PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 **:**
H04Q 3/00, H04L 29/06

A1

(11) International Publication Number: **WO 97/31492**

(43) International Publication Date: 28 August 1997 (28.08.97)

(21) International Application Number: PCT/IB96/00134

(22) International Filing Date: 21 February 1996 (21.02.96)

(71) Applicant *(for all designated States except US)*: INTERNATIONAL BUSINESS MACHINES CORPORATION [US/US]; Old Orchard Road, Armonk, NY 10504 (US).

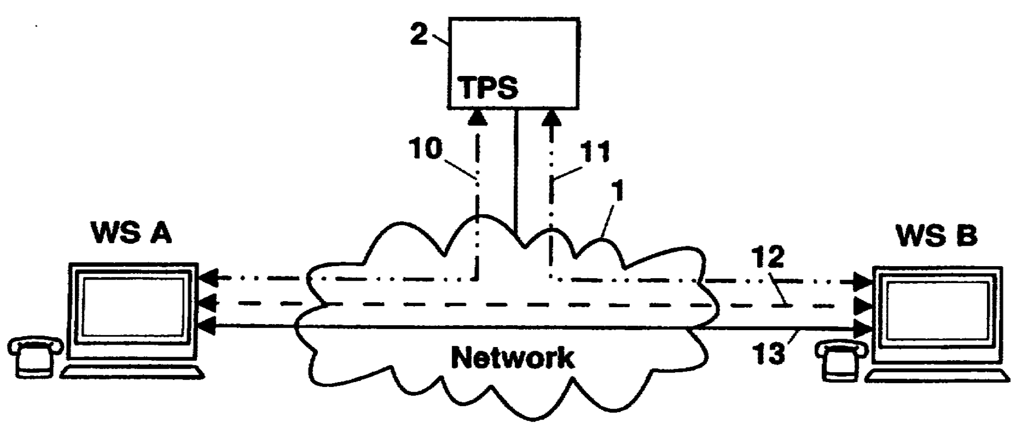
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: TRUONG, Hong, Linh [DE/CH]; Reidholzstrasse 37, CH-8805 Richterswil (CH). WONG, Johnny, Wai-Nang [CA/CH]; Leimbachstrasse 119, CH-8041 Zurich (CH).

(74) Agent: BARTH, Carl, Otto; International Business Machines Corporation, Säumerstrasse 4, CH-8803 Rüschlikon (CH).

(81) Designated States: BR, CA, CN, JP, KR, 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: DISTRIBUTED ARCHITECTURE FOR SERVICES IN A TELEPHONY SYSTEM



(57) Abstract

The invented method and system for enabling and controlling telephony over existing networks, e.g. ATM networks, the Internet or other data networks, uses essentially distributed control processing employing intelligence in the typical end-user devices, e.g. workstations or personal computers. Parallel use of a real-time channel (to provide the needed direct voice communication) and a control channel (for basic services like connection buildup and termination and for supplementary services) essentially established by and from the users's workstations (and in principle excluding the PBXs) allows implementation of practically any imaginable function.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia
AT	Austria
AU	Australia
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CS	Czechoslovakia
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgystan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakhstan
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam

DESCRIPTION

Distributed Architecture for Services in a Telephony System

FIELD OF THE INVENTION

This invention relates to telephony, in particular to a method and apparatus for enabling telephony over existing networks like the Internet or other data networks. Essentially, distributed call processing is employed using intelligence in the typical end-user devices, e.g. workstations or personal computers.

BACKGROUND AND PRIOR ART

Computer-telephony integration is quickly developing a wide variety of applications that use well known, existing networks, e.g. the telephone networks, as well as new, often quickly expanding data networks, e.g. the Internet.

Telephony requires a real-time channel to provide the needed direct and immediate voice communication which makes it so attractive. Today, it also must provide certain supplementary services. Such supplementary services are traditionally implemented in the telephone switches, the so-called PBXs (for Private Branch Exchanges), through which the users are connected. Some examples for such services are:

- Alternate Call - this supplementary service enables a user A to put a currently active call to another user B on hold and place a call to, or activate a previously "on hold" call with, user C.
- Call Back - user A calls user B and finds that user B is busy; this supplementary service enables user A to request a call back from user B.
- Camp on Call - user A calls user B and finds that user B is busy; this supplementary service enables the call to be placed again as soon as user B becomes free.
- Deflect Call - this supplementary service enables a user to re-direct (or forward) an incoming call to another user or phone.
- Call Transfer - this supplementary service enables user A to transform two of his calls (with users B and C) into a new call between users B and C.
- Directed Pickup Call - user A calls user B and the call is in the ringing state; this supplementary service enables a third user C to answer the call from a different destination.
- Multi-line Appearance - this supplementary service enables an incoming call to ring at two or more users; the first user who answers gets the call.
- Call do not Disturb - this supplementary service enables a user to reject all incoming calls.

As said above, these supplementary services are traditionally implemented in the switches (or PBXs). Such PBXs are usually located at user's premises and connected to the public telephone network.

With the advent of new and versatile networks like the Internet or ATM (for Asynchronous Transfer Mode) networks that allow the exchange and transmission of digital data, including real time exchange of digitized voice which can be used for telephony, the traditional telephone systems are getting competition. However, when using such novel transmission tools, those supplementary services that were usually implemented in the PBXs are no more be available.

Further, computer-network telephony requires more complex transmission management since voice transmission is much more susceptible than data transmission to even minimal delays. Traditional call control in existing telephone networks is not adapted to provide this service for a data network.

Also, PBXs use a centralized approach to basic telephony services, i.e. call placement and termination, and to supplementary services. Due to the many functions that are performed, PBXs are generally complex and costly. They also treat the end-user equipment (e.g. the telephone sets) as simple devices that are specialized for telephony. With the wide availability of powerful workstations, it becomes attractive to use their capabilities for providing at least part of these telephony services and possibly integrate computers and telephony.

Some approaches for integrating computers and phones are addressed by James Burton in: "Standard Issue" in BYTE, September 1995, pp. 201-207. Burton describes several CTI (for Computer-Telephone Integration) architectures and their characteristic layout. The architectures listed by Burton, however, provide for a combined transmission of voice and control data over at least partially the same connections and are based on connectivity to a telephone network or a PBX. The power of the end-user workstations is not exploited for basic or supplementary telephony services.

US patent 4 634 812 by Hornburger et al discloses a method for transferring information including voice between computers in a decentralized telephone control system. This system provides a data, also voice, transmitting multi-wire bus and two single wire control buses. A telephone system according to the Hornberger patent consists of identical PBXs, all being connected by two control buses and one data/voice multi-wire bus. Thus, this system provides a distributed control in a telephone system through multiple parallel channels and especially designed PBXs. It is a specially designed, so-to-speak self-contained, system for PBXs and does not address the idea of exploiting the power of end-user workstations for basic telephony services and supplementary services.

US patent 4 313 036 to Jabara et al describes a distributed computerized PBX, called CBX, system wherein the CBXs are connected by both a voice and a packet-switched network. Two links or channels are provided between the CBXs: a signalling data link and a voice link. The data link is part of a virtual network which may be provided by a packet-switched network. However, this system concerns communication between PBXs for call control purposes and does not address the potential of end-user workstations for basic telephony services and supplementary services.

Various systems that use the Internet for telephony have been proposed. One such is advertised in the World Wide Web (WWW) under the Universal Resource Locator (URL) http://www.vocaltec.com. An overview of some other such systems with more references can be found under the URL http://www.northcoast.com/~savetz/voice-faq.html. The systems described there exploit the power of the users' workstations for limited basic telephony services, but do neither address nor provide means for supplementary services.

Thus, it is an object of this invention to provide, for a telephone system, a distributed, i.e. workstation-oriented, architecture with more than one link between the workstations and a method for providing not only basic telephony services, such as call placement and termination, but also complex supplementary service functions.

Another object is to provide a telephone system with a distributed, i.e. not switch-centered, architecture that uses an existing network, preferably a packet-switched network, to implement desired basic and/or supplementary services.

The invention provides a solution to the need of using existing network infrastructure for telephony, in particular for complex supplementary services. By employing a workstation-oriented architecture, the invention provides an effective and versatile tool for implementing any desired supplementary services, that can be altered and adapted at any time with minimal effort and practically without disturbing an existing network architecture and/or protocols used.

SUMMARY OF THE INVENTION

In brief, the distributed, workstation-oriented architecture for basic and supplementary telephony services according to the invention, which services were traditionally implemented in the switches (PBXs), comprises setting up a first communication channel for transmitting first signals and setting up a second communication channel for second signals, whereby both channels directly connect the end-user devices, e.g workstations. Preferably, the first signals are control signals and the second signals voice signals. The two (or more) connections or channels can be established directly and independently, the second or voice channel being preferably set up subsequent to the first or control channel. The control channel, once established, is preferably maintained permanently during a communication session. A session in this context may include interruptions or pauses in the voice connection as long as an intent to continue the telephone communication is recognizable.

With the invention, telephony services can be implemented solely in workstations; the use of a server for a limited number of functions, e.g. address resolution or authentication, may however be required or advantageous. The switches, PBXs, if used at all, only need to provide the communication channels for voice and/or real-time data transport. They are not involved in the implementation of the services.

Details of the invention may be extracted from the following general and detailed description of preferred implementations.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an overview of one possible configuration using the invention;

Fig. 2 depicts the general function of the invention;

Fig. 3 exemplifies the call placement process executed by the invention;

Fig. 4 exemplifies the call back process executed by the invention;

Fig. 5 exemplifies the call transfer process executed by the invention;

Fig. 6 references one architecture of an implementation, and

Fig. 7 references another architecture according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A. General Description

A.I. Overview

Fig.1 shows an example for a general configuration in which the invention can be applied. A network 1, which may be an ATM network or an IP (Internet Protocol) network as examples for existing digital networks conventionally used for data transfer, links workstations (WS) 3a to 3d. Also connected to network 1 is a telephony server (TPS) 2. Further, to enable communication with a PBX 4, a first gateway (GW) 5 is also attached to network 1. A second gateway 7 links network 1 to an ISDN (Integrated Service Digital Network) 6. Each of PBX 4 and ISDN 6 have connected to it usual telephones 8 and 9 and/or appropriate workstations that allow telephony.

The gateways shown in Fig.1, which are not part of this invention, usually support interworking with an ISDN and/or with an existing PBX, respectively. Technically, a gateway is able provide signalling interworking (mapping of ISDN/PBX signalling and signalling used in a distributed, i.e. workstation-oriented, architecture), voice signal translation (between voice encoding scheme used in ISDN/PBX and that used in the distributed architecture), and/or proxy functions for ISDN/PBX users.

The dotted lines in Fig.1 shall illustrate the telephone calls between the users 3a to 3d, 8, and 9; the solid lines shall indicate the attachments to the network. This will be apparent in more detail from the following description of Fig.2.

Fig.2 shows an overview of the basic configuration and the essential data flow according to the invention. The invention uses a distributed, workstation-oriented architecture which will be apparent from the detailed description of embodiments of the invention below.

One key element of the novel architecture is the use of two separate end-to-end channels between the workstations for each phone call. As shown in Fig.2, a workstation-workstation control channel 12 is provided for call control and a voice channel 13 for voice communication. Workstations A and B exchange control messages over control channel 12. These messages could contain name or phone number of the calling and called users, qualify service parameters (e.g. voice encoding schemes supported by the workstation or preferred by the user), status information regarding the call (e.g. whether call is active or on hold), and specific requests by users (e.g. put user on call-back list). All messages transported on control channel 12 are handled by processes at the workstations; they are not interpreted by the switches or routers (Figs.3 and 4) which provide the means for these channels.

Another key element of the invention is that control channel 12 is maintained for the duration of the call, whereas voice channel 13 need not be sustained permanently, but is set up only when needed. For example, voice channel 13 can be released when a call is put on hold, and re-established when the call is activated again. The ability to exchange any control signals or messages over the maintained workstation-workstation control channel 12 allows the implementation of a wide variety of supplementary telephony services without involvement of the switches or routers.

Telephony server 2 may perform functions such as name/phone number registration, address resolution, and authentication. Workstations request service from server 2 over separate workstation-server control channels 10 and 11. These control channels are set up on a as-needed basis. So much for the general layout.

Since any of the channels mentioned, control channels 10, 11, or 12, as well as voice channel 13, respectively, can be provided by existing networks, e.g. ATM or IP networks, the invention allows the implementation of basic telephony services (i.e. call placement and termination) as well as supplementary telephony services on practically any of the existing and evolving data networks.

The following is a more general description of a set of functions implemented according to the invention; for someone skilled in the art, it is already sufficient for carrying out the invention. Still, a subset of these functions will be addressed in much more detail further down.

A.II. Basic Telephony Services

1. Place and Receive a Call

The steps for this process are depicted in Fig.3. User A wishes to place a call to user B; each is at one of the workstations 3a to 3d shown in Fig.1.

Step 1: User A's workstation (WS A) maps user B's name or phone number address onto the network address of user B's workstation (WS B). This "address mapping" function may be provided by an appropriate server process running at telephony server 2.

Step 2: Workstation A sets up a control channel (12 in Fig.2) to workstation B.

Step 3: Workstation A sends a "call request" message to workstation B over the control channel.

Step 4: Workstation B returns a "call confirm" message to workstation A, informing workstation A that workstation B is able to proceed with call placement

Step 5: Workstation B indicates to user B that there is an incoming call.

Step 6: User B responds that he is answering the call.

Step 7: Workstation B sends a "connect" message to workstation A over the control channel, informing workstation A that user B is answering the call, and asking workstation A to set up a voice channel.

Step 8: Workstation A sets up a voice channel to workstation B.

Step 9: Workstation B indicates to user B that the call is now active.

Step 10: Workstation A indicates to user A that the call is now active.

Step 11: User A and user B talk over the voice channel.

2. Call Termination

At any time, user A or user B may request call termination. Suppose call termination is initiated by user A. The steps are as follows:

Step 1: Workstation A sends a "terminate call" message to workstation B over the control channel, and releases the voice channel of the call.

Step 2: Workstation B returns a "terminate call" message to workstation A, and release voice channel also.

Step 3: Workstation A completes call termination by releasing the workstation-workstation control channel of the call.

A.III. Supplementary Services

1. Alternate Call

At some point in time, user A may have two or more calls in progress. One of these calls (to user B) is active while the others are on hold. Suppose user A wishes to put the call to user B on hold and activate the call to user C. The steps are as follows:

Step 1: Workstation A sends a "hold" message to workstation B over the control channel with workstation B, informing workstation B that the call is now on hold.

Step 2: Workstation A sends an "active" message to workstation C over the control channel with workstation C, informing workstation C that the call is now active.

2. Call Back

During call placement, workstation A finds that user B is busy at the initial message exchange over the control channel. User A then requests a call back. The steps are illustrated in Fig.4.

Steps 1 to 3: Same as those for placing a call (see above: Place and Receive a Call, described in connection with Fig.3).

Step 4: Workstation B responds with a "user busy" message, informing workstation A that user B is busy, but call back is possible.

Step 5: User A requests that he be put on user B's call back list.

Step 6: Workstation A sends a "call back request" message to workstation B over the control channel. This message contains user A's phone number.

Step 7: Workstation B enters user A's phone number onto user B's call-back record.

When user B subsequently checks the call-back record, he/she will learn that user A has requested a call back.

3. Camp on Call

This is similar to the above Call Back process, except that an attempt will be made to call user B again as soon as B becomes free.

Steps 1 to 3: Same as those for Place and Receive a Call.

Step 4: Workstation B responds with a "user busy" message, informing workstation A that user B is busy, but camp on busy is possible.

Step 5: User A requests camp on call.

Step 6: Workstation A sends a "camp on call" message to workstation B over the control channel.

Step 7: Workstation B returns a "camp on confirmed" message to workstation A.

Step 8: When user B becomes free and indicates that he is answering the camp on call, workstation B resumes the call placement with workstation A, at step 7 of Fig.3.

4. Deflect Call

User B may wish to forward an incoming call to another phone number (phone number M) immediately, or if he/she is busy, or if the call is not answered after a time-out interval. Suppose user A is placing a call to user B, the steps for the case of deflect after time-out are:

Steps 1 to 5: Same as those for Place an Receive a Call.

Step 6: User B has not answered after a time-out.

Step 7: Workstation B sends a "deflect call" message to workstation A over the control channel. This message contains the phone number to which the call is to be forwarded (phone number M).

Step 8: Workstation B releases the control channel to workstation A.

Step 9: Workstation A places a call to phone number M.

5. Call Transfer

Suppose user A has two calls in progress: a call with user B which is on hold and a call with user C which is active. User A requests to have user B and user C connected, and his/her calls to these users terminated. This process is shown in Fig.5. The steps are:

Step 1: Workstation A sends a "hold" message to workstation C over the control channel with workstation C.

Step 2: Workstation A sends a "receive transfer call" message to workstation C over the control channel with workstation C, requesting workstation C to accept a transfer call from workstation B.

Step 3: Workstation C returns a "transfer confirm" message to workstation A, and waits for a transfer call from workstation B.

Step 4: Workstation A sends a "place transfer call" message to workstation B over the control channel with workstation B, requesting workstation B to place a transfer call to workstation C.

Step 5: Workstation C returns a "transfer confirm" message to workstation A.

Step 6: Workstation B places a transfer call to workstation C.

Step 7: Workstation A initiates termination of his/her call to workstation B.

Step 8: Workstation A initiates termination of his/her call to workstation C.

6. Directed Pickup Call

Suppose user A calls user B and the call is in the ringing state. A third user C wishes to answer the call. The steps are as follows.

Step 1: Workstation C sets up a control channel to workstation B.

Step 2: Workstation C sends a "pickup query" message to workstation B to find out whether call pick-up is possible or not. User C's phone number is included in this message.

Step 3: Workstation B returns a "pickup allowed" message to workstation C.

Step 4: Workstation C sends a "pickup request" message to workstation B, requesting call pickup.

Step 5: Workstation B sends a "directed pickup" message to workstation A which contains user C's phone number, instructing workstation A to place a call to user C.

7. Multi-line Appearance

Suppose user A places a call to a phone number that has multi-line appearance. Workstation A maps the destination phone number onto a list of network addresses. This "address mapping" function is provided by a server process running at the telephony server. Workstation A then places separate calls to each of these addresses. Workstation A will proceed with the first destination that answers, and terminates the call placement to the other addresses.

8. Call do not Disturb

Suppose user B has requested call do not disturb. Any workstation A attempting to place a call to user B will get a "do not disturb" message over the control channel in return.

B. Detailed Description of Specific Functions

B.I. Reference Architecture

Figs.6 and 7 show the reference architecture of a communication system employing the invention. The basic telephony services (mainly call establishment, call termination) and supplementary services (e.g. call hold, call back, call transfer, call deflection) are implemented by an enabling layer at the workstation. Integrated are functions such as address resolution, voice encoding, and authentication.

Until now, a user was identified by a name or a phone number. In the following, users will be identified by their respective e-mail address.

Fig.6 depicts an architecture according to the invention in an ATM (Asynchronous Transfer Mode) environment. Physical layer 18 and ATM layer 17 are standard design features. TCP (Transmission Control Protocol) connection is set up over IP, i.e. Internet Protocol 15, which runs on top of AAL5, i.e. ATM Adaptation Layer 16. The implementation of IP on an ATM network is available off-the-shelf.

Voice communication requires QoS (Quality of Service) guarantee from transport services interface 14, e.g. acceptable end-to-end delay and delay jitter. The voice channel is established by a VCC (Virtual Channel Connection) with QoS. Encoded voice samples are sent in ATM cells. Q.2931 and SAAL (Signalling ATM Adaptation Layer) are signalling protocols for VCC setup and release. Transport services interface 14 provides transport for voice and control channels.

Enabling layer 19 uses the services provided by transport services interface 14 for establishing control channels and voice channels. Specifically, both workstation-server and workstation-workstation control channel are realized by TCP connections as indicated by block 15. Enabling layer 19 supports an

API (Application Programming Interface) which can be used for the development of telephony applications.

Fig.7 depicts an architecture according to the invention in an IP (Internet Protocol) environment. The physical layer is an IP subnet technology 26 able to provide the required services. QoS for the voice channel can be provided by a pair of RSVP (Resource Reservation Protocol) flows because an RSVP flow is uni-directional. Encoded voice samples are sent in UDP (User Datagram Protocol) packets using TCP/UDP protocol 24 and transport services interface 23. In this case, RSVP is the signalling protocol used between the workstations and the routers to establish the needed RSVP flows.

In such an IP subset, encoded voice packets can also be sent in UDP packets without RSVP. This is a best-effort service and no QoS guarantee is provided. Transport services interface 23 provides transport capacity for voice and control channels. Enabling layer 22 supports an API 21 which can be used for developing telephony applications.

So much for the functionality of the invention. Some selected functions will be described further below in extensive detail to clarify the invention.

The abbreviations already introduced above, e.g. WS for workstation, WS A for workstation of user A as shown in the drawings, will be exclusively used.

Control messages exchanged over WS-server and WS-WS control channels are used to implement the basic and supplementary services. These control channels are realized by TCP connections.

Each control message contains a code which indicates the name of the control message and optionally a list of parameters (this list may be empty). For convenience, a control message is denoted by:

message-name (parameter list)

This notation will be used in the description of how the basic and supplementary services are implemented. In addition, only the parameters relevant to the procedure being described are listed, in order not to include unnecessary details.

Several timers are used in the implementation descriptions. These timers operate as follows. A timer is stopped when an expected event occurs before it expires. If, for whatever reason, the timer expires, some recovery action will be taken. In the implementation descriptions, unless otherwise specified, the recovery action is to terminate the phone call, using the procedure described in Section B.II.2. below.

