining, using said first location data, one or more first geometric extents for a location of the first mobile station and a value related to an uncertainty of said one or more first geometric extents to thereby provide said first location input, and

wherein said second location finding technology includes obtaining second location data from a second source and determining, using said second location data, one or more second geometric extents for a location of the first mobile station and a value related to an uncertainty of said one or more second geometric extents to thereby provide said second location input, and

wherein the first source includes a non-terrestrial wireless transmitter above and not supported on the Earth's surface, and the second location data includes information related to a wireless signal time delay of transmissions between the first mobile station, and at least one terrestrial base station.

244. (Previously Presented) A method as set forth in claim 221, further comprising the steps of:

obtaining tracking information regarding movement of said first wireless mobile station; and

using said tracking information to derive location information.

245. (Previously Presented) A method for estimating, for each mobile station **M** of a plurality of mobile stations, an unknown terrestrial location (L_M) for **M** using wireless signal measurements obtained via transmissions between said mobile station **M** and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations is substantially co-located with one or more of a transmitter and a receiver for wirelessly communicating with said mobile station **M**, comprising:

initiating a plurality of requests for information related to the location of said mobile station **M**, the requests provided to each of at least two mobile station location evaluators, wherein there is at least a first of the requests provided to a first of the location evaluators and a second of the requests, different from the first request, provided to a second of the location evaluators, such that when said location evaluators are supplied with corresponding input data having values obtained using wireless signal measurements obtained via two way wireless communication between said mobile station **M**, and the communication stations, each of said first and second location evaluators determine corresponding location information related to L_M, and

wherein for at least one location **L** of one of the mobile stations, said first location evaluator and said second location evaluator output, respectively, first and second position information related to the one mobile station being at **L** wherein neither of the first and second position information is dependent upon the other;

obtaining a first collection of location information of said mobile station **M**, wherein the first collection includes first location information from the first location evaluator, and second location information from the second location evaluator;

determining resulting information related to the location L_M of the mobile station **M**, wherein the resulting information is dependent on geographical information in each of the first and second location information; and

transmitting, to a predetermined destination via a communications network, the resulting information.

246. (Previously Presented) The method of Claim 245, further including the following steps:

second obtaining, from an additional one or more of the location evaluators, additional location information using values obtained from wireless signal measurements for a time different from a time of the communications between the mobile station **M** and the communication stations for obtaining the first collection;

determining, as part of said resulting information, a resulting location estimate of the mobile station **M**, wherein said resulting location estimate is dependent upon a value obtained from said additional location information.

247. (Previously Presented) A method for locating mobile stations at one or more unknown terrestrial locations using wireless signal measurements obtained via transmissions between said mobile stations and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile stations, comprising:

receiving, from a plurality of location requesting sources, a plurality of input requests for locations of the mobile stations, wherein for each of the input requests there is a corresponding destination for a responsive output;

for each of the input requests, providing one or more location requests for location information, related to a location of one of said mobile stations, to one or more mobile station location determining sources;

first obtaining, in response to a first of the location requests received from a first of the requesting sources, at least first location information of a first location of a first of said mobile stations, said first location information determined using a first set of one or more wireless location techniques;

first determining, using said first location information, first output location data according to a first output criteria for the corresponding destination for the first request, said first output location data including a representation identifying a first geographical location of the first location;

second obtaining, in response to a second of the location requests received from a second of the requesting sources, at least second location information of a second location of a second of said mobile stations, said second location information determined using a second set of one or more wireless location techniques, wherein the second set determines the second location information by activating at least one location computing module for locating the second mobile station from at least a portion of the signal measurements, wherein the at least one location computing module is not activated for determining the first location information;

second determining, using said second location information, second output location data according to a second output criteria for the corresponding destination for the second request, said second output location data including a representation identifying a second geographical location of the second location;

wherein for at least one of said first and second output criteria, there is an output criteria for another of the location requests that is different from said at least one output criteria;

first transmitting said first output location data to its corresponding destination via a communications network; and

second transmitting said second output location data to its corresponding destination via a communications network, the first and second locations being different.

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248. (Previously Presented) The method of Claim 247, wherein for at least one of said location techniques of said first set, and for a different one of said location techniques of said second set there is a common predetermined interface at which said first and second location information are received.

249. (Previously Presented) The method of Claim 247, wherein said steps of first and second determining use at least one common mobile station location related component for determining, respectively, said first output location data and said second output location data

250. (Previously Presented) The method of Claim 247, wherein said steps of first and second transmitting includes outputting said first and second output location data via a common predetermined network interface.

251. (Previously Presented) The method of Claim 247, wherein said first determining step includes accessing mobile station location output frequency information of said first output criteria.

Claim 252 was previously cancelled.

253. (Previously Presented) The method of Claim 247, wherein at least one of said first determining and said first transmitting steps includes determining a particular protocol for outputting said first output location data on the communication network for transmission to the corresponding destination for the first location request.

254. (Previously Presented) The method of Claim 247, wherein said first output criteria includes information for determining said representation of said first geographical location using a location of a known geographical feature different from the communication stations.

255. (Previously Amended) The method of Claim 254, wherein the known geographical feature includes a roadway, and said determining step includes snapping to the roadway.

256. (Previously Presented) The method of Claim 247, wherein said corresponding destination for said first location request is for a first application, and said corresponding destination for said second location request is for a second application, wherein said first and second applications, respectively, use said first and second output location data differently;

wherein said first and second applications are for corresponding different ones of the following: responding to emergency calls, tracking, routing, and animal location including applications for confinement to or exclusion from certain areas.

Claim 257 was previously cancelled.

258. (Previously Presented) The method of Claim 247, wherein said corresponding destination for said first location request is for a first application, and said corresponding destination for said second location request is for a second application;

wherein said first output criteria includes information for determining a first location granularity at which a location estimate of the first mobile station is transmitted in said first output location data, wherein said first location granularity is dependent upon said first application.

259. (Previously Presented) The method of Claim 247, wherein said corresponding destination for said first location request is for a first application, and said corresponding destination for said second location request is for a second application;

wherein said first output criteria includes information for determining a first representation for said first output location data, wherein said first representation is dependent upon said first application, and said second output criteria includes information for determining a second representation for said second output location data, wherein said second representation is dependent upon said second application.

Claims 260 and 261 were previously cancelled.

262. (Previously Presented) The method of Claim 247, wherein at least one of said steps of receiving, first obtaining, second obtaining, first transmitting, and second transmitting receives or transmits wireless location related information on TCP/IP network.

263. (Previously Presented) The method of Claim 247, wherein said step of first obtaining includes receiving a first location estimate from a first of said location determining sources which performs an instance, I_1, of a first technique for estimating a location of the first mobile station using signal transmissions to the first mobile station from non-terrestrial transmitters above and not supported on the Earth's surface, wherein said instance I_1 also uses wireless signals, S, between the first mobile station and at least one of the communication stations to improve at least one performance characteristic of said instance I_1 over a performance of I_1 without use of the wireless signals between the first mobile station and the at least one communication station.

264. (Previously Presented) The method of Claim 263, wherein the instance I_1 uses first information for locating the first mobile station, wherein the first information is dependent upon signal timing measurements from the wireless signals S.

265. (Previously Presented) The method of Claim 263, wherein the instance I_1 uses first information from the wireless signals S, wherein the first information is dependent upon a wireless coverage area of the at least one communication station.

266. (Previously Presented) The method of Claim 247, further including a step of providing display information for displaying a representation of a location estimate L of the first mobile station, wherein said display information is for displaying a map of an area having the location estimate L, and for concurrently displaying information indicating an accuracy of the location estimate L.

267. (Previously Presented) The method of Claim 266, wherein said display information is displayed at a mobile station M that has requested a location of the first mobile station.

268. (Previously Presented) A method for locating a first wireless mobile station using measurements of wireless signals, wherein at least one of: (i) said measurements, and (ii) said wireless signals are transmitted between the first mobile station and at least one of a plurality of terrestrial transceivers, and for locating a second wireless mobile station using second measurements of second wireless signals, where at

least one of: (1) said second measurements, and (2) said second wireless signals are transmitted between the second mobile station and at least one of the plurality of terrestrial transceivers, wherein said transceivers are capable of at least wirelessly detecting a plurality of wireless transmitting mobile stations, including said first and second mobile stations, comprising:

providing access to first and second different mobile station location techniques, wherein each of said location techniques is capable of providing location information for each mobile station of at least some of said mobile stations when said location technique is supplied with corresponding data obtained from wireless signal measurements communicated between the mobile station and one or more of said plurality of transceivers, wherein for at least one location L of one of the mobile stations, said first location technique and said second location technique output, respectively, first and second position information related to the one mobile station being at L wherein neither of the first and second position information is dependent upon a change in the other;

first supplying said first location technique with first corresponding data obtained from wireless signal measurements communicated between one or more of: (a1) said first mobile station and one or more of said plurality of transceivers, and (a2) said second mobile station and one or more of said plurality of transceivers;

second supplying said second location technique with second corresponding data obtained from wireless signal measurements communicated between one or more of: (b1) said first mobile station and one or more of said plurality of transceivers, and (b2) said second mobile station and one or more of said plurality of transceivers;

first receiving from said first location technique, first location related information representing one or more of: a first range of locations for the first mobile station, and a second range of locations for the second mobile station;

second receiving from said second location technique, second location related information representing one or more of: a third range of locations for the first mobile station, and a fourth range of locations for the second mobile station;

determining resulting location information for each of the first and second mobile stations using at least one of: (c1) a first value obtained from said first location related information, and (c2) a second value obtained from said second location related information;

wherein there is at least one predetermined common location related component activated for determining the resulting location information for each of said first and second mobile stations, wherein:

(i) said common component is activated, for locating said first mobile station, after at least one step of said steps of first and second supplying, and

(ii) said common component is activated, for locating said second mobile station, after at least one step of said steps of first and second supplying;

providing said resulting location information for each of the first and second mobile stations for presentation, wherein said presentation for at least one of said first and second mobile stations is determined according to an expected accuracy of said resulting location information for the at least mobile station.

269. (Previously Presented) A method for locating a wireless mobile station, comprising:

repeatedly performing the following steps (A1) through (A3) for tracking the mobile station, wherein there is at least a first and a second mobile station location technique, each of the location techniques providing an instance of location information for a location of the mobile station to the step (A1) below at some time during said step of repeatedly performing;

wherein for at least one location L of the mobile station, said first mobile station location technique and said second mobile station location technique output location information instances having, respectively, first and second position information for the mobile station being at L, wherein neither of the first and second position information varies substantially as a result in a change in the other;

(A1) receiving an instance, I_1, of location information for the mobile station from at least one of the first and a second mobile station location techniques wherein I_1 includes position information for the mobile station;

(A2) determining at least one resulting instance of location information for said mobile station using at least one of: (a) a first value obtained from an instance of first location information received from said first location technique, and (b) a second value obtained from an instance of second location information received from said second location technique;

wherein said step of determining includes a step of determining a likely roadway upon which the mobile station is located;

(A3) outputting said resulting location information for display on a display device, wherein said resulting location information is displayed as at least one location of the mobile station on a map having roadways thereon.

270. (Previously Presented) The method of Claim 269, wherein at least one occurrence of said step of outputting includes transmitting said resulting location information via a telephony network.

271. (Previously Presented) The method of Claim 269, wherein said outputting step includes providing accuracy information indicating an accuracy of said resulting location information, wherein said accuracy information is displayed with said at least one location of the mobile station.

272. (Previously Presented) The method of Claim 269, wherein for at least one location of the mobile station said step of determining uses both said first and second values.

Claims 273 through 275 were previously cancelled.

276. (Previously Presented) A method for locating, from a plurality of wireless mobile stations, one of the wireless mobile stations using measurements of wireless signals, wherein at least one of: (i) said measurements and (ii) said wireless signals are transmitted between said one mobile station and at least one of a plurality of fixed location communication stations, each communication station capable of at least one of receiving wireless signals from, and transmitting wireless signals to said one mobile station, comprising:

receiving, from each of at least first and second mobile station location estimators, corresponding first and second information related to likely geographical approximations for a location of said one mobile station, wherein:

(a) for determining a likely geographical approximation, GA_A, for a location, L_A, of a second of the mobile stations at a time T_A, said first location estimator generates GA_A without requiring a prior likely geographical location approximation generated by said second location estimator for locating the second mobile station at substantially the location L_A at substantially the time T_A, and,

(b) for estimating a likely geographical approximation, $GA_{B,}$ for a location, L_B, of a third one of the mobile stations at a time T_B, said second location estimator generates GA_B without requiring a prior likely geographical location approximation generated by said first location estimator for locating the third mobile station at the location L_B at substantially the time T_B;

determining a resulting location estimate of said one mobile station, wherein said step of determining includes at least one of the substeps (B1) through (B2) following:

(B1) when said first and second information include, respectively, first and second likely geographical approximations, combining said first and second likely geographical approximations so that said resulting location estimate is dependent on each of said first and second location likely geographical approximations; and

(B2) selecting one of said first and second information for receiving preference in determining said resulting location, wherein said selecting is dependent upon location related data in at least one of said first and second information.

277. (Previously Presented) The method of Claim 276, further including a step of providing display information for: (a) displaying a representation of said resulting location estimate, wherein said

display information is for displaying with a map of an area having the resulting location estimate, and (b) concurrently displaying information indicative of an accuracy of the resulting location estimate.

278. (Previously Presented) A method for locating a wireless mobile station capable of wireless two way communication with a plurality of fixed location terrestrial stations, comprising:

providing access to a plurality of mobile station location estimating techniques, wherein each said location technique provides location information having a location estimate of said mobile station when said location technique is supplied with sufficient corresponding input information upon which the location estimate is dependent, and wherein the corresponding input information is at least partially derived from measurements of wireless signals transmitted from or received at the mobile station;

receiving, over time, a plurality of location estimates of the mobile station;

determining, a plurality of consecutive resulting location estimates for tracking the mobile station, wherein said step of determining includes steps (a) and (c) following:

(a) deriving, for at least one time during the tracking, a corresponding one of said resulting location estimates of the mobile station using one of said location estimates by said first location technique for locating the mobile station;

(b) deriving, for at least one time during the tracking, a corresponding one of said resulting location estimates of the mobile station using one of said location estimates by said second location technique for locating the mobile station;

(c) preferring a location estimate of said first location technique over a location estimate of said second location technique when both are available for substantially a same location of the mobile station.

279. (Previously Presented) The method as claimed in Claim 278, wherein said step of determining includes:

establishing a priority between a location estimate of said first location technique and a location estimate of said second location technique.

280. (Previously Presented) The method as claimed in Claim 279, wherein said step of establishing includes obtaining a confidence value for one or more of: (a) at least one of said location estimates for said first location technique; and (b) at least one of said location estimates for said second location technique;

wherein each said confidence value is indicative of a likelihood of the mobile station having a location represented by said corresponding location estimate for the confidence value.

Claim 281 was previously cancelled.

282. (Previously Presented) The method of Claim 278, further including the steps of: requesting one or more of the resulting location estimates via signals transmitted on the Internet .

283. (Previously Presented) The method of Claim 278, wherein said determining step includes determining at least one of said resulting location estimates as a function of a position of a known geographical feature that is sufficiently close to one of the first or second location estimates so that the closeness is used to determine said more likely location estimate.

284. (Previously Presented) The method as claimed in Claim 278, wherein said step of determining includes, for at least one of said resulting location estimates, determining one or more of: (a) a velocity of the mobile station, (b) an acceleration of the mobile station, and (c) one or more geographical features near said at least one resulting location estimate.

285. (Previously Presented) A method for locating a mobile station using wireless signal measurements obtained from transmissions between said mobile station and a plurality of fixed location communication stations, wherein each of said communications stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile station, comprising:

providing access to first and second mobile station location evaluators, wherein said location evaluators are able to determine information related to one or more location estimates of said mobile station when said location evaluators are supplied with data having values obtained during wireless signal two way communication between said mobile station and the communication stations;

wherein for at least one location L of the mobile station, said first mobile station location evaluator and said second mobile station location evaluator output location information instances having, respectively, first and second position information for the mobile station being at L, wherein neither of the first and second position information substantially changes with a change in the other of the first and second position information;

first obtaining, from said first location evaluator, first location related information for identifying a location of the mobile station for at least one of the following situations: a tracking of the mobile station, and in response to a request for a location of the mobile station;

second obtaining, from said second location evaluator, second location related information for identifying a location of the mobile station for said same at least one situation;

determining resulting location information of the mobile station dependent upon at least one of: (a) a first value obtained from said first location related information, and (b) a second value obtained from said second location related information;

wherein said determining step includes providing the resulting location information with:

(i) data indicative of one of: an error and a likelihood of the mobile station being at a location represented by said resulting location information; and

(ii) a timestamp indicative of when the resulting location information corresponds to a location of the mobile station.

286. (Currently Amended) The method as claimed in Claim 285, wherein said mobile station is co-located with a processor for activating at least one of said location evaluators, said processor receives signals from a non-terrestrial wireless transmitter above and not supported on the Earth's surface.

287. (Previously Presented) The method of Claim 285, further including a step of transmitting said resulting location estimate on a communications network to a destination requesting the location of the mobile station.

288. (Previously Presented) The method of Claim 285, further including a step of determining, using said resulting location information, output location information according to output criteria corresponding to an application requesting data related to a location of the mobile station.

289. (Previously Presented) The method of Claim 288, wherein said output criteria includes at least some of:

(a) a transmission protocol;

(b) a granularity of by which a location estimate of the mobile station represented by said resulting location information is to be provided;

(c) a frequency with which repeated location estimates of the mobile station are to be output to the application;

(d) destination data for determining where said resulting location information is to be transmitted;

(e) an indication as to whether a location estimate of the mobile station is to be adjusted according to a known geographical feature different from the communication stations; and

(f) a desired representation of a location estimate of the mobile station represented by said resulting location information.

290. (Previously Presented) A method for locating one or more mobile stations using wireless signal measurements obtained from transmissions between said mobile stations and a plurality of terrestrial communication stations, wherein each of said communication stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile stations, comprising:

receiving a location request for a location of a first of the mobile stations, wherein the first mobile station is capable of providing wireless telephony transmissions, and the first mobile station includes a substantially same collection of components that are in electronic contact with one another for performing each of at least most wireless telephony transmissions from the first mobile station;

generating one or more messages, for information related to a location of said first mobile station, said messages for requesting activation of one or more mobile station location estimators such that when said location estimators are supplied with corresponding input data having values obtained from wireless signal measurements obtained via transmissions between said first mobile station and the communication stations, said one or more location estimators determine location related information for the first mobile station;

first obtaining, from at least two of said location estimators, first mobile station related location information obtained as a result of an available at least two instances of said corresponding input data;

determining a resulting location estimate of the first mobile station obtained from said first mobile station related location information;

wherein at least one of said steps of generating, first obtaining, and determining includes a substep of one of: (i) transmitting information to a destination via a communication network, and (ii) receiving information from a source via a communication network;

using said resulting location information, to determine output location information according to output criteria corresponding to an application requesting data related to a location of the mobile station, wherein said output criteria includes at least some of:

(a) a transmission protocol;

(b) a granularity of by which a location estimate of the mobile station represented by said resulting location information is to be provided;

(c) a frequency with which repeated location estimates of the mobile station are to be output to the application;

(d) destination data for determining where said resulting location information is to be transmitted;

(e) an indication as to whether a location estimate of the mobile station is to be adjusted according to a known geographical feature different from the communication stations; and

(f) a desired representation of a location estimate of the mobile station represented by said resulting location information.

291. (Previously Presented) A method for locating a mobile station using wireless signal measurements obtained from transmissions between said mobile station and at least one of a plurality of terrestrial transceivers capable of wirelessly detecting said mobile station, comprising:

providing access to at least two location techniques;

determining whether an accessible first of the location techniques has its corresponding input available for determining a first location estimate of said mobile station;

determining a second location estimate of said mobile station by activating an accessible second of said location techniques different from said first location technique when the corresponding input for said second technique is available;

receiving at least one of said first and second location estimates;

obtaining resulting location information for transmitting on a communications network, wherein said resulting location information is obtained using at least one of said first location estimate and said second location estimate;

wherein when said mobile station is at a first location, an instance of at least said first location estimate is used in said obtaining step for obtaining a first corresponding instance of said resulting location information, and when said mobile station is at a second location, an instance of at least said second location estimate is used in said obtaining step for obtaining a second corresponding instance of said resulting location information; and

wherein for the first location, said obtaining step includes: (1) a step of improving upon said instance of at least said first location estimate, and (2) a step of providing information indicative of an accuracy of said first corresponding instance of said resulting location information.

292. (Previously Presented) A mobile station location system, comprising:

a gating module for communicating with two or more mobile station location estimating sources for determining corresponding geographic extents for locations of a plurality of mobile stations, such that for each mobile station **M** of at least some of the mobile stations, when one or more of the estimating sources are supplied with corresponding data obtained from measurements of wireless signals transmitted between the mobile station **M**, and at least one of (1) and (2) following:

(1) a plurality of communication stations capable of at least one of: wirelessly detecting said mobile stations, and being wirelessly detected by said mobile stations, and

(2) one or more non-terrestrial wireless signal transmitting stations,

then for said one or more location estimating sources supplied with their corresponding data, each such source outputs a corresponding geographic extent of a geographical location of the mobile station **M**;

wherein for a first of said mobile station location estimating sources, and for a second of said mobile station location estimating sources, for at least one instance of locating one of the mobile stations, said first and second sources can provide if activated, respectively, first and second different corresponding geographic extents for the one mobile station;

wherein the first corresponding geographic extent is not dependent upon the second corresponding geographic extent,and the second geographic extent is not dependent upon the first geographic extent;

wherein said gating module communicates on a communications network with at least the first of the location estimating sources for providing said location system with said corresponding geographic extent for a location L of the mobile station **M**; and

a resulting estimator for determining a likely location estimate of the location L of the mobile station **M** using two or more of said corresponding geographic extents for the mobile station **M**, said resulting estimator activating at least one of: (i) a selector for giving preference, as more indicative of the location L, to at least one geographic extent obtained from said corresponding geographic extents, and (ii) a combiner for combining said two or more corresponding geographic extents for obtaining said likely location estimate.

293. (Previously Presented) The location system, as claimed in Claim 292, wherein one or more of said estimating sources are capable of being at least one of: added, replaced and deleted by transmissions on a communication network between a portion of said location system and a site remote from said portion.

294. (Previously Presented) The location system as claimed in Claim 292, wherein two or more of:

(a) at least one of said one or more corresponding geographic extents, GE, has a corresponding value therewith indicative of a likelihood that the mobile station **M** resides in a geographical area represented by GE, and said combiner uses said corresponding value for obtaining said likely location estimate;

(b) said non-terrestrial wireless signal transmitting stations include GPS satellites;

(c) said communications network includes a portion of the Internet;

(d) the mobile station **M** has an ability to communicate with other of the mobile stations as a base station;

(e) said selector includes a filter for reducing a dependence of said likely location estimate on one of the corresponding geographic extents;

(f) said resulting estimator is at least partially included in a mobile base station; and

(g) said gating module routes activation information to said two or more estimating sources.

295. (Previously Presented) A mobile station location system, comprising:

a communications controller for selectively communicating with a plurality of mobile station location estimating sources for at least one of (1) and (2) following:

(1) activating a selected one or more of said mobile station location estimating sources; and

(2) receiving location related information for locating a plurality of mobile stations;

wherein for each mobile station **M** of at least some of the mobile stations, when one or more of said location estimating sources are supplied with corresponding data obtained from measurements of wireless signals transmitted between (i) and (ii) following:

(i) the mobile station **M**, and

(ii) at least one of: a network of communication stations cooperatively linked for use in locating the mobile stations, and one or more non-terrestrial wireless signal transmitting stations,

then each such source supplied with its corresponding data, outputs a corresponding location estimate of a geographical location of the mobile station **M**;

wherein for a first of said mobile station location estimating sources, when estimating a location L_1 of one of the mobile stations, said first source is dependent upon a result from a first location computing component for computing the location L_1, and for a second of said mobile station location estimating sources, when estimating a location L_2 of one of the mobile stations, said second source is dependent upon a result from a different second location computing component, wherein the first source is not dependent upon on an output from the second location computing component when estimating the mobile at the location L_1, and the second location computing component is not dependent upon an output from the first location computing component when estimating the mobile at the location L_2;

wherein for at least one instance of locating one of the mobile stations, said first and second sources can provide, if activated, different location estimates;

an interface in communication with said controller, said interface for communicating on a communications network with at least one of said first and second location estimating sources for thereby at least one of (3) and (4) following:

(3) requesting activation of said at least one location estimating source, and

(4) receiving, from said at least one location estimating source, said corresponding location estimate of the mobile station **M**;

a resulting estimator for determining a likely location estimate of a location L of the mobile station **M** using two or more of said corresponding location estimates for the mobile station **M** at L, wherein said resulting estimator includes at least one of:

(i) a selector for giving preference, as more indicative of the location L, to at least one preferred location estimate obtained from said corresponding location estimates; and

(ii) a combiner for obtaining said likely location estimate as a function of said two or more of said corresponding location estimates.

296. (Previously Presented) The method of Claim 221, wherein said common standardized format defines a plurality of location related data fields, each field having a common data representation for both of said first and second location inputs, said fields for including: (a) information indicative of one of: an error, and a confidence of the first mobile station being in a corresponding location estimate of the first mobile station, and (b) time related information indicative of when the first mobile station is in the corresponding location estimate.

297. (Previously Presented) The method of Claim 221, wherein said common standardized format defines a plurality of location related data fields, each field having a common data representation for both of said first and second location inputs, said fields for including information for identifying a corresponding one of the first and second location estimating sources.

298. (Previously Presented) The method of Claim 221, wherein said common standardized format defines a plurality of location related data fields, each field having a common data representation for both of said first and second location inputs, said fields for including descriptor having information indicative of location related processing performed by a corresponding one of the first and second location estimating sources.

299. (Previously Presented) The method of Claim 221, wherein said data includes first data for said first location input, and second data for said second location input, and said step of third obtaining includes a step of providing a preference to the first data over the second data when determining said requested information.

300. (Previously Presented) The method of Claim 245, wherein at least one of the wireless signal measurements for obtaining at least one of the values of the corresponding input data for the first location evaluator is such that this at least one wireless signal measuremt is for a wireless signal having its source as a non-terrestrial wireless transmitter above and not supported on the Earth's surface.

301. (Previously Presented) The method of Claim 247, wherein for locating at least one of the first and second mobile stations, the corresponding one of the first and second sets for performing the locating uses data form wireless signal measurements (S) obtained via transmissions between the at least one mobile station and a plurality of fixed location terrestrial communication stations, wherein at least one of the wireless signal measuremts of S is for a wireless signal having its source as a non-terrestrial wireless transmitter above and not supported on the Earth's surface.

302. (Previously Presented) The method of Claim 269, wherein said first location technique uses a measurement of a wireless signal, S, to the mobile station and from at least one non-terrestrial transceiver above and not supported on the Earth's surface, and said second location technique uses a measurement of a wireless signal transmission, T, between the first mobile station and at least one terrestrial transceiver to improve upon of said first location.

303. (Previously Presented) The method of Claim 302, wherein said second location technique includes a step of using information dependent upon a wireless coverage area of the at least one transceiver for improving said first location information

304. (Previously Presented) The method of Claim 303, wherein the at least one transceiver includes a base station for providing two way communication with the mobile station.