B.II. Basic Telephony Services

Basic telephony services include call placement and call termination.

1. Call Placement

Suppose user A at workstation A (WS A) wishes to place a call to user B at workstation B (WS B) and user B is free to accept the call. The basic steps are depicted in Fig.3, there using the generic terms of Section A.II. Details of the implementation at WS A and WS B are described below.

Step 1: WS A maps user B's e-mail address onto WS B's TCP address.

WS A procedure:
Upon receiving a request for call placement from user A, WS A sets up a TCP connection to the telephony server. This connection will be used as the WS-server control channel. The setting up of a TCP connection is a

well-known procedure. WS A then prepares a AdrQuery (user B's e-mail address) control message and sends this message to the telephony server.

The telephony server, upon receiving the AdrQuery control message, checks its address mapping database. If an entry for user B's e-mail address is found, the telephony server prepares an AdrRsp (WS B's TCP address) control message, and returns this message to WS A; otherwise, an AdrRsp (user B not registered) is prepared and returned. In both cases, the TCP connection between WS A and the telephony server is released. The address mapping function performed by the telephony server can be implemented by available nameserver technologies, e.g. the Internet domain name system.

Upon receiving the AdrRsp control message from the telephony server, WS A interprets the content of this message. If WS B's TCP address is included as a parameter, WS A proceeds to step 2 of call placement. On the other hand, if "user B is not registered" is indicated, WS A informs user A about this indication, and the call placement is finished.

Step 2: WS A sets up a WS-WS control channel to WS B.

WS A procedure:
WS A sets up a TCP connection to WS B. This connection will be used as the WS-WS control channel between WS A and WA-B. WS A then proceeds to step 3 of call placement.

WS B procedure:
As a result of WS A action to set up a TCP connection, WS B completes the connection setup, and starts timer TB1.

Step 3: WS A sends a "call request" control message to WS B.

WS A procedure:
WS A prepares a CallReq (user A's e-mail address, user B's e-mail address) control message, sends this message to WS B, and starts a timer TA2.

Step 4: WS B returns a "call confirm" control message to WS A, informing WS A that WS B is able to proceed with call placement.

WS B procedure:
Upon receiving the CallReq control message from WS A, WS B stops timer TB1, and checks whether user B's e-mail address matches that contained in the CallReq control message. If this check is positive and user B is free, WS B prepares a CallCnf (B free) control message, and returns this message to WS A. WS B then proceeds to step 5.

On the other hand, if the check is negative, WS B terminates call placement using the procedure described in Section B.II.2.

WS A procedure:
Upon receiving the CallCnf control message from WS B, WS A stops timer TA2 and starts another timer TA3.

Step 5: WS B indicates to user B that there is an incoming call.

WS B procedure:
WS B informs user B that there is an incoming call and starts a timer TB4.

Step 6: User B responds that he is answering the call.

WS B procedure:
WS B stops timer TB4 and proceeds to step 7.

Step 7: WS B informs WS A that user B is answering the call and asks WS A to set up a voice channel.

WS B procedure:
WS B prepares a Connect control message, sends this message to WS A and starts timer TB5.

Step 8: WS A sets up a voice channel to WS B.

WS A procedure:
Upon receiving the Connect control message from WS B, WS A stops timer TA3 and sets up a voice channel to WS B. This connection will be used for the phone conversation between user A and user B. The implementation of voice channel setup will be described in section B.II.1.1.

Step 9: WS B indicates to user B that the call is now active.

WS B procedure:
Upon receiving the voice call setup request from WS A, WS B completes the voice channel setup, stops timer TB5, and informs user B that the call is active.

Step 10: WS A indicates to user A that the call is now active.

WS A procedure:
WS A informs user A that the call is active.

Step 11: User A and user B talk over the voice channel.

WS A procedure:
During the phone conversation, WS A prepares voice messages which contain encoded voice samples from user A and sends these messages over the voice channel to WS B. WS A also decodes the voice samples contained in voice messages received from WS B.

WS B procedure:

During the phone conversation, WS B prepares voice messages which contain encoded voice samples from user B and sends these messages over the voice channel to WS A. WS B also decodes the voice samples contained in voice messages received from WS A.

1.1. Voice Channel Setup

The negotiation of the type of voice channels to be used is done during call setup. The voice channel types include ATM (Asynchronous Transfer Mode), RSVP (Resource Reservation Protocol), or best-effort UDP (User Datagram Protocol). ATM and RSVP support quality of service guarantees, but best-effort UDP does not. Best-effort UDP is the default type. The negotiation is implemented as follows.

At step 3 of call placement (Fig.3), WS A sends a CallReq control message to WS B. The parameters relevant to the negotiation are: WS A's preferred voice channel type, and the corresponding addressing information for voice channel setup. The addressing information for best-effort UDP is also included as a parameter if it is not the preferred type.

At step 4 of call placement, WS B confirms the voice channel preferred by WS A if it also has access to the same type, otherwise WS B confirms that best-effort UDP (the default) will be used. In the CallCnf control message sent by WS B to WS A, the relevant parameters are confirmed voice channel type, and the corresponding addressing information for voice channel setup.

At step 8 of call placement: WS A sets up a voice channel to WS B. For ATM and RSVP, standard protocols are specified, and the setup is therefore implemented by known procedures. For best-effort UDP, there is no need to implement voice channel set-up because UDP is a datagram protocol.

2. Call Termination

At any time, user A or user B can request call termination. Call termination can also be initiated because a timer has expired. Suppose WS A initiates call termination. The steps are as follows:

Step 1: WS A informs WS B of call termination.

WS A procedure:
WS A prepares a TermCall control message and sends this message to WS B. WS A also stops any running timer, releases any existing voice channel of the call, and starts timer TA6. Release of ATM and RSVP voice channel types are implemented by known procedures. For best effort-UDP, there is no need to implement voice channel release because UDP is a datagram protocol.

If TA6 expires before a TermCall control message is received from WS B, WS A completes call termination by releasing the WS-WS control channel to WS B.

Step 2: WS B informs WS A of call termination.

WS B procedure:
Upon receiving a TermCall control message from WS A, WS B stops any timer, releases any existing voice channel of the call, prepares a TermCall control message, sends this message to WS A, and releases the WS-WS control channel to WS A.

Step 3: WS A completes call termination.

WS A procedure:

Upon receiving a TermCall control message from WS B, WS A stops timer TA6 and releases the WS-WS control channel to WS B.

B.III. Supplementary Services

In the following, some implementations of supplementary services are described. As said above, one key to this invention is the ability to exchange control messages over the WS-WS control channel which is maintained for the duration of a call. Two types of control messages shall be first defined. This is followed by a description of the implementation of three exemplary supplementary services.

1. Control Message Definition

1.1. Status Control Message for Hold or Activate Call

When a call is in the "active" state, the users can carry out their conversation over the voice channel. On the other hand, when the call is in the "hold" state, conversation between the users is suspended. The Status control message is defined to support state changes.

Status (hold): the remote WS is informed that the state of the call has been changed to "hold".

Status (active): the remote WS is informed that the state of the call has been changed to "active".

1 1.2. Supplementary Service Control Message

The following four control messages are defined to support the implementation of the various supplementary services:

- SSInfo: This message is used to inform the remote WS about the possibility of activating a certain SS (Supplementary Service).

- SSReq: This message is used to request the remote WS to perform actions relating to a certain SS.

- SSCnf: This message is sent in response to a SSReq message to confirm the processing of a SS that the remote WS has requested.

- SSReject: This message is sent in response to a SSReq to reject the processing of a SS that the remote WS has requested; the reason for the rejection is included.

The above SS messages can be sent any time after the CallCnf control message (see step 4 of call placement, Fig.3), and before a TermCall control message (see step 1 of call termination).

2. Workstation Procedures for Supplementary Services

In this section, the implementation details of three supplementary services are described. These examples illustrate how the invention is to be used. Other supplementary services can be easily implemented by someone skilled in the art on the basis of these examples and the general description above.

2.1. Alternate Call

At any point in time, a user A may have two or more calls in progress. One of these calls (to user B) is active while the others are on hold. Suppose user A requests to put the call to user B on hold and activate the call to user C. The alternate call supplementary service is implemented as follows:

Step 1: WS A informs WS B that the call has been put on hold.

WS A procedure:
Upon receiving the request from user A, WS A changes the state of the call with WS B to "hold", disconnects the voice channel of this call from its audio subsystem, prepares a Status (hold) control message, and sends this message to WS B.

WS B procedure:
Upon receiving the Status message from WS A, WS B changes the state of the call with WS A to "hold" and disconnects the voice channel of this call from its audio subsystem.

Step 2: WS A informs WS C that the call has been activated.

WS A procedure:
WS A changes the state of the call with WS C to "active", attaches the voice channel of this call to its audio subsystem, prepares a Status (active) control message, and sends this message to WS C.

WS C procedure:
Upon receiving the Status message, WS C changes the state of the call with WS A to "active" and attaches the voice channel of this call to its audio subsystem.

2.2. Call Back

This process is depicted in Fig.4, there using the generic terms of Section A.III. Suppose user B has a "call back" record which is maintained by WS B. Any calling user A may request to have his e-mail address entered into this record, thus asking user B to call back at his convenience. This request is made during call placement in case user B is busy or does not answer. The call back supplementary service for the case of user B busy is implemented as follows (see Fig.4).

Steps 1 to 3: The procedures for WS A and WS B are identical to those for call placement (see Section B.II.1.).

Step 4: WS B returns a "call confirm" control message to WS A, informing WS A that user B is busy, but call back is possible.

WS B procedure:
Upon receiving the CallReq control message from WS A, WS B stops timer TB1 and checks whether user B's e-mail address matches that contained in the CallReq control message. If this check is positive but user B is busy, WS B prepares a CallCnf (user B busy, call back record) control message, returns this message to WS A, and starts timer TB4.

WS A procedure:
Upon receiving the CallCnf control message from WS B, WS A stops timer TA2, informs user A that user B is busy, but call back is possible, and starts timer TA3.

Step 5: User A requests that he be put on user B's call back record.

WS A procedure:
WS A stops timer TA3 and proceeds to step 6.

Step 6: WS A sends a SSReq control message to WS B.

WS A procedure:
WS A prepares a SSReq (call back request, user A's e-mail address) control message, sends this message to WS B, and starts timer TA5.

Step 7: WS B enters user A's e-mail address onto user B's call-back record.

WS B procedure:
Upon receiving the SSReq message from WS A, WS B stops TB4, enters user A's e-mail address to user B's call back record, prepares a SSCnf (call back confirmed) and returns this message to WS A. WS B also starts timer TB6.

Timer TB6 is stopped as part of call termination initiated by WS A at step 8 (see Section B.II.2.).

Step 8: WS A terminates call placement

WS A procedure:
Upon receiving the SSCnf control message from WS B, WS A stops timer TA5 and initiates procedure for call termination as described in Section B.II.2.

2.3. Call Transfer

This process is shown in Fig.5, there using the generic terms of Section A.III. Suppose user A has two calls in progress: a call with user B which is on hold and a call with user C which is active. User A requests to have user B and user C connected and his calls to these two users terminated. The implementation details of the call transfer supplementary service are described below. For ease of exposition, any timers used are not mentioned, but their usage is similar to that described in call placement (Section B.II.1.) and call back (Section B.III.2.).

Step 1: WS A puts its call to WS C on hold.

WS A procedure:
Upon receiving the call transfer request from user A, WS A changes the state of the call to WS C to "hold", disconnects the voice channel of this call from its audio subsystem, prepares a Status (hold) control message and sends this message to WS C.

WS C, upon receiving the Status control message, changes the state of the call with WS A to "hold" and disconnects the voice channel of this call from its audio subsystem.

Step 2: WS A requests WS C to receive a transfer call.

WS A procedure:
WS A prepares a SSReq (receive transfer call, user B's e-mail address) and sends this message to WS C.

Step 3: WS C confirms the transfer request.

WS C procedure:
Upon receiving the SSReq control message from WS A, WS C prepares a SSCnf (transfer confirmed) control message and sends this message to WS A. WS C also saves user B's e-mail address and enters the "wait for transfer" state.

While in the "wait for transfer" state, WS C only accepts calls initiated by a CallReq (transfer call) control message from WS B. All other CallReq control messages will be responded to by a CallCnf (user C busy).

Step 4: WS A requests WS B to place a transfer call.

WS A procedure:
Upon receiving the SSCnf control message from WS C, WS A prepares a SSReq (place transfer call, user C's e-mail address) and sends this message to WS B.

Step 5: WS B confirms the transfer request.

WS B procedure:
Upon receiving the SSReq control message from WS A, WS B prepares a SSCnf (transfer confirmed) and sends this message to WS A.

Step 6: WS B places a transfer call to WS C.

WS B procedure:
WS B places a "transfer" call to WS C using the procedure described in Section B.II.1.

Step 7: WS A terminates calls with WS B

WS A procedure:
Upon receiving the SSCnf control message from WS B, WS A initiates call termination for its call with WS B using the procedure described in Section B.II.2.

Step 8: WS A terminates calls with WS C

WS A procedure:
WS A initiates call termination for its call with WS C using the procedure described in Section B.II.2.

The above description of implementations shows how an architecture for services in a telephony system can be devised which integrates computer and telephony in a novel way by taking advantage of the computing power and versatility of today's workstations and personal computers as well as the quickly developing digital networks that connect virtually the whole globe. It is to be understood that the above description of embodiments merely illustrates the principles of the invention and its various applications in known, existing networks like the Internet and ATM networks, as well as new data networks being developed, and that someone skilled in the art can easily develop various modifications based on the above without departing from the spirit of this invention.

CLAIMS

1. A method for effecting and/or controlling telephony between at least two users connected through a network (1, 4-6), comprising

   - establishing a first communication channel (12) between end user devices (3a - 3d), each said device being associated with one of said users, for transmitting first signals,
   - establishing a second communication channel (13) between said end user devices (3a - 3d) for transmitting second signals,
   - said first and second communication channels being independent of each other.

2. The method according to claim 1, wherein

   the first signals exchanged between the end user devices (3a-3d) are control signals and the second signals are voice signals, preferably encoded voice signals.

3. The method according to claim 2, wherein

   the control signals exchanged between the end user devices (3a-3d) include signals providing and/or effecting basic telephony services and/or supplementary telephony services.

4. The method according to claim 3, wherein

   the control signals exchanged between the end user devices (3a-3d) are generated essentially by or within said devices, thus effecting desired channel establishing and control functions from said end user devices.

5. The method according to any of the preceding claims, wherein

in addition to the communication signals, a voice transmission function, especially enciphering/deciphering, is implemented in the end user devices (3a-3d).

6. The method according to claim 1, wherein

each of the two channels (12, 13) transparently, independently, and directly connects the end user devices (3c, 3d) of the users communicating or desiring to communicate.

7. The method according to claim 1, wherein

the first communication channel (12) is maintained essentially permanently through a telephony session, whereas the second communication channel (13) is designed to enable intermittent operation.

8. A distributed system for effecting and/or controlling telephony between at least two end user devices (3a-3d) over a decentralized network (1), wherein

- at least one of said end user devices (3a-3d) comprises means for establishing a first communication channel (12) essentially directly between said end user devices (3a-3d) for transmitting first signals, and
- at least one of said end user devices (3a-3d) comprises means for establishing an independent second communication channel (13) essentially directly between said end user devices (3a-3d) for transmitting second signals.

9. The system according to claim 8, wherein

the means in the end user devices (3a-3d) is designed to enable intermittent operation of one of the channels whereas the other channel is essentially permanently maintained.

10. The system according to claim 8, wherein

the means in the end user devices (3a-3d) is designed to produce and/or interpret control signals exchanged between said end user devices over one of the established channels to effect basic and/or supplementary telephony services.

11. The system according to claim 8, wherein

the means in the end user devices (3a-3d) is designed to process and/or interpret voice signals exchanged between said end user devices over one of the established channels to effect voice telephony between said end user devices (3a-3d).

12. The system according to claim 8, further comprising

a telephony server (2) for effecting desired central functions, in particular user and access control information, said telephony server being designed to communicate essentially directly and independently with each of the end user devices (3a-3d).

13. The system according to any of claim 8 to 12, wherein

the end user device (3a-3d) is a multi-purpose workstation or personal computer.