305. (Previously Presented) The method of Claim 290, wherein said output criteria includes at least two of: (a), (b), (c) and (e).

Remarks

Claim Amendments

Applicants request entry of the claim amendments provided herein. The only amendment herein is the amendment to Claim 286 to include marking to show changes relative to the immediately prior version of this claim.

Note that if additional fees are due, then the Applicant respectfully requests notification of the Applicant named below so that any additional fees can be timely paid.

Respectfully submitted,

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Filing Date:	26-Jan-2001
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Filer:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 3 months with $0 paid	2253	1	555	555

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**555**

Electronic Acknowledgement Receipt

EFS ID:	4286497
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Customer Number:	62914
Filer:	Dennis Jay Dupray.
Filer Authorized By:	
Attorney Docket Number:	1003-1
Receipt Date:	13-NOV-2008
Filing Date:	26-JAN-2001
Time Stamp:	17:38:55
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$555
RAM confirmation Number	3066
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1		Amendmt_Resp_11-13-08.pdf	201466 fccb7b283185f72a8c71a34feda025948be61e7d	yes	23

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment After Final	1	1
Claims	2	22
Applicant Arguments/Remarks Made in an Amendment	23	23

Warnings:

Information:

2	Fee Worksheet (PTO-06)	fee-info.pdf	30129 a03545e9b393f1e3b22c97c013af268de9396436	no	2

Warnings:

Information:

Total Files Size (in bytes):	231595

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 09/770,838	Filing Date 01/26/2001	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☒ RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	11/13/2008	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 77	Minus	** 77	= 0	X $26 =	0	OR	X $ =	
	Independent (37 CFR 1.16(h))	* 12	Minus	***12	= 0	X $110 =	0	OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE	**0**	OR	TOTAL ADD'L FEE	

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/SONYA R. HILLIARD/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

62914 7590 12/15/2008

DENNIS DUPRAY
1801 BELVEDERE DR.
GOLDEN, CO 80401

EXAMINER	
PHAN, DAO LINDA	
ART UNIT	PAPER NUMBER
3662	

DATE MAILED: 12/15/2008

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

TITLE OF INVENTION: GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$0	$700	$755	03/16/2009

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

62914 7590 12/15/2008

DENNIS DUPRAY
1801 BELVEDERE DR.
GOLDEN, CO 80401

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

TITLE OF INVENTION: GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$0	$700	$755	03/16/2009

EXAMINER	ART UNIT	CLASS-SUBCLASS
PHAN, DAO LINDA	3662	342-450000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 ____________________

2 ____________________

3 ____________________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee
❑ Publication Fee (No small entity discount permitted)
❑ Advance Order - # of Copies ____________________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.
❑ Payment by credit card. Form PTO-2038 is attached.
❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number ____________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ______________________________ Date ______________________________

Typed or printed name ______________________________ Registration No. ______________________________

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

62914 7590 12/15/2008

DENNIS DUPRAY
1801 BELVEDERE DR.
GOLDEN, CO 80401

EXAMINER	
PHAN, DAO LINDA	
ART UNIT	PAPER NUMBER
3662	

DATE MAILED: 12/15/2008

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 73 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 73 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

Notice of Allowability	**Application No.** 09/770,838	**Applicant(s)** DUPRAY ET AL.	
	Examiner Dao L. Phan	**Art Unit** 3662	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to _11/13/08_.
2. ☒ The allowed claim(s) is/are _221-251,253-256,258,259,262-272,276-280 and 282-305_.
3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date See Continuation Sheet
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

Continuation of Attachment(s) 3. Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date: 3/16/2008 & 10/17/2008.

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	09770838	DUPRAY ET AL.
	Examiner	**Art Unit**
	Dao L Phan	3662

ORIGINAL		INTERNATIONAL CLASSIFICATION					
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED
342	450	G	0	1	S	3 / 02 (2006.01.01)	

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
342	457				

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		40		79		118		157		196	15	235		274
	2		41		80		119		158		197	16	236		275
	3		42		81		120		159		198	17	237	49	276
	4		43		82		121		160		199	18	238	50	277
	5		44		83		122		161		200	19	239	51	278
	6		45		84		123		162		201	20	240	52	279
	7		46		85		124		163		202	21	241	53	280
	8		47		86		125		164		203	22	242		281
	9		48		87		126		165		204	23	243	54	282
	10		49		88		127		166		205	24	244	55	283
	11		50		89		128		167		206	25	245	56	284
	12		51		90		129		168		207	26	246	57	285
	13		52		91		130		169		208	27	247	58	286
	14		53		92		131		170		209	28	248	59	287
	15		54		93		132		171		210	29	249	60	288
	16		55		94		133		172		211	30	250	61	289

NONE

(Assistant Examiner) (Date)

Total Claims Allowed:

77

/Dao L Phan/
Primary Examiner.Art Unit 3662 12/5/2008

(Primary Examiner) (Date)

O.G. Print Claim(s)	O.G. Print Figure
49	5

Issue Classification	**Application/Control No.** 09770838	**Applicant(s)/Patent Under Reexamination** DUPRAY ET AL.
	Examiner Dao L Phan	**Art Unit** 3662

☐ **Claims renumbered in the same order as presented by applicant** ☐ **CPA** ☐ **T.D.** ☐ **R.1.47**

	17		56		95		134		173		212	31	251	62	290
	18		57		96		135		174		213		252	63	291
	19		58		97		136		175		214	32	253	64	292
	20		59		98		137		176		215	33	254	65	293
	21		60		99		138		177		216	34	255	66	294
	22		61		100		139		178		217	35	256	67	295
	23		62		101		140		179		218		257	68	296
	24		63		102		141		180		219	36	258	69	297
	25		64		103		142		181		220	37	259	70	298
	26		65		104		143		182	1	221		260	71	299
	27		66		105		144		183	2	222		261	72	300
	28		67		106		145		184	3	223	38	262	73	301
	29		68		107		146		185	4	224	39	263	74	302
	30		69		108		147		186	5	225	40	264	75	303
	31		70		109		148		187	6	226	41	265	76	304
	32		71		110		149		188	7	227	42	266	77	305
	33		72		111		150		189	8	228	43	267		
	34		73		112		151		190	9	229	44	268		
	35		74		113		152		191	10	230	45	269		
	36		75		114		153		192	11	231	46	270		
	37		76		115		154		193	12	232	47	271		
	38		77		116		155		194	13	233	48	272		
	39		78		117		156		195	14	234		273		

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 77	
/Dao L Phan/ Primary Examiner.Art Unit 3662 (Primary Examiner)	12/5/2008 (Date)	O.G. Print Claim(s) 49	O.G. Print Figure 5

Index of Claims	Application/Control No. 09770838	Applicant(s)/Patent Under Reexamination DUPRAY ET AL.
	Examiner Dao L Phan	Art Unit 3662

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/05/2008								
	1	-								
	2	-								
	3	-								
	4	-								
	5	-								
	6	-								
	7	-								
	8	-								
	9	-								
	10	-								
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	35	-								
	36	-								

Index of Claims	Application/Control No. 09770838	Applicant(s)/Patent Under Reexamination DUPRAY ET AL.
	Examiner Dao L Phan	Art Unit 3662

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/05/2008								
	37	-								
	38	-								
	39	-								
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	65	-								
	66	-								
	67	-								
	68	-								
	69	-								
	70	-								
	71	-								
	72	-								

Index of Claims	Application/Control No. 09770838	Applicant(s)/Patent Under Reexamination DUPRAY ET AL.
	Examiner Dao L Phan	Art Unit 3662

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/05/2008								
	73	-								
	74	-								
	75	-								
	76	-								
	77	-								
	78	-								
	79	-								
	80	-								
	81	-								
	82	-								
	83	-								
	84	-								
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	99	-								
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	101	-								
	102	-								
	103	-								
	104	-								
	105	-								
	106	-								
	107	-								
	108	-								

Index of Claims	Application/Control No. 09770838	Applicant(s)/Patent Under Reexamination DUPRAY ET AL.
	Examiner Dao L Phan	Art Unit 3662

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/05/2008								
	109	-								
	110	-								
	111	-								
	112	-								
	113	-								
	114	-								
	115	-								
	116	-								
	117	-								
	118	-								
	119	-								
	120	-								
	121	-								
	122	-								
	123	-								
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	135	-								
	136	-								
	137	-								
	138	-								
	139	-								
	140	-								
	141	-								
	142	-								
	143	-								
	144	-								

Index of Claims	Application/Control No. 09770838	Applicant(s)/Patent Under Reexamination DUPRAY ET AL.
	Examiner Dao L Phan	Art Unit 3662

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/05/2008								
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	146	-								
	147	-								
	148	-								
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	154	-								
	155	-								
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	157	-								
	158	-								
	159	-								
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	172	-								
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	175	-								
	176	-								
	177	-								
	178	-								
	179	-								
	180	-								

Index of Claims	Application/Control No. 09770838	Applicant(s)/Patent Under Reexamination DUPRAY ET AL.
	Examiner Dao L Phan	Art Unit 3662

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/05/2008								
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	182	-								
	183	-								
	184	-								
	185	-								
	186	-								
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	211	-								
	212	-								
	213	-								
	214	-								
	215	-								
	216	-								

Index of Claims	Application/Control No. 09770838	Applicant(s)/Patent Under Reexamination DUPRAY ET AL.
	Examiner Dao L Phan	Art Unit 3662

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/05/2008								
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	218	-								
	219	-								
	220	-								
1	221	=								
2	222	=								
3	223	=								
4	224	=								
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27	247	=								
28	248	=								
29	249	=								
30	250	=								
31	251	=								
	252	-								

Index of Claims	Application/Control No. 09770838	Applicant(s)/Patent Under Reexamination DUPRAY ET AL.
	Examiner Dao L Phan	Art Unit 3662

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/05/2008								
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33	254	=								
34	255	=								
35	256	=								
	257	-								
36	258	=								
37	259	=								
	260	-								
	261	-								
38	262	=								
39	263	=								
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41	265	=								
42	266	=								
43	267	=								
44	268	=								
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46	270	=								
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	273	-								
	274	-								
	275	-								
49	276	=								
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52	279	=								
53	280	=								
	281	-								
54	282	=								
55	283	=								
56	284	=								
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58	286	=								
59	287	=								
60	288	=								

Index of Claims	Application/Control No. 09770838	Applicant(s)/Patent Under Reexamination DUPRAY ET AL.
	Examiner Dao L Phan	Art Unit 3662

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/05/2008								
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62	290	=								
63	291	=								
64	292	=								
65	293	=								
66	294	=								
67	295	=								
68	296	=								
69	297	=								
70	298	=								
71	299	=								
72	300	=								
73	301	=								
74	302	=								
75	303	=								
76	304	=								
77	305	=								

Search Notes	Application/Control No. 09770838	Applicant(s)/Patent Under Reexamination DUPRAY ET AL.
	Examiner Dao L Phan	**Art Unit** 3662

SEARCHED

Class	Subclass	Date	Examiner
342	357.01, 357.06, 450, 453, 457, 463-465	3/6/2003	dp
455	456.2, 456.6		
Above updated		8/23/2003	dp
Updated		4/13/2004	dp
Updated		6/7/2006	dp
Updated		4/18/2007	dp
Updated		12/5/2008	dp

SEARCH NOTES

Search Notes	Date	Examiner
East text search (See searched history printout)	6/7/2006	dp
Updated	4/18/2007	dp
Updated	12/5/2008	dp

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner
PGPub text search - See interference searched printout		6/7/2006	dp
Updated		12/5/2008	dp

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	Phan, Dao Linda
	Attorney Docket Number	1003-1

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
/D.P./	1	5969673		1999-10-19	Bickley	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

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FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
/D.P./	1	PCT/IS95/07251	US		1995-12-14	Otten		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	Phan, Dao Linda
	Attorney Docket Number	1003-1

	1		☐
If you wish to add additional non-patent literature document citation information please click the Add button Add			

EXAMINER SIGNATURE			
Examiner Signature	/Dao Phan/	Date Considered	12/05/2008

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	PHAN, DAO LINDA
	Attorney Docket Number	1003-1

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
/D.P./	1	5202829		1993-04-13	Geier	
/D.P./	2	5343209		1994-08-30	Sennott et al.	
/D.P./	3	5555286		1996-09-10	Tendler	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
/D.P./	1	95/03598	WO		1995-02-02	WESBY, Philip, Bernard		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	09770838
	Filing Date	2001-01-26
	First Named Inventor	Dupray
	Art Unit	3662
	Examiner Name	PHAN, DAO LINDA
	Attorney Docket Number	1003-1

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T5
	1		☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/Dao Phan/	Date Considered	12/05/2008

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

62914 7590 12/15/2008

DENNIS DUPRAY
1801 BELVEDERE DR.
GOLDEN, CO 80401

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of EFILING

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

Dennis J. Dupray	(Depositor's name)
/Dennis J. Dupray/	(Signature)
March 16, 2009	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	01/26/2001	Dennis J. Dupray	1003-1	8410

TITLE OF INVENTION: GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$0	$700	$755	03/16/2009

EXAMINER	ART UNIT	CLASS-SUBCLASS
PHAN, DAO LINDA	3662	342-450000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Dennis J. Dupray
2 ____
3 ____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: TracBeam LLC

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Golden, Colorado

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

☒ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies ____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

☐ A check is enclosed.
☒ Payment by credit card. **Paid electronically via PAIR website**
☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number ____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /Dennis J. Dupray/ Date March 16, 2009

Typed or printed name Dennis J. Dupray Registration No. 46,299

Electronic Patent Application Fee Transmittal

Application Number:	09770838
Filing Date:	26-Jan-2001
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Filer:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	2501	1	755	755
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**755**

Electronic Acknowledgement Receipt

EFS ID:	4977845
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Customer Number:	62914
Filer:	Dennis Jay Dupray.
Filer Authorized By:	
Attorney Docket Number:	1003-1
Receipt Date:	16-MAR-2009
Filing Date:	26-JAN-2001
Time Stamp:	20:38:39
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$755
RAM confirmation Number	5732
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Issue Fee Payment (PTO-85B)	Fee_Transmittal_Filed.pdf	164294 3fde40fb631cac72f3b0d9ad1a8912e321438871	no	1
Warnings:					
Information:					
2	Fee Worksheet (PTO-06)	fee-info.pdf	29802 5fd8025412136ee5a3ef2b46a66e7b4595d3c56d	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	194096	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/770,838	04/28/2009	7525484	1003-1	8410

62914 7590 04/08/2009

DENNIS DUPRAY
1801 BELVEDERE DR.
GOLDEN, CO 80401

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 72 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Dennis J. Dupray, Golden, CO;
Charles L. Karr, Tuscaloosa, AL;

IR103 (Rev. 11/05)

TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT	Docket Number (Optional) 1003-1

In re Application of: Dennis J. Dupray et al.

Application No.: 09/770,838

Filed: September 30, 2002

For: Gateway and Hybrid Solutions for Wireless Location

The owner*, TracBeam LLC, of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term **prior patent** No. 7,764,231 as the term of said prior patent is defined in 35 U.S.C. 154 and 173, and as the term of said **prior patent** is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the **prior patent** are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term as defined in 35 U.S.C. 154 and 173 of the **prior patent**, "as the term of said **prior patent** is presently shortened by any terminal disclaimer," in the event that said **prior patent** later:

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- is found invalid by a court of competent jurisdiction;
- is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
- has all claims canceled by a reexamination certificate;
- is reissued; or
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2. ☑ The undersigned is an attorney or agent of record. Reg. No. 46,299

/Dennis J. Dupray/ — April 21, 2011
Signature — Date

Dennis J. Dupray
Typed or printed name

(303) 863-2975
Telephone Number

☑ Terminal disclaimer fee under 37 CFR 1.20(d) included.

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Electronic Patent Application Fee Transmittal

Application Number:	09770838
Filing Date:	26-Jan-2001
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Filer:	Dennis Jay Dupray./Amy Duarte
Attorney Docket Number:	1003-1

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Statutory or terminal disclaimer	2814	4	70	280
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**280**

Electronic Acknowledgement Receipt

EFS ID:	9934878
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Customer Number:	62914
Filer:	Dennis Jay Dupray./Amy Duarte
Filer Authorized By:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1
Receipt Date:	21-APR-2011
Filing Date:	26-JAN-2001
Time Stamp:	20:26:48
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$280
RAM confirmation Number	6143
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Terminal Disclaimer Filed	1003-1_Terminal_Disclaimer_7525484_disclaim_6249252.pdf	212196 0974e2ad67faf308866cf2d6bedbdd563e69e7e4	no	2
Warnings:					
Information:					
2	Terminal Disclaimer Filed	1003-1_Terminal_Disclaimer_7525484_disclaim_7274332.pdf	212156 9dcec6b0c48ee8969e6d98eb616f8d74edbada7b	no	2
Warnings:					
Information:					
3	Terminal Disclaimer Filed	1003-1_Terminal_Disclaimer_7525484_disclaim_7298327.pdf	211835 1c13ba53aa2ded685a46a38aed22433164e3c548	no	2
Warnings:					
Information:					
4	Terminal Disclaimer Filed	1003-1_Terminal_Disclaimer_7525484_disclaim_7764231.pdf	211715 e207dde148414f8572b599ccff5758bf89c6dea4	no	2
Warnings:					
Information:					
5	Fee Worksheet (PTO-875)	fee-info.pdf	30143 903fd2f2729c720dfe00bc5ad9d6553deec931a4	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	878045		

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT	Docket Number (Optional) 1003-1

In re Application of: Dennis J. Dupray et al.

Application No.: 09/770,838

Filed: September 30, 2002

For: Gateway and Hybrid Solutions for Wireless Location

The owner*, TracBeam LLC, of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term **prior patent** No. 6,249,252 as the term of said prior patent is defined in 35 U.S.C. 154 and 173, and as the term of said **prior patent** is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the **prior patent** are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

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is found invalid by a court of competent jurisdiction;
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has all claims canceled by a reexamination certificate;
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2. ☑ The undersigned is an attorney or agent of record. Reg. No. 46,299

/Dennis J. Dupray/ — Signature

April 21, 2011 — Date

Dennis J. Dupray — Typed or printed name

(303) 863-2975 — Telephone Number

☑ Terminal disclaimer fee under 37 CFR 1.20(d) included.

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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT	Docket Number (Optional) 1003-1

In re Application of: Dennis J. Dupray et al.

Application No.: 09/770,838

Filed: September 30, 2002

For: Gateway and Hybrid Solutions for Wireless Location

The owner*, TracBeam LLC, of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term **prior patent** No. 7,298,327 as the term of said prior patent is defined in 35 U.S.C. 154 and 173, and as the term of said **prior patent** is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the **prior patent** are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

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/Dennis J. Dupray/ — April 21, 2011
Signature — Date

Dennis J. Dupray
Typed or printed name

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Docket Number (Optional)
1003-1

In re Application of: Dennis J. Dupray et al.

Application No.: 09/770,838

Filed: September 30, 2002

For: Gateway and Hybrid Solutions for Wireless Location

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/Dennis J. Dupray/ — Signature

April 21, 2011 — Date

Dennis J. Dupray — Typed or printed name

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Disclaimer and Dedication

7,525,484 B2— Dennis J. Dupray et al., Denver, CO (US). GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION. Patent dated November 20, 2007. Disclaimer filed April 21, 2011, by the assignee, TracBeam, LLC.

The term of this patent shall not extend beyond the expiration date of patent no. 7,525,484.

(*Official Gazette January 10, 2012*)

Disclaimer

7,525,484 B2—Dennis J. Dupray, Denver, CO (US); Charles L. Karr, Tuscaloosa, AL (US). GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION. Patent dated April 28, 2009. Disclaimer filed April 21, 2011, by the assignee, TracBeam LLC.

The term of this patent shall not extend beyond the expiration date of Patent Nos. 7,764,231, 6,249,252, 7,298,327 and 7,274,332.

(*Official Gazette, February 14, 2012*)

AO 120 (Rev. 2/99)

TO: Commissioner of Patents P.O. Box 1450 Alexandria, VA 22313-1450	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court ___Colorado___ on the following Patents

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
11-cv-2519	**9/27/11**	**FOR THE DISTRICT OF COLORADO**

PLAINTIFF	DEFENDANT
TeleCommunication Systems, Inc.	Tracbeam, L.L.C.

PATENT OR	DATE OF PATENT	HOLDER OF PATENT OR TRADEMARK
1 7,764,231		**Please see copy of Complaint attached hereto**
2 7,525,484		
3		
4		
5		

In the above—entitled case, the following patent(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
GREGORY C. LANGHAM		

Copy 1—Upon initiation of action, mail this copy to Commissioner Copy 3—Upon termination of action, mail this copy to Copy 2—Upon filing document adding patent(s), mail this copy to Commissioner Copy 4—Case file copy

/s/ *Edward A. Pennington*

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Attorneys for Plaintiff,
TeleCommunication Systems, Inc.

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLORADO

Civil Action No.: __________

TELECOMMUNICATION SYSTEMS, INC.,
a Maryland company,

Plaintiff,

v.

TRACBEAM, L.L.C.,
a Colorado limited liability company,

Defendant.

COMPLAINT FOR DECLARATORY JUDGMENT AND JURY DEMAND

Plaintiff, TeleCommunication Systems, Inc. ("TCS"), by and through its undersigned counsel, alleges as follows:

NATURE OF THE CASE

1. This is an action for declaratory judgment of noninfringement and invalidity of two (2) United States patents pursuant to the Declaratory Judgment Act, 28 U.S.C. §§ 2201-02, the Patent Laws of the United States, 35 U.S.C. § 1 *et seq.*, and for such relief as the Court deems just and proper.

PARTIES

2. Plaintiff TCS is a Maryland corporation with its principal place of business at 275 West Street, Annapolis, MD 21401.

3. On information and belief, Defendant TracBeam L.L.C. ("Defendant" or "TracBeam") is a limited liability company incorporated in the State of Colorado and is the owner of the patents at issue in this case. TracBeam is identified as the assignee and owner of U.S. Patent No. 7,764,231 ("the '231 patent") and U.S. Patent No. 7,525,484 ("the '484 patent") (collectively "the patents-in-suit"). TracBeam is in the business of enforcing and licensing patents. On information and belief, TracBeam does not sell or offer for sale any products.

JURISDICTION AND VENUE

4. This Court has exclusive subject matter jurisdiction pursuant to 28 U.S.C. §§ 1331 and 1338(a), 2201, and 2202, and the Patent Laws of the United States, 35 U.S.C. § 1, *et seq.*

5. This Court has personal jurisdiction over TracBeam because TracBeam is incorporated in Colorado.

6. Venue is proper pursuant to 28 U.S.C. §§ 1391(b) and (c), and 1400(b), as on information and belief, TracBeam's principal place of business is within this judicial district.

FACTS

7. According to the U.S. Patent and Trademark Office ("USPTO") Assignments Database, TracBeam is the sole assignee of U.S. Patent No. 7,764,231 entitled "Wireless Location Using Multiple Mobile Station Techniques," which issued on July 27, 2010. A copy of the '231 patent is attached as Exhibit 1.

8. The USPTO Assignments Database also reflects that TracBeam is the sole assignee of U.S. Patent No. 7,525,484 entitled "Gateway and Hybrid Solutions for Wireless Location," which issued on April 28, 2009. A copy of the '484 patent is attached as Exhibit 2.

9. On February 25, 2011, TracBeam filed suit in the Tyler Division of the United States District Court for the Eastern District of Texas against AT&T Inc., AT&T Mobility L.L.C. (collectively "AT&T"), MetroPCS Communications, Inc., MetroPCS Wireless, Inc., Texas RSA 7B3, L.P. D/B/A/ Peoples Wireless Services, Sprint Nextel Corporation, Sprint Spectrum L.P., Nextel of California, Inc., Nextel Communications of the Mid-Atlantic, Inc., Nextel of New York, Inc., Nextel South Corp., Nextel of Texas, Inc., Nextel West Corp., and Cellco Partnership d/b/a Verizon Wireless ("Cellco") (collectively "Texas Action Defendants"), accusing the defendants of infringing the '231 and '484 patents (Case No. 6:11-cv-0096) ("the *Texas* action"). On May 19, 2011, TracBeam filed an Amended Complaint adding Google, Inc., and Skyhook Wireless, Inc. as defendants. TCS is not a named party to the *Texas* action.

10. The *Texas* action generally alleges that the Texas Action Defendants' products and services for determining the locations of wireless mobile devices infringe the '231 and '484 patents. TCS is the vendor for products and services for determining the locations of wireless mobile devices to MetroPCS Communications, Inc. and MetroPCS Wireless, Inc. (collectively "MetroPCS") and Sprint Nextel Corporation, Sprint Spectrum L.P., Nextel of California, Inc., Nextel Communications of the Mid-Atlantic, Inc., Nextel of New York, Inc., Nextel South Corp., Nextel of Texas, Inc., and Nextel West Corp. (collectively "Sprint").

11. MetroPCS and Sprint have tendered indemnification demands to TCS.

12. Separately, on August 30, 2011, TracBeam sent a letter notifying TCS of its patent portfolio, including the '231 and '484 patents. The notification letter to TCS is attached as Exhibit 3.

13. According to the Amended Complaint in the *Texas* action, TracBeam notified Cellco, Sprint, and AT&T of its patent *applications* over ten years before they matured into issued patents. On information and belief, TracBeam initiated a lawsuit against Cellco, Sprint, and AT&T when they refused to take a license to the patents. TracBeam's pattern of notification and subsequent initiation of a lawsuit is indicative of TracBeam's litigious intentions when a party refuses to take a license to its patent portfolio. TracBeam's past conduct, coupled with its notice to TCS and suit against TCS customers, results in a substantial controversy between the parties that is of sufficient immediacy and reality to warrant declaratory relief.

14. TCS's products and services for determining the locations of wireless mobile devices have not infringed and do not infringe, either directly or indirectly, any valid claim of the '231 or '484 patents, either literally or under the doctrine of equivalents. A substantial controversy exists between the parties that is of sufficient immediacy and reality to warrant declaratory relief.

15. TCS believes and alleges that one or more of the claims of the '231 and '484 patents are invalid.

COUNT I

Declaration of Non-Infringement of U.S. Patent No. 7,764,231

16. TCS repeats, realleges, and incorporates by reference herein the allegations contained in paragraphs 1 through 15 as though expressly set forth herein.

17. TracBeam has alleged that at least one customer of TCS infringes the '231 patent in the United States District Court for the Eastern District of Texas with products supplied by TCS.

18. TracBeam has also put TCS on notice of its patent portfolio, including the '231 patent that has been asserted against at least one TCS customer.

19. TCS's products and services for determining the locations of wireless mobile devices have not infringed and do not infringe, directly or indirectly, any valid claim of the '231 patent, either literally or under the doctrine of equivalents.

20. As a result of the acts described in the foregoing paragraphs, there exists a substantial controversy of sufficient immediacy and reality to warrant the issuance of a declaratory judgment as to whether TCS infringes, directly or indirectly, any claim of the '231 patent.

21. A judicial declaration is necessary and appropriate so that TCS may ascertain its rights regarding the '231 patent.

COUNT II

Declaration of Invalidity of U.S. Patent No. 7,764,231

22. TCS repeats, realleges, and incorporates by reference herein the allegations contained in paragraphs 1 through 21 as though expressly set forth herein.

23. The '231 patent is invalid for failure to meet the conditions of patentability and/or otherwise comply with one or more of 35 U.S.C. §§ 100 *et seq.*, including, but not limited to, sections 101, 102, 103, and/or 112.

24. As a result of the acts described in the foregoing paragraphs, there exists a substantial controversy of sufficient immediacy and reality to warrant the issuance of a declaratory judgment regarding the invalidity of the '231 patent.

25. A judicial declaration is necessary and appropriate so that Plaintiff TCS may ascertain its rights regarding the '231 patent.

COUNT III

Declaration of Non-Infringement of U.S. Patent No. 7,525,484

26. TCS repeats, realleges, and incorporates by reference herein the allegations contained in paragraphs 1 through 25 as though expressly set forth herein.

27. TracBeam has alleged that at least one customer of TCS infringes the '484 patent in the United States District Court for the Eastern District of Texas with products supplied by TCS.

28. TracBeam has also put TCS on notice of its patent portfolio, including the '484 patent that has been asserted against at least one TCS customer.

29. TCS's products and services for determining the locations of wireless mobile devices have not infringed and do not infringe, directly or indirectly, any valid claim of the '484 patent, either literally or under the doctrine of equivalents.

30. As a result of the acts described in the foregoing paragraphs, there exists a substantial controversy of sufficient immediacy and reality to warrant the issuance of a declaratory judgment as to whether TCS infringes, directly or indirectly, any claim of the '484 patent.

31. A judicial declaration is necessary and appropriate so that TCS may ascertain its rights regarding the '484 patent.

COUNT IV

Declaration of Invalidity of U.S. Patent No. 7,525,484

32. TCS repeats, realleges, and incorporates by reference herein the allegations contained in paragraphs 1 through 31 as though expressly set forth herein.

33. The '484 patent is invalid for failure to meet the conditions of patentability and/or otherwise comply with one or more of 35 U.S.C. §§ 100 *et seq.*, including, but not limited to, sections 101, 102, 103, and/or 112.

34. As a result of the acts described in the foregoing paragraphs, there exists a substantial controversy of sufficient immediacy and reality to warrant the issuance of a declaratory judgment regarding the invalidity of the '484 patent.

35. A judicial declaration is necessary and appropriate so that TCS may ascertain its rights regarding the '484 patent.

REQUEST FOR RELIEF

WHEREFORE, TCS respectfully requests that the Court enter judgment in favor of TCS granting the following relief:

A. A declaration that TCS does not and has not infringed, directly or indirectly, any valid claim of the patents-in-suit;

B. A declaration that the patents-in-suit are invalid for failure to meet the conditions of patentability and/or otherwise comply with the requirements of 35 U.S.C. §§ 100 *et seq.*, including, but not limited to, 101, 102, 103, and/or 112;

C. An injunction against TracBeam and others in active concert or participation with TracBeam from asserting infringement or instituting or continuing any legal action for infringement of the patents-in-suit against TCS or its suppliers, manufacturers, distributors, resellers of its products, customers, or end users of its products;

D. An order declaring that this is an exceptional case and awarding TCS its costs, expenses, disbursements, and reasonable attorney fees under 35 U.S.C. § 285 and all other applicable statutes, rules, and common law; and

E. Such other and further relief as this Court deems to be just or proper.

JURY DEMAND

TCS demands trial by jury for all claims triable by jury pursuant to Fed. R. Civ. P. 38.

Dated: September 27, 2011

Respectfully submitted,

s/ Victor M. Morales

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and

AO 120 (Rev. 08/10)

TO: **Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas, Tyler Division on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:14-cv-678	8/8/2014	Eastern District of Texas, Tyler Division

PLAINTIFF	DEFENDANT
TracBeam, L.L.C.	T-Mobile US, Inc. and T-Mobile USA, Inc.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 8,032,153 B2	10/4/2011	TracBeam, L.L.C.
2 7,764,231 B1	7/27/2010	TracBeam, L.L.C.
3 7,525,484 B2	4/28/2009	TracBeam, L.L.C.
4 7,298,327 B2	11/20/2007	TracBeam, L.L.C.
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	**DATE OF PATENT OR TRADEMARK**	**HOLDER OF PATENT OR TRADEMARK**
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

AO 120 (Rev. 08/10)

TO: **Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas, Tyler Division on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:14-cv-680	8/8/2014	Eastern District of Texas, Tyler Division
PLAINTIFF		DEFENDANT
TracBeam, L.L.C.		Apple Inc.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 8,032,153 B2	10/4/2011	TracBeam, L.L.C.
2 7,764,231 B1	7/27/2010	TracBeam, L.L.C.
3 7,525,484 B2	4/28/2009	TracBeam, L.L.C.
4 7,298,327 B2	11/20/2007	TracBeam, L.L.C.
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Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

Trials@uspto.gov
571.272.7822

Paper No. 8
Filed: December 1, 2015

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

T-MOBILE US, INC., T-MOBILE USA, INC.,
TELECOMMUNICATION SYSTEMS, INC., ERICSSON INC., and
TELEFONAKTIEBOLAGET LM ERICSSON
Petitioners,

v.

TRACBEAM, LLC
Patent Owner.

IPR2015-01682 (Patent 7,764,231)[1]
IPR2015-01684 (Patent 7,764,231)
IPR2015-01686 (Patent 7,764,231)
IPR2015-01709 (Patent 7,525,484)

Before KEVIN F. TURNER, RICHARD E. RICE, DAVID C. McKONE, JAMES A. TARTAL, BARBARA A. PARVIS, and MATTHEW R. CLEMENTS, *Administrative Patent Judges.*

TURNER, *Administrative Patent Judge.*

DECISION
Joint Motions to Terminate
37 C.F.R. § 42.71

---

[1] The parties are not authorized to use this case caption, or to file consolidated papers.

On November 24, 2015, the parties filed a Joint Motion to Terminate Proceedings in each of the above cited proceedings, as well as a Joint Submission of Narrowing Agreement in each (IPR2015-01682, Papers 8 and 9; IPR2015-01684, IPR2015-01686, and IPR2015-01709, Papers 6 and 7, in each proceeding), with joint requests to treat as confidential the submitted Narrowing Agreement (Exhibit 2001, in each proceeding).[2]

Under 35 U.S.C. § 317(a), applicable to *inter partes* review proceedings, a proceeding shall be terminated with respect to any petitioner upon the joint request of the petitioner and the patent owner, unless the Office has decided the merits of the proceeding before the request for termination is filed. These matters are in the preliminary stage. Patent Owner has not filed Preliminary Responses in any of the indicated cases, and decisions whether to institute trial have not been issued in any of the cases.

Under 35 U.S.C. § 317(b), any agreement or understanding between the Patent Owner and a Petitioner, including any collateral agreements referred to in such agreement or understanding, made in connection with, or in contemplation of, the termination of the proceeding, shall be in writing, and a true copy of such agreement or understanding shall be filed in the Office. The Narrowing Agreement appears to be a true copy of the agreement between the parties, specifies all of the affected Petitions, and identifies the claims that will continue to be asserted in the infringement action between the parties, limiting the set of claims previously asserted to be infringed. Ex. 2001. None of the identified claims are the subject of the Petitions in the proceedings that the parties seek to terminate.

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[2] The Motions and supporting documents are substantially identical in each case. Thus, for ease of reference we will refer to the filings in IPR2015-01682.

Under these circumstances, we determine that it is appropriate to dismiss the Petitions. *See* 37 C.F.R. §§ 42.5(a), 42.71(a). This paper does not constitute a final written decision pursuant to 35 U.S.C. § 318(a).

Accordingly, it is

ORDERED that the Joint Motions to Terminate Proceedings, filed in IPR2015-01682, IPR2015-01684, IPR2015-01686, and IPR2015-01709, are GRANTED; and

FURTHER ORDERED that the Narrowing Agreement, Exhibit 2001, be treated as business confidential information, be designated "Board Only," and be kept separate from the files of the involved patents.

PETITIONER:

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Paper 9
Entered: February 8, 2016

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

T-MOBILE US, INC., T-MOBILE USA, INC.,
TELECOMMUNICATION SYSTEMS, INC., ERICSSON INC., and
TELEFONAKTIEBOLAGET LM ERICSSON,
Petitioners,

v.

TRACBEAM, LLC,
Patent Owner.

Case IPR2015-01711
Patent 7,525,484 B2

Before KEVIN F. TURNER, DAVID C. McKONE, JAMES A. TARTAL, and BARBARA A. PARVIS, *Administrative Patent Judges.*

McKONE, *Administrative Patent Judge.*

DECISION
Institution of *Inter Partes* Review
37 C.F.R. § 42.108

I. INTRODUCTION

A. Background

T-Mobile US, Inc., T-Mobile USA, Inc., TeleCommunication Systems, Inc., Ericsson Inc., and Telefonaktiebolaget LM Ericsson (collectively, "Petitioner") filed a Petition (Paper 1, "Pet.") to institute an *inter partes* review of claims 27, 39, and 62 of U.S. Patent No. 7,525,484 B2 (Ex. 1002, "the '484 patent"). The parties reached agreement to remove claims 39 and 62 from the proceeding. Paper 6 (Joint Motion to Limit Petition); Paper 7 (Joint Submission of Narrowing Agreement). We accepted that agreement and limited this proceeding to claim 27. Paper 8.

Upon consideration of the Petition, we conclude, under 35 U.S.C. § 314(a), that Petitioner has established a reasonable likelihood that it would prevail with respect to claim 27. Accordingly, we institute an *inter partes* review of claim 27 of the '484 patent.

B. Related Matters

The '484 patent is the subject of several lawsuits filed in the United States District Court for the Eastern District of Texas. Pet. 2; Paper 5, 1–2.

The '484 patent also is the subject of *Apple Inc. v. TracBeam, LLC*, Case IPR2015-01696 (PTAB); *Apple Inc. v. TracBeam, LLC*, Case IPR2015-01697 (PTAB); and *T-Mobile US, Inc. v. TracBeam, LLC.*, Case IPR2015-01708 (PTAB). Pet. 1; Paper 5, 3.

Various related patents also are the subjects of these and other proceedings before the district courts and the Board. Paper 5, 1–3.

C. The Asserted Grounds

Petitioner contends that claim 27 would have been obvious, under 35 U.S.C. § 103, over Kauser (Ex. 1007, U.S. Patent No. 5,724,660, issued Mar. 3, 1998). Pet. 6.

D. The '484 Patent

The '484 patent describes location systems for wireless telecommunication infrastructures. Ex. 1002, Abstract. According to the '484 patent, the location techniques are useful for 911 emergency calls, vehicle tracking and routing, and location of people and animals. *Id.* at Abstract, 12:11–17.

Figure 4, reproduced below, illustrates an embodiment:

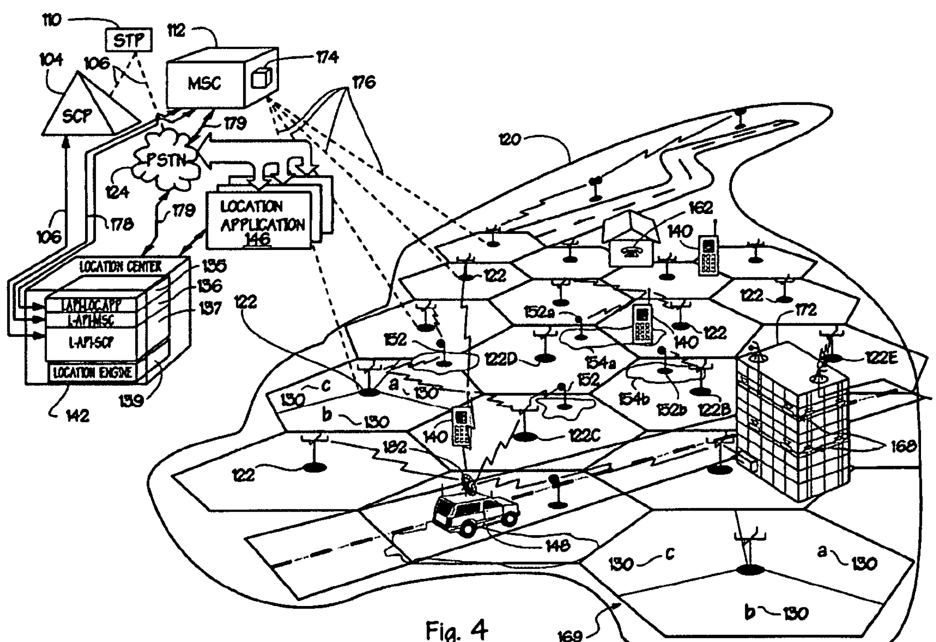

Fig. 4

Figure 4 is an overall view of a wireless radio location network architecture. *Id.* at 21:66–67. The network includes a plurality of mobile stations ("MS") 140, a mobile switching center ("MSC") 112, and a plurality of wireless cell sites forming radio coverage area 120, each site including a fixed-location base station 122 for voice and data communication with MSs 140. *Id.* at 24:41–57. The network also includes location base stations ("LBS") 152 with wireless location enablement, e.g., with transponders used primarily in communicating MS location related information to location center 142 (via base stations 122 and MSC 112). *Id.* at 24:57–64. LBSs can be placed, for example, in dense urban areas, in remote areas, along highways, or wherever more location precision is required than can be obtained using conventional wireless infrastructure components. *Id.* at 28:29–38.

Location center 142 determines a location of a target MS 140. *Id.* at 25:8–10, 37:43–46. The system uses a plurality of techniques for locating MSs, including two-way time of arrival ("TOA"), time difference of arrival ("TDOA"), and Global Positioning System ("GPS"). *Id.* at Abstract, 9:5–23, 11:7–55, 66:45–50. To determine a location for a MS, the system computes a first order model (also referred to as a hypothesis or estimate) for one or more of the locating techniques, computes a confidence value for each model indicating the likelihood that the model is correct, performs additional computations on the models to enhance the estimates, and computes from the models a "most likely" location for the MS. *Id.* at 12:62–13:20, 38:9–31. The most likely location can be composite of the estimates. *Id.* at 13:22–30, 66:45–50.

Location estimates can be provided to location requesting applications, such as 911 emergency, police and fire departments, taxi services, etc. *Id.* at 8:52–60, 13:20–22, 38:32–34.

Claim 27, the sole claim challenged in this proceeding, is reproduced below:

> 27. A method for locating mobile stations at one or more unknown terrestrial locations using wireless signal measurements obtained via transmissions between said mobile stations and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations includes one or more of a transmitter and a receiver for wirelessly communicating with said mobile stations, comprising:
>
> receiving, from a plurality of location requesting sources, a plurality of input requests for locations of the mobile stations, wherein for each of the input requests there is a corresponding destination for a responsive output;
>
> for each of the input requests, providing one or more location requests for location information, related to a location of one of said mobile stations, to one or more mobile station location determining sources;
>
> first obtaining, in response to a first of the location requests received from a first of the requesting sources, at least first location information of a first location of a first of said mobile stations, said first location information determined using a first set of one or more wireless location techniques;
>
> first determining, using said first location information, first output location data according to a first output criteria for the corresponding destination for the first request, said first output location data including a representation identifying a first geographical location of the first location;

second obtaining, in response to a second of the location requests received from a second of the requesting sources, at least second location information of a second location of a second of said mobile stations, said second location information determined using a second set of one or more wireless location techniques, wherein the second set determines the second location information by activating at least one location computing module for locating the second mobile station from at least a portion of the signal measurements, wherein the at least one location computing module is not activated for determining the first location information;

second determining, using said second location information, second output location data according to a second output criteria for the corresponding destination for the second request, said second output location data including a representation identifying a second geographical location of the second location;

wherein for at least one of said first and second output criteria, there is an output criteria for another of the location requests that is different from said at least one output criteria;

first transmitting said first output location data to its corresponding destination via a communications network; and

second transmitting said second output location data to its corresponding destination via a communications network, the first and second locations being different.

II. ANALYSIS

A. Claim Construction

We interpret claims of an unexpired patent using the broadest reasonable construction in light of the specification of the patent in which they appear. *See* 37 C.F.R. § 42.100(b); *In re Cuozzo Speed Techs., LLC*, 793 F.3d 1268, 1278 (Fed. Cir. 2015). In applying a broadest reasonable construction, claim terms generally are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire disclosure. *See In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

Petitioner points out that the District Court in *TracBeam, LLC v. AT&T, Inc.*, Case No. 6:11-CV-96 (E.D. Tex.), construed several terms of the challenged claims. Pet. 8–9 (citing Ex. 1017 (District Court's Claim Construction Order)). Petitioner argues that no constructions of these terms are necessary, but indicates that it would accept the District Court's claim constructions. *Id.* at 8–9. Patent Owner does not propose constructions for these terms. At this stage of the proceeding, we do not find it necessary to construe these terms expressly.

For purposes of this Decision, no other claim term requires express construction.

B. Asserted Grounds of Unpatentability

A claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are "such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." We resolve the question of obviousness on the basis of underlying factual determinations, including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) objective evidence of nonobviousness, i.e., secondary considerations. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

In an obviousness analysis, some reason must be shown as to why a person of ordinary skill would have combined or modified the prior art to achieve the patented invention. *See Innogenetics, N.V. v. Abbott Labs.*, 512 F.3d 1363, 1374 (Fed. Cir. 2008). A reason to combine or modify the prior art may be found explicitly or implicitly in market forces; design incentives; the "'interrelated teachings of multiple patents'"; "'any need or problem known in the field of endeavor at the time of invention and addressed by the patent'"; and the background knowledge, creativity, and common sense of the person of ordinary skill. *Perfect Web Techs., Inc. v. InfoUSA, Inc.*, 587 F.3d 1324, 1328–29 (Fed. Cir. 2009) (quoting *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418–21 (2007)).

1. Overview of Kauser

Kauser describes a technique for determining the location of a mobile telephone within a serving area of a mobile telephone system. Ex. 1007, Abstract. Figure 2, reproduced below, illustrates an example:

FIG. 2

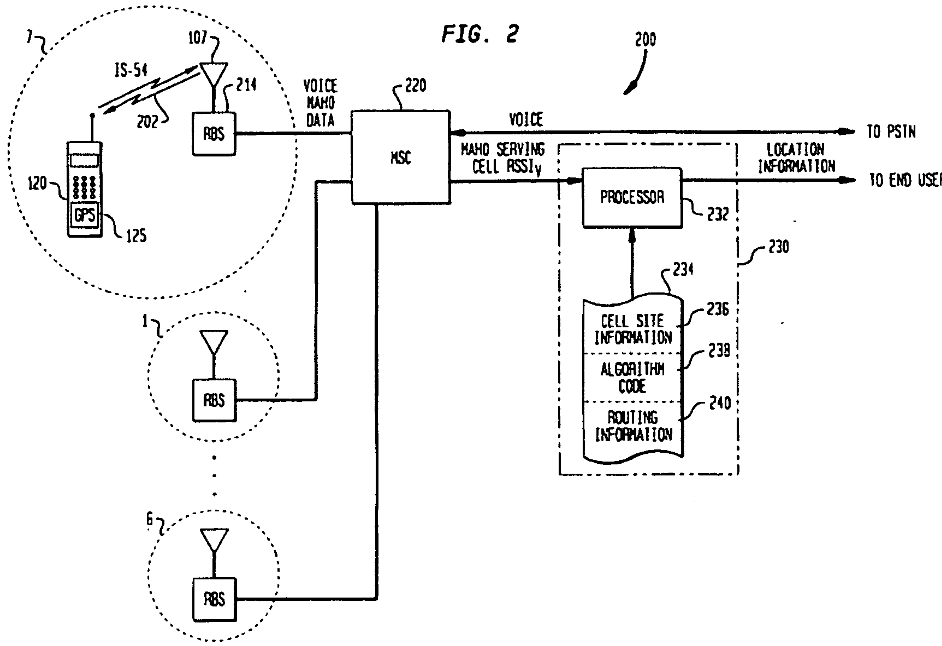

Figure 2 is a diagram of mobile telephone system 200. *Id.* at 3:25–26. Cell 7 is shown containing antenna 107 connected to radio base station ("RBS") 214. *Id.* at 3:59–60. RBS 214 (as well as other RBSs) is connected to mobile switching center ("MSC") 220. *Id.* at 4:15–16.

Mobile telephone 120 is also within cell 7, and is shown in communication with mobile telephone system 200 via air interface 202. *Id.* at 3:57–62. Mobile telephone 120 includes GPS receiver/processor unit 125. *Id.* at 4:8–11. To assist in handing off communication from one cell to another, mobile telephone 120 maintains a list of strengths of the signals it is receiving from various base stations in adjacent cells. *Id.* at 4:60–5:12. Mobile telephone 120 periodically sends this list to MSC 220. *Id.* at 5:17–22.

Mobile telephone system 200 also includes mobile location module ("MLM") 230 (which, in turn, includes processor 232 and memory 234) for determining the specific geographic location of mobile telephone 120. *Id.* at 5:23–32. MSC 220 performs an analysis on the telephone numbers of the caller and recipient and, based on that analysis, decides whether MLM 230 will determine the location of mobile telephone 120. *Id.* at 5:37–49. For example, if mobile telephone 120 dials 911, MLM 230 will determine the location of mobile telephone 120. *Id.* at 5:40–41. In another example, a company managing a fleet of vehicles may want a location determination performed each time a call is initiated from one of its cellular telephones. *Id.* at 5:40–42.

MLM 230 determines the best estimation of mobile telephone 120's location by analyzing several pieces of information. Figure 10, reproduced below, illustrates an example:

FIG. 10

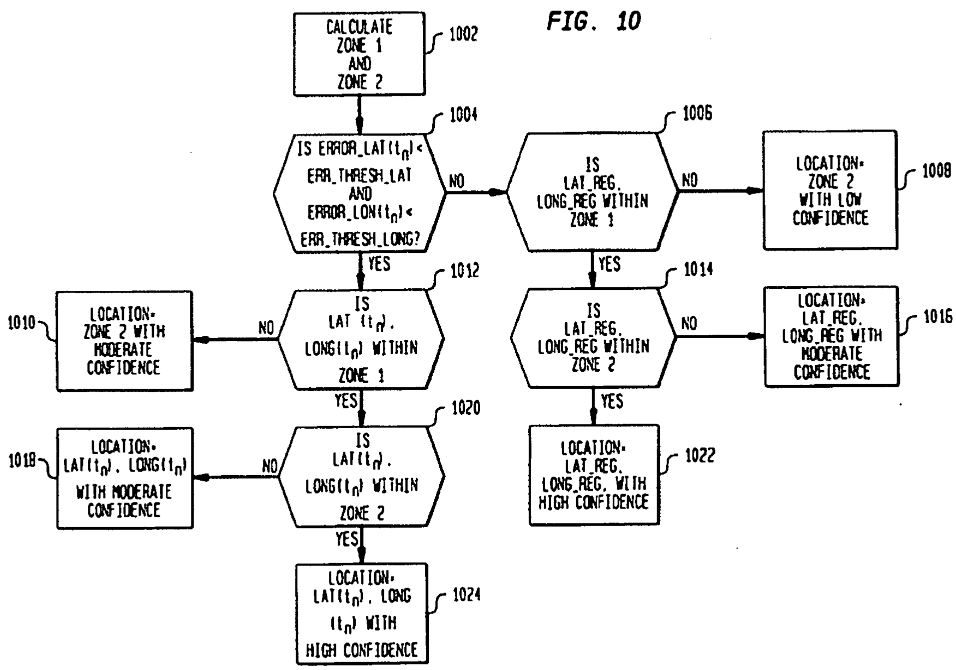

Figure 10 is a flow diagram of the steps for calculating the location of a mobile telephone. *Id.* at 3:42–43.

First, MLM 230 computes "zone 1" and "zone 2" location estimations. *Id.* at Fig. 10, box 1002. Zone 1 is defined by the geographic coverage area of the cell currently serving mobile telephone 120 (e.g., cell 7 in Figure 2). *Id.* at 6:16–22, 11:43–45. Zone 2 is an area calculated by estimating the distance of mobile telephone 120 from the three strongest signals received from adjacent cells. *Id.* at 6:21–36, 11:45–47. Next, MLM 230 compares calculated error values of the current GPS coordinates to thresholds to determine the accuracy of the GPS coordinates. *Id.* at 11:5–16, 11:48–54, Figure 10, box 1004. If the GPS coordinates are accurate enough to be acceptable (box 1004, "YES" branch), MLM 230 compares the GPS coordinates to zone 1 and zone 2 information and determines whether to use the GPS coordinates (boxes 1018, 1024) or, alternatively, to use zone 2 (box 1010) as the current location. *Id.* at 11:51–67. If the GPS coordinates are not accurate enough (box 1004, "NO" branch"), MLM 230 compares zone 1 and zone 2 information to previously stored GPS coordinates and determines whether to use the stored coordinates (boxes 1016, 1022) or zone 2 (box 1008) as the current location. *Id.* at 12:1–21.

Once MLM 230 determines the geographic location area of mobile phone 120, it routes the information to the appropriate end user (e.g., in the examples above, the appropriate service provider associated with 911, or to the appropriate fleet company). *Id.* at 12:22–35.

2. Claim 27

Petitioner provides a detailed mapping of Kauser to claim 27 in the Petition, at 30–45. Petitioner supports its contentions with the testimony of William R. Michalson, Ph.D. (Ex. 1006), which we have considered. To summarize, Petitioner contends, *inter alia*, that:

Kauser's description of providing location information to 911 providers and vehicle fleet management companies teaches "receiving, from a plurality of location requesting sources, a plurality of input requests for locations of the mobile stations" (Pet. 32);

MSC 220 initiating location functions in MLM 230 teaches "providing one or more location requests for location information, related to a location of one of said mobile stations, to one or more mobile station location determining sources" (*id.* at 33);

Kauser's description of locating any mobile telephone in a cellular network teaches "first obtaining" for a "first of said mobile stations" and "second obtaining" for a "second of said mobile stations" (*id.* at 33, 38);

Kauser's description of GPS technology teaches a "first set of one or more wireless location techniques" and its description of a "zone 2" location estimate teaches a "second set of one or more wireless location techniques" (*id.* at 35–36, 39);

Kauser's description of outputting GPS coordinates and a confidence value, determined, in part, from input GPS coordinates teaches "first determining, using said first location information, first output location data" and the stored routing information for each application/destination are "first output criteria" (*id.* at 36–38);

Kauser's description of outputting a zone 2 estimate based, in part, on a zone 2 input, teaches "second determining, using said second location information, second output location data" and GPS error thresholds are a "second output criteria," different from the identified first output criteria (*id.* at 40–44);

Kauser's description of sending resulting location estimates to appropriate end user destinations over the cellular network teaches "first transmitting" and "second transmitting" (*id.* at 44–45).

As to claim 27's limitation, "wherein the at least one location computing module is not activated for determining the first location information," Petitioner contends that MLM 230 is a "location computing module" that determines "zone 2" estimates while a different module determines GPS location information. *Id.* at 39–40. Petitioner further argues that the steps of claim 27 do not specify a particular order. *Id.* at 33–34. Nevertheless, Petitioner argues that even if claim 27 does specify an order to its steps, it would have been obvious to implement Kauser's location technique in that order, as it would have been a selection from a finite number of options, each with a reasonable expectation of success. *Id.* at 34–35 (citing Ex. 1006 § IX.G).

Patent Owner did not file a Preliminary Response and, thus, has not yet argued that Kauser lacks a teaching of any particular limitation of claim 27.

We have considered the evidence presented in the Petition, summarized above. On this record, we are persuaded that Petitioner has established a reasonable likelihood that it would prevail with respect to claim 27 as obvious over Kauser.

III. CONCLUSION

We institute an *inter partes* review of claim 27. We have not yet made a final determination of the patentability of this claim or the construction of any claim term.