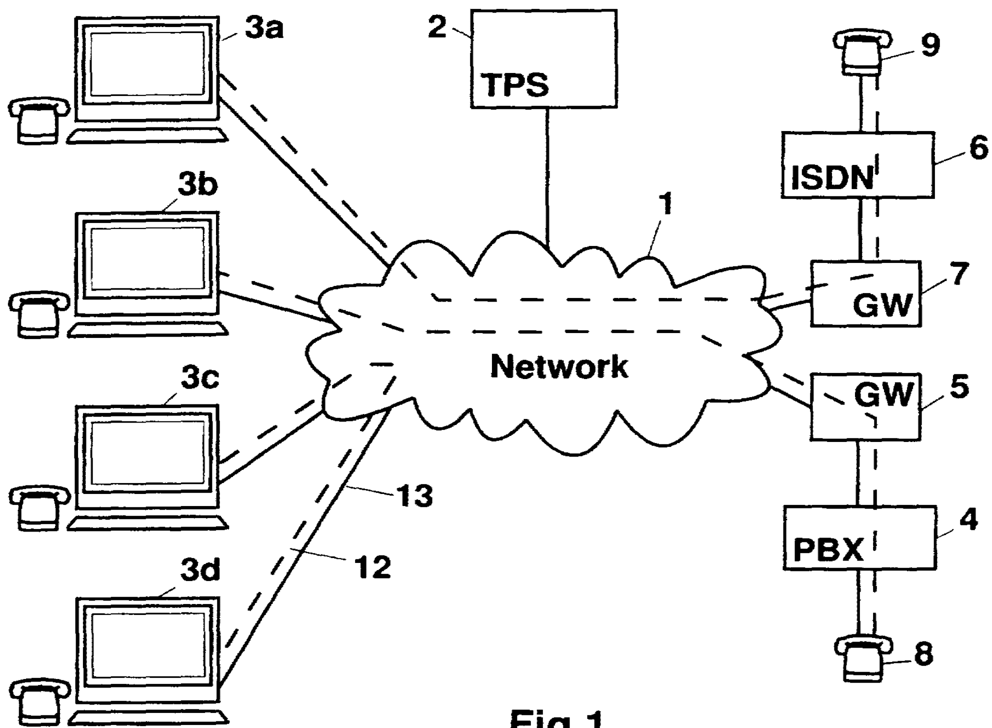

3a
2
TPS
9
6
ISDN
3b
1
7
GW
Network
3c
GW
5
13
4
PBX
3d
12
8

Fig.1

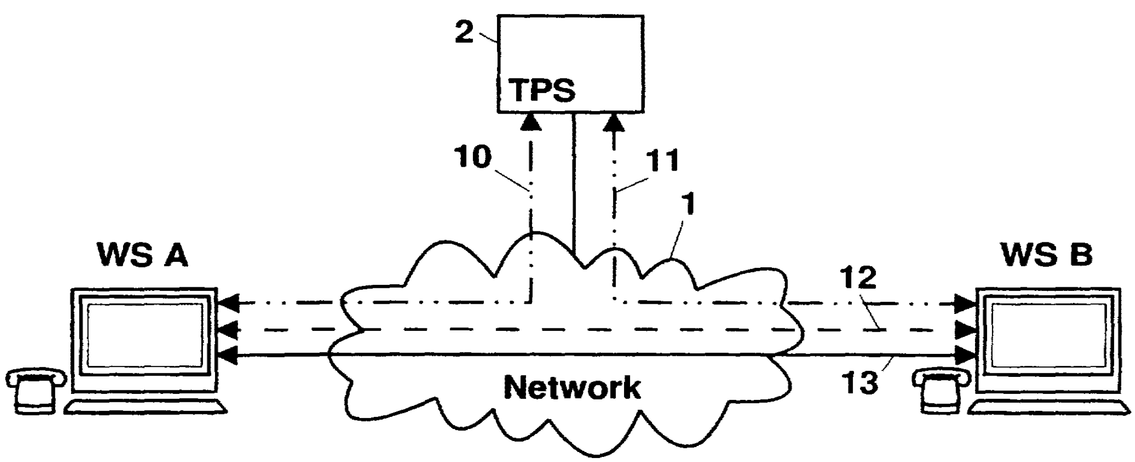

2
TPS
10
11
1
WS A
WS B
12
Network
13

Fig.2

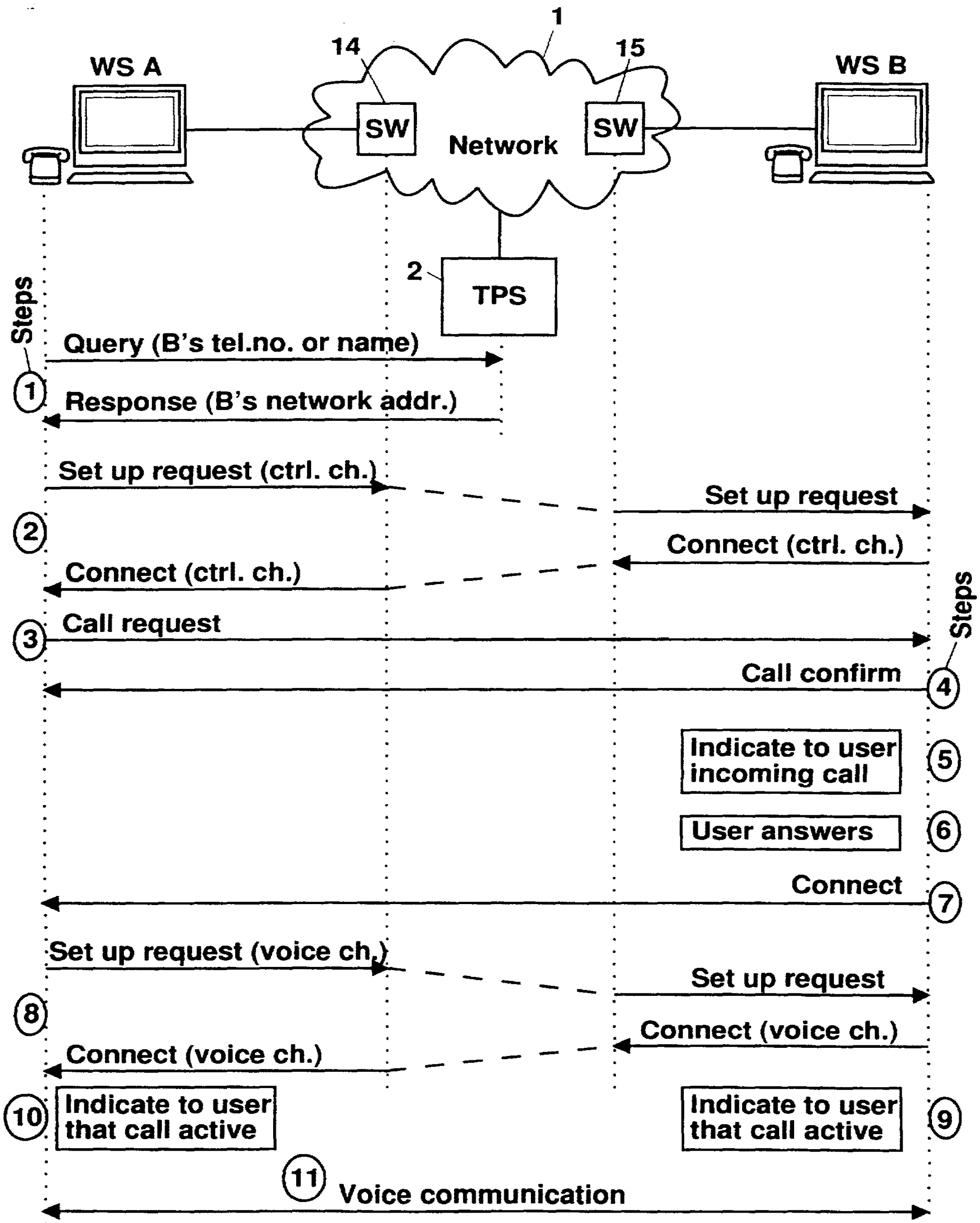
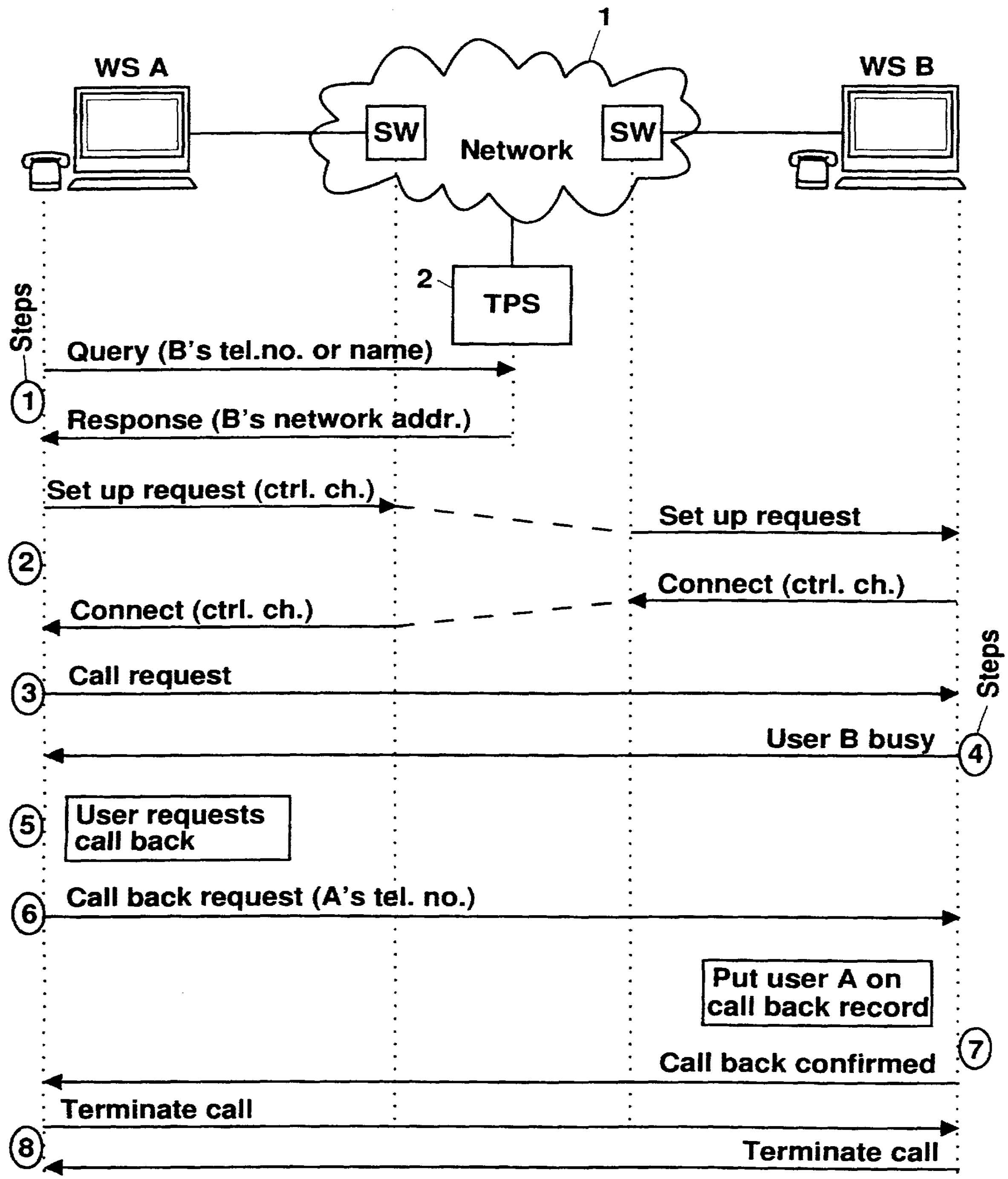
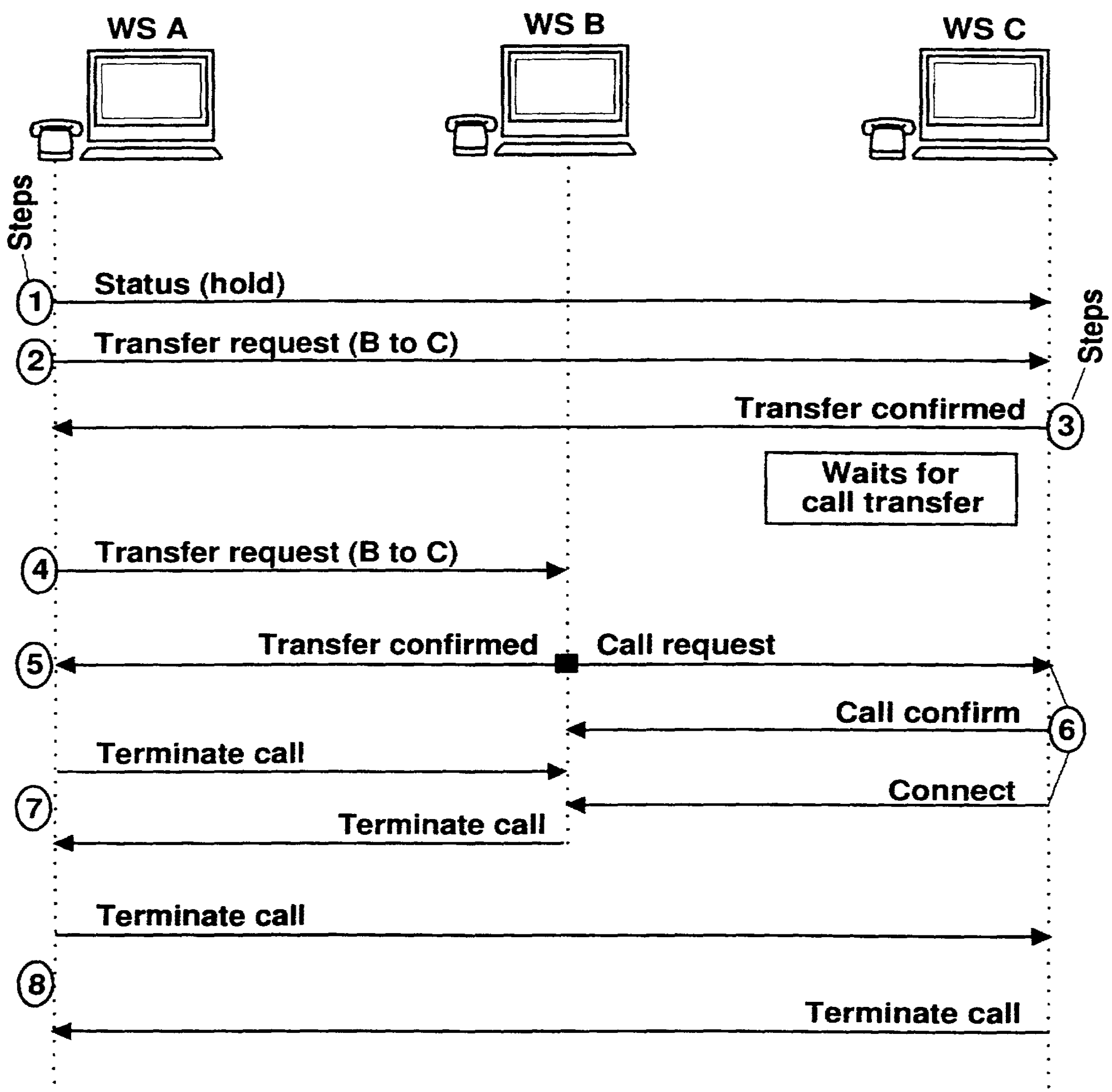

1
14
15
WS A
WS B
SW
Network
SW
2
TPS
Steps
Query (B's tel.no. or name)
1
Response (B's network addr.)
Set up request (ctrl. ch.)
Set up request
2
Connect (ctrl. ch.)
Connect (ctrl. ch.)
Steps
3
Call request
Call confirm
4
Indicate to user incoming call
5
User answers
6
Connect
7
Set up request (voice ch.)
Set up request
8
Connect (voice ch.)
Connect (voice ch.)
10
Indicate to user that call active
Indicate to user that call active
9
11
Voice communication

Fig.3



Call Back

Fig.4



Call Transfer

Fig.5

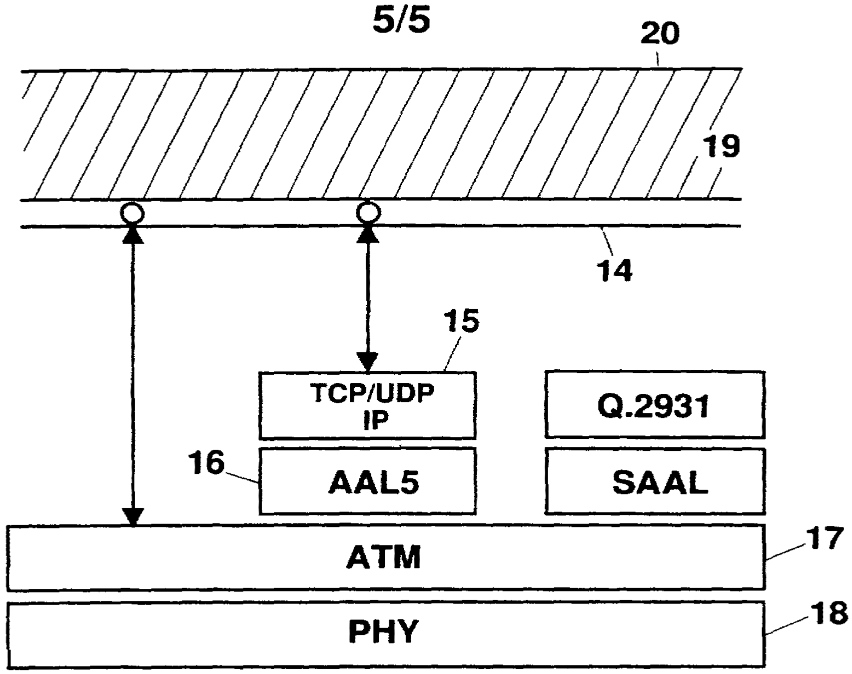

20
19
14
15
TCP/UDP
IP
Q.2931
16
AAL5
SAAL
ATM
17
PHY
18

Fig.6

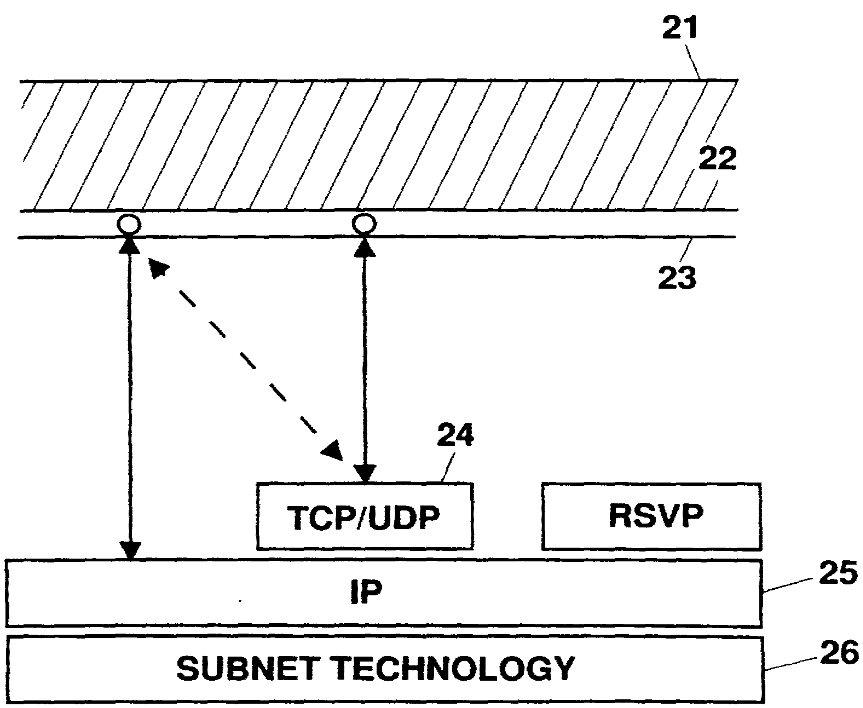

21
22
23
24
TCP/UDP
RSVP
IP
25
SUBNET TECHNOLOGY
26

Fig.7

INTERNATIONAL SEARCH REPORT

Inter ·ional Application No
PC ı/IB 96/00134

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q3/00 H04L29/06

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 H04Q H04L

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	BYTE, vol. 21, no. 2, February 1996, PETERBOROUGH US, pages 83-88, XP000549779 MULLER: "Dial 1-800-INTERNET" see page 84, middle column, line 6 - page 86, right-hand column, line 11 ---	1-4,6,8, 10-13
Y	IEEE SPECTRUM, vol. 33, no. 1, January 1996, pages 30-41, XP000566101 BELL ET AL.: "Communications" see page 35, left-hand column, paragraph 4 - page 36, right-hand column, paragraph 3 see page 39, middle column, paragraph 3 - page 41, left-hand column, paragraph 1 --- -/--	5

[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
5 November 1996	27.11.96
Name and mailing address of the ISA 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	Authorized officer Lambley, S

Form PCT/ISA/210 (second sheet) (July 1992)

Inte· ·onal Application No
PC|/IB 96/00134

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP,A,0 398 183 (NORTHERN TELECOM LTD) 22 November 1990 see column 2, line 11 - column 4, line 51 ---	1-6,8, 10-13
A	WO,A,95 23492 (HARRIS CORPORATION) 31 August 1995 see abstract; claims 1,2 -----	1,4,8,12

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IB 96/00134

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-398183	22-11-90	US-A- 4924500	08-05-90
		AU-B- 620240	13-02-92
		AU-A- 5379390	22-11-90
		CA-A- 1312394	05-01-93
		CN-B- 1022788	17-11-93
		DE-D- 69024257	01-02-96
		DE-T- 69024257	10-10-96
		JP-A- 2311065	26-12-90
		JP-B- 7077402	16-08-95
WO-A-9523492	31-08-95	US-A- 5455827	03-10-95

Form PCT/ISA/210 (patent family annex) (July 1992)

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification [6] : H04M 3/42 | A1

(11) International Publication Number: WO 97/33421

(43) International Publication Date: 12 September 1997 (12.09.97)

(21) International Application Number: PCT/US96/03064

(22) International Filing Date: 6 March 1996 (06.03.96)

(71) Applicant: BELL COMMUNICATIONS RESEARCH, INC. [US/US]; 445 South Street, Morristown, NJ 07960 (US).

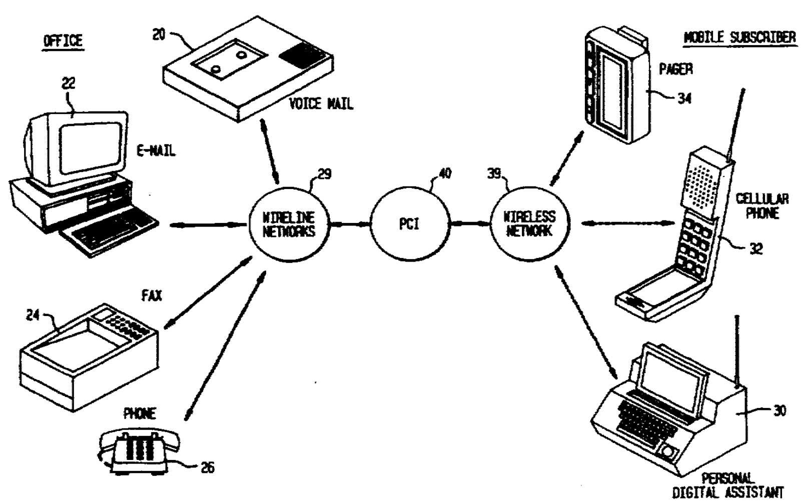
(72) Inventors: PEPE, David, Matthew; 51 Kings Highway, Middletown, NJ 07748 (US). BLITZER, Lisa, B.; 10 Gramercy Lane, Manalapan, NJ 07726 (US). BROCKMAN, James, Joseph; 15 Running Brook Drive, Perrineville, NJ 08535 (US). CRUZ, William; 9 Violante Court, Eatontown, NJ 07724 (US). HAKIM, Dwight, Omar; 20 Tina Place, Matawan, NJ 07747 (US). KRAMER, Michael; 6136 Fieldston Road, Bronx, NY 10471 (US). PETR, Dawn, Diane; 331 English Place, Basking Ridge, NJ 07920 (US). RAMAROSON, Josefa; 23 Terrance Terrace, Freehold, NJ 07728 (US). RAMIREZ, Gerardo; 3505 Sunny Slope Road, Bridgewater, NJ 08807 (US). WANG, Yang-Wei; 10 Cambridge Drive, Howell, NJ 07731 (US). WHITE, Robert, G.; 20 Knollwood Drive, Morristown, NJ 07960 (US).

(74) Agents: YEADON, Loria, B. et al.; c/o International Coordinator, Room 1G112R, 445 South Street, Morristown, NJ 07960-6438 (US).

(81) Designated States: AU, CN, KR, MX, SG.

Published
With international search report.

(54) Title: PERSONAL COMMUNICATIONS INTERNETWORKING



(57) Abstract

A personal communications internetworking (40) provides a network subscriber with the ability to remotely control the receipt and delivery of wireless and wireline voice and text messages. The network operates as an interface between various wireless (39) and wireline (29) networks, and also performs media translation, where necessary. The subscriber's message receipt and delivery options are maintained in a database which the subscriber may access by wireless or wireline communications to update the options programmed in the database. The subscriber may be provided with CallCommand service which provides real-time control of voice calls while using a wireless data terminal or PDA (30).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	**GB**	United Kingdom	**MW**	Malawi
AT	Austria	**GE**	Georgia	**MX**	Mexico
AU	Australia	**GN**	Guinea	**NE**	Niger
BB	Barbados	**GR**	Greece	**NL**	Netherlands
BE	Belgium	**HU**	Hungary	**NO**	Norway
BF	Burkina Faso	**IE**	Ireland	**NZ**	New Zealand
BG	Bulgaria	**IT**	Italy	**PL**	Poland
BJ	Benin	**JP**	Japan	**PT**	Portugal
BR	Brazil	**KE**	Kenya	**RO**	Romania
BY	Belarus	**KG**	Kyrgystan	**RU**	Russian Federation
CA	Canada	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CF	Central African Republic			**SE**	Sweden
CG	Congo	**KR**	Republic of Korea	**SG**	Singapore
CH	Switzerland	**KZ**	Kazakhstan	**SI**	Slovenia
CI	Côte d'Ivoire	**LI**	Liechtenstein	**SK**	Slovakia
CM	Cameroon	**LK**	Sri Lanka	**SN**	Senegal
CN	China	**LR**	Liberia	**SZ**	Swaziland
CS	Czechoslovakia	**LT**	Lithuania	**TD**	Chad
CZ	Czech Republic	**LU**	Luxembourg	**TG**	Togo
DE	Germany	**LV**	Latvia	**TJ**	Tajikistan
DK	Denmark	**MC**	Monaco	**TT**	Trinidad and Tobago
EE	Estonia	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**UG**	Uganda
FI	Finland	**ML**	Mali	**US**	United States of America
FR	France	**MN**	Mongolia	**UZ**	Uzbekistan
GA	Gabon	**MR**	Mauritania	**VN**	Viet Nam

PERSONAL COMMUNICATIONS INTERNETWORKING

FIELD OF THE INVENTION

The present invention is directed to an internetwork for personal communications and, more particularly, to a network which allows a mobile communications subscriber to remotely control personal communications delivery options.