IV. ORDER

For the reasons given, it is:

ORDERED that *inter partes* review is instituted on the following ground:

Claim 27, under 35 U.S.C. § 103(a), as obvious over Kauser;

FURTHER ORDERED that the trial is limited to the ground identified above, and no other ground is authorized; and

FURTHER ORDERED that pursuant to 35 U.S.C. § 314(a), *inter partes* review of U.S. Patent No. 7,525,484 B2 is hereby instituted commencing on the entry date of this Order, and pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4, notice is hereby given of the institution of a trial.

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Paper 10
Entered: February 8, 2016

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

T-MOBILE US, INC., T-MOBILE USA, INC.,
TELECOMMUNICATION SYSTEMS, INC., ERICSSON INC., and
TELEFONAKTIEBOLAGET LM ERICSSON,
Petitioner,

v.

TRACBEAM, LLC,
Patent Owner.

Case IPR2015-01708
Patent 7,525,484 B2

Before KEVIN F. TURNER, DAVID C. McKONE, JAMES A. TARTAL, and BARBARA A. PARVIS, *Administrative Patent Judges.*

McKONE, *Administrative Patent Judge.*

DECISION
Institution of *Inter Partes* Review
37 C.F.R. § 42.108

I. INTRODUCTION

A. Background

T-Mobile US, Inc., T-Mobile USA, Inc., TeleCommunication Systems, Inc., Ericsson Inc., and Telefonaktiebolaget LM Ericsson (collectively, "Petitioner") filed a Petition (Paper 1, "Pet.") to institute an *inter partes* review of claims 1, 2, 6, 24, 25, 51, 71, and 72 of U.S. Patent No. 7,525,484 B2 (Ex. 1002, "the '484 patent"). TracBeam, LLC ("Patent Owner") filed a Preliminary Response (Paper 6, "Prelim. Resp."). The parties reached agreement to remove claims 2, 6, 24, 71, and 72 from the proceeding. Paper 7 (Joint Motion to Limit Petition); Paper 8 (Joint Submission of Narrowing Agreement). We accepted that agreement and limited this proceeding to claims 1, 25, and 51. Paper 9.

Upon consideration of the Petition and Preliminary Response, we conclude, under 35 U.S.C. § 314(a), that Petitioner has established a reasonable likelihood that it would prevail with respect to claims 1 and 51, but not as to claim 25. Accordingly, we institute an *inter partes* review of claims 1 and 51 of the '484 patent.

B. Related Matters

The '484 patent is the subject of several lawsuits filed in the United States District Court for the Eastern District of Texas. Pet. 2; Paper 5, 1–2.

The '484 patent also is the subject of *Apple Inc. v. TracBeam, LLC*, Case IPR2015-01696 (PTAB); *Apple Inc. v. TracBeam, LLC*, Case IPR2015-01697 (PTAB); and *T-Mobile US, Inc. v. TracBeam, LLC.*, Case IPR2015-01711 (PTAB). Pet. 1; Paper 5, 3.

Various related patents also are the subjects of these and other proceedings before the district courts and the Board. Paper 5, 1–3.

C. References Relied Upon

Petitioner relies upon the following prior art references:

Ex. 1008	Loomis	US 5,936,572	Aug. 10, 1999
Ex. 1009	Wortham	US 6,748,226 B1	June 8, 2004

D. The Asserted Grounds

Petitioner contends that claims 1, 25, and 51 would have been obvious, under 35 U.S.C. § 103, over Loomis and Wortham. Pet. 6.

E. The '484 Patent

The '484 patent describes location systems for wireless telecommunication infrastructures. Ex. 1002, Abstract. According to the '484 patent, the location techniques are useful for 911 emergency calls, vehicle tracking and routing, and location of people and animals. *Id.* at Abstract, 12:11–17.

Figure 4, reproduced below, illustrates an embodiment:

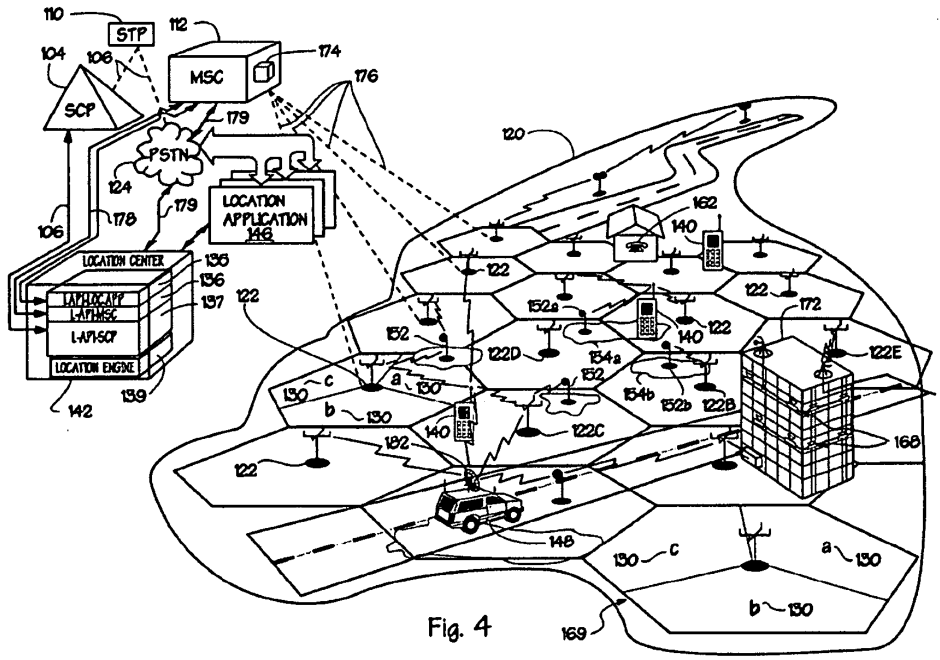

Figure 4 is an overall view of a wireless radio location network architecture. *Id.* at 21:66–67. The network includes a plurality of mobile stations ("MS") 140, a mobile switching center ("MSC") 112, and a plurality of wireless cell sites forming radio coverage area 120, each site including a fixed-location base station 122 for voice and data communication with MSs 140. *Id.* at 24:41–57. The network also includes location base stations ("LBS") 152 with wireless location enablement, e.g., with transponders used primarily in communicating MS location related information to location center 142 (via base stations 122 and MSC 112). *Id.* at 24:57–64. LBSs can be placed, for example, in dense urban areas, in remote areas, along highways, or wherever more location precision is required than can be obtained using conventional wireless infrastructure components. *Id.* at 28:29–38.

Location center 142 determines a location of a target MS 140. *Id.* at 25:8–10, 37:43–46. The system uses a plurality of techniques for locating MSs, including two-way time of arrival ("TOA"), time difference of arrival ("TDOA"), and Global Positioning System ("GPS"). *Id.* at Abstract, 9:5–23, 11:7–55, 66:45–50. To determine a location for a MS, the system computes a first order model (also referred to as a hypothesis or estimate) for one or more of the locating techniques, computes a confidence value for each model indicating the likelihood that the model is correct, performs additional computations on the models to enhance the estimates, and computes from the models a "most likely" location for the MS. *Id.* at 12:62–13:20, 38:9–31. The most likely location can be composite of the estimates. *Id.* at 13:22–30, 66:45–50.

Location estimates can be provided to location requesting applications, such as 911 emergency, police and fire departments, taxi services, etc. *Id.* at 8:52–60, 13:20–22, 38:32–34.

Claim 1, reproduced below, is illustrative of the claimed subject matter:

> 1. A method for obtaining requested location information regarding a first of a plurality of terrestrial wireless mobile stations using location information from location estimating sources, and to provide the requested location information to an application using wireless location, the location estimating sources, including a first location estimating source and a second location estimating source, the first and second location estimating sources providing information regarding locations of various of the mobile wireless stations, the method comprising the steps of:
>
> first receiving a location request regarding the first of said wireless mobile station from the application, said

location request seeking said requested location information;

first obtaining a first location input obtained using an instance, I_1, of location information from said first location estimating source, wherein I_1 is indicative of one or more locations of said first wireless mobile station, and

second obtaining a second location input obtained using an instance, I_2, of location information provided from said second location estimating source, wherein I_2 is indicative of one or more locations of said first wireless mobile station;

wherein said first location estimating source employs a first location finding technology that provides I_1, and said second location estimating source employs a second location finding technology different than said first location finding technology that provides I_2; and

wherein said steps of first and second obtaining includes a step of providing said first and second location inputs in a common standardized format;

storing data in memory relating to said first location input and said second location input;

third obtaining said requested location information by selectively using portions of said data from said memory, wherein said requested location information is determined according to information indicative of a manner in which said application prefers said requested location information; and

outputting said requested location information to said application.

II. ANALYSIS

A. Claim Construction

We interpret claims of an unexpired patent using the broadest reasonable construction in light of the specification of the patent in which they appear. *See* 37 C.F.R. § 42.100(b); *In re Cuozzo Speed Techs., LLC*, 793 F.3d 1268, 1278 (Fed. Cir. 2015). In applying a broadest reasonable construction, claim terms generally are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire disclosure. *See In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

Petitioner points out that the District Court in *TracBeam, LLC v. AT&T, Inc.*, Case No. 6:11-CV-96 (E.D. Tex.), construed several terms of the challenged claims. Pet. 8–10 (citing Ex. 1017 (District Court's Claim Construction Order)). For the majority of these terms, Petitioner argues that no constructions are necessary, but indicates that it would accept the District Court's claim constructions. *Id.* at 8–9. Patent Owner does not propose constructions for these terms. At this stage of the proceeding, we do not find it necessary to construe these terms expressly.

Claim 25 (emphasis added) recites "obtained using wireless signal measurements *obtained via two way wireless communication* between said mobile station M, and the communication stations." Petitioner argues that we should construe "obtained via two way wireless communication" the same as the District Court construed a similar term, "obtained by transmission," recited in a claim of a related patent. Pet. 9–10. Specifically, the District Court, accepting Patent Owner's argument and rejecting Petitioner's, construed "obtained by transmission" to cover either

"(A) transmitting the actual wireless signal measurements; or (B) measuring the characteristics of the transmitted wireless signals." Ex. 1017, 27–28. Patent Owner does not propose a construction of "obtained via two way wireless communication" in this proceeding. For purposes of this Decision, we accept Petitioner's proposed construction of "obtained via two way wireless communication."

Patent Owner asserts that "Claim 1 recites an order." Prelim. Resp. 7 (referring to the "first obtaining" and "second obtaining" recited in claim 1). Nevertheless, Patent Owner does not advance, in the Preliminary Response, an argument based on such an order. Rather, Patent Owner foreshadows that it "will demonstrate that Petitioner's asserted combination fails to disclose or render obvious the ordered 'obtaining' steps of claim 1, if a proceeding is instituted," but indicates that it "need not do so here" because of its reliance on other arguments. *Id.* Thus, at this stage, Patent Owner has not put forward evidence or argument to support limiting the steps of claim 1 to a specific order, or to show that the prior art fails to teach this order. At this stage, we decline to construe claim 1 to include claim steps that must be performed in a specific order. Nevertheless, Patent Owner is free to raise such an argument in its Patent Owner Response.

For purposes of this Decision, no other claim term requires express construction.

B. Asserted Grounds of Unpatentability

A claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are "such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." We resolve the question of obviousness on the basis of underlying factual determinations, including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) objective evidence of nonobviousness, i.e., secondary considerations. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

In an obviousness analysis, some reason must be shown as to why a person of ordinary skill would have combined or modified the prior art to achieve the patented invention. *See Innogenetics, N.V. v. Abbott Labs.*, 512 F.3d 1363, 1374 (Fed. Cir. 2008). A reason to combine or modify the prior art may be found explicitly or implicitly in market forces; design incentives; the "'interrelated teachings of multiple patents'"; "'any need or problem known in the field of endeavor at the time of invention and addressed by the patent'"; and the background knowledge, creativity, and common sense of the person of ordinary skill. *Perfect Web Techs., Inc. v. InfoUSA, Inc.*, 587 F.3d 1324, 1328–29 (Fed. Cir. 2009) (quoting *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418–21 (2007)).

1. Overview of Loomis

Loomis describes an apparatus for determining a location of a mobile user, both inside and outside of buildings and structures, using two different location determining techniques. Ex. 1008, Abstract. Loomis observes that location technology such as GPS, Global Orbiting Navigation Satellite System ("GLONASS"), and Long Range Navigation ("LORAN") "provide object location estimates over regions with diameters of hundreds of kilometers (km) but do not work well where some of the signal sources are obscured by structures outdoors, or when the object to be located is positioned indoors." *Id.* at 1:19–34. In contrast, "[frequency modulation ("FM")] subcarrier signals can be used over smaller regions to estimate the location of an object inside or outside a building or other structure," but such systems "tend[] to be limited to smaller regions, with diameters of the order of 20–50 km." *Id.* at 38–46. To take advantage of both types of technologies, Loomis's system "provides an integrated, mobile or portable system for location determination that combines beneficial features of two or more LD systems." *Id.* at 4:39–42.

Figure 1, reproduced below, illustrates an example:

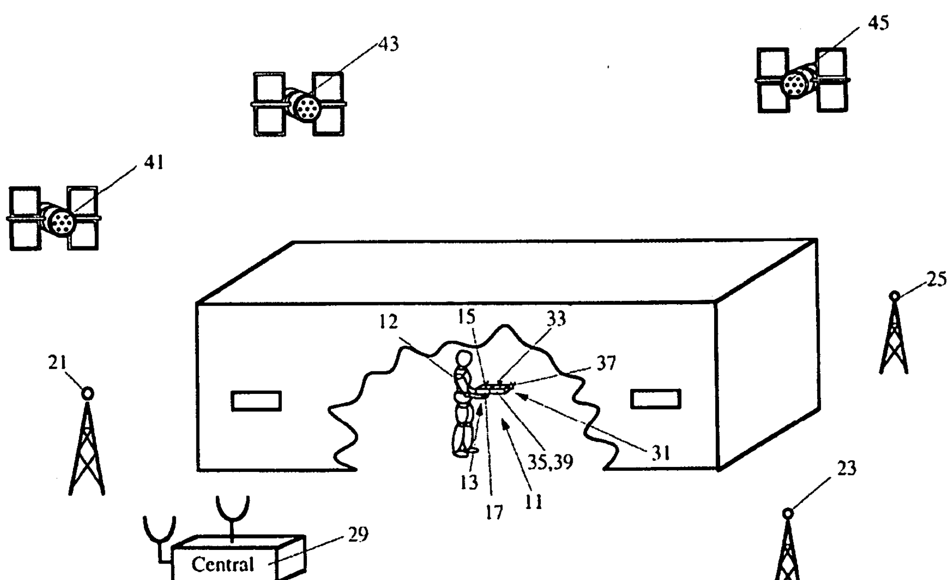

FIG. 1

Figure 1 is a schematic illustrating user 12 operating hybrid location determining ("LD") system 11. *Id.* at 6:21–29. Hybrid LD system 11 includes two different technologies for receiving location information.

Specifically, radio LD unit 13 (renumbered 71 in Figure 6) receives FM signals from radio LD signal sources 21, 23, and 25, and outdoor LD unit 31 (renumbered 81 in Figure 6) receives GPS or GLONASS signals from satellites 41, 43, and 45. *Id.* at 6:20–29, 7:9–22.

A controller receives location coordinates (in x, y, z format) from the radio LD unit and from the outdoor LD unit, along with indicia resulting from the comparison of the FM and outdoor signals to thresholds (i.e., indicia indicating the accuracy of the respective location coordinates). *Id.* at 12:21–27. In Figure 6, the controller is depicted as part of hybrid LD unit 11, although, in an alternative embodiment, "information from the radio LD signals and/or the outdoor LD signals may be transmitted, unprocessed or partly processed or fully processed, to a central processing station 29 (optional), located at or near the site R, to allow determination of the present location of the user 12 at selected times." *Id.* at 8:29–34; *accord id.* at 20:29–36. The controller can choose the radio coordinates or satellite coordinates, depending on which is the most accurate (or choose neither, if both are determined to be too inaccurate). *Id.* at 12:47–13:4. "[H]ybrid LD system 11 then processes the LD signals further, or transmits or stores or displays the location of the hybrid LD system." *Id.* at 19:53–55.

For the radio LD unit to make a location determination, it must first know the relative phases of the FM signals from the radio LD signal sources. *Id.* at 4:9–14. To that end:

> The outdoor LD unit 31 in FIG. 1 includes a radio LD signal antenna and receiver/processor 37 and controller/interface 39 that also receives radio LD signals from the radio LD sources 21, 23 and 25, determines the relative phases of these radio LD signals, and provides this relative phase information with little or no time delay for use by the radio LD unit 13.

Id. at 7:23–29; *accord id.* at 11:66–12:8:

> The outdoor LD unit 81 includes an FM subcarrier signal antenna 83, an outdoor signal receiver/processor 85 associated with and connected to the outdoor antenna 83, and a phase information antenna 87. The phase information antenna and receiver 87 receives the radio LD signals from the radio LD signal sources and passes these signals to the outdoor LD signal receiver/processor 85 for determination of the relative phases of the radio LD signal sources. This relative phase information is then passed to the radio LD unit 71 through the controller interface 91.

The outdoor LD unit determines its own location and uses that location estimate to determine the relative phases. *Id.* at 7:31–38; 19:37–47.

2. *Overview of Wortham*

Wortham describes integrating a differential positioning system, such as a satellite-based or land-based positioning system, with a mobile communications network. Ex. 1009, Abstract. Figure 1, reproduced below, illustrates an example:

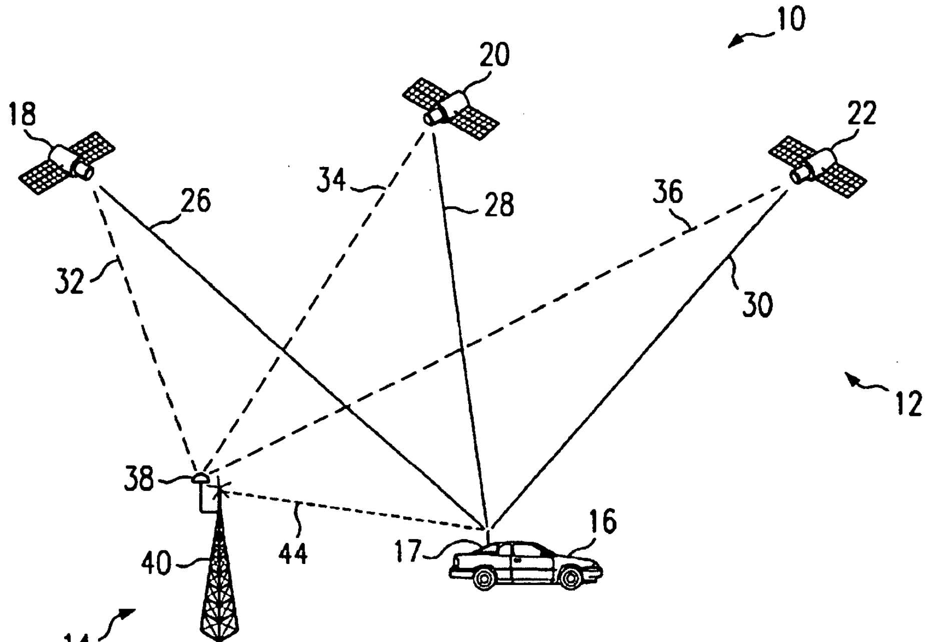

FIG. 1

Figure 1 is a drawing of differential positioning system 10. *Id.* at 2:44.

Vehicle 16, depicted as an automobile, includes a person carrying portable or hand-held mobile unit 17. *Id.* at 4:26–33. Mobile unit 17 receives position signals over message data streams 26, 28, 30 from satellites 18, 20, 22, respectively, and determines the mobile unit's position from those signals. *Id.* at 5:6–23. Satellites 18, 20, 22 also send message data streams 32, 34, and 36, respectively, to a transmitter site 40. *Id.* at 5:29–33. Reference positioning receiver 38 at transmitter site 40 determines a position fix from position signals received from satellites 18, 20, 22. *Id.* at 5:34–36. Traditional surveying techniques can be used to determine the actual coordinates of transmitter site 40. *Id.* at 42–43. Reference positioning receiver 38 compares the computed position fix to the known (e.g., surveyed) position coordinates and generates correction data, which are transmitted over correction data stream 44 to mobile unit 17. *Id.* at 5:37–41.

3. Petitioner's Proposed Combination

Petitioner proposes incorporating Loomis's location technology into a cellular telephone network, such as described in Wortham and, in the process, modifying the system of Loomis to replace its FM terrestrial location capabilities with cellular-based signals, such as would be transmitted by the transmitter sites in Wortham. Pet. 12–13, 21. Petitioner contends that design incentives and market forces would have motivated such a change, giving the Federal Communications Commission's ("FCC") proposed rules for locating wireless callers (Ex. 1014) as an example. *Id.* at 21. According to Petitioner, the FCC's proposed rules requiring cellular providers to locate wireless 911 callers both inside and outside of buildings would have motivated the combination. *Id.* at 22. Dr. Michalson testifies that such modification would have been within the level of skill in the art. Ex. 1006 § X.B; Pet. 24–25. Patent Owner does not challenge Petitioner's reasons to combine Loomis and Wortham in the Preliminary Response. On this record, we are persuaded that Petitioner is reasonably likely to show that a skilled artisan would have combined Loomis and Wortham.

4. Claim 1

Petitioner argues that Loomis's outdoor LD unit is "a first location estimating source" and Loomis's radio LD unit is "a second location estimating source," as recited in claim 1. Pet. 28. Petitioner argues that, used in a wireless network such as Wortham's, the resulting system would provide location information for claim 1's "plurality of wireless mobile stations." *Id.* at 26–27, 29. As to "first receiving a location request," as recited in claim 1, Petitioner argues that the location request described in Loomis could come from an application described in Wortham. *Id.* at 29.

Petitioner argues that pseudorange measurements from GPS satellites correspond to "an instance, I_1, of location information from said first location estimating source"; GPS coordinates and signal indicium correspond to "first location input"; phase measurements of radio signals correspond to "an instance, I_2, of location information provided from said second location estimating source"; and radio coordinates and signal indicium correspond to "second location input." Pet. 30–31. Petitioner contends that these aspects of Loomis teach the "first obtaining" and "second obtaining" limitations of claim 1. *Id.*

Patent Owner responds that "[t]he act of 'obtaining'" location information requires "acquiring or gaining possession of" that information. Prelim. Resp. 7 (citing Ex. 2002 (a definition from Webster's New World College Dictionary)). According to Patent Owner, Petitioner has not shown that "determining" location information constitutes "obtaining" location information. *Id.* at 8. On the present record, we do not agree with the distinction Patent Owner draws. Calculating GPS and radio coordinates is one way of acquiring or gaining possession of those coordinates. Accordingly, we are persuaded that Petitioner is reasonably likely to show that Loomis and Wortham teach the "first obtaining" and "second obtaining" limitations of claim 1.

Petitioner further argues that Loomis's GPS technique is "a first location finding technology," that "provides I_1" (the GPS pseudorange measurements), and that Loomis's FM radio location technique is "a second location finding technology" that "provides I_2" (phase differences of the signals arriving from each radio LD signal source[1]) and is "different than said first location finding technology," as recited in claim 1. Pet. 32–33. According to Petitioner, the (x, y, z) format in which Loomis provides GPS location coordinates and radio location coordinates is "a common standardized format." *Id.* at 33–34. Dr. Michalson testifies that "[a] person of ordinary skill in the art would understand that providing the coordinates in a coordinate triple format and indicia using a common metric" meets this limitation. Ex. 1006 ¶ 254.

Patent Owner responds that Petitioner has not shown that coordinate triples constitutes a standardized format and that "[s]howing that the inputs both include 'coordinate triples' and signal indicium values merely indicates that the first and second location inputs contain the same type of contents; it does not show that those contents are instantiated into a data structure having the same format (standardized or otherwise)." Prelim Resp. 8–9. Patent Owner does not explain persuasively why a coordinate triple is not a common standardized format. In any case, Loomis describes instantiating data into structures having that format:

> The controller 93 receives the present location coordinates $(x_u,y_u,z_u)_{rad}$ of the user 12 from the radio LD signal

---

[1] The Petition refers to radio coordinates "calculated using phase measurements of the radio signals (*i.e., "an instance, I_2, of location information"*). Pet. 31. Nevertheless, the Petition's citations to Loomis refer to the determinable phase differences of the signals arriving from the FM sources. *See, e.g.,* Ex. 1002, 9:62–65. We do not understand Petitioner to be referring to the phase measurements performed by the outdoor LD unit. *See, e.g., id.* at 7:31–38.

> receiver/processor 75, receives the present location coordinates $(x_u,y_u,z_u)_{out}$ of the user 12 from the outdoor LD signal receiver/processor 85, and receives the indicia I_{rad} and I_{out}, for comparison with the respective indicia thresholds $I_{rad,thr}$ and $I_{out,thr}$.

Ex. 1008, 12:21–27. We are persuaded that Petitioner is reasonably likely to show that Loomis and Wortham teach providing the location inputs in a "common standardized format."

Petitioner, in reliance on Dr. Michalson's testimony, further contends that Loomis's location coordinates and signal indicium would need to be stored in memory while performing comparisons and computations. Pet. 34–35 (citing Ex. 1006 § X.H.1). Petitioner further argues that Loomis's description of comparing signal indicium to thresholds teaches the "third obtaining" step of claim 1. *Id.* at 35–36. Finally, Petitioner contends that Loomis's description of providing location information to "an interested person or facility" and Wortham's description of providing location information to "applications" are examples of "outputting said requested location information to said application," as recited in claim 1. *Id.* at 36–37 (quoting Ex. 1008, 12:30–40; Ex. 1009, 4:26–39).

On the current record, we are persuaded that Petitioner has established a reasonable likelihood that it would prevail with respect to claim 1 as obvious over Loomis and Wortham.

5. Claim 25

Claim 25 is similar, in many respects, to claim 1. Claim 25 (emphasis added), however, recites "said first location evaluator and said second location evaluator output, respectively, first and second position information related to the one mobile station being at L *wherein neither of the first and* *second position information is dependent upon the other*." By its terms, the emphasized claim language requires that the first position information is independent of the second position information, and that the second position information is independent of the first position information. Patent Owner argues that, contrary to the claim language, Loomis teaches that the second position information (radio coordinates) depends on the first position information (GPS coordinates). Prelim. Resp. 18.

Petitioner maps the GPS signal processor of Loomis's outdoor LD module to claim 25's "first location evaluator," the GPS location coordinates to the "first position information," the radio LD module to the "second location evaluator," and the radio coordinates to the "second position information." Pet. 49–50. Petitioner cites (without further explanation) to Loomis's description that "[t]he outdoor LD system operates independently of the radio LD signal system," and "the outdoor LD unit 31 also complements the radio LD unit 13 by providing an <u>independent determination</u> of location of the hybrid LD unit 11," as a teaching of claim 25's "wherein neither of the first and second position information is dependent upon the other." *Id.* at 50 (quoting Ex. 1008, 5:7–9, 7:41–44).