BACKGROUND OF THE INVENTION

The use of messaging as a means of day-to-day communications continues to grow and evolve, particularly in a business context. Messaging includes electronic mail (e-mail), facsimile transmissions (fax), paging, voice mail, and telephone communications. The introduction of the cellular phone and other wireless communications facilitated the advent of the "mobile office". The mobile office allows an employee, for example, to work away from the office on a portable computer and be in constant touch with the office via a cellular phone.

The messaging options described above are available to businesses of all sizes, as well as individual users, from a variety of service providers. Many offices have some or all of the messaging options described above. The office may have certain messaging equipment (referred to as "consumer premises equipment" or "CPE") connected to one or more wireline networks. That is, the office may have telephones, fax servers, and voice mail systems connected to phone lines, and computers having modems for e-mail connected to packet networks which are connected via phone lines. The mobile employee may have certain wireless messaging equipment, such as a pager, a cellular telephone, or a personal digital assistant ("PDA"), which is typically a notebook computer connected to a wireless communication network.

One important goal of personal communication services is to allow users to communicate from anywhere to anywhere at any time. Such personal communication services generally involve multiple service providers including local and long distance telephone companies and cellular telephone companies. An example of a personal communication service is as follows:

A personal communication service provider (e.g., a cellular telephone company) enables traveling users to rent a wireless portable phone from a rental phone company (e.g., from an airline or car rental company). Using the rental phone, the user is provided with basic mobile phone service from the personal communication service provider. In addition, the user would like the following features:

1) The user wants calls directed to his/her office or home to be automatically forwarded to the rental portable phone, without informing anyone that he/she is traveling.

2) To avoid unimportant incoming calls (and corresponding incoming call charges), the user would like to restrict the number of people who can call the rented portable phone.

3) It is important to the user that the rental phone features be activated instantly, so that calls can be made immediately upon the user's arrival at the visiting location.

This kind of personal communication service involves a plurality of service providers. These providers are (a) the local telephone company at the home location, (b) a long distance telephone company, (c) the local telephone company at the visiting location, and (d) the personal communication service provider (i.e., the cellular telephone company) at the visiting location. All of these are referred to herein as "service providers".

To enable this kind of personal communication service, involving multiple service providers, interoperability problems among the different service providers must be resolved. The interoperability problems can be divided into two categories: (a) location tracking and (b) service management.

The interoperability problem for location tracking has been addressed by adopting signaling protocols used by the mobile phone industry. Location tracking functions are implemented using two location registers. One of the registers, maintained by the local telephone company of the user's home location, is called the Home Location Register (HLR). The other register, maintained by the local telephone company of the visiting location, is called the Visiting Location Register (VLR). The HLR stores customer profile data and the location of the VLR of the user. The customer profile data contains important information such as the user's name, address, preferred long distance carrier, service features (e.g., call forwarding and call restriction), billing, and other administrative related information. When the user travels to a new visiting location, a new VLR is created in the new location. A part of the profile data stored in the HLR is transmitted and loaded into the VLR such that the service provider at the visiting location can implement service features for the visiting user. When the user travels to a new visiting location the location of the VLR stored in the HLR is changed to the new VLR location, and the VLR in the previously visited location is deleted. The process of creating a new VLR, loading profile data to the VLR, and updating the visiting location of a user in the HLR is called "automatic roamer registration".

The interoperability problem for service management is much more complex than that for location tracking. Service management refers to a collection of functions required to enable a personal communication service user to subscribe to, modify, and activate service features anywhere and at any time. Examples of service management functions include phone number administration, customer profile data management, service activation, and security administration. The phone number administration function is important for maintaining the uniqueness of phone numbers. The customer profile data management function provides customer profile databases and user interfaces for creating, modifying, or transferring such databases. The service activation function extracts part of the data specifying service features from the profile data and loads this data into physical communication systems that process calls. The service activation function also controls the activation and deactivation of the service features. The security administration function prevents or detects unauthorized uses of services and service management functions.

Service management functions of this type are needed to provide personal communication services involving multiple service providers. Such service management functions generally require interactions between application software and various databases owned and operated by the different service providers. Consider an application which enables a nomadic user to subscribe to a personal communication service from any service provider at any location. An example of such a service is call forwarding to a temporarily rented portable phone. The application may, for example, need to perform the following database access operations at databases maintained by various different service providers:

× check credit databases owned by credit card companies or phone companies to determine whether the user is able to pay for the service;

× check the customer profile database in the user's HLR to determine whether the user is currently located in a place other than the visiting location currently stored in the HLR;

× check the credit and network databases of long distance phone companies specified by the user to determine whether the user can use a particular long distance carrier in the visiting location;

× load profile data into the VLR at the visiting location and update the HLR with the location of the VLR if necessary; and

× load the profile data to the call processing systems and activate the service.

The user may need to send or receive messages from any or all of the messaging options described above at a visiting location. That is, the user may want to receive or receive notification of e-mail, faxes, phone calls, or voice mail at a visiting location or to send e-mail or faxes from a wireless terminal. The need to integrate these various types of messaging options and to interconnect the many service providers has, until now, been largely unaddressed.

It is also desirable for the mobile employee to be able to limit the messages sent to the wireless messaging equipment, so that only urgent messages are received when away from the office and unwanted in-coming calls are avoided. The mobile employee may also wish to route certain incoming wireless messages and phone calls to other destinations, such as an office fax machine or a colleague's telephone.

Therefore, it is an object of the present invention to provide a mobile service subscriber the ability to control and integrate a plurality of messaging options.

It is another object of the present invention to provide a mobile service subscriber with the ability to remotely control the addressability, routing, accessibility, and delivery of messaging options.

It is yet a further object of the present invention to provide an internetwork which interconnects messaging services with both wireless and wireline networks.

It is yet a further object of the present invention to provide a subscriber with real-time control of voice calls while using a wireless data terminal or PDA.

It is yet a further object of the invention to provide a control over the messages routed to wireless messaging options.

SUMMARY OF THE INVENTION

These objects are obtained by a personal communications internetwork providing a network subscriber with the ability to remotely control the receipt and delivery of wireless and wireline voice and text messages. The network operates as an interface between various wireless and wireline networks, and also performs media translation, where necessary. The subscriber's message receipt and delivery options are maintained in a database which the subscriber may access by wireless or wireline communications to update the options programmed in the database. The subscriber may be provided with CallCommand service which provides real-time control of voice calls while using a wireless data terminal or PDA.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the invention will become apparent from the following drawings, wherein:

Fig. 1-3 are overviews of the PCI networks;

Fig. 4 is an overview of one node of the PCI network according to the present invention;

Fig. 5 is a block diagram of an exemplary PCI server according to the present invention;

Fig. 6 is a block diagram of an exemplary embodiment of a PCI database according to the present invention;

Fig. 7 is a block diagram of the logical connections between the PCI server and PCI database according to the present invention;

Figs. 8-11 illustrate exemplary message flows between a server and a database according to the present invention;

Fig. 12 is a block diagram of a personal digital assistant according to the present invention;

Figs. 13-20 illustrate exemplary message flows between a PDA and PCI server;

Fig. 21 is a block diagram of a text messaging portion of a PCI network;

Fig. 22 is a block diagram of a voice messaging portion of a PCI network;

Fig. 23 is a block diagram of a facsimile messaging portion of a PCI network;

Fig. 24 is a diagram illustrating an exemplary CallCommand service network;

Figs. 25-27 illustrate exemplary message flows in the PCI network; and Figs. 28-45 illustrate exemplary screens displayed to a PCI subscriber using a wireless PDA.

DETAILED DESCRIPTIONS OF PREFERRED EMBODIMENTS

For clarity of presentation, the detailed description is set out in the following subsections:

I. PCI Overview

The overall network is illustrated in Figs. 1-4 The network is an interface between a plurality of wireless and wireline networks, providing a subscriber with a variety of wireless and wireline message and voice delivery and receipt options.

II. The PCI Server

The PCI Server is illustrated in Fig. 5. The PCI server is a peripheral which performs messaging and call redirection functions and interfaces with the PCI database to update the subscriber profile.

III. The PCI Database

The PCI Database is illustrated in Fig. 6. The PCI database maintains the subscriber profile, controls CallCommand functions, and handles DTMF-based subscriber profile updates.

IV. The Server/Database Interface

The Server/Database interface is illustrated in Figs. 7 - 11. The PCI server/PCI database interface provides for the transfer of information regarding the subscriber profile and the CallCommand services.

V. The PDA/PCI Interface

The PDA/PCI interface is illustrated in Figs. 12 - 20. The PDA/PCI interface provides for the transfer of information between a remote wireless subscriber and the PCI.

VI. Services

A. E-Mail Messaging

E-Mail messaging in the PCI is illustrated in Fig. 21. The PCI network provides the subscriber with a variety of e-mail delivery, receipt, and notification options, including screening and selective destination delivery of incoming e-mail.

B. Voice Messaging

Voice messaging in the PCI is illustrated in Fig. 22. The PCI provides the subscriber with a variety of voice mail delivery, receipt, and notification options, including screening and selective destination delivery of incoming voice mail.

C. Facsimile Messaging

Facsimile messaging in the PCI is illustrated in Fig. 23. The PCI provides the subscriber with a variety of facsimile delivery, receipt, and notification options, including screening and selective destination delivery of incoming faxes.

D. CallCommand

The CallCommand service is illustrated in Fig. 24. CallCommand service provides real-time control of voice calls while using a wireless data terminal or PDA.

VII. Message Flows

Certain message flows for wireless messaging in the PCI are illustrated in Figs. 25 - 27. The three message flows illustrated are sending a message from one subscriber to another, receiving a message regardless of whether the subscriber is using a wireless or wireline terminal, and sending a message to a non-subscriber.

VIII. The PDA Application

The application residing in the PDA is described in Figs. 28 - 45, which illustrate exemplary screens displayed to a PCI subscriber using a wireless PDA.

IX. Billing

Billing procedures for a PCI network use is briefly described.

X. Conclusion

A glossary of acronyms used in this specification is attached as Appendix A.

I. PCI Overview

Fig. 1 is a simplified overview of a personal communications internetworking ("PCI") according to the present invention. A consumer, an office for example, has various messaging equipment, such as a voice mail system 20, an e-mail terminal 22, fax machines 24, and telephones 26. These are all connected to wireline networks 29. For example, the fax 24, phone 26, and voicemail system 20 may be connected to a Public Switched Telephone Network (PSTN), part of which belongs to a particular local phone service company, and part of which belongs to a particular long distance service provider. The e-mail terminal 22 may be connected to a data packet network, such as Internet, whose packets are carried over phone lines.

A mobile communications subscriber (for example an employee who works at the office described above and travels frequently) has various portable messaging equipment, such as a PDA 30, a cellular phone 32, and a pager 34. These are connected to wireless networks 39. These wireless messaging options may be provided by different service providers. That is, the cellular phone may be connected to a wireless network of a cellular phone service provider, the pager may be connected to a different wireless network maintained by a pager service provider, and the PDA may be connected to a third wireless communications network maintained by yet another service provider.

A Personal Communications Internetworking ("PCI") 40 according to the present invention is connected between the wireless 39 and wireline networks 29. The PCI 40 permits the mobile communications subscriber to send and receive messages between disparate networks and messaging systems and a variety of service providers. The mobile communications subscriber can receive e-mail, fax, pages, and voice messages under a single phone number while using either a wireless or wireline network. The subscriber may also select the media format and serving network used to receive messages. The subscriber may also select cross-media notification of incoming messages, (i.e., the subscriber may receive notification from a pager message that a voice mail message was received).

The subscriber selects the wireline or wireless network and media format to be used for delivering messages or notification of message receipt. The PCI 40 will perform a media conversion to allow, for instance, an e-mail message to be delivered to a fax server. The PCI 40 may also include accessibility controls which allow the user to screen messages by selected criteria such as media type (e.g., e-mail, fax, etc.), message length (e.g., voice mail messages less than three minutes), or sender (e.g., only messages from the office and a certain client are to be forwarded).

For example, the subscriber may have notification of a voice mail or fax message receipt directed to a wireless PDA in the form of e-mail messages. If the subscriber's wireless PDA is not turned on or otherwise not operating, the notification may be routed to an alternate wireless or wireline network. Notification to the subscriber that a voice mail message was received may be, for example, rerouted to the subscriber's pager, and notification that a fax has been received may be rerouted to the wireline e-mail.

Fig. 2 is a simplified version of the interconnections between various messaging systems and a PCI. As shown in Fig. 2, a subscriber provides the network with message routing and delivery instructions. These instructions are received by a PCI database 44 and stored in a "subscriber profile" for that subscriber. This database controls the delivery of outgoing messages and the routing of incoming messages and message notification. (In Fig. 2, wireline communications are indicated with solid line connections and wireless communications are indicated with dashed line connections. The instructions to the PCI are shown with a solid line, but as will be explained in greater detail below, the instructions may be sent either by a wireline or wireless network.)

The PCI database 44 supports access to information authenticating the subscriber's identity and validating the types of services subscribed to, the subscriber's message delivery (incoming messages) options and origination (outgoing messages) options and voice (telephone call and voice mail) options. For origination, the subscriber may select message distribution lists with specific media delivery options. The database 44 also supports access to the portions of the subscriber profile that the subscriber may control.

The subscriber may use a personal telephone number to register at alternate wireline and wireless terminals while maintaining use of the message screening and delivery options selected and stored in a subscriber's profile. This is called "personal mobility". Information about the location of a wireless or wireline network location to which the subscriber's terminal is connected automatically registers and deregisters a subscriber's terminal. This is called "terminal mobility."

Fig. 3 shows the PCI 40. The CPE (voice mail 20, e-mail 22, fax 24, and phone 26) are connected to wireline networks 29. The mobile subscriber equipment (PDA 30, cellular phone 32, and pager 34) are connected to wireless networks 39. Both the wireline and wireless networks 29, 39 are connected to a PCI 40 at a service provider. The networks 29, 39 are connected to a local exchange carrier (LEC) 42 for the personal communications internetworking.

A PCI database 44 is a physical communication system which provides call processing functions for a collection of central office switches. The PCI database 44 includes the mobile subscriber's profile, including message sending, message receiving, and service control options. The PCI database 44 may be a service control point or a network adjunct. The PCI database may be connected via a service management system (SMS) interface to a service integrator 46. The service integrator 46 allows the service provider to update subscriber data and create and modify subscriber profiles.

The PCI database 44 preferably stores and updates the subscriber profiles. The profiles contain service related information for mapping services to subscribers (e.g., screening, routing, terminal selection by subscriber selected parameters, custom calling features, and the like); subscriber authentication data (e.g., password and user I.D.); user status (registered or not registered); generic service profile for non-call associated service, such as subscriber address or social security number; specific profile for a non-call service (based on subscriber selected parameters); wireless data providers identification (e.g., what cellular phone provider is used); and specific profile for call associated services (e.g., call forwarding), based on user selected parameters.

Fig. 4 is a more detailed depiction of the one node 43 of the PCI. The PCI has a plurality of nodes and is preferably built on the Advanced Intelligent Network (AIN) architecture. Other network architectures may be used, but for illustrative purposes, the description is directed to an AIN-based network.

A PCI server 48 is a peripheral which performs messaging and call redirection functions and interfaces with the PCI database 44 to update the subscriber profile. The PCI server may be an AIN Intelligent Peripheral, such as a Bellcore Intelligent Services Peripheral, or a network adjunct. The PCI server is connected to a switch 50. In the AIN architecture, this switch is a Service Switching Point Access Tandem (SSP AT), but may be any suitable switch, depending on the architecture. The SSP AT 50 connects wireline networks to the CPE. The SSP AT 50 also connects the PCI server 48 with a central office (CO) 52. The SSP AT 50 also connects to the SCP 44. The PCI database 44 and the PCI server 48 are directly connected. The LEC of Fig. 3 is part of a large network and includes the PCI database 44, the PCI server 48, and the SSP AT 50. The PCI database may be connected to an SMS interface to a system integrator 46, as described above.

The PCI server 48 is also connected to various wireless and wireline networks 49 via signaling connections in these networks to transmit and receive information for all of the messaging options. Illustratively, the PCI server provides access to Public Packet Switched Networks (PPSN), Public Switched Telephone Network, (PSTN), Integrated Signaling Digital Networks (ISDN), X.25 networks and TCP/IP networks and may include access to asynchronous transfer mode (ATM), Switched Multimegabit Digital Service (SMDS), and Frame Relay networks.

The mobile subscriber may access his or her subscriber profile to change message sending, message receiving, and service control options. These option changes are sent to the PCI database 44 to be stored in the subscriber profile. Fig. 4 shows, for example, a PDA 30 connected to the PCI server 48 by a wireless network, but the subscriber may also use wireline e-mail, or wireless or wireline telephones (using DTMF signals) to access the subscriber profile. The messages from the PDA, for example, are sent by a wireless network 54 to the PCI server 48 using, for example, an X.25 transport.

Delivering PCI service to a subscriber who may be present on a number of different systems requires storage, movement and caching of the service profile associated with that subscriber. A mobility controller 49, located in the PCI server 48, is a controller and data store, which dynamically maintains service control information for a Message Transfer Agent (MTA), described below, in the PCI server 48, which connects the PCI server 48 to wireless data networks.

Data storage functions are handled by two tiered entities. The subscriber profile is preferably located in the PCI database 44 and is the top of the hierarchy where permanent records such as service profile, authentication and validation information, and the like of the subscriber or device are maintained and performing status and location management and mapping are performed. A service profile cache 51 is preferably located in the PCI server 48 and is a local cache entity which stores on a "needs basis" information such as service profiles and validation status and maintains a local repository for the service recipient. It also administers information necessary to serve the wireless data network entity, as well as sending updates to the permanent storage entity PCI database. The service profile cache 51 maintains the personal data associated with the processing of the mobility controller 49. The mobility controller 49 interacts with the PCI database-based subscriber profile (or third party data base) on behalf of the cache to obtain service profiles and location information related to wireless terminals.

PCI may also provide directory services as a value-added component. The X.400 MTA can query a local directory serving agent in the PCI server 48 for addressing and routing information. If the information is not local, the PCI server 48 will need to get the addressing information from another PCI server 48 at another PCI node or an interconnected private directory serving agent which maintains a separate information base. By using the existing standard, the PCI network and mail PCI servers message handling can independently manage the networks without interfering with the PCI service.

II. The PCI Server

The PCI server is a peripheral which performs messaging and call redirection functions and interfaces with the PCI Database to update the subscriber profile. The PCI server performs a variety of functions. For example, an illustrative PCI server:

× is an X.400 Gateway;

× routes messages using the X.400 messaging protocol;

× connects proprietary messaging protocols into X.400 protocol;

× interfaces with wireless data networks;

× interfaces with messaging systems;

× interfaces with the PCI database to access subscriber profiles information;

× processes messages as specified by the user in the service profile;

× provides media conversion such as text to fax or fax to text;

× provides access to an X.500 directory to determine addressing schemes for packet data;

× supports signaling between wireless data networks for management functions such as registration; and

× maintains a service profile cache.

Fig. 5 is a detailed illustration of a preferred embodiment of a PCI server 48 according to the present invention. The PCI server 48 includes three main elements: a call processor 110, a data messaging peripheral 112, and a shared disk memory 113.

The call processor 110 comprises a plurality of interconnected computers. The messaging peripheral 112 maybe implemented by a computer such as a DEC XAP system.

The call processor 110 includes a PCI applications server 114. The application server is the central decision making point of the wireless messaging service described below in Section VI. Thus, the server 114 controls message routing, screening, and notification for the wireless messaging service.

The application server 114 is connected to a PDA protocol handler 115. The protocol handler is the interface to the wireless network 54, for example the RAM wireless network. This handles messages to be sent to and from the subscribers PDA 30. A plurality of personal digital assistants (PDA) 30 are connected to the wireless network 54.

The application server 114 also manages a PCI database protocol handler 126. The protocol handler 126 is the interface between the call processor 110 and the PCI database 44. The application server 114 also manages a Service Profile Cache 51. The Service Profile Cache 51 is maintained in the memory of the application server 114. The cache 51 stores a subset of the data in the subscriber profile stored in the PCI database 44. This subset is subscriber profile information which currently needs to be accessed frequently by the PCI server 48.

The Service Profile Cache 51 stores and accesses data related to access systems such as wireless data providers and messaging services, and subscriber location. The Service Profile Cache 51 may store and update data related to the subscriber location such as routing address for subscribers specific wireless terminals; store and updates services related data for a particular terminal type (such as uni- or bi- direction); maintain a list of the subscribers wireless data provides and message services; track the subscribers terminal status (registered or not registered); provide a generic service profile for non-call messaging service; and provide a specific profile for a non-call associated service based on subscriber selected parameters.