While the passages cited by Petitioner arguably show that the coordinates provided by Loomis's outdoor LD unit do not depend on those provided by the radio LD unit, the passages fail to address whether the coordinates from the radio LD unit depend on those from the outdoor LD unit. Patent Owner argues that the coordinates from the radio LD unit in fact do depend on the GPS coordinates. Prelim. Resp. 18–20. According to Patent Owner, the radio LD unit relies on FM signal phase measurements from the outdoor LD unit to generate radio LD coordinates and that those phase measurements, in turn, depend on a location estimate by the outdoor LD unit. *Id.* at 19–20 (citing Ex. 1008, 7:31–38, Fig. 9).

We agree with Patent Owner. According to Loomis:

> The relative phases of the radio signals transmitted by the sources 21, 23 and 25 may change from time to time. When the radio LD unit 13 is provided with a recent measurement of these relative phases, the radio LD unit can determine the location of its antenna 15, using intersections of three or more hyperboloids that are defined by the relative times of arrival of the three radio LD signals at the antenna.

Ex. 1008, 6:46–52. Thus, to interpret the radio signals and generate coordinates from those signals, radio LD unit 13 must first be provided by a measurement of the phases of those radio signals. Loomis describes the outdoor LD unit as providing this phase information. For example,

> The outdoor LD unit 31 in FIG. 1 includes a radio LD signal antenna and receiver/processor 37 and controller/interface 39 that also receives radio LD signals from the radio LD sources 21, 23 and 25, determines the relative phases of these radio LD signals, and provides this relative phase information with little or no time delay for use by the radio LD unit 13.

Id. at 7:23–29; *accord id.* at 11:66–12:8, 19:42–47. The outdoor LD unit's phase determination is, in turn, dependent on a computation of the location of the outdoor LD unit: "The outdoor LD unit 31 determines the (approximate) location of itself and of the adjacent radio LD unit 13 and uses this information in determining the relative phases of the radio LD signals transmitted by the sources 21, 23 and 25." *Id.* at 7:29–35. Thus, the coordinates (second position information) generated by the radio LD unit are dependent on a determination of the phases of the radio signals, a determination that is dependent on the outdoor LD unit's computation of GPS coordinates (first position information). As Patent Owner notes

(Prelim. Resp. 20), Loomis describes this as "an important feature of the invention." *Id.* at 7:35–38.

We are persuaded by Patent Owner's citations to Loomis. We read Loomis to teach that second position information is dependent on the first. While Petitioner has argued that the first position information is not dependent on the second, Petitioner has not provided adequate argument or evidence to show the converse. We note that Petitioner does not cite to testimony from Dr. Michalson on this point. Nevertheless, we have considered paragraphs 243–45 of his declaration (Ex. 1006), which present argument substantially the same as in the Petition, which we find deficient. Petitioner does not cite any teaching from Wortham on this point.

On this record, Petitioner cannot show that Loomis and Wortham teach "wherein neither of the first and second position information is dependent upon the other." Accordingly, Petitioner has not shown a reasonable likelihood that it would prevail with respect to claim 25 as obvious over Loomis and Wortham.

6. Claim 51

Claim 51 is directed to a method of tracking a MS over time. Similar to claim 1, it recites a plurality of mobile station location estimating techniques, which Petitioner maps to Loomis's GPS and radio LD techniques. Pet. 53–55. Specifically, claim 51 recites "providing access to a plurality of mobile station location estimating techniques." Petitioner argues that this limitation is met by Loomis's teaching of radio LD and outdoor LD modules generating location estimates using measurements of wireless signals as inputs. *Id.* at 54.

Patent Owner contends that Petitioner has not demonstrated that "the asserted combination 'provides access to' each of the radio location technique and the GPS technique." Prelim. Resp. 23–24. Patent Owner does not provide any argument or evidence that Loomis fails to teach this limitation—Patent Owner simply argues that Petitioner's argument and evidence is insufficient. *Id.* We disagree. As shown in the Petition (at 12–13, 15–19, 54–55), and explained above with respect to claim 1, Loomis describes in detail providing access to both radio location techniques (such as FM) and satellite-based location techniques (such as GPS).

As to "receiving, over time, a plurality of location estimates of the mobile station" and "determining, a plurality of consecutive resulting location estimates for tracking the mobile station," as recited in claim 51, Petitioner cites to Loomis's disclosure of performing its techniques "[a]t one or more selected times," and to Loomis's example of determining locations "at selected times (e.g., second-by-second, or more or less often, if desired)." *Id.* at 56 (citing Ex. 1008, 8:26–38, 12:34–40).

Claim 51 further recites "wherein said step of determining includes steps (a) and (c) following:" wherein (a) is a step of deriving a location estimate using a first location technique, (b) is a step of deriving a location estimate using a second location technique, and (c) is a step of preferring one estimate over the other.[2] Petitioner points to Loomis's description of an

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[2] We note that claim 51 recites "steps (a) and (c)." Patent Owner argues that this is a typographical error and that it should read "steps (a) through (c)." Prelim. Resp. 25. Patent Owner cites to no evidence in support of this argument, nor does Patent Owner cite to a certificate of correction addressing the alleged typographical error. Nevertheless, Petitioner has introduced evidence that each of steps (a), (b), and (c) is taught in Loomis and Wortham. Thus, it is not necessary to decide whether claim 51 includes

outdoor LD unit as showing step (a), Loomis's description of a radio LD unit as showing step (b), and Loomis's description of choosing GPS coordinates over radio location coordinates as showing step (c). Pet. 57–58 (citing Ex. 1008, 12:53–63).

Patent Owner argues that "the Petition fails to assert that steps (a) through (c) are performed as part of the 'determining.'" Prelim. Resp. 25. Patent Owner further argues that "the Petition's analysis of element 51.3–51.5 fails to show how steps (a) through (c) form a part of the 'determining' in element 51.2."[3] *Id.* We disagree. Reading the Petition's analysis of elements 51.2–51.5 together, it is clear that Petitioner argues that steps (a) through (c) are performed as part of the "determining" of element 51.2.

We have considered Petitioner's evidence in light of Patent Owner's Preliminary Response and, on this record, we are persuaded that Petitioner has shown a reasonable likelihood that it would prevail with respect to claim 51 as obvious over Loomis and Wortham.

III. CONCLUSION

We institute an *inter partes* review of claims 1 and 51, but not of claim 25. We have not yet made a final determination of the patentability of these claims or the construction of any claim term.

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a typographical error.

[3] Petitioner's designation 51.2 refers to "receiving, over time, a plurality of location estimates of the mobile station; determining, a plurality of consecutive resulting location estimates for tracking the mobile station, wherein said step of determining includes steps (a) and (c) following"; 51.3 refers to claim 51's step "(a)"; 51.4 refers to claim 51's step "(b)"; and 51.5 refers to claim 51's step "(c)."

IV. ORDER

For the reasons given, it is:

ORDERED that *inter partes* review is instituted on the following ground:

Claims 1 and 51, under 35 U.S.C. § 103(a), as obvious over Loomis and Wortham;

FURTHER ORDERED that the trial is limited to the grounds identified above, and no other ground is authorized; and

FURTHER ORDERED that pursuant to 35 U.S.C. § 314(a), *inter partes* review of U.S. Patent No. 7,525,484 B2 is hereby instituted commencing on the entry date of this Order, and pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4, notice is hereby given of the institution of a trial.

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Paper 8
Entered: February 17, 2016

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

TRACBEAM, LLC,
Patent Owner.

Case IPR2015-01697
Patent 7,525,484 B2

Before KEVIN F. TURNER, RICHARD E. RICE, BARBARA A. PARVIS, and MATTHEW R. CLEMENTS, *Administrative Patent Judges*.

CLEMENTS, *Administrative Patent Judge*.

DECISION
Institution of *Inter Partes* Review
37 C.F.R. § 42.108

I. INTRODUCTION

A. Background

Apple Inc. (collectively, "Petitioner") filed a Petition (Paper 1, "Pet.") to institute an *inter partes* review of claims 25–27, 31, 36–40, 45, 49–51, 56, 57, 60, 61, 63, and 72 of U.S. Patent No. 7,525,484 B2 (Ex. 1001, "the '484 patent"). TracBeam, LLC ("Patent Owner") filed a Preliminary Response (Paper 6, "Prelim. Resp.").

Upon consideration of the Petition and Preliminary Response, we conclude, under 35 U.S.C. § 314(a), that Petitioner has established a reasonable likelihood that it would prevail with respect to claims 51, 56, 57, 60, 61, and 63. Accordingly, we institute an *inter partes* review of claims 51, 56, 57, 60, 61, and 63 of the '484 patent.

B. Related Matters

The '484 patent is the subject of several lawsuits filed in the United States District Court for the Eastern District of Texas. Pet. 1; Paper 5, 1–2.

The '484 patent also is the subject of *Apple Inc. v. TracBeam, LLC,* Case IPR2015-01696 (PTAB), *T-Mobile US, Inc.. v. TracBeam, LLC*, Case IPR2015-01708 (PTAB), and *T-Mobile US, Inc. v. TracBeam, LLC,* Case IPR2015-01711 (PTAB). Pet. 1; Paper 5, 3.

Various related patents also are subjects of these and other proceedings before the district courts and the Board. Paper 5, 1–3.

C. The '484 Patent

The '484 patent describes location systems for wireless telecommunication infrastructures. Ex. 1001, Abstract. According to the

'484 patent, the location techniques are useful for 911 emergency calls, vehicle tracking and routing, and location of people and animals. *Id.* at Abstract, 12:11–17.

Figure 4, reproduced below, illustrates an embodiment:

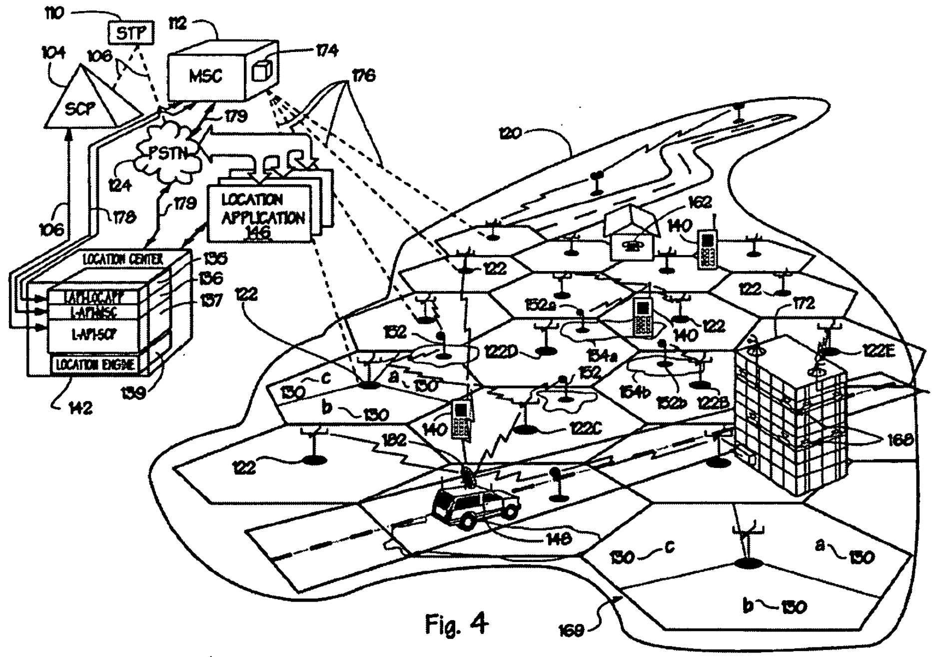

Figure 4 is an overall view of a wireless radio location network architecture. *Id.* at 21:66–67. The network includes a plurality of mobile stations ("MS") 140, a mobile switching center ("MSC") 112, and a plurality of wireless cell sites forming radio coverage area 120, each site including a fixed-location base station 122 for voice and data communication with MSs 140. *Id.* at 24:41–57. The network also includes location base stations ("LBS") 152 with wireless location enablement, e.g., with transponders used primarily in communicating MS location related information to location center 142 (via base stations 122 and MSC 112). *Id.* at 24:57–64. LBSs can be placed, for example, in dense urban areas, in remote areas, along highways, or wherever more location precision is required than can be obtained using conventional wireless infrastructure components. *Id.* at 28:29–38.

Location center 142 determines a location of a target MS 140. *Id.* at 25:8–10, 37:43–46. The system uses a plurality of techniques for locating MSs, including two-way time of arrival ("TOA"), time difference of arrival ("TDOA"), and Global Positioning System ("GPS"). *Id.* at Abstract, 9:5–23, 11:7–55, 66:45–50. To determine a location for a MS, the system computes a first order model (also referred to as a hypothesis or estimate) for one or more of the locating techniques, computes a confidence value for each model indicating the likelihood that the model is correct, performs additional computations on the models to enhance the estimates, and computes from the models a "most likely" location for the MS. *Id.* at 12:62–13:20, 38:9–31. The most likely location can be a composite of the estimates. *Id.* at 13:22–30, 66:45–50.

Location estimates can be provided to location requesting applications, such as 911 emergency, police and fire departments, taxi services, etc. *Id.* at 8:52–60, 13:20–22, 38:32–34.

D. Illustrative Claim

Of the challenged claims, claims 25, 27, 45, 49, 51, 57, and 63 are independent. Claim 25, reproduced below, is illustrative of the claimed subject matter:

> 25. A method for estimating, for each mobile station M of a plurality of mobile stations, an unknown terrestrial location (L_M) for M using wireless signal measurements obtained via transmissions between said mobile station M and a plurality of fixed location terrestrial communication

stations, wherein each of said communications stations is substantially co-located with one or more of a transmitter and a receiver for wirelessly communicating with said mobile station M, comprising:

initiating a plurality of requests for information related to the location of said mobile station M, the requests provided to each of at least two mobile station location evaluators, wherein there is at least a first of the requests provided to a first of the location evaluators and a second of the requests, different from the first request, provided to a second of the location evaluators, such that when said location evaluators are supplied with corresponding input data having values obtained using wireless signal measurements obtained via two way wireless communication between said mobile station M, and the communication stations, each of said first and second location evaluators determine corresponding location information related to L_M, and

wherein for at least one location L of one of the mobile stations, said first location evaluator and said second location evaluator output, respectively, first and second position information related to the one mobile station being at L wherein neither of the first and second position information is dependent upon the other;

obtaining a first collection of location information of said mobile station M, wherein the first collection includes first location information from the first location evaluator, and second location information from the second location evaluator;

determining resulting information related to the location L_M of the mobile station M, wherein the resulting information is dependent on geographical information in each of the first and second location information; and

transmitting, to a predetermined destination via a communications network, the resulting information.

Ex. 1001, 174:11–63.

E. References Relied Upon

Petitioner relies upon the following prior art references:

Ex. 1007	Bruno	US 5,604,765	Feb. 18, 1997
Ex. 1008	Loomis	US 5,936,572	Aug. 10, 1999
Ex. 1009	LeBlanc	US 5,602,903	Feb. 11, 1997
Ex. 1010	Yokouchi	US 4,903,212	Feb. 20, 1990

Petitioner also relies upon a Declaration of Kevin S. Judge. Ex. 1002 ("Judge Decl.").

F. Asserted Grounds of Unpatentability

Petitioner argues that the challenged claims are unpatentable based on the following grounds (Pet. 6):

Reference(s)	**Basis**	**Claim(s) challenged**
Bruno	§ 103	25–27, 31, 36, 37, 39, 40, 49, 51, 56, 60, 61, and 72
Bruno and LeBlanc	§ 103	38, 45, 50, 57, and 63
Loomis	§ 103	25–27, 31, 36, 37, 39, 40, 49, 51, 57, 60, 61, 63, and 72
Loomis and LeBlanc	§ 103	38, 45, 50
Loomis and Yokouchi	§ 103	56

II. ANALYSIS

A. Claim Construction

We interpret claims of an unexpired patent using the broadest reasonable construction in light of the specification of the patent in which they appear. *See* 37 C.F.R. § 42.100(b); *In re Cuozzo Speed Techs., LLC*, 793 F.3d 1268, 1278 (Fed. Cir. 2015), *cert. granted*, *Cuozzo Speed Techs. LLC v. Lee*, 84 U.S.L.W. 3218 (U.S. 2016). In applying a broadest reasonable construction, claim terms generally are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire disclosure. *See In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

1. *"information related to the location," "position information," "location information," "geographical information," "location estimate," "location data," "geographical approximation," and "geographical location approximation"*

Petitioner contends that these terms should all be construed to mean "information that pertains to location." Pet. 10–11. Specifically, Petitioner contends that "[t]he written description of the '484 patent does not support ascribing meanings to these similarly-themed terms that are materially distinct from each other." *Id.* at 11 (citing Judge Decl. ¶ 25). Petitioner's expert, Mr. Judge, testifies that the terms identified "simply mean information that pertains to location," but does not cite to, or explain, the underlying facts or data on which his opinion is based, if any. *See* 37 C.F.R. § 42.65(a). Patent Owner does not challenge Petitioner's proposed construction.

Petitioner has not persuaded us that all of these terms should be construed to have the same meaning. Moreover, we are not persuaded that Petitioner's proposed construction adds anything to the plain language of the claim terms themselves. Accordingly, on this record, we determine that no express construction is necessary for purposes of this Decision.

2. *"granularity"*

Claims 36 and 41 use the term "granularity." Petitioner contends that this term "should be construed to encompass precision in either location or time." Pet. 11 (citing Judge Decl. ¶ 26). Patent Owner does not dispute Petitioner's proposed construction. On this record, we determine that no express construction is necessary for purposes of this Decision.

3. "location technique" / "evaluator"

Claims 25, 26, 57, and 72 recite "evaluator." Claims 27, 45, 51, and 63 recite "location technique." Petitioner contends that these terms "encompass[] reception of satellite signals at the mobile station for purposes of location determination" because other claims, such as 39 and 72, recite a "non-terrestrial" signal source. Pet. 11–12. Patent Owner does not dispute Petitioner's proposed construction.

Petitioner does not explain persuasively why its proposed construction is correct. Apart from mentioning claims 39 and 72, Petitioner provides neither citations to the '484 patent nor declaration testimony to support its proposed construction. On this record, and for purposes of this Decision, we determine that this term does not require express construction.

B. Claims 25–27, 31, 36, 37, 39, 40, 49, 51, 56, 60, 61, and 72 – Obviousness over Bruno

Petitioner argues that claims 25–27, 31, 36, 37, 39, 40, 49, 51, 56, 60, 61, and 72 are unpatentable under 35 U.S.C. § 103(a) as obvious over Bruno. Pet. 13–26.

1. Bruno (Ex. 1007)

Bruno teaches a system for position determination via radio frequency (RF) navigation signals. Ex. 1007, 2:14–16. The system comprises three elements including (1) a Global Positioning System (GPS), (2) GPS-like signals broadcast at a different frequency, and (3) GPS-like RF signposts. *Id.* at 2:17–19. The first element of the system provides world-wide positioning via a receiver that determines its position by using signals broadcasted by GPS satellites. *Id.* at 2:20–24. The second element of the system involves embedding GPS-like signals within the communication bandwidth of wireless communication systems. *Id.* at 2:25–30. The third element involves use of GPS-like RF broadcasts that mark the location of the broadcast. *Id.* at 2:53–55.

2. Analysis

In light of the arguments and evidence of record, Petitioner has not established a reasonable likelihood that any claims are unpatentable as obvious over Bruno. Pet. 32–47.

Claims 25, 26, and 72

Independent claim 25 recites "said first location evaluator and said second location evaluator output, respectively, first and second position information related to the one mobile station being at L *wherein neither of the first and second position information is dependent upon the other*" (emphasis added). By its terms, the emphasized claim language requires that the first position information is independent of the second position information, and that the second position information is independent of the first position information.

Petitioner contends that "Bruno discloses receiving estimated location information from software instances using GPS, broadcast signals, and RF signpost techniques, which are independent." Pet. 17 (citing Ex. 1007, 2:17–63, 3:52–56, 4:1–67, 8:48–9:4, 10:8–11, Fig. 2 (17, 18, 20), Fig. 9). Petitioner also provides an annotated illustration of Figure 9 of Bruno, reproduced below, showing highlighted red, blue, and green components to support that "the three techniques can be combined." *Id.* at 14.

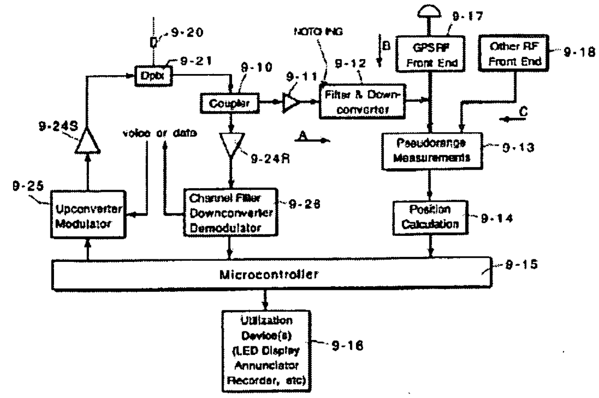

FIGURE 9

Figure 9 illustrates a block diagram of a communication terminal. As shown, a communication terminal receives cellular signals along path A (red), GPS signals along path B (blue), and RF signpost signals along path C (green). Pet. 14.

On this record, we are not persuaded that Bruno teaches "neither of the first and second position information is dependent upon the other." Bruno teaches, for example, that incoming signals—cellular, GPS, and RF signpost—"have separate front ends, but share the middle and end stages of the GPS receiver." Ex. 1007, 9:2–4. Specifically, they are all routed to Pseudorange Measurements stage 9-13 of the GPS receiver, and then are sent to Position Calculation stage 9-14. *See* Ex. 1007, Fig. 9, 9:21–23. This is consistent with Bruno's teaching that the broadcast signals and signpost signals are "GPS-like." *Id.* at 2:17–19. Additionally, Bruno teaches that the system is "integrated" (*id.* at 10:34). Bruno also teaches the timing of the navigation signal sent over the communication or cellular system "preferably, is slaved to the GPS system." *Id.* at 3:67–4:1. As a result, Petitioner has not shown sufficiently that Bruno teaches "neither of the first and second position information is dependent upon the other," as required by claim 25, and claims 26 and 72, which depend therefrom.

Claims 27, 31, 36, 37, 39, and 40

Independent claim 27 recites:

> first transmitting said first output location data to its corresponding destination via a communications network; and
>
> second transmitting said second output location data to its corresponding destination via a communications network, the first and second locations being different.

Petitioner states only "*See above.*" Pet. 20. It is not clear, however, what Petitioner is referring to because there is no limitation of commensurate scope discussed above. To the extent "different" is used in previous limitations, it refers not to different locations but to "different" requests (claim 25) and to "different" times (claim 26). On this record, Petitioner has not adequately identified any teaching in Bruno of a first and second location being different. As a result, we are not persuaded that Bruno teaches this limitation of independent claim 27, or of claims 31, 36, 27, 39, and 40, which depend therefrom.

Claim 49

For multiple elements of claim 49, Petitioner states only "*See above.*" or "*See below.*" Pet. 22–23. It is not clear, however, what portions of Bruno Petitioner is referring to as these exact limitations are not found above and Petitioner provides no explanation of which other limitation(s) it believes is commensurate in scope and why. On this record, Petitioner has not adequately identified any teaching in Bruno of these various limitations. As a result, we are not persuaded that Bruno teaches these limitations of independent claim 49.

Claims 51 and 56

For multiple elements of claim 51, Petitioner states only "*See above.*" Pet. 24. It is not clear, however, what portions of Bruno Petitioner is referring to as these exact limitations are not found above and Petitioner provides no explanation of which other limitation(s) it believes is commensurate in scope and why. On this record, Petitioner has not adequately identified any teaching in Bruno of these limitations. As a result, we are not persuaded that Bruno teaches these limitations of independent claim 51, or of claim 56 which depends therefrom.

Claims 60 and 61

Claim 60 depends from independent claim 57, and claim 61 depends from claim 60. Petitioner provides no analysis for independent claim 57. Pet. 25. On this record, Petitioner has not adequately identified teachings in Bruno of each and every limitation of independent claim 57. As a result, we are not persuaded that Bruno renders obvious claim 57, or claims 60 and 61, which depend therefrom.

3. Conclusion

We have considered Petitioner's evidence in light of Patent Owner's Preliminary Response and, on this record, we are not persuaded that Petitioner has shown a reasonable likelihood that it would prevail with respect to any claim as obvious over Bruno.

C. Claims 38, 45, 50, and 63 – Obviousness over Bruno and LeBlanc

Petitioner argues that claims 38, 45, 50, and 63 are unpatentable under 35 U.S.C. § 103(a) as obvious over Bruno and LeBlanc. Pet. 26–32.

1. Analysis

In light of the arguments and evidence of record, Petitioner has not established a reasonable likelihood that any of claims 38, 45 and 50 are unpatentable as obvious over Bruno and LeBlanc. Pet. 26–32. However, as discussed further below, we are persuaded that Petitioner has shown a reasonable likelihood that it would prevail with respect to claim 63 as obvious over Bruno and LeBlanc.

Claims 38 and 50

Claim 38 depends from independent claim 27. Claim 50 depends from independent claim 49. As discussed above, we are not persuaded that independent claims 27 and 49 are obvious over Bruno. In this ground, Petitioner relies upon LeBlanc only for the additional limitations recited in dependent claims 38 and 50. Pet. 47–50. Petitioner does not allege that LeBlanc teaches the limitations that we determined were not taught by Bruno. As a result, Petitioner has not established a reasonable likelihood that claims 38 and 50 are obvious over Bruno and LeBlanc.

Claim 45

Independent claim 45 recites:

> wherein for at least one location L of the mobile station, said first mobile station location technique and said second mobile station location technique output location information instances having, respectively, first and second position information for the mobile station being at L, *wherein neither of the first and second position information varies substantially as a result in a change in the other*

Emphasis added. Petitioner contends that "Bruno discloses receiving estimated location information from software instances using GPS, broadcast signals, and RF signpost techniques, which are independent."

Pet. 28 (citing Ex. 1007, 2:17–63, 3:52–56, 4:1–67, 8:48–9:4, 10:8–11, Fig. 2, (17, 18, 20), Fig. 9).

As discussed above, we are not persuaded that Bruno teaches "neither of the first and second position information varies substantially as a result in a change in the other." Bruno teaches, for example, that incoming signals—cellular, GPS, and RF signpost—"have separate front ends, but share the middle and end stages of the GPS receiver." Ex. 1007, 9:2–4. Specifically, they are all routed to Pseudorange Measurements stage 9-13 of the GPS receiver, and then are sent to Position Calculation stage 9-14. *See* Ex. 1007, Fig. 9, 9:21–23. This is consistent with Bruno's teaching that the broadcast signals and signpost signals are "GPS-like." *Id.* at 2:17–19. Additionally, Bruno teaches that the system is "integrated" (*id.* at 10:34). Bruno also teaches the timing of the navigation signal sent over the communication or cellular system "preferably, is slaved to the GPS system." *Id.* at 3:67–4:1. As a result, we are not persuaded that Bruno teaches "neither of the first and second position information varies substantially as a result in a change in the other," as required by claim 45.

Claim 63

Independent claim 63 is directed to a method of locating a MS. Petitioner provides an element-by-element analysis of where each limitation is taught by Bruno and LeBlanc. Pet. 31–32. For example, claim 63 recites "providing access to at least two location techniques." Petitioner cites generally to Bruno's teaching of using three different types of signals—GPS, broadcast, and RF signpost—to determine location. Pet. 28 (citing Ex. 1007, 2:17–63, 3:52–56, 4:1–67, 8:48–9:4, 10:8–11, Fig. 7 (elements 7-17, 7-18, 7-20), Fig. 9). We are persuaded that Petitioner's citations support its contentions. Petitioner contends that a person of ordinary skill in the art would have combined Bruno and LeBlanc because "doing so would simply be use of known technique to improve similar devices." Pet. 25 (citing Judge Decl. ¶ 44). On the record before us, we are persuaded that Petitioner has provided an articulated reasoning with some rational underpinning sufficient to support the legal conclusion of obviousness. *See KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418 (2007) (citing *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)).

Patent Owner contends that "Petitioner suggests that 'obtaining' is met by 'determining' but provides no explanation or analysis to support this contention." Prelim. Resp. 23. Patent Owner does not provide any argument or evidence that Bruno fails to teach this limitation—Patent Owner simply argues that Petitioner's argument and evidence are insufficient. *Id.* On the present record, we do not agree with the distinction Patent Owner draws. Calculating GPS coordinates is one way of "obtaining" those coordinates. Accordingly, we are persuaded that Petitioner is reasonably likely to show that Bruno teaches the "obtaining" limitation of claim 63.

2. Conclusion

We have considered Petitioner's evidence in light of Patent Owner's Preliminary Response and, on this record, we are persuaded that Petitioner has shown a reasonable likelihood that it would prevail with respect to claim 63 as obvious over Bruno and LeBlanc.

D. Claims 25–27, 31, 36, 37, 39, 40, 49, 51, 57, 60, 61, 63, and 72 – Obviousness over Loomis

Petitioner argues that claims 25, 26, 27, 31, 36, 37, 39, 40, 49, 51, 56, 57, 60, 61, and 72 are unpatentable under 35 U.S.C. § 103(a) as obvious over Loomis. Pet. 32–47.

1. Loomis (Ex. 1008)

Loomis describes an apparatus for determining a location of a mobile user, both inside and outside of buildings and structures, using two different location determining techniques. Ex. 1008, Abstract. Loomis observes that location technology such as GPS, Global Orbiting Navigation Satellite System ("GLONASS"), and Long Range Navigation ("LORAN") "provide object location estimates over regions with diameters of hundreds of kilometers (km) but do not work well where some of the signal sources are obscured by structures outdoors, or when the object to be located is positioned indoors." *Id.* at 1:19–34. In contrast, "[frequency modulation ("FM")] subcarrier signals can be used over smaller regions to estimate the location of an object inside or outside a building or other structure," but such systems "tend[] to be limited to smaller regions, with diameters of the order of 20–50 km." *Id.* at 1:38–46. To take advantage of both types of technologies, Loomis's system "provides an integrated, mobile or portable system for location determination that combines beneficial features of two or more LD systems." *Id.* at 4:39–42.

Figure 1, reproduced below, illustrates an example:

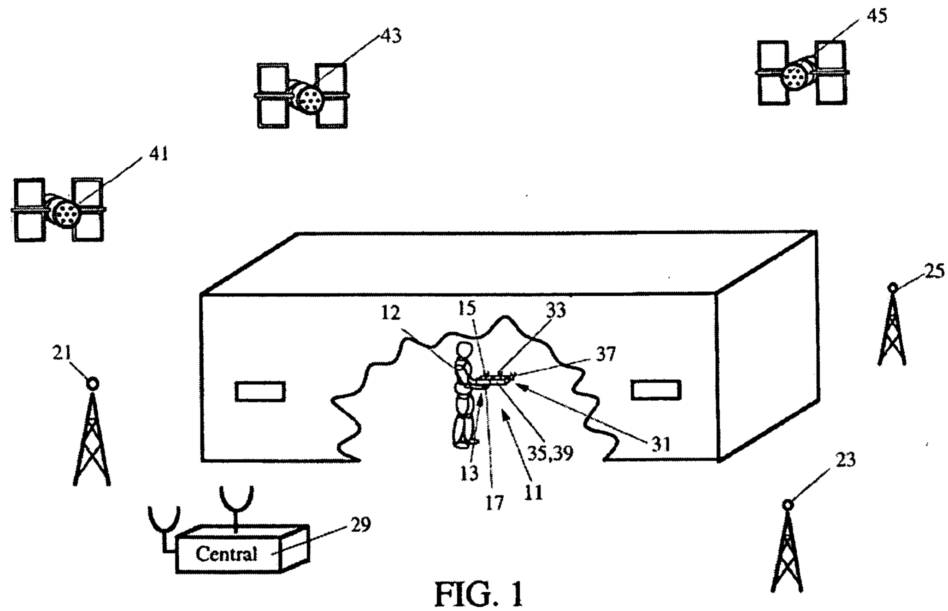

FIG. 1

Figure 1 is a schematic illustrating user 12 operating hybrid location determining ("LD") system 11. *Id.* at 6:21–29. Hybrid LD system 11 includes two different technologies for receiving location information. Specifically, radio LD unit 13 (renumbered 71 in Figure 6) receives FM signals from radio LD signal sources 21, 23, and 25, and outdoor LD unit 31 (renumbered 81 in Figure 6) receives GPS or GLONASS signals from satellites 41, 43, and 45. *Id.* at 6:20–29, 7:9–22.

A controller receives location coordinates (in x, y, z format) from the radio LD unit and from the outdoor LD unit, along with indicia resulting from the comparison of the FM and outdoor signals to thresholds (i.e., indicia indicating the accuracy of the respective location coordinates). *Id.* at 12:21–27. In Figure 6, the controller is depicted as part of hybrid LD unit 11, although, in an alternative embodiment, "information from the radio LD signals and/or the outdoor LD signals may be transmitted, unprocessed or partly processed or fully processed, to a central processing station 29 (optional), located at or near the site R, to allow determination of the present location of the user 12 at selected times." *Id.* at 8:29–34; *accord id.* at 20:29–36. The controller can choose the radio coordinates or satellite coordinates, depending on which is the most accurate (or choose neither, if both are determined to be too inaccurate). *Id.* at 12:47–13:4. "[H]ybrid LD system 11 then processes the LD signals further, or transmits or stores or displays the location of the hybrid LD system." *Id.* at 19:53–55.

For the radio LD unit to make a location determination, it must first know the relative phases of the FM signals from the radio LD signal sources. *Id.* at 4:9–14. To that end:

> The outdoor LD unit 31 in FIG. 1 includes a radio LD signal antenna and receiver/processor 37 and controller/interface 39 that also receives radio LD signals from the radio LD sources 21, 23 and 25, determines the relative phases of these radio LD signals, and provides this relative phase information with little or no time delay for use by the radio LD unit 13.

Id. at 7:23–29; *accord id.* at 11:66–12:8:

> The outdoor LD unit 81 includes an FM subcarrier signal antenna 83, an outdoor signal receiver/processor 85 associated with and connected to the outdoor antenna 83, and a phase information antenna 87. The phase information antenna and receiver 87 receives the radio LD signals from the radio LD signal sources and passes these signals to the outdoor LD signal receiver/processor 85 for determination of the relative phases of the radio LD signal sources. This relative phase information is then passed to the radio LD unit 71 through the controller interface 91.

The outdoor LD unit determines its own location and uses that location estimate to determine the relative phases. *Id.* at 7:31–38, 19:37–47.

2. Analysis

In light of the arguments and evidence of record, Petitioner has established a reasonable likelihood that claims 51 and 63 are unpatentable as obvious over Loomis. Pet. 32–47.

Claims 25, 26, and 72

Independent claim 25 recites "said first location evaluator and said second location evaluator output, respectively, first and second position information related to the one mobile station being at L *wherein neither of the first and second position information is dependent upon the other*" (emphasis added). By its terms, the emphasized claim language requires that the first position information is independent of the second position information, and that the second position information is independent of the first position information.

Petitioner cites to Loomis's teachings of an outdoor LD module that determines GPS location coordinates, and a radio LD module that determines radio coordinates. Pet. 36–37. Petitioner cites (without further explanation) to Loomis's description that "[t]he outdoor LD system operates independently of the radio LD signal system," as teaching "wherein neither of the first and second position information is dependent upon the other." *Id.* at 37 (quoting Ex. 1008, 5:7–9).

While the passage cited by Petitioner arguably shows that the coordinates provided by Loomis's outdoor LD unit do not depend on those provided by the radio LD unit, Petitioner has not shown sufficiently that the coordinates from the radio LD unit do not depend on those from the outdoor LD unit. Based on our review of Loomis, we determine that radio LD unit coordinates in fact do depend on the GPS coordinates. Specifically, the radio LD unit relies on FM signal phase measurements from the outdoor LD unit to generate radio LD coordinates and that those phase measurements, in turn, depend on a location estimate by the outdoor LD unit. Ex. 1008, 7:31–38, Fig. 9. According to Loomis:

> The relative phases of the radio signals transmitted by the sources 21, 23 and 25 may change from time to time. When the radio LD unit 13 is provided with a recent measurement of these relative phases, the radio LD unit can determine the location of its antenna 15, using intersections of three or more hyperboloids that are defined by the relative times of arrival of the three radio LD signals at the antenna.

Ex. 1008, 6:46–52. Thus, to interpret the radio signals and generate coordinates from those signals, radio LD unit 13 must first be provided by a measurement of the phases of those radio signals. Loomis describes the outdoor LD unit as providing this phase information. For example,

> The outdoor LD unit 31 in FIG. 1 includes a radio LD signal antenna and receiver/processor 37 and controller/interface 39 that also receives radio LD signals from the radio LD sources 21, 23 and 25, determines the relative phases of these radio LD signals, and provides this relative phase information with little or no time delay for use by the radio LD unit 13.

Id. at 7:23–29; *accord id.* at 11:66–12:8, 19:42–47. The outdoor LD unit's phase determination is, in turn, dependent on a computation of the location of the outdoor LD unit: "The outdoor LD unit 31 determines the (approximate) location of itself and of the adjacent radio LD unit 13 and uses this information in determining the relative phases of the radio LD signals transmitted by the sources 21, 23 and 25." *Id.* at 7:29–35. Thus, these passages of Loomis describe the coordinates (second position information) generated by the radio LD unit as dependent on a determination of the phases of the radio signals—a determination that is dependent on the outdoor LD unit's computation of GPS coordinates (first position information). Loomis describes this as "an important feature of the invention." *Id.* at 7:35–38. As a result, we read Loomis to teach that second position information is dependent on the first.

On this record, we are not persuaded that Loomis teaches "wherein neither of the first and second position information is dependent upon the other," as recited in independent claim 25, and claims 26 and 72, which depend therefrom.

<u>Claims 27, 31, 36, 37, 39, and 40</u>

Independent claim 27 recites:

> first transmitting said first output location data to its corresponding destination via a communications network; and
>
> second transmitting said second output location data to its corresponding destination via a communications network, the first and second locations being different.

Petitioner relies upon Loomis's teaching that the LD system transmits its location. Pet. 39 (citing Ex. 1008, 19:60–65, Fig. 9, step 187). With respect to "the first and second locations being different," Petitioner relies upon Loomis's teaching that "the controller module notifies any interested person or facility that the methods used for location determination have an unacceptably high errors associated with them and should not be used, or should be used with caution." *Id.* (citing Ex. 1008, 12:65–66). This portion of Loomis, however, teaches only that *both* the indicium representing the signal strength or signal quality of the outdoor LD system *and* the indicium representing the signal strength or signal quality of the radio LD system may be less than their respective indicia thresholds, $I_{rad,thr}$ and $I_{out,thr}$. It does not teach that the coordinates produced by the two LD units are different. As a result, we are not persuaded by Petitioner's contentions that Loomis teaches this limitation of independent claim 27, or of claims 31, 36, 37, 39, and 40, which depend therefrom.

<u>*Claim 49*</u>

Independent claim 49 recites:

> (a) for determining a likely geographical approximation, GA_A, for a location, L_A, of a second of the mobile stations at a time T_A, said first location estimator generates GA_A *without requiring a prior likely geographical location approximation generated by said second location estimator* for locating the second mobile station at substantially the location L_A at substantially the time T_A, and,
>
> (b) for estimating a likely geographical approximation, GA_B, for a location, L_B, of a third one of the mobile stations at a time T_B, said second location estimator generates GA_B *without requiring a prior likely geographical location approximation generated by said first location estimator* for locating the third mobile station at the location L_B at substantially the time T_B

Ex. 1001, 179:15–29 (emphasis added). Petitioner cites (without further explanation) to Loomis's description that "information from the radio LD signals and/or the outdoor LD signals may be transmitted, unprocessed or partly processed or fully processed, to a central processing station 29 (optional), located at or near the site R, to allow determination of the present location of the user 12 at selected times" as teaching this limitation. Pet 41–42 (quoting Ex. 1008, 8:29–35). Petitioner also cites to Figure 7 and a description thereof. *Id.* (citing Ex. 1008, 15:47–50 ("FIG. 7 is similar to FIG. 6, except that the radio LD unit 13 and the outdoor LD unit 31 (or 51) are now physically separated from, and move independently of, each other. The radio LD unit 11 is portable and moves with the user 12.")).

Petitioner has not shown sufficiently that the coordinates provided by Loomis's radio LD unit can be determined without requiring a prior determination of location by the outdoor LD unit. Based on our review of Loomis, we determine that the coordinates determined by the radio LD unit in fact do depend on the GPS coordinates. Specifically, the radio LD unit relies on FM signal phase measurements from the outdoor LD unit to generate radio LD coordinates and those phase measurements, in turn, depend on a location estimate by the outdoor LD unit. Ex. 1008, 7:31–38, Fig. 9. According to Loomis:

> The relative phases of the radio signals transmitted by the sources 21, 23 and 25 may change from time to time. When the radio LD unit 13 is provided with a recent measurement of these relative phases, the radio LD unit can determine the location of its antenna 15, using intersections of three or more hyperboloids that are defined by the relative times of arrival of the three radio LD signals at the antenna.

Ex. 1008, 6:46–52. Thus, to interpret the radio signals and generate coordinates from those signals, radio LD unit 13 must first be provided by a measurement of the phases of those radio signals. Loomis describes the outdoor LD unit as providing this phase information. For example,

> The outdoor LD unit 31 in FIG. 1 includes a radio LD signal antenna and receiver/processor 37 and controller/interface 39 that also receives radio LD signals from the radio LD sources 21, 23 and 25, determines the relative phases of these radio LD signals, and provides this relative phase information with little or no time delay for use by the radio LD unit 13.

Id. at 7:23–29; *accord id.* at 11:66–12:8, 19:42–47. The outdoor LD unit's phase determination is, in turn, dependent on a computation of the location of the outdoor LD unit: "The outdoor LD unit 31 determines the (approximate) location of itself and of the adjacent radio LD unit 13 and uses this information in determining the relative phases of the radio LD signals transmitted by the sources 21, 23 and 25." *Id.* at 7:29–35. Thus, for determining coordinates (i.e., "a likely geographical approximation, GA_B"), the radio LD unit (i.e., "second location estimator") requires a determination of the phases of the radio signals, which determination requires the outdoor LD unit's computation of GPS coordinates (i.e., "a prior likely geographical location approximation generated by said first location estimator"). As a result, we read Loomis to teach that its radio LD unit (i.e., "said second location estimator") cannot estimate "a likely geographic approximation, GA_B," "without requiring a prior likely geographical location approximation generated by said first location estimator," as required by claim 49.

Claim 51

Independent claim 51 is directed to a method of tracking a MS over time. Petitioner provides an element-by-element analysis of where each limitation is taught by Loomis. Pet. 42–43. For example, claim 51 recites "providing access to a plurality of mobile station location estimating techniques." Petitioner cites generally to Loomis's teaching of radio LD and outdoor LD modules generating location estimates using measurements of wireless signals as inputs. *Id.* at 43. For "receiving, over time, a plurality of location estimates of the mobile station" and "determining, a plurality of consecutive resulting location estimates for tracking the mobile station," as recited in claim 51, Petitioner cites to Loomis's disclosure of performing its techniques "[a]t one or more selected times," and to Loomis's example of determining locations "at selected times (e.g., second-by-second, or more or less often, if desired)." *Id.* at 43 (citing Ex. 1008, 8:29–35). Claim 51 further recites "wherein said step of determining includes steps (a) and (c) following:" wherein (a) is a step of deriving a location estimate using a first location technique, (b) is a step of deriving a location estimate using a second location technique, and (c) is a step of preferring one estimate over the other.[1] Petitioner points to Loomis's description of an outdoor LD unit as showing step (a), Loomis's description of a radio LD unit as showing step (b), and Loomis's description of choosing GPS coordinates over radio location coordinates as showing step (c). Pet. 43 (citing Ex. 1008, 12:48–62, 19:48–63). We are persuaded that Petitioner's citations support its contentions regarding independent claim 51.

Patent Owner contends that Petitioner does not address "'input information' or how it is at least partially derived from the required measurements." Prelim. Resp. 28. Patent Owner does not provide any argument or evidence that Loomis fails to teach this limitation—Patent Owner simply argues that Petitioner's argument and evidence are insufficient. *Id.* We disagree. Petitioner cites to, *inter alia*, Loomis's Abstract (Pet. 43), which teaches that (1) Loomis's radio LD unit "receives radiowaves from at least three radio LD signal sources, such as FM carrier or subcarrier signals;" (2) Loomis's outdoor LD unit "receives outdoor LD signals from at three other satellite-based or ground-based outdoor LD signal sources, such as GPS, GLONASS, or Loran-C signal sources;" and (3) "[t]he radio LD signals and outdoor LD signals are used to (1) determine the location of the radio LD module, (2) determine the location of the outdoor LD module" (Ex. 1008, Abstract). On this record, we are persuaded that the Petition adequately identifies teachings in Loomis of "input information"

[1] We note that claim 51 recites "steps (a) and (c)." Nevertheless, Petitioner has introduced evidence that each of steps (a), (b), and (c) is taught in Loomis. Thus, it is not necessary to decide whether claim 51 includes a typographical error.

that "is at least partially derived from measurements of wireless signals transmitted from or received at the mobile station."

Claims 57, 60, and 61

Independent claim 57 recites "said location evaluators are supplied with data having values obtained during wireless signal two way communication between said mobile station and the communication stations." Petitioner cites generally to Loomis's teaching of radio LD and outdoor LD modules generating location estimates using measurements of wireless signals as inputs. Pet. 44 (citing Ex. 1008, Abstract, 4:39–65, 6:46–55, 8:29–35, 19:56–60, Fig. 6, Fig. 9). We are persuaded that Petitioner's citations support its contentions regarding independent claim 57. We also are persuaded that Petitioner's citations support its contentions regarding claims 60 and 61, which depend from independent claim 57. Pet. 45 (citing Ex. 1008, 8:29–35, 12:47–52).

Patent Owner contends that Petitioner does not address "data having values obtained during wireless signal two way communication between said mobile station and the communications stations," as recited in claim 57. Prelim. Resp. 29. We disagree. Petitioner cites to column 8, lines 29 to 35, of Loomis, which states, "[a]lternatively, information from the radio LD signals and/or the outdoor LD signals may be transmitted, unprocessed or partly processed or fully processed, to a central processing station 29 (optional), located at or near the site R, to allow determination of the present location of the user 12 at selected times (e.g., second-by-second, or more or less often, if desired)." In this embodiment, the location evaluators are at central processing station 29, and the data supplied to it has values obtained via two way communication between the mobile station and a communication station. Thus, on this record, we are persuaded that the

Petition adequately identifies teachings in Loomis of location evaluators being supplied with "data having values obtained during wireless signal two way communication between said mobile station and the communications stations."

Claim 63

Independent claim 63 is directed to a method of locating a MS. Petitioner provides an element-by-element analysis of where each limitation is taught by Loomis. Pet. 45–46. For example, claim 63 recites "providing access to at least two location techniques." Petitioner cites generally to Loomis's teaching of radio LD and outdoor LD modules generating location estimates using measurements of wireless signals as inputs. *Id.* (citing Ex. 1008, Abstract). We are persuaded that Petitioner's citations support its contentions.

Patent Owner contends that "Petitioner asserts that Loomis discloses 'obtaining…' but does not explain what claim element 'obtaining…' is supposed to satisfy—the first or second 'determining' or the 'receiving.'" Prelim. Resp. 30. Patent Owner does not provide any argument or evidence that Loomis fails to teach this limitation—Patent Owner simply argues that Petitioner's argument and evidence are insufficient. *Id.* We disagree. Petitioner cites to, *inter alia*, Loomis's Abstract (Pet. 43), which teaches that (1) Loomis's radio LD unit "receives radiowaves from at least three radio LD signal sources, such as FM carrier or subcarrier signals;" (2) Loomis's outdoor LD unit "receives outdoor LD signals from at three other satellite-based or ground-based outdoor LD signal sources, such as GPS, GLONASS, or Loran-C signal sources;" and (3) "[t]he radio LD signals and outdoor LD signals are used to (1) determine the location of the radio LD module, (2) determine the location of the outdoor LD module" (Ex. 1008, Abstract). Petitioner also cites column 19, lines 47 to 63, of Loomis, which teaches:

> In step 179, the controller determines whether the outdoor LD signals, or the radio LD signals, or both, or neither, is adequate to allow determination of the location of the associated LD unit antenna, relying in part on the indicium or indicia associated with that signal or signals. If the outdoor LD signals are adequate and the outdoor LD unit is selected, in step 181, to determine the location, the system (or controller) uses the outdoor LD unit information to determine the present location of the user. If the radio LD signals are adequate and the radio LD unit is selected, in step 183, to determine the location, the system (or controller) uses the radio LD unit information to determine the present location of the user.

On this record, we are persuaded that the Petition has identified adequately teachings in Loomis of the recited "determining" and "receiving" steps.

3. Conclusion

We have considered Petitioner's evidence in light of Patent Owner's Preliminary Response and, on this record, we are persuaded that Petitioner has shown a reasonable likelihood that it would prevail with respect to claims 51, 57, 60, 61, and 63 as obvious over Loomis.

E. Claims 38, 45, and 50 –
Obviousness Over Loomis and LeBlanc

Petitioner argues that claims 38, 45, and 50 are unpatentable under 35 U.S.C. § 103(a) as obvious over Loomis and LeBlanc. Pet. 47–50.

1. Analysis

In light of the arguments and evidence of record, Petitioner has not established a reasonable likelihood that any of claims 38, 45, or 50 are unpatentable as obvious over Loomis and LeBlanc. Pet. 47–50.

Claims 38 and 50

Claim 38 depends from independent claim 27. Claim 50 depends from independent claim 49. As discussed above, we are not persuaded that independent claims 27 and 49 are obvious over Loomis. In this ground, Petitioner relies upon LeBlanc only for the additional limitations recited in dependent claims 38 and 50. Pet. 47–50. Petitioner does not allege that LeBlanc teaches the limitations that we determined were not taught by Loomis. As a result, Petitioner has not established a reasonable likelihood that claims 38 and 50 are obvious over Loomis and LeBlanc.

Claim 45

Independent claim 45 recites:

> wherein for at least one location L of the mobile station, said first mobile station location technique and said second mobile station location technique output location information instances having, respectively, first and second position information for the mobile station being at L, *wherein neither of the first and second position information varies substantially as a result in a change in the other*

Emphasis added. Petitioner contends that "Loomis discloses that the different location determiners (outdoor and radio LD units) can be independent of each other." Pet. 49 (citing Ex. 1008, 5:7–9 ("The outdoor LD system operates independently of the radio LD signal system"), Fig. 6, Fig. 9).

While the passage cited by Petitioner arguably shows that the coordinates provided by Loomis's outdoor LD unit do not vary as a result of a change in those provided by the radio LD unit, Petitioner has not shown sufficiently that the coordinates from the radio LD unit do not vary as a result of a change in those provided by the outdoor LD unit. Based on our review of Loomis, we determine that radio LD unit coordinates in fact do depend on the GPS coordinates. Specifically, the radio LD unit relies on FM signal phase measurements from the outdoor LD unit to generate radio LD coordinates and those phase measurements, in turn, depend on a location estimate by the outdoor LD unit. Ex. 1008, 7:31–38, Fig. 9. According to Loomis:

> The relative phases of the radio signals transmitted by the sources 21, 23 and 25 may change from time to time. When the radio LD unit 13 is provided with a recent measurement of these relative phases, the radio LD unit can determine the location of its antenna 15, using intersections of three or more hyperboloids that are defined by the relative times of arrival of the three radio LD signals at the antenna.

Ex. 1008, 6:46–52. Thus, to interpret the radio signals and generate coordinates from those signals, radio LD unit 13 must first be provided by a measurement of the phases of those radio signals. Loomis describes the outdoor LD unit as providing this phase information. For example,

> The outdoor LD unit 31 in FIG. 1 includes a radio LD signal antenna and receiver/processor 37 and controller/interface 39 that also receives radio LD signals from the radio LD sources 21, 23 and 25, determines the relative phases of these radio LD signals, and provides this relative phase information with little or no time delay for use by the radio LD unit 13.

Id. at 7:23–29; *accord id.* at 11:66–12:8, 19:42–47. The outdoor LD unit's phase determination is, in turn, dependent on a computation of the location of the outdoor LD unit: "The outdoor LD unit 31 determines the (approximate) location of itself and of the adjacent radio LD unit 13 and uses this information in determining the relative phases of the radio LD signals transmitted by the sources 21, 23 and 25." *Id.* at 7:29–35. Thus, the coordinates (second position information) generated by the radio LD unit vary as a result of a change in the phases of the radio signals, which depends on the outdoor LD unit's computation of GPS coordinates (first position information). As a result, we read Loomis to teach that second position information varies as a result of a change in the first position information.

2. Conclusion

We have considered Petitioner's evidence in light of Patent Owner's Preliminary Response and, on this record, we are not persuaded that Petitioner has shown a reasonable likelihood that it would prevail with respect to any of claims 38, 45, or 50 as obvious over Loomis and LeBlanc.

F. Claim 56 –
Obviousness Over Loomis and Yokouchi

Petitioner argues that claim 56 is unpatentable under 35 U.S.C. § 103(a) as obvious over Loomis and Yokouchi. Pet. 50–51.

1. Analysis

In light of the arguments and evidence of record, Petitioner has established a reasonable likelihood that claim 56 is unpatentable as obvious over Loomis and Yokouchi. Pet. 50–51.

Claim 56 recites:

> The method as claimed in claim 51, wherein said step of determining includes, for at least one of said resulting location estimates, determining one or more of: (a) a velocity of the mobile station, (b) an acceleration of the mobile station, and (c) one or more geographical features near said at least one resulting location estimate

Petitioner contends that "Yokouchi discloses determining velocity along with a location estimate." Pet. 51 (citing Ex. 1010, Abstract, 9:32–39, Fig. 4B, Fig. 5, Fig. 6). Yokouchi teaches that "the moving velocity and/or acceleration are calculated (step S4)." Ex. 1010, 9:38–39. Petitioner contends that the combination of Loomis and Yokouchi "is simply the application of a known technique to a known method ready for improvement to yield predictable results." Pet. 50 (citing Judge Decl. ¶ 53). On the record before us, we are persuaded that Petitioner has provided an articulated reasoning with some rational underpinning sufficient to support the legal conclusion of obviousness. *See KSR*, 550 U.S. at 418.

2. *Conclusion*

We have considered Petitioner's evidence in light of Patent Owner's Preliminary Response and, on this record, we are persuaded that Petitioner has shown a reasonable likelihood that it would prevail with respect to claim 56 as obvious over Loomis and Yokouchi.

III. CONCLUSION

We institute an *inter partes* review of claims 51, 56, 57, 60, 61, and 63, but not of claims 25–27, 31, 36–40, 45, 49, 50, 57, 60, 61, and 72. We have not yet made a final determination of the patentability of these claims or the construction of any claim term.