The application server 114 also manages the registration status of each application on each PDA 30 and controls customer profile information via each PDA 30.

The call processor 110 also includes an IP Functions Server 130. The IP Function Server 130 manages CallCommand applications. This server is also connected to the PCI database protocol handler 126 for communication with the PCI database 44 and the PDA protocol handler 115 for communication with the wireless network 54. The PCI database protocol handler 126 handles both interfaces between the PCI database and the PCI server, as described below.

Thus, the two main application servers in the call processor 110 are the IP Function server 130 for CallCommand applications and the PCI applications server 114 for wireless messaging services.

The call processor 110 also includes a plurality of communication interfaces. The protocol handlers 115 and 126 have already been discussed. The alphanumeric paging server (APS) 132 gives the call processor 110 the ability to provide alphanumeric paging services. The APS 132 includes one or more modems to communicate with terminal equipment of a network 134 maintained by a paging service provider. The APS communicates with the paging service provider using, for example, the TAP protocol (Telocator Alphanumeric Protocol).

The call processor 110 also includes a plurality of control processes which control peripheral equipment external to the call processor 110. These controllers are as follows:

A message controller 136 controls the data messaging peripheral 112 and controls the sending of messages between the call processor 110 and the data peripheral 112.

The mobility controller 49 comprises the PCI database protocol handler 126, the IP function server 130, the service profile cache 51, and the PCI application server 114. The mobility manager provides control logic for user authentication, service request validation, location management, user access to service profile, access registration, and communication management such as routing to user-specified destinations. The mobility controller 49 contains the service logic and handles service related processing for personal data and service access such as service feature analysis; access system mapping relationship information; identity management; subscriber validation and authentication; billing information based on the subscriber; wireless data specific routing information for message delivery and subscriber paging; subscriber service validation; and subscriber review and modification of the subscriber's profile.

A transaction controller 150 controls a switch controller 152 and a voice peripheral controller 154. The switch controller 152 controls the digital switch 156 which connects to the public switched telephone network 58. The voice peripheral controller 154 controls the voice peripherals 160, which are for example text-to-speech converters.

The switch 156 and the voice peripheral 160 are also connected by a T1 line 161. The digital switch 156 is connected to the public switched telephone network by a plurality of transmission media such as T1 lines 162, fax lines 163, and ADSI lines 164.

The data messaging peripheral 112, which is optional, is now discussed in greater detail. The data messaging peripheral is the gateway to the wireline electronic mail network, which network is designated 170. The data messaging peripheral has a message transfer agent 158 for transferring messages between the call processor 110 and the data networks 170, 54 either directly or through the PDA protocol handler 115. The messaging peripheral 112 also includes a POP (post office protocol) server 190 and associated memory 192 for providing a message storing capability. The message directory 194 is used for storing a subset of service profile cache 51 relating to the routing of e-mail messages.

The messaging peripheral 112 includes the message gateway 140. The message gateway 140 has the following capabilities:

1) Notifying the PCI application server 114 in the call processor that e-mail has arrived from the wireline e-mail network 170 for a subscriber.

2) Accept a request from the PCI application server 114 to send an e-mail message to a wireline address.

3) Accept a request from the application server 114 to provide all unread messages stored in the server 190 which would have been sent to a primary destination if the subscriber had been registered.

4) Accept a request from the application processor 114 to rewrite to the message store server 190 or back to the sender.

Using the call processor 110 and its associated peripherals, a wide variety of services may be performed. These have been discussed above briefly and are described in detail in Section VI below. However, to understand how the call processor 110 operates to provide these services, some exemplary descriptions for certain services is provided.

For example, when a wireline e-mail message arrives at the PCI server's Data Messaging Peripheral 112, the messaging gateway 140 and messaging Controller 136 send notification to the PCI application server 114 of the e-mail arrival. The PCI application server 114 will query the profile cache 51, or if necessary, the PCI database 44. Driven by data in the subscriber's profile, the PCI application server 114 executes service logic to determine where to forward the e-mail (i.e., forward to PDA 30 or to POP server 190 depending on screening outcome), and what media, if any, to use to send notification of the e-mail arrival.

For another example, when a CallCommand call arrives at the PCI server 48, the procedure is as follows. The switch controller 152 and transaction controller 150 forward the call to the IP Functions Server 130 based on the dialed number. The IP functions 130 sends a provide_instructions 1129+ message to the PCI database 44 to determine how to handle the call. The PCI database 44 and IP functions applications servers 130 begin a conversation of messages which perform a sequence of functions which play an announcement to the caller, send notification to the PDA, etc. When a response arrives from the PDA 30, the IP functions server 130 forwards the response to the PCI database 44. The PCI database 44 will then direct IP functions server 130 to forward the call to a routing number and/or play a synthesized message to the caller.

If a subscriber wishes to update the subscriber profile by DTMF, the procedure is as follows. A call arrives at the PCI server 48. The switch controller 152 and transaction controller 150 forward the call to the IP functions server 130 based on the dialed number. The IP functions server 130 sends a provide_instructions 1129+ message to the PCI database 44 to determine how to handle the call. The PCI database 44 sends a request to play an announcement and collect digits ("please enter PIN", collect PIN). The IP functions server 130 returns the result of this request to the PCI database 44. Again the PCI database 44 sends a request to the IP functions server 130 to play an announcement and collect digits ("voice menu", menu selection). The IP functions server 130 returns the result of this request to the PCI database 44.

This process repeats as users are guided through menus and change profile elements. The PCI database 44 interprets the collected DTMF tones and updates the subscriber's profile accordingly.

When a PDA 30 sends an e-mail message addressed to a wireline address the procedure is as follows. The PDA 30 sends a UDP send_mail message to the PCI application server 114. The PCI application server 114 detects the message is not destined for another PCI subscriber and forwards the request to the messaging controller 136, which forwards it to the messaging gateway 140 which is in the Data and Messaging Peripheral 112. The messaging gateway 140 interfaces with the MTA 158 to send the e-mail to the wireline network 170, using, for example, the Simple Messaging Transfer Protocol (SMTP).

The PCI server 48 may be based, for example, on either an X.400 MTA or an SMTP router and can convert between both protocols. The PCI server 48 may receive text messages from a variety of different text messaging systems such as Internet mail, third party messaging systems, or proprietary messaging systems. In the example where PCI routes messages using an X.400 MTA, these messages must be converted to conform with X.400 protocol before they can be routed. Thus, an exemplary messaging gateway is an X.400 gateway, which can be designed and built by a person of ordinary skill in the art.

II. The PCI Database

A PCI Database 44 maintains the subscriber profile, controls the Call Command functions, and handles DTMF-based subscriber profile updates.

The PCI database architecture shown in Fig. 6 comprises several application and support components. The application components include Multiple Services Application Platform (MSAP) 202; Service Provisioning and Creation Environment (SPACE) 204; and Data and Report Subsystem (DRS) 206.

The service components include the Maintenance and Operation Console (MOC) 208; the Intelligence Peripheral Interface (IPI) 210; the Generic Data Interface (GDI) 212; the Service Network Interface (SNI) 214; and the Data and Report database (D&R) 218.

The service network interface (SNI) 214 provides a communication interface to external systems such as switch 50 and PCI server 48. These interfaces include the IPI 210 and GDI 212 which connect the PCI database to the PCI server via the TCP/IP network 213. The GDI 212 is used for uploading and downloading a subscriber profile to the PCI server 48. The IPI 210 is used for transmitting DTMF commands from a user via the PCI server 48. For redundancy, each intelligent peripheral interface (IPI) and generic data interface (GDI) processor preferably requires two logical connections to the PCI server.

The Multiple Services Application Platform (MSAP) 202 includes a call processor 220, a first call process request (CPR) database 222, an MSAP common 224, a shared memory 226, and a call contact database (CCDB) 228. The call processor 220 receives messages from and sends messages to a message distributor 219 in the SNI 214. The message distributor determines whether the message received from the call processor 220 is to be sent to the IPI 210 or the GDI 212. The call processor receives messages from the message distributor and sends them to the first CPR database, the CCDB 228, and/or the shared memory 226. The first CPR database 222 stores the subscriber profiles. The MSAP 224 connects the first CPR database 222 with the second CPR 230, which resides in SPACE 204. MSAP common 224 updates one of the CPR databases 222, 230 when changes have been made to the other CPR database. The CCDB 228 is a temporary, dynamic storage for storing subscriber profiles, and related data during profile update procedures. The shared memory 226 allows different processors to use the same data.

SPACE 204 is a service provider-operated module through which new PCI database applications are created and new subscriber profiles are initiated. SPACE 206 includes the second CPR database 230 which contains the identical information as the first CPR database 222 in MSAP 202. When a new subscriber profile is to be created, a service provider uses a display terminal 232 in SPACE to provision a new service profile including certain subscriber information. The subscriber profile is activated through MSAP when the user initially registers. Service provider changes made to the second CPR database 230 are transmitted to the first CPR database 222 in MSAP via the MSAP common 224. Changes made to the second CPR database 230 by a service provider are not transmitted to the service profile cache 51 in the PCI server 48 until a later time. That is, the PCI database 44 does not send data to the PCI server 48 unless requested by the server 48. The server profile cache 51 will be updated with this new information the next time the PCI server 48 requests a profile download, for instance when the subscriber next registers. SPACE 204 provides a function parallel to the Service Management System described above.

The Data and Report Subsystem (DRS) 206 collects data about the PCI database 44 usage which may be helpful to the service provider. For example, errors made by the subscriber when updating the user profile are noted. The types of alterations made, times such alterations are made, and the like are also stored for future use by the service provider.

MOC 110 is a network maintenance support system which monitors the status of the network and checks for system failures and the like.

When a subscriber wishes to update the subscriber profile using a PDA 30, the procedure is as follows. The PDA 40 communicates with the PCI server 48. The PCI server 48 sends a GetData message having a "Service Key", which is a preferably a ten digit PCI subscriber number (e.g., a telephone number), to the PCIdatabase 44 over the GDI 212. The GDI 212 translates the GetData message into a format understandable by the PCI database 44. The message is sent through the message distributor 219 and call processor 220 to the first CPR database 222 where the subscriber profile resides. The Service Key is used to obtain the correct subscriber profile and the profile is sent through the call processor 220 to the message distributor 219. The message distributor determines that this message is to be sent to the PCI server 48 via the GDI 212. (The reason for this is discussed below.) The GDI 212 translates the data into a format suitable for the TCP/IP network and is transmitted to the PCI server 48. The requested changes are performed in the PCI server 48 and the updated profile is sent back to the PCI database 44 through the TCP/IP network, the GDI 212, message distributor 219, call processor 220 and to the first CPR database 222. The call processor 220 also sends a message through the GDI 212 to the PCI server 48 which will be sent a wireless transmission to the PDA 30 acknowledging the subscriber profile update. The changes are also sent to the MSAP common 222 where they are sent to the second CPR database 230 in SPACE 204.

During this process, information may be temporarily stored in the Call Contact Database (CCDB) 228. The CCDB database 228 provides temporary storage for subscriber profile updates that are suspended because they are waiting for action by a subscriber or waiting for data from an external system, such as the PCI server 48. During the time intervals between action by the user or delays in receiving data from an external system, the call processor 220 stores the information in the CCDB database 228 and processes other calls.

When a subscriber desires to update his or her subscriber profile using a touch tone phone, the procedure is as follows. The subscriber calls, for example, a service number provided by the service provider. The call is routed to the PCI server 48. The PCI server 48 sends a message to the PCI database 44 via the IPI 210 that the DTMF commands are present. The message is sent through the message distributor 219 to the call processor 220. The appropriate subscriber profile is retrieved from the first CPR database 222 in the MSAP 202.

The call processor 220 instructs the PCI server 48 to play a voice announcement instructing the caller to enter the subscriber ID and password, by pressing the appropriate digits on the touch-tone phone. The information is entered by the caller, and the PCI database 44 validates this information. If the validation determines that the caller is an authorized subscriber, the PCI database 44 instructs the PCI server 48 to ask the subscriber to select which subscriber profile information is to be modified. Only two fields are modifiable using DTMF messaging: changing a wireline registration or recording a personalized greeting. The subscriber selects either registering at a wireline phone or recording a personalized greeting. If wireline registration is selected, the PCI database 44 instructs the PCI server 48 to prompt a ten digit telephone number to which all incoming calls will be routed. If the subscriber selects to record a personalized greeting, the PCI database 44 instructs the PCI server 48 to prompt the subscriber for a new greeting.

If invalid information is entered at any time, the PCI server 48 plays an error message to the subscriber and the subscriber retries the modification. If the retry fails, the call is terminated. Otherwise, the subscriber's profile is updated according to the modification, data synchronizing the messages are sent to the PCI server 48 and the call processor 220 instructs the PCI server 48 to inform the subscriber that the PCI service profile was updated.

The call processor 220 also sends a message through the message distributor 219 to the GDI 212 and to the PCI server 48 which updates the service profile cache 51 in the PCI server 48. The changes stored back in the first CPR database 220 are sent to the MSAP common 224 where they are sent to the second CPR database 230. Note that DTMF function signals, which use the 1129+ protocol, are routed through the IPI 210 and the subscriber profile data, which uses the GDI protocol, are routed through the GDI 212.

IV. The PCI Server/Database Interface

The interface between the PCI server 48 and the PCI database 44 is based on two protocols. The first protocol is 1129+. This protocol will be used to support the PCI Call Command feature and for subscriber initiated profile manipulation using DTMF. The second protocol is Generic Data Interface. The GDI is used for subscriber profile management, specifically downloading a subscriber profile from the PCI database 44 to the PCI server 48 and for applying updates to the profile stored in the PCI database 44.

Fig. 7 shows the logical links from the PCI database 44 to the PCI server 48. The PCI database 44 consists of a mated pair of PCI databases 44a, 44b, each containing three call processors 220 which each share the load. The links 250 are TCP/IP links between Intelligent Peripheral Interface (IPI) 210 and the Generic Data Interface (GDI) 212 processors on the PCI database 44 to the PCI server call processor. Two logical connections are made from each IPI 210 and GDI 212 processors to the PCI server for redundancy. Thus, a full SCP configuration supporting PCI would preferably require 24 logical links, as shown in Fig. 7. The PCI database initiates the opening of the logical links.

In this illustrative embodiment the CallCommand feature employs the 1129+ protocol. For the wireless messaging feature, PCI uses the GDI protocol. The GDI tag IDs assigned for the PCI subscriber profile elements are provided in Appendix B.

Appendix B also shows the PCI profile data, including the profile elements, their data types, maximum lengths, and GDI tag IDs. An * indicates elements which were shortened to 32 bytes because of GDI byte limitations. The description of the types and lengths of these elements is as follows:

dN BCD-encoded digits. The number N represents the maximum number of BCD digits, not octets.

cN Up to N ASCII characters.

cN Binary integer N bytes in length, in network byte order (highest order bit transmitted first).

Because the portion of the PCI subscriber profile downloaded to the PCI server is large (preferably approximately 1,000 bytes), and a maximum Transaction Capable Application Program (TCAP) message size is 256 bytes, the profile must be managed in segments. The service profile is divided into six segments as shown in Table 1. Each segment is assigned a unique numeric identifier.

PCI Profile Segment	Segment ID (decimal)
Personal data	1
CC service profile	2
E-mail routing	3
E-mail subject screening	4
E-mail from screening	5
Voice mail profile	6

Certain data in a subscriber profile provides a subscriber's preferred media for messages delivery and notification. The encoding for these types are given in Table 2.

Media Type	Code
Alphanumeric Pager	A
E-mail message store	S
Fax	F
PDA	P
Voice mail	V
Wireline e-mail	E
Null	Z

For example, if the subscriber prefers to receive e-mail which passes screening via the PDA 30, then the "primary destination one" profile element will contain a "P".

Fig. 8 illustrates a message flow for profile retrieval using the GDI protocol. A subscriber attempts to register with the PCI server either explicitly or implicitly (registration is discussed in detail below). The PCI server 48 send a GDI GetData query to the PCI database 44 over one of the GDI links (line 260). The PCI server 48 may send one GetData data query for each PCI profile segment. Each query will be processed by the PCI database 44 as an independent transaction with a unique TCAP transaction ID. Each GetData query sent by the PCI server 48 will include a "Service Key" parameter which is a ten-digit PCI subscriber number (e.g., a telephone number). This key should be used by the PCI database 44 to identify the subscriber. In each GetData is a list of tag IDs listed in the profile elements to be retrieved. The PCI database 44 responds to the GetData data query with a GetData response (line 262). The response contains a return code and data for each element requested in the GetData data query.

Fig. 9 provides a message flow between the PCI server 48 and the PCI database 44 for a profile update originating from a wireless PDA 30. This wireless profile update uses the GDI protocol. A subscriber performs a profile manipulation activity, and the PDA 30 sends a profile data message to the PCI server 48. The PCI server 48 sends a GDI SendData query to the PCI database 44 over one of the GDI links (line 264). The PCI server 48 may send one SendData query for each PCI profile segment for which a profile element was updated. Each query will be processed by the PCI database 44 as an independent transaction with a unique TCAP transaction ID.

Each Send Data query sent by the PCI server 48 will include a "Service Key" parameter which is the ten digit PCI subscriber number. This key should be used by the PCI database 44 to identify the subscriber. Each SendData query contains a list of tag IDs provided in Appendix B and data for the profile elements to be updated. Not all tags in this segment may be included in the SendData query; only those profile elements which are actually updated by the subscriber will be sent. The PCI database 44 should not update data for which no tag was included in the SendData query.

The PCI database 44 responds to the SendData query with a Send Data response (line 266). The response contains a return code for each element requested in the SendData query.

Fig. 10 is an illustrative example of one possible CallCommand message flow between the PCI server 48 and the PCI database 44. (CallCommand is discussed in more detail in section VI D.) The exact call flow for CallCommand depends upon the implementation of the service logic by the service designer, and upon options selected by the CallCommand subscriber. The CallCommand functions illustratively use the 1129+ protocol and the IPI 210 (see Figs. 6 and 7).

As illustrated in Fig. 10, a CallCommand call arrives in the PCI server 48. The PCI server 48 sends a provide_instructions query to the PCI database over one of the 1129+ links (line 268). A TCAP transaction ID is generated for the query. The dialed number digits parameter contains the personal numbers of the PCI subscriber (i.e., Service Key). The ANI digits contain the automatic number identification, if any, of the caller (ANI is a telephone network capability). The PCI database sends a 1129+ send_to_resource command to the PCI server 48 to play an announcement and collect digits (line 270). The PCI server 48 plays the announcement, collects the digits, and sends a response containing a return code and the digits collected (line 272).

PCI database 44 sends a 1129+ play_application command to the PCI server 48 to notify the PDA 40 of the incoming call (line 274). The PCI server 48 responds with a return code and a destination number (entered by the subscriber at the PDA 30) to which the call is routed (line 276). The PCI database 44 sends a 1129+ switch_to_resource command to the PCI server 48 instructing the PCI server 48 to route the call to a destination number (line 278). The PCI server responds with the return code executing that request (line 280).

Fig. 11 is an illustrative example of one possible message flow between the PCI server 48 and the PCI database 44 for a DTMF profile manipulation message. The DTMF profile manipulator uses the 1129+ protocol through the IPI 210. The exact call flow for DTMF profile manipulation depends upon the implementation of service logic by the service designer, and upon options selected by the PCI subscriber.

As shown in this illustrative example, when a call arrives at the PCI server, the PCI server sends an 1129+ provide_instructions query to the PCI database (line 282). The called number contains a dialed number (i.e., the service number for a DTMF updates), while the ANI field contains the ANI, if . The PCI DTMF profile manipulations Call Process Request CPR is triggered by the dialed service number. The CPR 222 instructs the PCI server to play announcements and collect digits, guiding the subscriber through voice menus and prompts (lines 284, 288). The PCI server responds to each request with digits collected (lines 286, 290, 294). The CPR updates subscriber's profile with data collected via DTMF.

V. PDA/PCI Interface

Communication between the PDA and PCI use, for example, an X.25 transport using the UDP IP protocol. A brief discussion of the PDA structure is provided. The PDA 30 is preferably a notebook or palm top computer having a wireless network interface. The PDA may be, for example a Hewlett Packard Omnibook 300 notebook computer running a PCI application. Fig. 12 illustrates an exemplary PDA. The PDA 30 has a central processing unit 295 connected to a bus B. The central processing unit ("CPU") 295 performs most of the computing and logic functions of the PDA 30. A memory 295 is connected to the bus B, which stores information to be provided to the CPU 295 or otherwise used by the PDA 30. An input/output device 297, such as a keyboard, is also connected to the bus B which allows a user to input data for storage in memory 296 or for use by CPU 295. A display 298 is connected to the bus B. The PDA 30 also has a wireless communication interface 299 for communication with a wireless communication network.

The PDA/PCI interface involves six types of message flow. These messages are: (1) registration/deregistration; (2) wireless messaging; (3) retrieving E-Mail; (4) cross-media notification; (5) CallCommand; and (6) profile management.

There are two types of registration and deregistration: explicit and implicit. Explicit registration occurs when a PCI subscriber starts the PCI application software on the PDA 30 (this is called start-up registration) or when the subscriber clicks a status check button or one of the service registration request buttons on the PDA 30 either for the CallCommand or wireless messaging service. Once successfully registered, if the subscriber's profile is not already present in the service profile cache 51 maintained by the PCI server 48, the PCI server 48 will request a download of the subscriber's profile from the PCI database 44 to the service profile cache 51. The PCI server 48 sets the subscriber's registration status in the cache 51 to match those requested by the subscriber for the wireless messaging service for the call command service.

Fig. 13 illustrates one example of the message flow between the PDA 30 and PCI server 48 during explicit registration. This flow is also used by a subscriber to check registration of CallCommand or wireless messaging services. A subscriber starts the PCI application software on the PDA or clicks the service status check, CallCommand registration, or wireless messaging registration buttons on the PDA. The PDA sends a registration request to the PCI server 48 with the subscriber's validation information (subscriber ID and password (line 300)). The PDA 30 also starts a timer during which the PDA 30 will wait for a response from the PCI server 48. The PCI server 48 server receives the registration request and checks if the subscriber is provisioned and if the subscriber ID and password are correct. The PCI server then sends a registration acknowledgement (line 302). If the subscriber is not provisioned, no service profile exists and the acknowledgement includes an "unrecognized subscriber" response. If the subscriber ID and password are invalid, the acknowledgement includes an "incorrect password/PIN" response. Otherwise, the PCI server acknowledgement includes a "success" response. If the PDA 30 does not receive an acknowledgement from the PCI server within a predetermined time, it aborts the registration attempt and tells the subscriber to try again later.

Implicit registration automatically registers a subscriber for the wireless messaging service when the subscriber is currently not registered and wishes to send or fetch E-Mail from or to a PDA 30. Implicit registration is done as follows. The PCI server receives a fetch or send request from a subscriber who is not registered for the wireless messaging service. The PCI server 48 retrieves a copy of the subscriber's service profile from the PCI database 44, if necessary, and validates the subscriber's ID and password. The PCI server 48 validates the profile contents to make sure that subscriber may use the wireless messaging service. If wireless messaging is permitted, the PCI server 48 processes the request. Otherwise, it sends an acknowledgement indicating the reason why the subscriber is not permitted to use the wireless messaging service. The message flow is the same as illustrated in Fig. 13.

Once the subscriber is registered for either the CallCommand service or the wireless messaging service, the subscriber remains registered until the subscriber explicitly deregisters by either quitting the application or clicking the deregistration button on the PDA 30. The subscriber can also be implicitly deregistered for the wireless messaging service by the PCI server 48 provided the PCI did not detect any wireless messaging activities to or from that subscriber for a given duration of time. Although the subscriber is deregistered, the subscriber's service profile will remain in the service profile cache 51. The profile remains in the cache as long as the PCI server has some activity for the subscriber, such as incoming e-mail messages within a predetermined time, such as four hours.

No PDA-to-PCI server messages may be sent be the subscriber to implicitly register for CallCommand, thus, a subscriber should not be implicitly deregistered from this service. Implicit registration and deregistration occurs only for the wireless messaging service, and not for CallCommand. A subscriber remains registered for CallCommand as long as he or she is running the CallCommand software application on the PDA.

Explicit deregistration occurs when a subscriber quits the PCI application software on the PDA (this is called exit deregistration) or when the subscriber clicks one of the service deregistration request buttons on the PDA for the CallCommand or wireless messaging services. Fig. 14 is an illustrative embodiment of a message flow between the PDA 30 and PCI server 48 for explicit deregistration. A subscriber quits the PCI application software on the PDA or clicks a deregistration button on the PDA. The PDA 30 sends a deregistration request to the PCI server 48 with the subscriber's validation information (the subscriber ID and password) (line 304). The PDA 30 also starts a timer during which the PDA will wait for a response from the PCI server 48. The PCI server 48 sends an acknowledgement (line 306). The PCI server 48 receives the deregistration request and checks if the subscriber ID and password are correct. If the subscriber ID and password are not correct, the acknowledgement includes an "incorrect password/PIN" response. Otherwise, the acknowledgement includes a "success" response. If the PDA 30 does not receive an acknowledgement from the PCI server 48 after a predetermined time, the PDA 30 assumes that it is out of radio coverage and informs the subscriber to retry later.

Implicit deregistration occurs when the PCI does not detect any wireless messaging activity from or to the subscriber for a given duration of time, for example four hours. The PCI will also try to implicitly deregister a subscriber from the wireless messaging service in the middle of the night in the event that the subscriber inadvertently left the PDA 30 turned on. The PCI server 48 keeps a time-stamp of the most recent wireless messaging activity for each registered subscriber in the subscriber's service profile maintained in the service profile cache 51. Whenever the PCI server 48 detects any wireless messaging activities to or from a particular subscriber, the time-stamp is updated to the current time. The stored time-stamp of a registered subscriber is periodically compared to the current time. When a predetermined time elapses, the PCI server 48 assumes that the subscriber is out of radio coverage or has quit the PCI application.

For implicit (or automatic) deregistration, the message flow is the same as illustrated in Fig. 14. The PCI server 48 sends to the PDA 30 a deregistration request containing registration information about the subscriber. The PCI server 48 also sets a timer during which it will wait for a response from the PDA 30. When the PDA 30 receives the deregistration request, it responds with registration acknowledgement which contains the registration information currently known to PDA. When the PCI server 48 receives the registration acknowledgement, it updates the subscriber's registration status based on information in the acknowledgement. The PCI server 48 also updates the wireless messaging time-stamp associated with the subscriber to the current time. If the PCI server 48 does not receive an acknowledgement within a predetermined time as described above, the PCI server 48 assumes that the subscriber is no longer registered and removes all references to the subscriber from the service profile cache 51.

Sending and receiving e-mail wireless messages involves two types of message flows: sending messages from the PDA 30 to the PCI server 48 and from the PCI server 48 to the PDA 30.

Fig. 15 is an illustrative example of a message flow sending an E-mail from a PDA 30 to an PCI server 48. When a subscriber sends an E-Mail notification from the PDA 30, the PDA 30 forwards the E-Mail notification to the PCI server 48. The body of the E-mail contains, for example, "to;from;subject;cc" information (line 308). The PCI server acknowledges this notification (line 310). If the E-mail is longer than can be transmitted in a single message, the PDA 30 segments the E-mail into multiple, sequentially numbered messages and sends them to the PCI server (lines 312, 316, 320). Each message sent from the PDA is responded to with an acknowledgement containing the reception status of the message and the sequence number it is acknowledging (lines 314, 318, 322). The PDA 30 and PCI server 38 use the sequence number to maintain a sequential flow of packets. Out of sequence messages are discarded. Once all of the packets are received, the PCI server 48 puts them into their original order using the sequence number and forwards the now assembled E-mail to a message transfer agent, which then forwards the E-mail to its intended destination.

The PDA 30 starts a timer each time it sends out an E-mail. If the PDA 30 does not receive an acknowledgement after a predetermined time (for example ten seconds), the send operation is aborted and the E-mail is stored in a local outbound queue for redelivery in the future.

When an E-mail is being delivered from an PCI server 48 to a PDA 30, a similar message flow is used. The only difference is that the PCI server 48 initiates the flow and sends the initial messages instead of the PDA 30.

Retrieving E-mail involves two types of message flows: retrieving undelivered E-mail addressed to the PDA 30 and retrieving E-mail delivered a messaging system, such as a wireline e-mail system. When a subscriber is out of radio coverage or is not registered with PCI, the PCI sends E-mails addressed to be delivered to the PDA (PDA-bound E-mail) to an external mail storage system. The PCI server will also send certain E-mail directly to an external mail storage system (MS-bound E-mail), such as the subscriber's wireline E-mail connected to his or her personal computer, according to the subscriber profile stored in the PCI database 44.

A registered subscriber can retrieve PDA 30 bound E-mail at any time by starting "FETCH" operation. The PCI will send the PDA bound mail from the external mail storage and will also summarize MS-bound E-mail.

An illustrative example of the message flow between the PDA and the PCI server for retrieving undelivered PDA bound E-mail is shown in Figs. 16a and (b). If there are no MS-bound messages, an illustrative message flow is shown in Fig. 16(a). The PDA 30 sends a fetch request to the PCI server 48 (line 324) and starts a timer, which waits for an acknowledgement. If no acknowledgement is received within a predetermined time, for example twelve seconds, the PDA 30 assumes it is out of radio coverage and informs the subscriber to try again later. In response to the request, the PCI server 48 logs into an external mail storage system specified in the subscriber's profile. If any PDA- bound E-mail is stored in the external storage system, the PCI server 48 will (a) move the PDA bound E-mail from the external mail storage system into a pending area in the PCI server; (b) send an acknowledgement to the PDA indicating the number of PDA bound E-mail now residing in the pending area; and (c) initiate delivery of these PDA bound E-mail from the pending area to the PDA (line 326).

If there are MS-bound E-mail messages, an illustrative message flow is shown in Fig. 16(b). The PDA sends a fetch request (line 328) and starts a timer. Whenever the PCI server sends a summary message, it starts a timer. If the PCI server 48 does not receive an acknowledgement within a certain predetermined time, for example ten seconds, it will assume that the PDA 30 is out of radio coverage, abort the send operation and discard the summary information. In response to the request, the PCI server 48 will (a) send an acknowledgement to the PDA indicating the number of MS-bound E-mail present (line 300); (b) extract summary information from those messages; and

(c) send the summary to the subscriber's PDA (line 332). When the PDA receives an acknowledgement from the PCI server, it informs the subscriber based on the contents.

Summary information for the MS-bound E-mail is formatted into one ASCII text per E-mail and sent to the PDA. If the summary information, or the number of summarized E-mail require more than one message, the PCI server 48 splits the summary information into multiple sequentially numbered segments and sends each segment in a separate message (lines 336, 340). Each message from the PCI server 48 is responded to by the PCI server with an acknowledgement containing the reception status of the message and the sequence number it is acknowledging (lines 334, 338, 342). Out of sequence messages are discarded. Once all of the packets are received, the PDA 30 puts them into their original order using the sequence number.

Once the summary information describing the MS-bound E-mail messages is reviewed, the subscriber may start a FETCH operation to retrieve these MS-bound E-mail messages. Fig. 17 is an illustrative example of a message flow between the PDA 30 and the PCI server 48 retrieving MS-bound E-mail. The subscriber selects an MS-bound E-mail message to be received. The PDA 30 sends a retrieve request to the PCI server 48 containing the message selected by the subscriber (line 344). The PCI server 48 responds with an acknowledgement (line 346). The PCI server 48 logs into the external message storing system specified in the subscriber's service profile and moves the MS-bound E-mail specified in the request out of the storage system into a pending area in the PCI server 48. The PCI server 48 initiates a send operation which delivers the E-mail in the same manner as discussed above.

Cross media notification (e.g., PDA notification of voice mail message receipt) is sent to the PDA 30 using the same delivery as a wireless E-mail message to the subscriber. The PCI server 48 originates the notification E-mail and the e-mail subject is "message notification". The body of the notification E-mail contains the message sender's address (i.e., the phone number for a voice mail), the date and time the message arrived at the PCI; the type of media, (i.e., voice mail, FAX, E-mail or other); whether the message is marked urgent (if detectable); the length of the message (for example, in minutes for a voice mail message); and, if appropriate, the subject of the message.

CallCommand allows a PCI subscriber to reroute or direct calls in real time. The subscriber may receive notification on the PDA 30 that a call is waiting. Using the PDA 30, the subscriber may instruct the PCI to route the call to specified destination number or have the PCI server play a message entered by the subscriber using synthesized speech.

When a call is made to a CallCommand subscriber's number, it is routed to an PCI server 48. The PCI server 48 queries the PCI database 44 to determine how the subscriber's profile has directed the call to be processed. If the subscriber is registered at a known telephone number, the PCI database 44 instructs the PCI server 48 to route the incoming call to the given telephone number (assuming that the call meets any screening requirements). If the subscriber is not registered at a known telephone number, the PCI database 44 will provide a default routing number and a timer value instructs the PCI to play an announcement customized by the subscriber to the caller and start collecting DTMF digits within that time period. The PCI plays the announcement and starts the timer provided by the PCI database 44 and then begins collecting DTMF digits entered by the caller. If no digits are collected within a predetermined time period, the PCI routes the call to a default number indicated by the subscriber's profile in the PCI database 44. If DTMF digits are collected, the PCI puts the caller on hold determines if the caller meets screening requirement, and handles the call accordingly. If the call is to be directed to the subscriber, the PCI attempts to contact the subscriber.

Fig. 18 is an illustrative example of the message flow between the PDA 30 and PCI server 48 for a CallCommand call. The PCI server 48 sends a notification message to the subscriber's PDA 30 to notify the subscriber that a call is waiting (line 348). The message contains the DTMF digits entered by the caller. The PCI server 48 starts two timers, which are the time interval the PCI server 48 expects to receive an acknowledgement from the PDA 30 and the time interval the PCI server 48 expects to receive a response from the PDA 30, respectively. The typical values for these timers are ten and forty seconds, respectively. The time to receive an acknowledgement should be less than the time for the response.

After receiving a notification message, the PDA sends an acknowledgement to the PCI (line 350). This informs the PCI server 48 that the PDA 30 is within radio coverage and that the subscriber has been notified about the incoming call. Once the acknowledgement is received, it cancels the acknowledgement timer, but leaves the response timer ticking, waiting for a response to come from the PDA 30. If the PCI server 48 does not receive an acknowledgement within the predetermined time, it assumes that the PDA is either out of radio range or is turned off and cancels the response timer and routes the call to a default number programmed into the user profile in the PCI database 44. The subscriber is notified of the incoming call by the CallCommand interface on the PDA 30. The DTMF digits entered by the caller provide the subscriber with the name and/or telephone number of the incoming caller.

The subscriber can decide to route the call to directory number or voicemail, enter a text message to be played to the caller, or both. The PDA will send a response to the PCI server 48, which carries the number to which the call should be routed, a short text message to be played to the caller through synthesized voice, or both (line 352). When the PCI server receives the response, it cancels the response timer and executes the subscriber's decision in the response and sends an acknowledgement which contains how the subscriber's decision is to be carried out (line 354).

If the response timer expires before the PCI server 48 receives a response, the PCI server 48 routes the call to a default number obtained from the PCI database 44 and send a status message to the PDA 30 to inform the subscriber that the caller is no longer waiting (line 356). Also, if the caller decided not to wait any longer (that is hangs up or presses "*", which allows the caller to go to the default number) the PCI sends a status message providing this information. The PDA acknowledges the status message (line 358).

Profile management allows the subscriber to modify wireless messaging and Call Command services by updating certain elements in the subscriber's service profile stored in the PCI database 44 and the service profile cache 51 in the PCI server 48. Profile information is not stored locally on a PDA 30. Updating the subscriber's profile using a PDA 30 always requires the subscriber to have a profile download from the PCI.

Profile management involves two types of message flows, profile download and profile upload. Fig. 19 is an illustrative example of the message flow between the PDA 30 and the PCI server 48 for a profile download. As indicated above, any profile change requires a profile download because the profile is never stored in the PDA 30. A subscriber starts a profile management application on a PDA 30 and requests a profile download. The PDA 30 sends a download request to the PCI server and requests a copy of the subscriber's modifiable profile elements to be downloaded to the PDA 30 (line 360). The PCI validates the identity of the subscriber through its subscriber ID and password. If the subscriber's identity is not validated, the PCI sends an acknowledgement and an error code and terminates the profile update session. If the subscriber's identity is validated, the PCI downloads the subscriber's modifiable profile elements (lines 362, 366, 370). Attached as Appendix C is a list of tags for modifiable profile elements. The PDA 30 acknowledges the received data (lines 364, 368, 372). The PDA starts a timer after sending the download request. If the PDA does not receive an acknowledgement or data from the PCI server within a predetermined amount of time, for example, ten seconds, it assumes that it is out of radio coverage and informs the subscriber to try again later. The PCI server 48 starts a timer each time it sends out data to the PDA 30. If the PCI server 48 does not receive an acknowledgement from the PDA 30 within a predetermined time, for example ten seconds, it will abort the profile download operation.

Once the subscriber finishes editing the profile on the PDA, a profile upload request is issued. An illustrative example of the message flow between the PDA 30 and the PCI server 48 for a profile upload is shown in Figs. 20(a) and (b). After the subscriber issues a profile upload request, the PDA 30 sends an upload request to the PCI server 48 requesting permission to send the updated profile elements (step 374). The PCI server 48 validates the identity of the subscriber, for example by checking the subscriber ID and password, and checks if there is an associated download request issued by the same subscriber. The check for an associated previous download request is necessary so that the PCI server 48 is sure that the profile the subscriber wants to change is the profile that the PCI server 48 has just sent. If the subscriber's identity is not validated, or there is no associated download request packet, the PCI server sends an error code to the PDA 30 and terminates the profile update session. If the subscriber's identity is validated and there is an associated download request, the PCI server 48 honors the request by sending an acknowledgement and a status code of "OK" to the PDA 30 (line 376). When the PDA 30 receives the OK, it formats the updated profile elements and sends them to the PCI server 48 in the same way the profile was sent to the PDA 30 during the download phase (lines 378-386). If no error is detected, the PCI server 48 sends the updated profile elements to the PCI database 44 to commit the change. After a confirmation is received from the PCI database 44, the PCI server 48 sends an acknowledgement with status code of "OK" to the PDA to confirm and conclude the profile update session (line 388), as shown in Fig. 20(a).

Fig. 20(b) is an illustrative message flow when the PCI server 48 detects errors in an uploaded profile. The upload proceeds as above (lines 390-398). If the PCI server 48 detects errors in the updated profile elements it responds with an error message to notify the subscriber about the invalid profile element (line 400). The PDA acknowledges receipt of the error message (line 402). The PCI server 48 sends the invalid profile elements in a similar way as the profile was sent to the PDA 30 during the download phase (lines 404, 406).

The PDA 30 starts a timer when its sends out an upload request or sends out data. If the PDA 30 does not receive an acknowledgement from the PCI server 48 within a certain predetermined time, it will abort the profile upload operation and inform the subscriber to retry at a later time.

VI. Services

A. Wireless E-mail Messaging

PCI includes several wireless text message sending, receiving, and service control features. PCI's wireless text messaging services are based on three network-based capabilities:

× message integration combining voice message notification, voice mail, telephone calls, e-mail, and fax;

× message routing and delivery, i.e., the PCI is a wireless and wireline network gateway;

× database access, i.e., subscriber profile, authentication, and validation.

The PCI uses personal communications service-integration capabilities to integrate the wireless service capabilities available to the subscriber. This is accomplished by providing the subscriber with control over the message routing and delivery by the subscriber accessible "subscriber profile" stored in the PCI. The subscriber profile contains subscriber programmed instructions on message receipt, origination, and notification. Thus, PCI operates as a messaging gateway for providing access to multiple wireline and wireless networks, while using subscriber profile information to control sending and receiving options. PCI allows wireless service providers to integrate the voice messaging, e-mail, and fax message services for one subscriber through a single telephone number. Thus, one phone number may provide a single link between the service provider and the subscriber's voice and data communications lines.

The message sending features include communications across disparate networks and broadcast communications. A subscriber may send voice mail, e-mail, and fax messages between different service providers and networks. A subscriber may also send broadcast e-mail and fax messages, which broadcasts may mix e-mail and fax messages within a single distribution list. For example, the subscriber may type a message on a PDA and send it to a distribution list over a wireless network. The distribution list may direct the PCI to deliver the message to the office as an e-mail and to a client as a fax.

The message receiving features include personal number addressing, selection of message receipt media format, selection of cross-media message notification, and selection of message screening and delivery options. A subscriber may receive voice (e.g., phone), voice mail notification, e-mail, and fax communications under a single personal telephone number. A subscriber may direct e-mail and fax delivery based on selected parameters, such as time-of-day, day-of-week, etc. A subscriber's media message notification, voice mail notification of e-mail or fax messages, e-mail notification of voice mail or fax messages, and fax notification of e-mail or voice mail messages may be delivered to the subscriber based on selected options and parameters.

Alternatively, if the subscriber's wireless terminal is not activated, e-mail messages may be automatically routed to alternate destinations as defined by the subscriber's profile. For example, the subscriber may not want to receive all telephone calls at a visiting location to avoid unnecessary interruptions and unwanted incoming call charges. The subscriber directs the PCI to send notification of phone calls to the pager and to route the call to voice mail. Once notified, the user can determine from the phone number included in the pager notification whether to call the person directly, check voice mail, or ignore the call until a later time. The subscriber may also direct which messages are to be routed to the subscriber's current serving network, which are to be sent to another network, and what media is to be used to receive certain messages. The subscriber may also designate, for example, that if the wireless terminal is off, all text messages to be sent to e-mail and all voice messages are to be sent to voice mail.

The PCI service control features include supporting subscriber profile management, supporting personal mobility across wireless and wireline networks, and supporting wireless terminal mobility. A subscriber's profile may be updated by sending text messages from a PDA over a wireless network or DTMF (touch-tone) messages from either a wireline or wireless terminal. The subscriber may program the profile to select media for receiving and sending information; select cross media for message notification; select message screening and delivery options; select single voice mailbox storage (for subscriber's with more than one voice mailbox); and select a PCI service password. All of these options may be maintained over wireless or wireline terminals. The subscriber may automatically register and deregister a wireless terminal thus updating the subscriber's profile to receive or reroute messages as preprogrammed in the profile.

The wireless data network provides data transport between the PCI server 48 and the subscriber using a wireless data terminal, such as a PDA 48. The wireless data network may connect to the PCI server in a variety of ways, using a variety of protocols. For example, the wireless data network may connect to the PCI using a leased line and run a proprietary protocol to connect the PCI server via standardized protocols such as TCP/IP.

Text messaging systems may be connected to the PCI server through for example, Frame Relay, SMDS, ISDN, leased line interface, or other transport mechanism effective for supporting data communications may be used. An inter-message handling system protocol, such as X.400 (in which case X.400 gateway conversion is needed), or Internet SMTP or other protocols supported by an interworking unit terminating the data transport interface, may be used to forward messages between the PCI server 48 and the system accessing the PCI.