IV. ORDER

For the reasons given, it is:

ORDERED that *inter partes* review is instituted on the following grounds:

1. Claim 63, under 35 U.S.C. § 103(a), as obvious over Bruno and LeBlanc;
2. Claims 51, 57, 60, 61, and 63, under 35 U.S.C. § 103(a), as obvious over Loomis;

3. Claim 56, under 35 U.S.C. § 103(a), as obvious over Loomis and Yokouchi;

FURTHER ORDERED that the trial is limited to the grounds identified above, and no other ground is authorized; and

FURTHER ORDERED that pursuant to 35 U.S.C. § 314(a), *inter partes* review of U.S. Patent No. 7,525,484 B2 is hereby instituted commencing on the entry date of this Order, and pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4, notice is hereby given of the institution of a trial.

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Paper 7
Entered: February 19, 2016

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

TRACBEAM, LLC,
Patent Owner.

Case IPR2015-01696
Patent 7,525,484 B2

Before KEVIN F. TURNER, RICHARD E. RICE, BARBARA A. PARVIS, and MATTHEW R. CLEMENTS, *Administrative Patent Judges.*

CLEMENTS, *Administrative Patent Judge.*

DECISION
Denying Institution of *Inter Partes* Review
37 C.F.R. § 42.108

I. INTRODUCTION

A. Background

Apple Inc. (collectively, "Petitioner") filed a Petition (Paper 1, "Pet.") to institute an *inter partes* review of claims 25–28, 31, 36–43, 45, 47–51, 55–57, 60–61, 63, and 72 of U.S. Patent No. 7,525,484 B2 (Ex. 1001, "the '484 patent"). TracBeam, LLC ("Patent Owner") filed a Preliminary Response (Paper 6, "Prelim. Resp.").

Upon consideration of the Petition and Preliminary Response, we conclude, under 35 U.S.C. § 314(a), that Petitioner has not established a reasonable likelihood that it would prevail with respect to at least one challenged claim of the '484 patent. Accordingly, under the standard of § 314, we deny the Petition and decline to institute an *inter partes* review of the challenged claims of the '484 patent.

B. Related Matters

The '484 patent is the subject of several lawsuits filed in the United States District Court for the Eastern District of Texas. Pet. 1; Paper 5, 1–2.

The '484 patent also is the subject of *Apple Inc. v. TracBeam, LLC,* Case IPR2015-01697 (PTAB), *T-Mobile US, Inc.. v. TracBeam, LLC*, Case IPR2015-01708 (PTAB), and *T-Mobile US, Inc. v. TracBeam, LLC*, Case IPR2015-01711 (PTAB). Pet. 1; Paper 5, 3.

Various related patents also are subjects of these and other proceedings before the district courts and the Board. Paper 5, 1–3.

C. The '484 Patent

The '484 patent describes location systems for wireless telecommunication infrastructures. Ex. 1001, Abstract. According to the '484 patent, the location techniques are useful for 911 emergency calls, vehicle tracking and routing, and location of people and animals. *Id.* at Abstract, 12:11–17.

Figure 4, reproduced below, illustrates an embodiment:

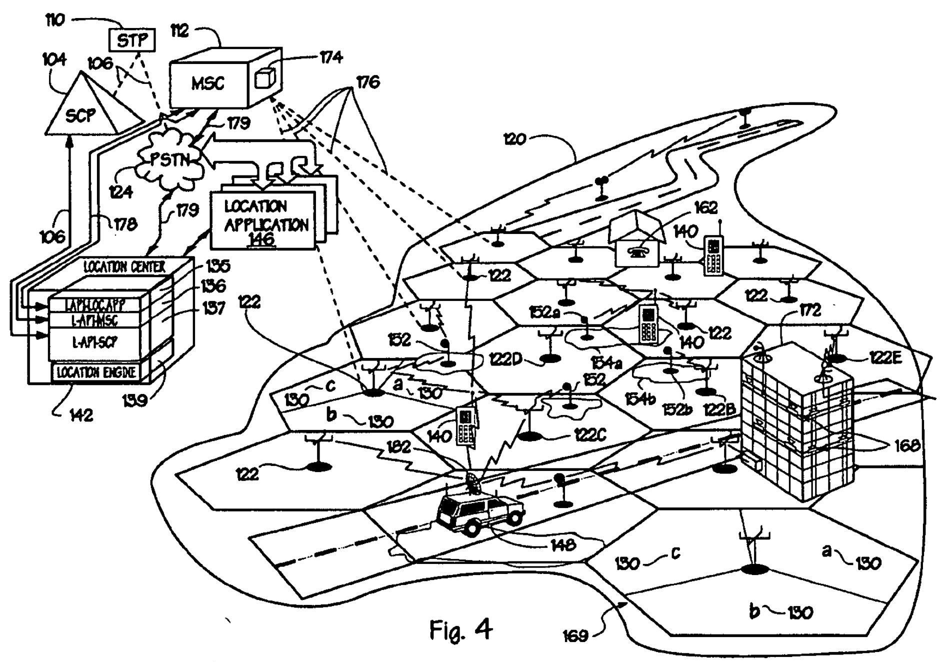

Fig. 4

Figure 4 is an overall view of a wireless radio location network architecture. *Id.* at 21:66–67. The network includes a plurality of mobile stations ("MS") 140, a mobile switching center ("MSC") 112, and a plurality of wireless cell sites forming radio coverage area 120, each site including a fixed-location base station 122 for voice and data communication with MSs 140. *Id.* at 24:41–57. The network also includes location base stations ("LBS") 152 with wireless location enablement, e.g., with transponders used primarily in communicating MS location related information to location center 142 (via base stations 122 and MSC 112). *Id.* at 24:57–64. LBSs can be placed, for example, in dense urban areas, in remote areas, along highways, or wherever more location precision is required than can be obtained using conventional wireless infrastructure components. *Id.* at 28:29–38.

Location center 142 determines a location of a target MS 140. *Id.* at 25:8–10, 37:43–46. The system uses a plurality of techniques for locating MSs, including two-way time of arrival ("TOA"), time difference of arrival ("TDOA"), and Global Positioning System ("GPS"). *Id.* at Abstract, 9:5–23, 11:7–55, 66:45–50. To determine a location for a MS, the system computes a first order model (also referred to as a hypothesis or estimate) for one or more of the locating techniques, computes a confidence value for each model indicating the likelihood that the model is correct, performs additional computations on the models to enhance the estimates, and computes from the models a "most likely" location for the MS. *Id.* at 12:62–13:20, 38:9–31. The most likely location can be a composite of the estimates. *Id.* at 13:22–30, 66:45–50.

Location estimates can be provided to location requesting applications, such as 911 emergency, police and fire departments, taxi services, etc. *Id.* at 8:52–60, 13:20–22, 38:32–34.

D. Illustrative Claim

Of the challenged claims, claims 25, 27, 45, 49, 51, 57, and 63 are independent. Claim 25, reproduced below, is illustrative of the claimed subject matter:

> 25. A method for estimating, for each mobile station M of a plurality of mobile stations, an unknown terrestrial location (L_M) for M using wireless signal measurements obtained via transmissions between said mobile station M and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations is substantially co-located with one or more of a transmitter and a receiver for wirelessly communicating with said mobile station M, comprising:
>
> initiating a plurality of requests for information related to the location of said mobile station M, the requests provided to each of at least two mobile station location evaluators, wherein there is at least a first of the requests provided to a first of the location evaluators and a second of the requests, different from the first request, provided to a second of the location evaluators, such that when said location evaluators are supplied with corresponding input data having values obtained using wireless signal measurements obtained via two way wireless communication between said mobile station M, and the communication stations, each of said first and second location evaluators determine corresponding location information related to L_M, and
>
> wherein for at least one location L of one of the mobile stations, said first location evaluator and said second location evaluator output, respectively, first and second position information related to the one mobile station being at L wherein neither of the first and second position information is dependent upon the other;
>
> obtaining a first collection of location information of said mobile station M, wherein the first collection includes first location information from the first location evaluator, and

second location information from the second location evaluator;

determining resulting information related to the location L_M of the mobile station M, wherein the resulting information is dependent on geographical information in each of the first and second location information; and

transmitting, to a predetermined destination via a communications network, the resulting information.

Ex. 1001, 174:11–63.

E. References Relied Upon

Petitioner relies upon the following prior art references:

Dupray ("PCT '307)"	WO 98/10307	Mar. 12, 1998	Ex. 1003
Federal Communications Commission, *Third Report and Order*, 14 FCC Rcd. 17012 (1999) ("FCC 99-245")			Ex. 1012
Stilp	US 5,327,144	July 5, 1994	Ex. 1032

Petitioner also relies upon a Declaration of Kevin S. Judge. Ex. 1002 ("Judge Decl.").

F. Asserted Grounds of Unpatentability

Petitioner argues that the challenged claims are unpatentable based on the following grounds (Pet. 41):

Reference(s)	**Basis**	**Claim(s) challenged**
PCT '307 and FCC 99-245	§ 103	25–28, 31, 36–42, 45, 47–51, 55–57, 60, 61, 63, and 72
PCT '307, FCC 99-245, and Stilp	§ 103	43

II. ANALYSIS

A. Claim Construction

We interpret claims of an unexpired patent using the broadest reasonable construction in light of the specification of the patent in which they appear. *See* 37 C.F.R. § 42.100(b); *In re Cuozzo Speed Techs., LLC*, 793 F.3d 1268, 1278 (Fed. Cir. 2015), *cert. granted*, *Cuozzo Speed Techs. LLC v. Lee*, 84 U.S.L.W. 3218 (U.S. 2016). In applying a broadest reasonable construction, claim terms generally are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire disclosure. *See In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

For the purposes of this Decision, we are not persuaded that any of the terms identified by Petitioner requires express construction, because even if we were to adopt Petitioner's proffered positions on claim construction, Petitioner has not met its burden to show that it is reasonably likely to succeed in showing that the challenged claims are unpatentable. *See Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) ("[O]nly those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy.").

B. Prior Art Status of PCT '307

Petitioner argues that (1) claims 25–28, 31, 36–42, 45, 47–51, 55–57, 60, 61, 63, and 72 are unpatentable under 35 U.S.C. § 103(a) as obvious over the combination of PCT '307 and FCC 99-245; and (2) claim 43 is unpatentable under 35 U.S.C. § 103(a) as obvious over the combination of PCT '307, FCC 99-245, and Stilp. Pet. 41–59. Both grounds are predicated upon Petitioner's assertion that the challenged claims are not entitled to priority, under 35 U.S.C. § 120, of the parent U.S. Patent Application No. 09/194,367 ("'367 application"), which is the National Stage application corresponding to International Application No. PCT/US97/15892 ("PCT

'892"), filed on September 8, 1997, because that applications "lack[s] written description support" for the challenged claims. Pet. 2–3, 32–40. As a result, according to Petitioner, the publication of PCT '892—PCT '307—is prior art. *Id.*

Petitioner contends specifically that PCT '892—published as PCT '307—"does not contain any disclosure whatsoever of a GPS handset." *Id.* at 34. Patent Owner points out correctly that the challenged claims do not recite expressly "GPS handset." Prelim. Resp. 8.

Even assuming that the claims encompass a GPS handset as Petitioner asserts, we are not persuaded, based on the arguments and evidence presented, that PCT '307 fails to disclose a GPS handset. PCT '307 provides more than 200 pages of textual description and more than 50 pages of drawings. *See generally* Ex. 1003. PCT '307 includes, amongst that disclosure, a non-exclusive list of wireless technologies that the mobile stations may use to communicate with any of "infrastructure base stations 122," "mobile base stations(s) 148," and "LBS [location base stations] 152." *Id.* at 26.[1] Furthermore, as Patent Owner points out (Prelim. Resp. 13–14), PCT '307 discloses that the "mobile location unit" in a mobile base station may be similar to that in a mobile unit: "For example . . . the electronics of the mobile location unit may be little more than an onboard MS 140." Ex. 1003, 102. This is consistent with the definitions section, which indicates that the term "mobile station" ("MS") is synonymous with "location unit." *Id.* at 11 (explaining in definition 3.2 that "in some contexts herein instead or in addition to MS, the following terms are also used . . . 'location unit' (LU).

1 Citations are to the page numbers of the PCT '307, not to the page numbering provided in the footer.

In general these terms may be considered synonymous."). PCT '307 further discloses that a GPS receiver may be incorporated into that "mobile location unit"—which may be "little more than an onboard MS 140." *Id.* ("In an enhanced version of the mobile location unit, a GPS receiver may also be incorporated so that the location of the mobile location unit may be determined."). Therefore, in light of these disclosures and the arguments before us, we determine that even if the claims require a GPS handset as Petitioner asserts, the evidence considered in its entirety supports the conclusion that the inventor had possession of the invention as of the filing date of PCT '892 and, therefore, it's publication—PCT '307—is not prior art.

Petitioner relies on the Declaration of Mr. Judge (*see, e.g.,* Pet. 35–36 (citing Ex. 1002 ¶¶ 28–38)), who testifies that "one of ordinary skill in the art would have understood the disclosure of GPS in the '892 application as applying to use of GPS only in base stations, not GPS in mobile stations or handsets." Ex. 1002 ¶ 37. Mr. Judge acknowledges that PCT '307 describes (1) "use of a GPS receiver in a mobile *base station*;" and (2) use of "the included GPS" to determine "the mobile station's location." *Id.* ¶ 35. Mr. Judge testifies, however, that "if the inventors had contemplated and were in possession of GPS in a mobile station or handset, one of skill in the art would have expected them to have similarly included such disclosure in the application as was included for GPS in the mobile base station." *Id.* ¶ 37.

We are not persuaded by Mr. Judge's testimony, which is conclusory and does not disclose sufficiently the underlying facts or data on which his opinion is based. *See* 37 C.F.R. § 42.65(a). As a result, we give little weight to Mr. Judge's testimony regarding, for example, the expectation of one of ordinary skill in the art in light of the disclosure of PCT '307 considered in its entirety. As Patent Owner points out, Mr. Judge and the Petition also do not consider sufficiently the "definitions" section of PCT '307, which we are persuaded is highly relevant to understanding what PCT '307 discloses. Prelim. Resp. 15.

Petitioner bears the overall burden of persuasion to prove unpatentability, but the burden of production may, in certain circumstances, shift to Patent Owner. *See Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378–80 (Fed. Cir. 2015). It is unnecessary, however, to determine whether the burden of production shifted on the issue of written description support for the challenged claims because, even if Patent Owner bore the burden, we determine that it identified sufficient written description support in PCT '307, as discussed above. The proper inquiry is whether PCT '307 "reasonably conveys to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date." *Ariad Pharms., Inc. v. Eli Lilly and Co.*, 598 F.3d 1336, 1351 (Fed. Cir. 2010) (en banc). Furthermore, "[t]he disclosure as originally filed does not . . . have to provide *in haec verba* support for the claimed subject matter at issue," nor must it describe "every conceivable and possible future embodiment of [the] invention." *Cordis Corp. v. Medtronic AVE, Inc.*, 339 F.3d 1352, 1364–65 (Fed. Cir. 2003) (internal quotation marks omitted).

Based on the evidence in the Petition, including Mr. Judge's testimony and the respective portions of PCT '307 cited by Petitioner and Patent Owner, we determine that the record here indicates there is sufficient written description support for the challenged claims. Petitioner, therefore, has not persuaded us that PCT '307 is prior art to the challenged claims.

Accordingly, we determine that Petitioner has not demonstrated a reasonable likelihood of prevailing in showing that the challenged claims are unpatentable on the grounds that they would have been obvious over PCT '307 in combination with either FCC 99-245 alone or with FCC 99-245 and Stilp.

III. CONCLUSION

We do not institute an *inter partes* review of any challenged claim.

IV. ORDER

For the reasons given, it is:

ORDERED that the Petition is denied and no *inter partes* review is instituted.

PETITIONER:

David L. Fehrman
Martin M. Noonen
MORRISON & FOERSTER LLP
10684-TracBeam-IPR@mofo.com

PATENT OWNER:

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Steven C. Sereboff
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Trials@uspto.gov
Tel: 571.272.7822

Paper 14
Entered: April 8, 2016

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

TRACBEAM, LLC,
Patent Owner.

Case IPR2015-01695 (Patent 7,298,327 B2)
Case IPR2015-01697 (Patent 7,525,484 B2)
Case IPR2015-01701 (Patent 8,032,153 B2)
Case IPR2015-01703 (Patent 7,764,231 B1)[1]

Before KEVIN F. TURNER, RICHARD E. RICE, DAVID C. McKONE, JAMES A. TARTAL, BARBARA A. PARVIS, and MATTHEW R. CLEMENTS, Administrative Patent Judges.

PARVIS, *Administrative Patent Judge*.

DECISION
Joint Motion to Terminate Pursuant to Settlement
35 U.S.C. § 317(a) and 37 C.F.R. §§ 42.72–42.74

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[1] This Decision addresses the same issue in these four *inter partes* reviews. We exercise our discretion to issue one Order to be docketed in each case. The parties, however, are not authorized to use this style of filing in subsequent papers, without prior authorization.

On April 5, 2016, and pursuant to 35 U.S.C. § 317(a), the parties filed a joint motion to terminate in each of the above cited proceedings. IPR2015-01695, Paper 12; IPR2015-01697, Paper 12; IPR2015-01701, Paper 10; IPR2015-01703, Paper 9. Along with each joint motion, the parties filed a Settlement Agreement. IPR2015-01695, Ex. 1012; IPR2015-01697, Ex. 1011; IPR2015-01701, Ex. 1012; IPR2015-01703, Ex. 1012. The parties also filed in each case a joint request that the settlement agreement be treated as business confidential information pursuant to 35 U.S.C. § 317(b) and 37 C.F.R. § 42.74(c). IPR2015-01695, Paper 13; IPR2015-01697, Paper 13; IPR2015-01701, Paper 11; IPR2015-01703, Paper 10. We authorized the above filings on April 1, 2016.

The parties represent that they have settled their disputes and memorialized their settlement in the written agreement submitted in each case. IPR2015-01695, Paper 12; IPR2015-01697, Paper 12; IPR2015-01701, Paper 10; IPR2015-01703, Paper 9. In the joint motions, the parties also represent that the settlement agreement resolves all disputes between the parties in the *inter partes* reviews and the related lawsuit. IPR2015-01695, Paper 12; IPR2015-01697, Paper 12; IPR2015-01701, Paper 10; IPR2015-01703, Paper 9.

The joint motion identifies defendants other than Petitioner that are involved in the related lawsuit. The other defendants have filed other petitions. On this record, no motion by any third party for joinder with these *inter partes* reviews is pending.

This matter is at a stage prior to its final hearing, with no decision on the merits having been made. Upon consideration of the facts before us, we determine that it is appropriate to terminate the proceedings with respect to both parties. *See* 35 U.S.C. § 317(a); 37 C.F.R. §§ 42.72, 42.74. Therefore, the joint motions to terminate the proceedings are granted. This paper does not constitute a final written decision pursuant to 35 U.S.C. § 318(a).

ORDER

For the foregoing reasons, it is:

ORDERED that the parties' joint request in each proceeding that the settlement agreement (IPR2015-01695, Ex. 1012; IPR2015-01697, Ex. 1011; IPR2015-01701, Ex. 1012; IPR2015-01703, Ex. 1012) be treated as business confidential information and be kept separate from the patent file is *granted*; and

FURTHER ORDERED that the joint motions to terminate in each of the IPR2015-01695, IPR2015-01697, IPR2015-01701, and IPR2015-01703 proceedings are *granted* and each of the proceedings is terminated with respect to both Petitioner and Patent Owner.

PETITIONER:

David L. Fehrman
Martin M. Noonen
10684-TracBeam-IPR@mofo.com

PATENT OWNER:

Sean A. Luner
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Steven C. Sereboff
ssereboff@socalip.com

AO 120 (Rev. 08/10)

TO: **Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas, Tyler Division on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO. 6:14-cv-680	DATE FILED 8/8/2014	U.S. DISTRICT COURT Eastern District of Texas, Tyler Division
PLAINTIFF TracBeam, L.L.C.		DEFENDANT Apple Inc.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 8,032,153 B2	10/4/2011	TracBeam, L.L.C.
2 7,764,231 B1	7/27/2010	TracBeam, L.L.C.
3 7,525,484 B2	4/28/2009	TracBeam, L.L.C.
4 7,298,327 B2	11/20/2007	TracBeam, L.L.C.
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

All claims for relief asserted against APPLE INC. by TRACBEAM herein are dismissed, with prejudice. All attorneys' fees, costs of court and expenses shall be borne by each party incurring the same

CLERK	(BY) DEPUTY CLERK	DATE
David A O'Toole	Michael Lantz	04/08/2016

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

Trials@uspto.gov
Tel: 571-272-7822

Paper 11
Entered: May 25, 2016

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

T-MOBILE US, INC., T-MOBILE USA, INC.,
TELECOMMUNICATION SYSTEMS, INC., ERICSSON INC., and
TELEFONAKTIEBOLAGET LM ERICSSON,
Petitioner,

v.

TRACBEAM, LLC,
Patent Owner.

Case IPR2016-00728
Patent 7,525,484 B2

Before KEVIN F. TURNER, DAVID C. McKONE, JAMES A. TARTAL, and BARBARA A. PARVIS, *Administrative Patent Judges.*

McKONE, *Administrative Patent Judge.*

DECISION
Denying Institution of *Inter Partes* Review
37 C.F.R. § 42.108
Denying Motion for Joinder
37 C.F.R. § 122(b)

I. INTRODUCTION

A. Background

T-Mobile US, Inc., T-Mobile USA, Inc., TeleCommunication Systems, Inc., Ericsson Inc., and Telefonaktiebolaget LM Ericsson (collectively, "Petitioner") filed a Petition (Paper 1, "Pet.") to institute an *inter partes* review of claim 25 of U.S. Patent No. 7,525,484 B2 (Ex. 1002, "the '484 patent"). Concurrently, Petitioner filed a Motion for Joinder (Paper 3, "Mot. for Joinder"), requesting that we join this proceeding to IPR2015-01708, in which we instituted *inter partes* review of claims 1 and 51 of the '484 patent, but declined to institute as to claim 25.

TracBeam, LLC ("Patent Owner") filed a Preliminary Response (Paper 9, "Prelim. Resp."). Patent Owner also filed an Opposition to the Motion for Joinder (Paper 8, "Opp. to Mot. for Joinder"). Petitioner, in turn, filed a Reply in support of its Motion for Joinder. Paper 10.

Upon consideration of the Petition and Preliminary Response, we exercise our discretion, under 35 U.S.C. § 325(d), to deny institution of *inter partes* review as to claim 25.

B. The '484 Patent

The '484 patent describes location systems for wireless telecommunication infrastructures. Ex. 1002, Abstract. According to the '484 patent, the location techniques are useful for 911 emergency calls, vehicle tracking and routing, and location of people and animals. *Id.* at Abstract, 12:11–17.

Figure 4, reproduced below, illustrates an embodiment:

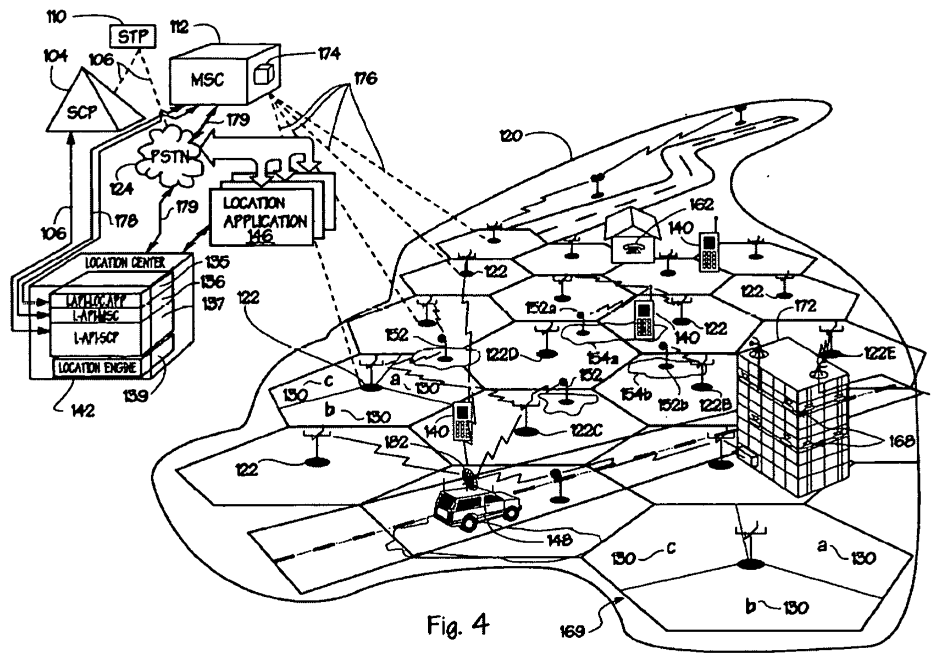

Fig. 4

Figure 4 is an overall view of a wireless radio location network architecture. *Id.* at 21:66–67. The network includes a plurality of mobile stations ("MS") 140, a mobile switching center ("MSC") 112, and a plurality of wireless cell sites forming radio coverage area 120, each site including a fixed-location base station 122 for voice and data communication with MSs 140. *Id.* at 24:41–57. The network also includes location base stations ("LBS") 152 with wireless location enablement, e.g., with transponders used primarily in communicating MS location related information to location center 142 (via base stations 122 and MSC 112). *Id.* at 24:57–64. LBSs can be placed, for example, in dense urban areas, in remote areas, along highways, or wherever more location precision is required than can be obtained using conventional wireless infrastructure components. *Id.* at 28:29–38.

Location center 142 determines a location of a target MS 140. *Id.* at 25:8–10, 37:43–46. The system uses a plurality of techniques for locating MSs, including two-way time of arrival ("TOA"), time difference of arrival ("TDOA"), and Global Positioning System ("GPS"). *Id.* at Abstract, 9:5–23, 11:7–55, 66:45–50. To determine a location for a MS, the system computes a first order model (also referred to as a hypothesis or estimate) for one or more of the locating techniques, computes a confidence value for each model indicating the likelihood that the model is correct, performs additional computations on the models to enhance the estimates, and computes from the models a "most likely" location for the MS. *Id.* at 12:62–13:20, 38:9–31. The most likely location can be a composite of the estimates. *Id.* at 13:22–30, 66:45–50.

Location estimates can be provided to location requesting applications, such as 911 emergency, police and fire departments, taxi services, etc. *Id.* at 8:52–60, 13:20–22, 38:32–34.