The PCI server will preferably support sending and receiving faxes in the T.434 format. The PCI server may also preferably support sending and receiving faxes using the simple mail transfer protocol (SMTP) supported by the TCP/IP transport protocol.

Fig. 21 shows an illustrative embodiment of a PCI service supporting text messaging systems. In this example, a subscriber has a personal computer 402 at the office connected to a local area network (LAN) 414 and an enterprise text messaging system (for example, a local network e-mail) 413, a personal computer at home 416, and a wireless terminal, such as PDA 30 that may send and receive messages. All of these devices are connected to the PCI. For example, the subscriber's home personal computer 416 may be connected to the PCI 40 via a modem and a wireline data network 418 over either a PSTN or ISDN.

Persons connected to the LAN may send text messages to the subscriber by using the local text messaging system without using the PCI. That is, the user of computer 420 can send an e-mail to the subscriber's office computer 412 without entering the PCI node 40. Because the enterprise text messaging system 413 is connected to PCI, all enterprise messaging users may send messages to and receive messages from all PCI subscribers (including those not connected to the local text messaging system 413) by using an appropriate PCI address.

A person connected to a different enterprise messaging system, such as text message handling system 2 422, can send messages to the subscriber on message handling system 1 413 by routing the message through the PCI Server 48.

PCI subscribers are assigned a single personal telephone for both voice and data communication. For example, an E.164 address (i.e., a telephone number) may be assigned to a PCI subscriber to use as the single PCI address. These phone numbers may be geographically based according to current PSTN architecture, but it is also possible to use portable universal numbers. Fifteen digit number formats may be desirable to permit sub-addressing. For example, a message destined for a PCI subscriber may be addressed to the subscriber's telephone number, e.g., 201-555-5555. If an originating mail system such as a LAN mail system or third party message handling system requires a domain identifier, the originator may have to specify 201-555-5555 @ PCI, or on the Internet 201-555-5555 @ pci.net. When the PCI server 48 receives the message, it will look at the subscriber's profile stored in call process request database 222 stored in an PCI database 44 to determine how to handle the incoming message. An example of a few of the options that PCI may provide for the subscriber are to:

× send the message to the subscriber's wireless PDA;

× send the message to the subscriber's wireline computer at home;

× send the message to the destination text messaging system at the office;

× send a notification of an incoming message to the wireless data terminal and the actual message to the text messaging system.

× send the message to any or all of the above;

The subscriber may send text messages over the wireless data network or wireline data network to the PCI server 48. The PCI server 48 consults with the subscriber's profile at the PCI database 44 and forwards the message to the appropriate destination, depending on the routing destination found in the profile. Text messaging systems not connected to the PCI 40 may send text messages to PCI subscribers by using another network connected between the sender's text messaging system and the PCI subscriber's text messaging system, for example, the non-connected text message may be connected to a PCI over the Internet.

The flow for wireless messaging is now described.

The flow for a PCI subscriber receiving an e-mail message to a wireless PDA 30, for example, is as follows. An e-mail message is sent from a wireline or wireless sender to a PCI subscriber and arrives at the PCI server 48. The incoming e-mail contains a recipient address in the format of "201-555-5555 @ pci.net" where 201-555-5555 is the subscriber's ten-digit personal number and pci.net is the PCI server's domain name in the Internet.

The PCI server 48 checks the subscriber's service profile, either from the profile service cache 51 in the PCI server or by downloading the subscriber profile from the PCI database 44 into the cache 51 to determine how to process the e-mail message. The profile contains screening and routing information and cross media notification information. The PCI server 48 uses this information to send incoming e-mail to an actual destination address that can be a wireless, wireline, or paging address using, for instance, the UDP/IP protocol over a wireless data network; the Internet SMTP protocol over the Internet wireline network; or the Telocater Alpha Numeric Protocol (TAP), respectively. In this case, the subscriber has programmed into the subscriber profile to have the e-mail sent to a PDA 30. The PCI server 48 receives the e-mail message and forwards it to the wireless data network programmed into the profile. The e-mail is transmitted over a wireless data network 39 for receipt by the PDA 30.

If the e-mail cannot be delivered, the PCI server returns the e-mail to the original sender with a short description of why the delivery was unsuccessful, using the SMTP protocol.

If an e-mail message is to be delivered to an alphanumeric paging address, the PCI server translates the e-mail message into a paging message and sends the paging message to the paging network specified in the subscriber profile. The protocol between the PCI server and the paging network is the Telocater Alpha Numeric Protocol (TAP). The PCI server formats the paging message into a maximum page limit with a maximum number of characters per page. For example, the page limit may be two pages and a maximum of 256 characters per page. The PCI server does not verify whether a paging message is actually delivered by the paging service provider. It will, however, verify that the message was successfully sent to the paging service provider. Because the PCI server does not provide this verification, it is under the assumption that messages sent to a pager arrive successfully at the pager.

If the subscriber profile contains an option for voice message notification of e-mail messages, the PCI server generates and sends a digitized prerecorded voice announcement to the address specified in the subscriber service profile. The protocol used to deliver the voice message notification is the AMIS-Analog Protocol.

In this illustrative embodiment, a preferred PCI server node functions as an X.400 message transport agent or SMTP router and routes messages destined for PCI subscribers and to those destined for users connected on other systems. In the case of an X.400 message transfer agent (MTA), X.400 addresses are used to internally represent subscriber addresses. The translation from the "user friendly" subscriber addresses such as E.164 numbering to the X.400 address would be done via a look-up table (ROM or other memory device) at the PCI access module or the X.400 gateway. Destination or source addresses from users on other networks are not converted to X.400 addresses, but are left in the native address format of the sending or receiving system. An X.400 gateway address may be added to the message header, however, to allow PCI to route the message to an appropriate gateway.

The PCI server 48 is responsible for delivering a message to the subscriber listed in the destination field of the message. In a simple case, the subscriber has an X.400 or Internet mailbox accessible to the PCI via one of its access connections. Alternatively, the subscriber profile may contain forwarding addresses which route the message for delivery to unusual destinations. For example, the subscriber's mailbox may reside on another message handling system, a wireless data network, wireline data network, or PSTN destination associated with a fax machine. The delivery of such a message to a final destination is handled by an interworking unit which is responsible for doing address translation and, if necessary, format translation as defined by the subscriber profile entry.

For subject e-mail screening, the subject field is analyzed to determine if a match exists before comparing the address field. If the subject field matches an entry on the screening list, the treatment for a matched entry will occur. That means, in this illustrative embodiment, that subject screening takes precedence over address sender screening. That is, if e-mail originated from an address that is excluded from the e-mail screening address list, the e-mail will still be delivered according to the screening criteria.

If the PDA 30 is not registered for the wireless messaging service or if the PDA 30 is out of radio coverage at the time the message arrives at the PCI server 48, the message will be sent to the subscriber's external message storage system, such as the text message system 413.

B. Voice Messaging

Fig. 22 shows an illustrative embodiment of a PCI service for voice mail system. The voice mail systems 430 may use the public telephone network 432 and Audio Messaging Interface Specification (AMIS) - Analog Protocol to connect analog voice messages to the PCI. Alternatively, the voice mail system may use a modem 434, a private line 436, or an ISDN BRI AMIS - Digital Protocol 438 to connect digital voice mail signals to the PCI.

Voice messaging systems on the PCI must be able to send a message to the PCI server 48 providing notification that the subscriber has received a voice message. The voice mail system may send this text message using, for example, by asynchronous interfaces with a modem; X.25; ISDN BRI, or TCP/IP interfaces. Preferably, the PCI server 48 supports the AMIS Analog and Digital interfaces.

The PCI voice messaging call flow is as follows. Using the AMIS-Analog Protocol the system originating the voice message sends message information to the PCI server 48 specifying the type of message to be delivered, the message length (in minutes), the originator's mailbox number, and the recipient's mailbox number. When the message arrives at the PCI server 48, the originator's mailbox is extracted from AMIS-Analog Protocol and is compared to the subscriber's voice mailbox number stored in the subscriber profile. If the two values match, the voice message is already in the mailbox designated by the subscriber. In this case, the PCI server 48 sends a bogus error code to the originating voice messaging system using the AMIS-Analog protocol so that the voice message is rejected and is not forwarded to the PCI server 48. The PCI server 48, however, has header information needed to send a notification message to the subscriber, if such notification is required by the subscriber profile.

If the originator's mailbox does not match the subscriber's voice mailbox number, the PCI server 48 analyzes the message length parameter. If this parameter exceeds a certain predetermined length, for example three minutes, the PCI server 48 sends a response message to the originating voice messaging system with an error code specifying that the message is too long. No further processing of the voice message occurs. If the message length is not longer than the predetermined time, the PCI server 48 sends a response message to the originating voice messaging system accepting the message. The originating voice messaging system will then forward the voice message to the PCI server.

When the voice message arrives at the PCI server 48, the PCI server 48 attempts to route the voice message according to the screening, registration, and routing options contained in the subscriber profile. Using AMIS-Analog Protocol, the PCI server 48 sends message information to the subscriber's destination voice messaging system, specifying the type of message to be delivered, length of the message in minutes, the originator's mailbox number, and the recipient's mailbox number.

For voice messages that cannot be delivered to the destination, for example if the mailbox is full, the destination system sends a non-delivery notification message to the PCI server 48 specifying the reason why the message is undeliverable. The PCI server 48 retries delivering for up to a system defined time period. If all of the retries fail, the PCI server 48 uses the AMIS-Analog Protocol to return the voice message to the originating voice messaging system with an appropriate non-delivery notification. A pre-recorded non-delivery announcement is sent to notify the message originator that the message was undeliverable. No further processing occurs. If the destination system accepts the message, the PCI server 48 forwards the voice message to the destination system.

If the subscriber chooses e-mail notification of incoming voice messages, the notification is sent via wireless or wireline network to the subscriber as specified in the subscriber profile. If the subscriber selected page notification, the notification will be sent through the paging network according to the profile. Either notification contains the mailbox number that originated the voice message, the date and time the message was received, and the length of the voice message in minutes.

In another example, a user having a digital voice mail system creates a voice mail message and addresses it to a user of analog voice mail system. The destination telephone number indicates that the message must be routed to the PCI server 48. The PCI server 48 checks the recipient's user profile and determines that the destination recipient has an analog voice mail system. The message is then passed into the analog voice mail system via the AMIS - Analog Protocol.

The subscriber will receive all of the voice mail messages at the voice mail system, if that is what is selected in the subscriber's profile. The subscriber may also set up the profile to receive at a wireless data terminal a text message that provides a notification of a voice mail message and envelope information of the message. Alternatively, a recipient voice mail system may send a text message containing a notification and envelope information of the message.

One feature of the AMIS-Digital Protocol is that if the original voice message is marked urgent by the sender, the AMIS-Digital Protocol includes as priority status information in the message sent from the voice messaging system to the PCI server. Using this information, the PCI can screen priority messages.

The voice messaging gateway converts vendor proprietary voicemail format to the X.400 format and vice versa, thus bridging different messaging formats. It is responsible for voice transcoding from proprietary to or from X.400 form. It also maps options to or from the X.400 protocol as specified in AMIS.

C. Facsimile Messaging

Fig. 23 illustrates a PCI service for fax messaging. The PCI server 48 is connected to public switch telephone networks 432 via analog lines 444 or a T1 trunk 445. Fax machines 440 and fax servers 442 are connected to the PSTN 432. The PCI server 48 may also be connected to fax machines 440 and fax servers 442 by private lines 446 or an ISDN 438. For a subscriber to receive faxes, the fax machine telephone number must be supplied to the subscriber profile. The PCI will send a fax to the designated number and may send a text notification message or take other action as the user has selected in the profile. If the user has specified a wireless data terminal to receive the fax, the PCI server 48 will perform the necessary wireless adaptation and send a fax through a wireless data terminal.

A fax may be sent to a PCI subscriber by routing the fax to the PCI node, the user must dial the telephone number of the PCI server 48 to send the fax to the subscriber. The PCI server 48 will send the fax to the subscriber's telephone number. The PCI server will check the subscriber's user profile to determine how the fax should be delivered. In this example, the fax message is sent to a fax machine at a designated telephone number.

Fax users having existing fax machines 440 must place a call over the PSTN network in order to access the PCI. This is because existing fax machines 420, unlike fax servers 422, are designed for point - to -point communication, not fax network communication. Users of the existing fax machine 420 can access the PCI in two ways. One way is by two stage dialing. The sender first dials the PCI 48 and then dials the recipient's number after receiving a prompt from the PCI. Alternatively, the user can dial *FX+destination address. The fax machine user can directly dial from the fax terminal the recipient telephone number proceeded by *FX, which signals the switch to automatically forward the fax call through the PCI server.

Fax servers that support X.400 messaging will include the personal number in the X.400 address field and there is no reason for the PCI to prompt the user for the personal number.

D. CallCommand

PCI CallCommand (CC) service provides subscribers real-time control of voice calls while using a wireless data terminal or PDA. CC is designed to enhance personal number services (i.e., HLR), by providing real time call management capabilities to nomadic users.

CC provides the subscriber with four call management options:

× *location independence* (supplementing personal number/HLR applications);

× *real-time call screening* (using ANI and/or prompting the caller to enter a number);

× *real-time call redirection* (routing calls to any telephone number based on the calling party); and

× *real-time short messaging* (inputing or selecting a short message to be played to the caller).

When a caller dials a PCI subscriber's telephone number, the caller's telephone number is entered for screening. After the caller's number is entered, the PDA 30 can map the calling number to a name and alert the subscriber of an incoming call. The PDA 30 visually displays the name and/or number of the caller. The subscriber can then use the PDA 30 to accept the call by entering the telephone number of a nearby telephone to which the call will be routed. The subscriber can alternatively have the call forwarded to another number, such as a colleague's phone or a voice mailbox. If the subscriber decides not to respond to the caller, the caller is played an announcement and forwarded to a pre-determined default telephone number, such as a voice mail box or secretary.

CC allows the subscriber to send a brief message to the caller. Upon being alerted to an incoming call, the subscriber can select from a pre-defined list of messages, or type a new message, on the PDA 30. The message is transmitted to the PCI server 48 which converts the text message into speech and plays the message to the waiting caller. The caller receives the message and can leave voice mail for the subscriber, or be forwarded by the subscriber to an alternate telephone number.

Call command enables nomadic subscribers to manage, in real time, incoming calls using screening, rerouting and messaging to the caller. Call command subscribers having a PDA 30 are visually informed of the name and or number of the caller. The subscriber can elect to either accept the call, routing it to a specified number, such as the number of a nearby telephone; route the call to an alternate number, such as a voice mailbox, colleague phone number or secretary phone number; or respond to the caller with a brief keyed in message, which is played back to the caller in synthesized speech. The service also provides a number of non-real time call management features including predetermined screening lists, day of week\time of day routing schedules; and location sequencing. Call command allows mobile subscribers to manage and receive telephone calls using a personal digital assistant.

Call command users pre-subscribe to a wireless data service such as Ardis or RAM mobile data for E-mail, call management, and other wireless data applications. The wireless data provider provides a radio interface to the subscriber's PDA 30. A local exchange carrier interfaces with the wireless data provider over a PCI interface. When a caller enters his or her number the local exchange carrier forwards a data message containing the caller party information. The wireless data provider locates the subscriber and forwards the calling party information to the subscriber's PDA 30 where the subscriber is alerted of the call. The subscriber then forwards the data packet containing a routing number to the PCI. The PCI reroutes the call accordingly.

Fig. 24 is an illustrative example of a CallCommand service network. A caller, Joe 450, wishes to speak with Mary. Mary, who is away from the office, is a PCI subscriber having the CallCommand service. She has a PDA 30, which is turned on and registered at a visiting location. Joe dials Mary's office phone number. This phone number connects Joe's call to the PCI server 48. The PCI server 48 network instructs Joe to type in his telephone number. The PCI server 48 puts Joe on hold and plays back a message using synthesized speech informing Joe that the network is trying to locate Mary. The network recognizes that Mary is registered at a visiting location and sends a phone notification over a wireless data network 39. Mary is notified on a PDA 30 that a phone call is coming from a particular phone number. If Mary has already programmed a name corresponding to that phone number in a directory on her PDA 30, that name will also appear. Therefore, she is aware that she has a phone call from Joe Smith. Mary has several options. She may type or select a preselected message to be sent from the PDA 30 to the PCI network which converts the message into synthesized speech and play it back to Joe; she may forward the call to a nearby telephone, such as a cellular phone or a nearby pay phone 452 or forward the call to her secretary or colleagues's phone number; she may send a message and forward the call; or she may direct the call to her voice mail. In this illustration, Mary selects that the call be routed to a local public pay telephone 452. The call is routed over public switched telephone networks 432 to the selected telephone and Mary and Joe speak.

CallCommand has several advantageous features. Call command includes real time call screening which allows the subscriber to direct calls in a predetermined fashion based on the caller, the time or date, etc. Call command also has real time call rerouting which allows the subscriber to reroute calls to any phone number on a per call basis. That is, when a call is received, the subscriber may enter a phone number to which she wishes the call to be routed. For example, it may be a phone in an office she is visiting, a rented cellular phone, or a public telephone. In the event that a subscriber cannot respond to a caller because PDA is out of range, the subscriber is preoccupied, the PDA is turned off, etc., the subscriber may select a default routing number. Such a default number could be a voice mailbox, secretary, colleague, or other phone number.

Call command also has a call messaging option. This allows the subscriber to send a brief message to a calling party. The message is typed on the PDA 30 and sent by wireless means to the PCI. The PCI converts the signal into synthesized speech and plays it to the caller. For example, a subscriber may be on an important customer call when his supervisor calls, expecting a response. The call command subscriber can send a message to the manager ("Talking to customer, call you back"), while still communicating with the customer.

The call messaging feature has two aspects. The first is the wireless messaging from the PDA 30 to the PCI. The second is the text to speech translation. The subscriber may type in a message on the PDA 30. The message originates as a data message from the wireless data provider network and is forwarded to a local exchange carrier network over the PCI interface. The PCI server 48 translates the wireless text message into speech and plays it back to the caller.

Call command also has a predetermined call management option. This feature allows a subscriber to have unanswered calls sent to predetermined default telephone numbers. For example, in the event a call cannot be answered, it is first routed to, for example, a service hotline; if the service hotline does not answer, it is forwarded to a secretary; and if the secretary does not answer, then it is forwarded to voice mail. Each time the call is forwarded to the next number a message is played back to the caller. The routing numbers and sequence order may be altered by updating the subscriber profile in the PCI database.

This feature also allows the subscriber to predetermine the management of certain numbers. For an example, a subscriber may want to be notified in real time only if a calling party number matches that of an immediate family member, supervisor, or important client. In other cases, the subscriber may wish to have calls automatically rerouted to a default number, such as a voice mailbox or secretary. For a company which does business over a large geographic area, the subscriber may wish to have the phone call routed to different places based on the geographic origin of the call. For example, calls originating from New York or New Jersey may be routed to a sales representative for that area and calls originating from California are routed to a sales representative for that geographic area.

The call management feature allows the subscriber to predetermine call routing based on the time of day. For example, a subscriber may wish to have calls forwarded to a customer service staff during business hours and be personally notified of calls during non-business hours.

Wireless technologies make subscribers constantly available, therefore it is important to give them the ability to accept or decline communication attempts at their discretion. While delivering the calling number to the PDA 30 allows a subscriber to locally screen each attempt as they occur, the subscriber may be in an environment where distractions are unacceptable such as an important meeting. Therefore, the subscriber is able to create lists against which callers are screened by the network delivering the service. These network resident lists reduce the number of call attempts to the subscriber's remote wireless device. The CallCommand service allows subscribers to turn screening on and off and add or remove numbers and names from these lists.

Like the wireless data services, CallCommand service profile management allows subscribers to modify or update their subscriber profiles which preferably reside in a PCI database 44. Profiles are created and deleted by the service integrator controlled by the service provider. A subscriber may modify the profile by either wireless or wireline messaging using DTMF tones or data.

The subscriber profile can be updated by a wireless device such as a PDA 30. A subscriber profile may be modified by wireline communications as well. A subscriber may use a telephone or wireline data terminal to contact an PCI database 44. The PCI server 48 acts as a mediation device between wireless terminals and an PCI database 44 for DTMF profile updates. It is preferable that the wireline network be supported by a service management operating system capable of prompting subscribers using a DTMF telephone for a profile update that is completed when the service management operating system makes the appropriate changes in the subscriber's profile in the PCI database 44. When a service management operations system is used to modify the profile in the PCI database 44, the changes should also be reported to PCI server 48 so that the service profile cache 51 may be modified accordingly.

Call command has its locus of control in service logic in the PCI database 44. The PCI database 44 service logic provides (1) service status maintenance, which maintains the status of the subscriber as registered or deregistered; (2) call screening, which provides network based screening of incoming calls; (3) call routing, which provides routing destinations for each call; this information is based on information received from the subscriber in real time via the PCI server 48 or by preprogrammed instructions in the subscriber profile in the PCI database 44; (4) profile management support, which is service logic in the PCI database which permits "downloading" of the subscriber's profile to the PCI server 48 for presentation to an update by the subscriber through the PDA 30; (5) security, wherein subscriber authentication and validation must be supported to safeguard the subscriber's personal information and status such as location; and (6) accounting management, the PCI database 44 collects accounting parameters to support service provider billing.

The subscriber profile in the PCI database 44 must contain certain information. This type of information includes a subscriber identifier; subscriber authentication information; wireless data provider parameters; registration status; service mode (default, override, or command); screening lists; and routing tables (including day of week and time of day parameters).

The application supporting the CallCommand server in the PCI server 48 includes a mobility management function. The mobility management function provides status location information to a database in the PCI database 44 and is responsible for delivering a Temporary Location Destination number on request from the PCI database 44. To do this, the PCI server 48 is responsible for (1) location registration, the PCI server 48 updates the PCI database 44 with the subscriber's PDA 30 status (for example, registered on a wireless data network or registered on a wired telephone); (2) play announcements and digit collection for caller information and presentation to the subscriber; (3) remote alerting, such as formatting and sending call information through a wireless data network to the PDA 30 for presentation to the subscriber; (4) profile management support (the PCI server 48 must support the "downloading" of the subscriber's profile and packaging for presentation to update by the subscriber through the PDA 30); (5) security (the subscriber authentication invalidation information must be supported to safeguard the subscriber's personal information and status such as location); and (6) account management, the PCI server should collect accounting parameters for presentation to the service provider for billing.

VII. Message Flows

PCI wireless messaging involves three types of message flow. The first is sending a message from one subscriber to another, the second is receiving a message regardless of whether the subscriber is using a wireless or wireline terminal, and the third is sending a message to a non-subscriber.

Fig. 25 is an illustrative example of the message flow of a PCI wireless subscriber sending a message. The PCI user submits a message 502. The message is received by a message transfer agent in the PCI server. The MTA copies and temporarily stores the originating and destination addresses 504. The MTA sends to the mobility manager function in the PCI server a request to validate the sending user as a PCI subscriber 506. The mobility manager sends this validation request to the PCI database and waits for a response 508. Upon receipt of an affirmative validation from the PCI database, the mobility manager sends the validation response to the MTA 510, 512. The MTA then sends the mobility manager a request for the address of the user's home

MTA 514. The mobility manager routes this request to the PCI database 516. Upon receipt of a response from the PCI database, the mobility manager routes the home MTA address to the MTA 518, 520. The MTA then routes the message to the home MTA 522. If a third party PCI database must be consulted, the home MTA request will be directed from the PCI database to a third party PCI database 524, 526.

Fig. 26 illustrates an example of the message flow of a wireless PCI user receiving a message. When the PCI receives a message from a subscriber, the MTA in the PCI server copies and temporarily stores the destination address and the message 530. The MTA sends to the mobility manager function in the PCI server a request for the PCI subscriber's user profile 532. The mobility manager will retrieve this profile request from the PCI database 534 (If third party PCI database is involved, the local PCI database contacts the third party PCI database through a switch transfer point 536, 538.) Upon receipt of the subscriber's profile from the PCI database 540, the mobility manager requests the message from the MTA using a "message forward request" message 542. When the mobility manager receives the message from the MTA 544, the mobility manager processes the message as indicated by the subscriber's profile, which may involve media conversion or screening 546. After processing the message, the mobility manager sends the message to the MTA for delivery 548, 550. Alternatively, the PCI server mobility manager function may directly deliver the message to the termination receiver 552.

Fig. 27 illustrates an example of a message flow from a PCI wireless subscriber to a non-subscriber. When the MTA receives a message from a PCI subscriber 560, the MTA copies and temporarily stores the originating addresses and the message 562. The MTA sends the mobility manager a request to validate the originating address as a PCI subscriber 564. The mobility manager will send this validation request to the PCI database and wait for a response 566. When the mobility manager receives an affirmative validation response from the PCI database 568, the mobility manager sends the validation response to the MTA 570. Next, the mobility manager sends to the PCI database a request for the PCI subscriber's profile 572. Upon receipt of the subscriber's profile from the PCI database 574, the mobility manager requests the message from the MTA using a "message forward request" 576. Upon receipt of the message from the MTA 578, the mobility manager processes the message as indicated by the user's profile, which may require media conversion or obtaining the addresses for the distribution list for the message 580. After processing the message, the mobility manager sends the message to the MTA for delivery 582, 584. Alternatively, the MTA may directly deliver the message 586.

VIII The PDA Application

To better understand the capabilities of PCI and PDA/PCI server interface, a discussion of the PDA user interface is helpful. The user interface is application software residing in the PDA. This software is described by describing the screens displayed on a PCI subscriber's PDA screen. The following discussion is for an illustrative embodiment of the PDA user interface. A person skilled in the art recognized that the interface may be implemented in a myriad of ways.

Fig. 28 is an illustrative example of a PDA user interface main menu. The menu allows the user to enter the CallCommand or wireless messaging services, update the user profile, or check the status of the system by clicking on buttons 610, 612, 614, 616, respectively.

Fig. 29 shows a computer screen after "status request" 616 is selected. The status request screen shows that there are five local originating messages (waiting to be sent by the PDA) and three outgoing messages (waiting to be retrieved) in boxes 618, 620, respectively. The various services' status is also displayed. As seen in Fig. 29, this subscriber's wireline registration is on, as seen in box 622. This registers the subscriber on a particular wireline telephone, seen in box 624. This registration will direct calls to this phone number. The status request also advises this subscriber about the status of the CallCommand and wireless messaging features, as seen in boxes 626, 628.

Fig. 30 illustrates an exemplary screen if the subscriber clicks "Call Command" 610 on the main menu (Fig. 28). If the subscriber clicks on "YES" 630, a screen such as Fig. 31 appears. The screen includes a window 632 which shows the status of various received telephone calls. The status indicates whether an incoming call was answered, forwarded to another number, was hung up before being answered; unanswered; or forwarded to voice mail. The phone number and receipt time and date of each call are displayed. The subscriber may save or delete any entry the subscriber by clicking box 634 or 636, respectively, The subscriber may also connect or disconnect the CallCommand service by clicking box 638, 640, respectively.

Fig. 32 is an illustrative example of a screen if the subscriber selected "Wireless Messaging" 512 on the main menu (Fig 28). The subscriber will be connected to the wireless messaging service if "YES" 642 is clicked.

Fig. 33 is an example of a screen which may appear if the subscriber selected "Profile" 614 from the main menu (Fig. 28). If the subscriber selects "Fax" 644 from this screen, a screen such as that shown in Figure 34 may appear, which allows the subscriber to enter a phone number into box 646 to which faxes will be directed. Turning on e-mail screening activates both the subject and address screening. Subject screening takes priority over address screening parameters.

If the subscriber selected "e-mail" 648 on the screen Fig. 33, a screen such seen in Fig. 35 appears. The subscriber can select where e-mail messages should be delivered (destination screening) 650, where notification of e-mail receipt should be delivered (notification screening) 652, whether messages should be screened at all 654 and, if so, how they should be screened 656, 658.

The destination 650 allows the subscriber to select destinations for incoming e-mail. Messages that satisfy the screening requirement may be sent to two destinations (match A, match B). As shown in this illustrative example, e-mail received which match the subscriber's preprogrammed screening criteria are to be delivered only to a wireline e-mail, such as the subscriber's personal computer at the office, because match A 660 and match B 662 designate the same destination. All received e-mail messages which do not meet either criteria ("not matched") are sent to a selected fax machine 664, for example, the fax machine at the subscriber's office.

The subscriber also indicates where notification of a received e-mail should be sent 652. Notification for all e-mail messages meeting the screening requirement should be sent to a selected fax machine 666. The PCI network will select information about the e-mail origination such as the author, recipient, and subject matter and convert it to a facsimile format and send the message to a fax machine. Notification of all e-mail that does not meet the screening criteria are sent to a pager 668. The PCI network will take the originating message information and turn it into alphanumeric information according to the TAP protocol and send it to the subscriber's pager. If the screening option is turned off, notification of all incoming e-mail is sent to voicemail 670. The PCI network will convert the origination information from text to synthesized speech and send the information to a selected voice mailbox.

The user may also select whether to screen incoming e-mail messages at all 654. If the screening is on, the user may screen e-mail based on the originating address 656 or subject matter 658.

Fig. 36 is an illustrative screen which the subscriber may use to edit e-mail screening according to address by clicking box 656 (Fig. 35). The subscriber may input new e-mail addressees into box 672 and add them to a list by clicking a box 674 or select addresses already entered to be included in a screening criteria as seen in box 676. For example, the user may want e-mail messages originating from the following addresses to be routed according to the screening criteria: cc!stanp, cc!rizzo, and cc!rupin. E-mail messages originating from these addresses will be routed and notified according to the criteria selected on the screen illustrated in Fig. 35.

If the user selected to edit the "subject" a screening criteria based on "subjects" by clicking box 658 (Fig. 35), a screen such as that illustrated in Fig. 37 is presented. The user may type in to boxes 678 particular subjects which should be routed according to a screening criteria. The subject will search the incoming e-mail origination information to determine the subject of the e-mail. Subjects may include "urgent", "personal", the name of a client or project, etc.

If the subscriber viewing the "profile menu" (Fig. 33) clicked "voice mail" 680, a screen such as that illustrated in Fig. 38 is presented. The subscriber can type into a box 682 in the destination voice mail system phone number. The subscriber may also select notification based on certain screening criteria 684. If the incoming voice mail message matches the screening criteria, the subscriber has selected to be notified by a message sent to the PDA 686. If the voice mail message does not match a screening parameter, the subscriber has selected to not be notified 688. If the screening option is turned off, the subscriber has decided to not be notified of any voice mail messages 690.

The user has the option of turning the screening on or off 692. If the screening is on, the messages are screened by caller 694. If the user decides to screen by caller by clicking box 694, a screen such as illustrated in Fig. 39 is displayed. The user may type into boxes 696 certain incoming phone number which meet the screening parameters.

If the subscriber viewing the "profile menu" (Fig. 33) clicked "Call Command", 698 a screen such as illustrated in Fig. 40 is displayed. The subscriber may type in a box 700 a wireline registration telephone number, which is a number to which incoming calls may be forwarded. The subscriber has the option to edit screening criteria phone numbers or to edit reply messages to be sent to the caller.

If the subscriber wishes to edit forwarding call numbers box 702 is clicked and a screen such as illustrated in Fig. 41 is displayed. The user may type into boxes 704 or select certain phone numbers which are to be forwarded to a preselected phone number if screening is on.

If the subscriber viewing the "Call Command" screen (Fig. 39) clicked "edit messages" 706, a screen such as illustrated in Fig. 42 is displayed. The user may compose a unique message in box 708 or edit one already on a list shown in box 710.

If the subscriber has connected the Call Command and an incoming call is received, a screen such as that illustrated in Fig. 43 is displayed. This screen displays in a box 712 the number from which the incoming call originates. The user has the option of sending a message and forwarding the call by clicking box 714, forwarding the call without a message by clicking box 716, sending a message and not forwarding the call by clicking box 718, or routing the call to voice mail by clicking box 720.

If either the "message and forward" or "forward" 716 option is selected, a screen such as that illustrated in Fig. 44 is displayed. This allows the subscriber to select one of several the preselected phone numbers 722-728 to forward, or select another phone number, such as a nearby telephone to which the call is to be forwarded. This phone number may be typed into a box 730.

If the user selected the "message and forward" 714 or "message only" 718 selections, a screen such as that shown in Fig. 45 is displayed. This allows the subscriber to type in a message into a box 732 or select a predetermined message shown in box 4134 to be sent to the incoming caller. This message is sent by wireless communications to the PCI network where the ISP converts the message into synthesized speech and plays it for the caller. For example, if the subscriber desires to call back the incoming caller as soon as possible, the message "will call back ASAP" is selected. This message is transmitted from the PDA by wireless communications to the PCI network. The ISP will receive the message and convert it to synthesize speech and send the synthesize speech message to the incoming caller.

IX. Billing

Billing operations is supported by an Automatic Message Accounting Network Function. The automatic network accounting measures, collects, formats and outputs network usage information to upstream billing and other operation application and service purposes. Preferably, automatic message accounting data is collected at various stages of service flows across network equipment and services.

X. Conclusion

A system has been described which enables a wireless PDA user to remotely control a large number of messaging and call handling options.

While the invention has been described by the reference to specific embodiments, this was for purposes of illustration only and should not be construed to limit the spirit or the scope of the invention.

We claim:

1. A personal communication internetworking for sending and receiving wireless and wireline messages:

(1) a server, including:

(a) a message transfer agent interfaced with at least one wireline data network;

(b) a wireless data network protocol handler connected to the message transfer agent and interfacing with at least one wireless data network;

(c) a mobility controller, including

i. a subscriber profile cache;

ii. a message router responsive to message routing parameters in the subscriber profile;

iii. an interface connected to exchange message routing parameters between the subscriber profile and the at least one wireless network;

iv. an interface connected to exchange message routing parameters between the subscriber profile and a personal communication control point; and

v. an interface with at least one of a telephone network, an alphanumeric pager network, and a voice peripheral; and

(2) the personal communication control point connected to the server, including:

(a) a first interface connected to exchange DTMF message routing parameter signals with the server;

(b) a second interface connected to exchange generic data message routing parameter signals with the server;

(c) a subscriber profile connected to receive and maintain message routing parameters; and

(d) a call processor connected between the subscriber profile and the first and second interfaces.

2. The personal communication internetworking of claim 1, wherein the internetworking is built on an Advanced Intelligent Network architecture, the server is an Intelligent Peripheral, and the control point is a Service Control Point.

3. The personal communication internetworking of claim 1, further including a personal digital assistant having a wireless data network interface connected to exchange message routing parameters and an application designed to communicate with the interface to receive, update, and transmit the message routing parameters.

4. The personal communication internetworking of claim 1, wherein the server further comprises:

a message converter connected to receive from an interface a message in a first format and output to another interface the message in second format.

5. A method for personal communications internetworking, comprising the steps of:

(a) storing a subscriber profile containing message routing commands for a subscriber;

(b) receiving any of an electronic mail, a facsimile, and a voice mail message addressed to the subscriber from either of a wireless and a wireline network;

(c) consulting the subscriber profile for instructions for routing the received message; and

(d) routing the received message to any of a wireless or wireline network according to the instructions in the subscriber profile.

6. The method of claim 5, further comprising the step of converting the received message into a different format if the subscriber profile instructs routing the received message in the different format.

7. The method of claim 5, further comprising the step of remotely updating the routing commands in the subscriber profile via one of a wireless and a wireline data network.

8. The method of claim 5, wherein the received message is addressed to a single subscriber telephone number regardless of format.

9. The method of claim 5, further comprising the step of sending a message notifying the subscriber of the received message.

10. A method for routing incoming telephone calls, comprising the steps of:

(a) storing a subscriber profile containing telephone, routing, and screening parameters including at least one of incoming telephone call origin, time of day, and day of week;

(b) receiving a telephone call directed to the subscriber;

(c) consulting the subscriber profile to determine where to route the received telephone call; and

(d) routing the telephone call according to the subscriber profile.

11. The method of claim 10, further comprising the step of remotely updating the subscriber profile via a wireless data network.

12. The method of claim 10, further comprising the step of remotely updating the subscriber profile via either a wireless and a wireline telephone network.

13. The method of claim 10, further comprising the steps of:

(a) if the subscriber profile so instructs, notifying the subscriber of the received telephone call via a wireless data network message; and

(b) the subscriber selecting one of:

(i) forwarding the call to a subscriber selected telephone number;

(ii) selecting a text message to be transmitted over the wireless data network and converted into synthesized speech and played to the incoming telephone call; and

(iii) forwarding the call and selecting a text message.

14. A communication apparatus, comprising:

a personal communications internetworking:

(i) having a number of subscribers, each subscriber having a single address to which all incoming communications are addressed;

(ii) being connected to receive and transmit communications from a plurality of wireless and wireline communications networks;

(iii) having a profile configured to store communication forwarding options for each subscriber; and

(iv) having a communication router connected to receive the received communications from the plurality of wireless and wireline networks and being responsive to the profile for transmitting the received communications according to the stored communication forwarding options.

15. The communications apparatus of claim 14, wherein the communication information includes incoming communication delivery and outgoing communication origination information.

16. The communication apparatus of claim 14, wherein the profile is connected to receive and store revised communication forwarding options from a subscriber.

17. The communication apparatus of claim 16, wherein the profile is connected to receive the revised communication forwarding options from one of a wireless and a wireline network.

18. The communication apparatus of claim 17, wherein the profile is connected to receive revised communication forwarding options in the form of dual tone modulated frequency signals from a telephone.

19. The communication apparatus of claim 17, wherein the profile is connected to receive revised communication forwarding options in the form of generic data messages from a generic data interface.

20. The communication apparatus of claim 14, wherein the single address is a telephone number.

21. The communication apparatus of claim 14, wherein the communications include at least one of telephone, pager, facsimile, voice mail, and electronic text communications.

22. The communication apparatus of claim 14, wherein the communication router further includes a media format translation device configured to translate a received communication into a different communication medium for transmission.

23. The communication apparatus of claim 14, wherein the profile further stores cross-media notification information and the personal communications internetworking further includes a cross-media notification device responsive to the received communication received on one of the plurality of wireless and wireline communications networks, and to the profile, and being configured to transmit in a first preselected medium a notification signal indicating receipt of the received communication.

24. The communication apparatus of claim 23, wherein the cross-media notification information includes a second preselected medium and, when the first preselected medium is not available, the cross-media notification device transmits in the second predetermined medium the notification signal indicating receipt of the received communication.

25. The communication apparatus of claim 14, wherein the profile further includes received communication screening information and the communication router is further responsive to the screening information.

26. The communication apparatus of claim 25, wherein the received communication screening information includes information to screen communications based on at least one of a received communication's media type, time of day received, day of week received, origin, and sender.

27. The communication apparatus of claim 14, further including a server connected to the profile.

28. The communication apparatus of claim 27, wherein the server includes a call processor.

29. The communication apparatus of claim 28, wherein the call processor comprises a plurality of interconnected computers.

30. The communication apparatus of claim 28, wherein the call processor includes an interface with at least one of the profile, a wireless data network, an alphanumeric paging network, a telephone network switch, and a voice peripheral.

31. The communication apparatus of claim 30, wherein the voice peripheral includes a text-to-speech converter.

32. The communication apparatus of claim 28, wherein the call processor further includes a service profile cache which contains a subset of information stored in the profile, which subset of information is currently frequently needed.

33. The communication network of claim 27, wherein the server further includes a data messaging peripheral.

34. The communication device of claim 33, wherein the data messaging peripheral includes an interface with at least one electronic messaging network.

35. The apparatus of claim 14, wherein the internetworking is built on an Advanced Intelligent Network architecture.

36. The apparatus of claim 14, wherein the internetworking is a network adjunct.

37. The communication device of claim 14, wherein the communication router further comprises an audio messaging interface specification analog protocol connected to a public telephone network.

38. The communication device of claim 14, wherein the communication router further comprises an audio messaging interface specification digital protocol connected to at least one of a modem, a private line, and an integrated signalling digital network basic rate interface.

39. The communication device of claim 14, wherein the communication router further comprises at least one of an analog line connected to a public switched telephone network, a private line, and an integrated signalling digital network.

40. The method of claim 7, wherein the step of updating is done via a wireless network and further includes:

a. transmitting a data request from a terminal over a wireless network to the profile;

b. transmitting the requested data from the profile over the wireless network to the terminal;

c. updating the routing commands at the terminal;

d. transmitting the updated routing commands over the wireless network to the profile; and

e. storing the updated routing commands in the profile.

41. The method of claim 40, further including after the step of transmitting the updated routing commands:

a. generating an update acknowledgement signal; and

b. transmitting the update acknowledgement signal over the wireless network to the terminal.

42. The method of claim 9, wherein the step of sending a message further includes notifying the subscriber of a received telephone call.

43. The method of claim 42, further including after the step of notifying, the step of selecting any one of:

a. forwarding the telephone call to a selected telephone number;

b. selecting a text message to be transmitted over the wireless data network and converting the text message into synthesized speech and played to the incoming telephone call; and

c. forwarding the call and selecting a text message.

44. The method of claim 42, further including the step of remotely updating the subscriber profile via either one of a wireless and a wireline telephone network.

45. The method of claim 44, wherein the step of updating includes using DTMF signals to update the subscriber profile and storing the updated profile.

46. The method of claim 44, further including after the step of updating:

a. generating an update acknowledgement signal; and

b. transmitting the update acknowledgement signal over the telephone network.

47. The method of claim 5, further including delivering a single message according to a distribution list stored in the subscriber profile, the distribution list instructing the message to be delivered to a plurality of addresses via one of an electronic mail and a facsimile format.

48. The method of claim 5, wherein the step of receiving a voice mail message addressed to the subscriber further includes the steps of:

a. receiving from an originating voice mail system voice mail information including identification information;

b. extracting the identification information from the message to determine the origin of the voice mail message;

c. the step of consulting further comprising determining if the identification of the originator indicates that the originator is also the subscriber;

d. if the originator is the subscriber, the step of routing further comprises the steps of:

i. not forwarding the voice mail message to the communication network; and

ii. extracting header information from the identification information and transmitting a notification to the subscriber containing the header information;

e. if the originator is not the subscriber, the step of routing further includes the steps of:

i. if the message exceeds a predetermined length, rejecting the message; and

ii. if the message is less than or equal to the predetermined length, the communication router accepting the message; and

f. the step of routing the received message further includes routing the voice mail message according to routing instructions in the profile.

49. The method of claim 48, wherein before the step of routing, the step of translating the voice mail message from analog format into a digital format.

50. The method of claim 48, wherein before the step of routing, the step of translating the voice mail message from a digital format into an analog format.

51. The personal communication internetworking of claim 1, wherein the internetworking is a network adjunct.

FIG. 1