Claim 25, the only claim challenged in the Petition, is reproduced below:

> 25. A method for estimating, for each mobile station M of a plurality of mobile stations, an unknown terrestrial location (L_M) for M using wireless signal measurements obtained via transmissions between said mobile station M and a plurality of fixed location terrestrial communication stations, wherein each of said communications stations is substantially co-located with one or more of a transmitter and a receiver for wirelessly communicating with said mobile station M, comprising:
>
> initiating a plurality of requests for information related to the location of said mobile station M, the requests provided to each of at least two mobile station location evaluators, wherein there is at least a first of the requests provided to a first of the location

evaluators and a second of the requests, different from the first request, provided to a second of the location evaluators, such that when said location evaluators are supplied with corresponding input data having values obtained using wireless signal measurements obtained via two way wireless communication between said mobile station M, and the communication stations, each of said first and second location evaluators determine corresponding location information related to L_M, and

wherein for at least one location L of one of the mobile stations, said first location evaluator and said second location evaluator output, respectively, first and second position information related to the one mobile station being at L wherein neither of the first and second position information is dependent upon the other;

obtaining a first collection of location information of said mobile station M, wherein the first collection includes first location information from the first location evaluator, and second location information from the second location evaluator;

determining resulting information related to the location L_M of the mobile station M, wherein the resulting information is dependent on geographical information in each of the first and second location information; and

transmitting, to a predetermined destination via a communications network, the resulting information

C. Related Matters; IPR-1708

The '484 patent is the subject of several lawsuits filed in the United States District Court for the Eastern District of Texas. Pet. 12; Paper 6, 1–2. These include *TracBeam, LLC v. T-Mobile US, Inc.*, Case No. 6:14-cv-678 (E.D. Tex.) ("the '678 litigation"), and *TracBeam, LLC v. AT&T, Inc.*, Case No. 6:11-cv-96 (E.D. Tex.) ("the '96 litigation"). Various related patents also are the subjects of these and other proceedings before the district courts and the Board. Paper 6, 1–4.

The '484 patent also is the subject of *Apple Inc. v. TracBeam, LLC*, Case IPR2015-01696 (PTAB); *Apple Inc. v. TracBeam, LLC*, Case IPR2015-01697 (PTAB); and *T-Mobile US, Inc. v. TracBeam, LLC.*, Case IPR2015-01711 (PTAB). Paper 6, 3.

Most pertinent to this proceeding, the '484 patent also is the subject of *T-Mobile US, Inc. v. TracBeam, LLC.*, Case IPR2015-01708 (PTAB) ("IPR-1708"). In a Decision on Institution in IPR-1708, we instituted *inter partes* review as to claims 1 and 51, but denied institution as to claim 25 (the claim challenged in the instant proceeding). IPR-1708, Paper 10 ("1708-Dec."). Petitioner seeks to join this proceeding to IPR-1708. *See* Mot. for Joinder.

In IPR-1708, as it does here, Petitioner contended that claim 25 would have been obvious over Loomis[1] and Wortham.[2] As summarized in the 1708-Decision on Institution, Loomis describes a hybrid location determining ("LD") system that includes an outdoor LD unit that determines location using GPS technology and a radio LD unit that determines location

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[1] Ex. 1008, U.S. Patent No. 5,936,572, issued Aug. 10, 1999.

[2] Ex. 1009, U.S. Patent No. 6,748,226 B1, issued June 8, 2004.

using FM radio technology. 1708-Dec. 9–11. In order to determine a location estimate from the FM signals it receives, Loomis's radio LD unit must first know the relative phases of the FM signals. *Id.* at 11. For those phases, the radio LD unit relies on determinations from the outdoor (GPS) LD unit. *Id.* at 11–12. Wortham describes a differential positioning system for a mobile communication (cellular telephone) network in which GPS signals are evaluated at a fixed station with known (surveyed) coordinates to generate correction data. The correction data are sent via the mobile communication system to mobile receivers for use in correcting the GPS coordinate determinations made at the mobile receivers. *Id.* at 12–14. Petitioner argued that a skilled artisan would have modified Loomis to replace its FM terrestrial location capabilities with cellular-based signals, as would be transmitted by Wortham's transmitter sites. *Id.* at 14.

In IPR-1708, Petitioner relied on Loomis to show "wherein neither of the first and second position information is dependent upon the other," as recited in claim 25, arguing that Loomis's outdoor LD and radio LD units are independent of one another. IPR-1708, Paper 1, 49–50. We determined that the respective position information generated by the radio LD unit and outdoor LD unit are not independent, because the radio LD unit's position information depends on the outdoor LD unit's determination of phase, which depends on the outdoor LD unit's computation of GPS coordinate position information. 1708-Dec. 19–20. Accordingly, Petitioner did not demonstrate a reasonable likelihood of success in showing that claim 25 would have been obvious over Loomis and Wortham. Petitioner did not request rehearing of that determination.

D. The Asserted Grounds

Petitioner contends that claim 25 would have been obvious, under 35 U.S.C. § 103, over Loomis and Wortham. Pet. 15. Citing the same references, Petitioner advances two theories as to how a skilled artisan would have applied Loomis and Wortham. In the first theory, Petitioner contends that a skilled artisan would have used a stationary FM signal monitor, as in Loomis's description of the prior art, rather than Loomis's outdoor LD unit, to supply phase information to the radio LD unit. Pet. 29–31.[3] In the second theory, Petitioner contends that Wortham describes using cellular time of arrival ("TOA") techniques, rather than GPS techniques, to determine location. *Id.* at 31–33. According to Petitioner, a skilled artisan would have swapped Wortham's cellular TOA technique for Loomis's FM radio LD unit. *Id.* at 33–34.

Petitioner contends that its application of Loomis and Wortham merely "provides further clarification on how the *Loomis-Wortham* combination satisfies the claim limitations relied on in the Board's prior decision not to institute review of this claim," Pet. 9, and introduces "nominal additional subject matter," *id.* at 10.

E. One Year Bar Under 35 U.S.C. § 315(b) and Joinder Under 35 U.S.C. § 315(c)

According to 35 U.S.C. § 315(b):

> An inter partes review may not be instituted if the petition requesting the proceeding is filed more than 1 year after the date

[3] Loomis criticizes this prior art technique (Ex. 1008, 4:9–17) and describes using the outdoor LD unit to remedy such deficiencies as "an important feature of the invention" (*id.* at 7:31–38).

> on which the petitioner, real party in interest, or privy of the petitioner is served with a complaint alleging infringement of the patent. The time limitation set forth in the preceding sentence shall not apply to a request for joinder under subsection (c).

Patent Owner contends that the Petition is barred by Patent Owner's complaint (Ex. 2003) in the '678 litigation, allegedly served on Petitioner on August 11, 2014, more than one year prior to the March 8, 2016, filing date of the Petition. Prelim. Resp. 2–5.

Petitioner argues that the Petition is not barred by a prior lawsuit filed by Patent Owner against MetroPCS and TeleCommunication Systems, Inc., arguing that "[t]hose lawsuits were dismissed without prejudice, and thus are treated as if they had never been filed." Pet. 14. Here, Petitioner refers to the '96 litigation. *Id.* (citing Ex. 1019). Nevertheless, Petitioner states that "Patent Owner TracBeam is currently asserting the '484 Patent . . . against Petitioner T-Mobile in" the '678 litigation. *Id.* at 12. Petitioner does not appear to address whether the '678 litigation bars the Petition.

Petitioner also has filed a motion to join the instant Petition to IPR-1708. Mot. for Joinder. Petitioner argues that the Petition is timely by virtue of its Motion for Joinder. Pet. 13–14; *see also* 35 U.S.C. § 315(b) ("The time limitation set forth in the preceding sentence shall not apply to a request for joinder under subsection (c).").

Joinder, however, is appropriate only when the underlying petition sought to be joined warrants institution. According to 35 U.S.C. § 315(c) (emphasis added):

> If the Director institutes an inter partes review, the Director, in his or her discretion, may join as a party to that inter partes review any person who properly files a petition under section 311 that the Director, after receiving a preliminary response under section 313 or the expiration of the time for filing such a

> response, *determines warrants the institution of an inter partes review under section 314.*

As explained below, we have considered the Petition and the Preliminary Response and determine that the Petition does not warrant the institution of an *inter partes* review. Accordingly, we do not reach whether the Petition is time barred or whether joinder otherwise would be appropriate.

Petitioner's Motion for Joinder is denied as moot.

II. ANALYSIS

Institution of *inter partes* review is subject to Board discretion. "At any time prior to institution of *inter partes* review, the Board may deny some or all grounds for unpatentability for some or all of the challenged claims. Denial of a ground is a Board decision not to institute *inter partes* review on that ground." 37 C.F.R. 42.108(b). In particular, "[i]n determining whether to institute or order a proceeding under this chapter, chapter 30, or chapter 31, the Director may take into account whether, and reject the petition or request because, the same or substantially the same prior art or arguments previously were presented to the Office." 35 U.S.C. § 325(d). This is an instance in which Petitioner presents the same prior art in a second petition along with arguments to correct errors in a first petition.

Previous panels of this Board have expressed concern with permitting a petitioner to file an inadequate first petition and subsequently allowing the petitioner to correct errors in the first petition through the filing of a second petition. For example, in *ZTE Corp. v. ContentGuard Holdings Inc.*, Case IPR2013-00454 (PTAB Sept. 25, 2013) (Paper 12), slip op. at 5–6, a panel explained:

> The Board is concerned about encouraging, unnecessarily, the filing of petitions which are partially inadequate. A decision to institute review on some claims should not act as an entry ticket, and a how-to guide, for the same Petitioner who filed an unsuccessful joinder motion, and is outside of the one-year statutory period, for filing a second petition to challenge those claims which it unsuccessfully challenged in the first petition.

Similarly, another panel denied a petition with grounds that served as "second bites at the apple" and used a prior decision "as a roadmap to remedy [the first petition's] prior, deficient challenge," explaining that "[a]llowing similar, serial challenges to the same patent, by the same petitioner, risks harassment of patent owners and frustration of Congress's intent in enacting the Leahy-Smith America Invents Act." *Butamax Advanced Biofuels LLC, v. Gevo, Inc.*, Case IPR2014-00581, 2014 WL 5299385, at *6 (PTAB Oct. 14, 2014) (Paper 8). Patent Owner contends that we should follow this guidance and deny the Petition. Prelim. Resp. 10–19. We agree with Patent Owner that this is a factor that weighs against institution of the Petition.

Petitioner (Pet. 6) contends that the Petition is justified by three factors:

> (1) the prejudice to Petitioners caused by Patent Owner's assertion of an unreasonable number of claims in the co-pending litigation; (2) recent deposition testimony from Dr. Dennis Dupray, a named inventor of the '484 Patent, that was not available when IPR proceedings IPR2015-01708 and IPR2015-01711 were filed; and (3) the public interest in adjudicating the validity of a clearly invalid claim and having consistent outcomes concerning similar sets of claimed subject matter and prior art.

As to its first factor, Petitioner argues that, in an act of gamesmanship, Patent Owner asserted over 140 claims against Petitioner in the co-pending district court litigation and dropped the majority of those claims only after Petitioner had filed IPR2015-01708 and IPR2015-01711. *Id.* at 6–7. Petitioner argues that "[t]his gamesmanship made it unrealistic for the initial IPR petitions to proactively address every conceivable argument from the Patent Owner." *Id.* at 7. Patent Owner disputes Petitioner's accusation of gamesmanship and argues that it properly followed a procedure set by the District Court for electing a reasonable number of claims. Prelim. Resp. 21–22. Patent Owner then follows up with its own gamesmanship accusations concerning the timing of Petitioner's submissions of invalidity contentions in district court. *Id.* at 23–24.

We are not persuaded by Petitioner's argument. In IPR-1708, Petitioner devoted a significant portion of its petition to addressing independent claim 25 on the same prior art as asserted here. IPR-1708, Paper 1, 42–53. Even if there was gamesmanship in the district court litigation, Petitioner was unsuccessful as to claim 25 in IPR-1708 not because it failed to anticipate an argument made by Patent Owner, but because it failed to present evidence that the location determination by Loomis's radio LD unit is independent of the location determination by the outdoor LD unit. 1708-Dec. 18–20.

For its second justification, Petitioner argues that, since filing the IPR-1708 petition, Petitioner deposed Dr. Dennis Dupray, a named inventor on the '484 patent, who allegedly admitted that the limitation of claim 25 we found not established was, in fact, known in the art. Pet. 7–8. According to Petitioner, "Dr. Dupray's testimony confirms the teachings of *Loomis* and *Wortham*: that multiple, independent location techniques can output location estimates that are independent of each other." *Id.* at 8. In response, Patent Owner argues that Dr. Dupray was not testifying about Loomis and Wortham, the cited prior art. Prelim. Resp. 25.

We are not persuaded by Petitioner's second justification. Dr. Dupray testified that cell tower triangulation "may or may not be" dependent on GPS "in certain circumstances" and that he believed there existed prior art techniques for cell tower triangulation that were not dependent on GPS. Ex. 1027, 332:5–334:12. To the extent that this testimony is relevant at all, Petitioner does not explain persuasively how it bears on whether the prior art references asserted by Petitioner (in the instant Petition or in the IPR-1708 petition) would have taught such a feature.

For its third justification, Petitioner argues that "it would be against the public's interest not to institute *inter partes* review of this clearly invalid claim." Pet. 8. Patent Owner responds that it is against public interest to expend the Board's limited resources on petitions that merely attempt to fix issues that were not presented adequately in an earlier petition. Prelim. Resp. 27 (citing *ATopTech, Inc. v. Synopsys, Inc.*, Case IPR2015-00760, slip op. at 8–9 (PTAB July 21, 2015) (Paper 14) ("[W]e are mindful that permitting second chances without constraint undermines judicial efficiency by expending the Board's limited resources on issues that were not presented adequately the first time around.").

We are not persuaded by Petitioner's third justification. In IPR-1708, Petitioner failed to establish a reasonable likelihood of prevailing with respect to the same prior art. While we do not reach whether the second Petition demonstrates a reasonable likelihood of prevailing on that art, Petitioner has not shown that claim 25 is so clearly unpatentable as to undermine public interest.

We have considered Petitioner's proffered justifications as well as Patent Owner's concerns regarding allowing Petitioner to correct its first petition through filing a second Petition advancing the same prior art. We exercise our discretion, under Section 325(d), to deny the Petition because "the same or substantially the same prior art or arguments previously were presented to the Office."

III. CONCLUSION

We exercise our discretion to deny the Petition under 35 U.S.C. § 325(d). Because we deny the Petition, we deny Petitioner's Motion for Joinder as moot.

IV. ORDER

Accordingly, it is:

ORDERED that, pursuant to 35 U.S.C. § 325(d), an *inter partes* review is not instituted for claim 25 of U.S. Patent No. 7,525,484 B2; and

FURTHER ORDERED that Petitioner's Motion for Joinder is denied as moot.

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DISCLAIMER IN PATENT UNDER 37 CFR 1.321(a)

Name of Patentee	Docket Number (Optional)
TracBeam, LLC	1003-1
Patent Number	**Date Patent Issued**
7,525,484	04-28-2009

Title of Invention

GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

I hereby disclaim the following complete claims in the above identified patent:
Claims 27 and 51

The extent of my interest in said patent is (if assignee of record, state liber and page, or reel and frame, where assignment is recorded): assignee of record (Reel 011331, Frame 0887)

The fee for this disclaimer is set forth in 37 CFR 1.20(d).

- [ ] Patentee claims small entity status. See 37 CFR 1.27.
- [ ] Small entity status has already been established in this case, and is still proper.
- [ ] A check in the amount of the fee is enclosed.
- [X] Payment by ~~credit card. Form PTO-2038 is attached.~~ EFS-web
- [X] The Director is hereby authorized to charge any fees which may be required or credit any overpayment to Deposit Account No. 50-5775 .

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

Signed at Golden , State of Colorado , this 18th day of August 20 16 .

/Dennis J. Dupray/ — Signature

46,299 — Registration Number, if applicable

Dennis J. Dupray — Typed or printed name of patentee/ attorney or agent of record

303-895-7538 — Telephone Number

1801 Belvedere Street — Address

Golden, CO 80401 — City, State, Zip Code or Foreign Country as applicable

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PTO/SB/96 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: TracBeam, LLC

Application No./Patent No.: 7,525,484 Filed/Issue Date: 04-28-2009

Titled: GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

TracBeam, LLC, a limited liability company
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. [X] the assignee of the entire right, title, and interest in;

2. [ ] an assignee of less than the entire right, title, and interest in
(The extent (by percentage) of its ownership interest is ________ %); or

3. [ ] the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)

the patent application/patent identified above, by virtue of either:

A. [ ] An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel ________, Frame ________, or for which a copy therefore is attached.

OR

B. [X] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: Dennis J. Dupray et al. To: Intellabs LLC
The document was recorded in the United States Patent and Trademark Office at
Reel 010328, Frame 0085, or for which a copy thereof is attached.

2. From: Intellabs LLC To: TracBeam, LLC
The document was recorded in the United States Patent and Trademark Office at
Reel 011331, Frame 0887, or for which a copy thereof is attached.

3. From: ________ To: ________
The document was recorded in the United States Patent and Trademark Office at
Reel ________, Frame ________, or for which a copy thereof is attached.

[ ] Additional documents in the chain of title are listed on a supplemental sheet(s).

[X] As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Dennis J. Dupray/ 2016-08-18
Signature Date

Dennis J. Dupray Patent Agent, 46299
Printed or Typed Name Title

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	09770838
Filing Date:	26-Jan-2001
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Filer:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1

Filed as Large Entity

Filing Fees for **Utility under 35 USC 111(a)**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Statutory or Terminal Disclaimer	1814	1	160	160
		Total in USD ($)		**160**

Electronic Acknowledgement Receipt

EFS ID:	26687446
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Customer Number:	62914
Filer:	Dennis Jay Dupray.
Filer Authorized By:	
Attorney Docket Number:	1003-1
Receipt Date:	18-AUG-2016
Filing Date:	26-JAN-2001
Time Stamp:	22:36:12
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$160
RAM confirmation Number	6472
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Terminal Disclaimer Filed	1003-1_Disclaimer_1321a.pdf	202260 1f4c78aa2b6e377e61d5c295f2e8c0d7004594fe	no	2
Warnings:					
Information:					
2	Assignee showing of ownership per 37 CFR 3.73	1003-1_373b-Statement.pdf	426869 7be23f6444e236a95fdf900bb3bf25653f8da821	no	2
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	30385 78ca9690b196db96bdd7104e404b3e90ec3833e7	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	659514		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Trials@uspto.gov
Tel: 571-272-7822

Paper 14
Entered: August 23, 2016

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

T-MOBILE US, INC., T-MOBILE USA, INC.,
TELECOMMUNICATION SYSTEMS, INC., ERICSSON INC., and
TELEFONAKTIEBOLAGET LM ERICSSON,
Petitioners,

v.

TRACBEAM, LLC,
Patent Owner.

Case IPR2015-01711
Patent 7,525,484 B2

Before KEVIN F. TURNER, DAVID C. McKONE, JAMES A. TARTAL, and BARBARA A. PARVIS, *Administrative Patent Judges.*

McKONE, *Administrative Patent Judge.*

JUDGMENT
Request for Adverse Judgment
37 C.F.R. § 42.73(b)

On February 8, 2016, we instituted an *inter partes* review of claim 27 of U.S. Patent No. 7,525,484 B2 ("the '484 patent"). Paper 9. On August 19, 2016, Patent Owner filed a Patent Owner Response representing that it had filed with the Patent Office a statutory disclaimer, under 35 U.S.C. § 253(a) and 37 C.F.R. § 1.321(a), of claim 27. Paper 13, 1. A copy of the statutory disclaimer is included as Exhibit 2002. Patent Owner argues that this proceeding is now moot and states that it anticipates seeking permission to file a motion to terminate, to the extent that such a motion is necessary. Paper 13, 1–2.

No separate motion to terminate is necessary. Under 37 C.F.R. § 42.73(b), a party may request judgment against itself at any time during a proceeding. Furthermore, under § 42.73(b)(2), actions construed as a request for entry of adverse judgment include cancellation or disclaimer of claims such that the party has no remaining claim in the trial.

Patent Owner has filed with the Patent Office a disclaimer of the sole claim involved in this *inter partes* review, such that after the disclaimer it will have no remaining claim in the trial. We construe this disclaimer as a request for entry of adverse judgment and grant such request.

Accordingly, it is

ORDERED that judgment is entered against Patent Owner under 37 C.F.R. § 42.73(b); and

FURTHER ORDERED that this constitutes a final written decision under 35 U.S.C. § 318(a).

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PTO/SB/43 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

DISCLAIMER IN PATENT UNDER 37 CFR 1.321(a)

Name of Patentee	Docket Number (Optional)
TracBeam, LLC	1003-1
Patent Number	**Date Patent Issued**
7,525,484	04-28-2009

Title of Invention

GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION

I hereby disclaim the following complete claims in the above identified patent: Claim 1

The extent of my interest in said patent is (if assignee of record, state liber and page, or reel and frame, where assignment is recorded): Assignment recorded at 039470 / 0643, Change of Name at 039470 / 0626

The fee for this disclaimer is set forth in 37 CFR 1.20(d).

- [ ] Patentee claims small entity status. See 37 CFR 1.27.
- [ ] Small entity status has already been established in this case, and is still proper.
- [ ] A check in the amount of the fee is enclosed.
- [X] Payment ~~by credit card. Form PTO-2038 is attached.~~ XXXXXXXXXXXXXXXXX via EFS-web
- [X] The Director is hereby authorized to charge any fees which may be required or credit any overpayment to Deposit Account No. 50-5775 .

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

Signed at Golden , State of Colorado , this 30th day of October 2016 .

/Dennis J. Dupray/ — Signature

46,299 — Registration Number, if applicable

Dennis J. Dupray — Typed or printed name of patentee/ attorney or agent of record

303-895-7538 — Telephone Number

1801 Belvedere Street — Address

Golden, CO 80401 — City, State, Zip Code or Foreign Country as applicable

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	09770838
Filing Date:	26-Jan-2001
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Filer:	Dennis Jay Dupray.
Attorney Docket Number:	1003-1

Filed as Large Entity

Filing Fees for **Utility under 35 USC 111(a)**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
STATUTORY OR TERMINAL DISCLAIMER	1814	1	160	160
		Total in USD ($)		**160**

Electronic Acknowledgement Receipt

EFS ID:	27363917
Application Number:	09770838
International Application Number:	
Confirmation Number:	8410
Title of Invention:	GATEWAY AND HYBRID SOLUTIONS FOR WIRELESS LOCATION
First Named Inventor/Applicant Name:	Dennis J. Dupray
Customer Number:	62914
Filer:	Dennis Jay Dupray.
Filer Authorized By:	
Attorney Docket Number:	1003-1
Receipt Date:	30-OCT-2016
Filing Date:	26-JAN-2001
Time Stamp:	19:24:09
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$160
RAM confirmation Number	103116INTEFSW19243000
Deposit Account	
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Statutory disclaimers per MPEP 1490	Disclaimer-Cl-1_484.pdf	162591 854866097407af455c6ac393575ffaa8035a9d58	no	2

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Fee Worksheet (SB06)	fee-info.pdf	30272 f7b1a33fff487e0dbcba3b615acc27685e8e4f92	no	2

Warnings:

Information:

Total Files Size (in bytes):	192863

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Trials@uspto.gov
Tel: 571.272.7822

Paper 18
Date Entered: November 1, 2016

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

T-MOBILE US, INC., T-MOBILE USA, INC., TELECOMMUNICATION SYSTEMS, INC., ERICSSON INC., AND TELEFONAKTIEBOLAGET LM ERICSSON,
Petitioner,

v.

TRACBEAM, LLC,
Patent Owner.

Case IPR2015-01708
Patent 7,525,484 B2

Before KEVIN F. TURNER, DAVID C. McKONE, and BARBARA A. PARVIS, *Administrative Patent Judges*.

MCKONE, *Administrative Patent Judge*.

JUDGMENT
Granting Request for Adverse Judgment After Institution of Trial
37 C.F.R. § 42.73(b)

I. BACKGROUND

T-Mobile US, Inc., T-Mobile USA, Inc., TeleCommunication Systems, Inc., Ericsson Inc., and Telefonaktiebolaget LM Ericsson (collectively, "Petitioner") filed a Petition (Paper 1) to institute an *inter partes* review of claims 1, 2, 6, 24, 25, 51, 71, and 72 of U.S. Patent No. 7,525,484 B2 (Ex. 1002, "the '484 patent"). TracBeam, LLC ("Patent Owner") filed a Preliminary Response (Paper 6). The parties reached agreement to remove claims 2, 6, 24, 71, and 72 from the proceeding; we accepted that agreement and limited this proceeding to claims 1, 25, and 51. Papers 7–9. Subsequently, we instituted an *inter partes* review of claims 1 and 51 of the '484 patent, but not claim 25. Paper 10.

On August 19, 2016, in its Patent Owner Response (Paper 14), Patent Owner notified the Board that it had filed a statutory disclaimer under 37 C.F.R. § 1.321(a) of claim 51 of the '484 patent. *See* Ex. 2005 (statutory disclaimer). On October 31, 2016, Patent Owner notified the Board that it had filed a further statutory disclaimer of claim 1 of the '484 patent, which constitutes the only remaining claim at issue in this *inter partes* review. Paper 17. Patent Owner also filed a copy of the disclaimer, as well as an electronic acknowledgement receipt of the filing, as Appendicies to the Notice. *Id.*

II. DISCUSSION

A party may request adverse judgment against itself at any time. *See* 37 C.F.R. § 42.73(b). Here, Patent Owner requests adverse judgment because no claims remain in the trial after Patent Owner's disclaimer of all the claims at issue in this proceeding. *See* 37 C.F.R. § 42.73(b)(2). We *grant* Patent Owner's request and enter judgment against Patent Owner under 37 C.F.R. § 42.73(b). Our prior Order granting Petitioner's request for oral hearing is hereby *dismissed* as moot. *See* Paper 16.

III. ORDER

Accordingly, it is:

ORDERED that Patent Owner's request for adverse judgment is *granted*, and judgment is entered against Patent Owner under 37 C.F.R. § 42.73(b);

FURTHER ORDERED that this constitutes a final written decision under 35 U.S.C. § 318(a); and

FURTHER ORDERED that the previously granted oral hearing in this proceeding is *dismissed* as moot.

FOR PETITIONER:

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AO 120 (Rev. 08/10)

TO: **Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas, Tyler Division on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:14-cv-680	8/8/2014	Eastern District of Texas, Tyler Division

PLAINTIFF	DEFENDANT
TracBeam, L.L.C.	Apple Inc.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 8,032,153 B2	10/4/2011	TracBeam, L.L.C.
2 7,764,231 B1	7/27/2010	TracBeam, L.L.C.
3 7,525,484 B2	4/28/2009	TracBeam, L.L.C.
4 7,298,327 B2	11/20/2007	TracBeam, L.L.C.
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	**DATE OF PATENT OR TRADEMARK**	**HOLDER OF PATENT OR TRADEMARK**
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT
All claims for relief asserted against APPLE INC. by TRACBEAM herein are dismissed, with prejudice. All attorneys' fees, costs of court and expenses shall be borne by each party incurring the same

CLERK	(BY) DEPUTY CLERK	DATE
David A O'Toole	Michael Lantz	04/08/2016

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

TO: **Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas, Tyler Division on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:14-cv-678	8/8/2014	Eastern District of Texas, Tyler Division

PLAINTIFF	DEFENDANT
TracBeam, L.L.C.	T-Mobile US, Inc. and T-Mobile USA, Inc.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 8,032,153 B2	10/4/2011	TracBeam, L.L.C.
2 7,764,231 B1	7/27/2010	TracBeam, L.L.C.
3 7,525,484 B2	4/28/2009	TracBeam, L.L.C.
4 7,298,327 B2	11/20/2007	TracBeam, L.L.C.
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT
All claims asserted by TracBeam in this action against T-Mobile are DISMISSED WITH PREJUDICE. All counterclaims asserted by T-Moblie, Ericsson and Telecommunication Systems against TracBeam are DISMISSED WITHOUT PREJUDICE

CLERK	(BY) DEPUTY CLERK	DATE
David A O'Toole	Michael Lantz	05/11/2017

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy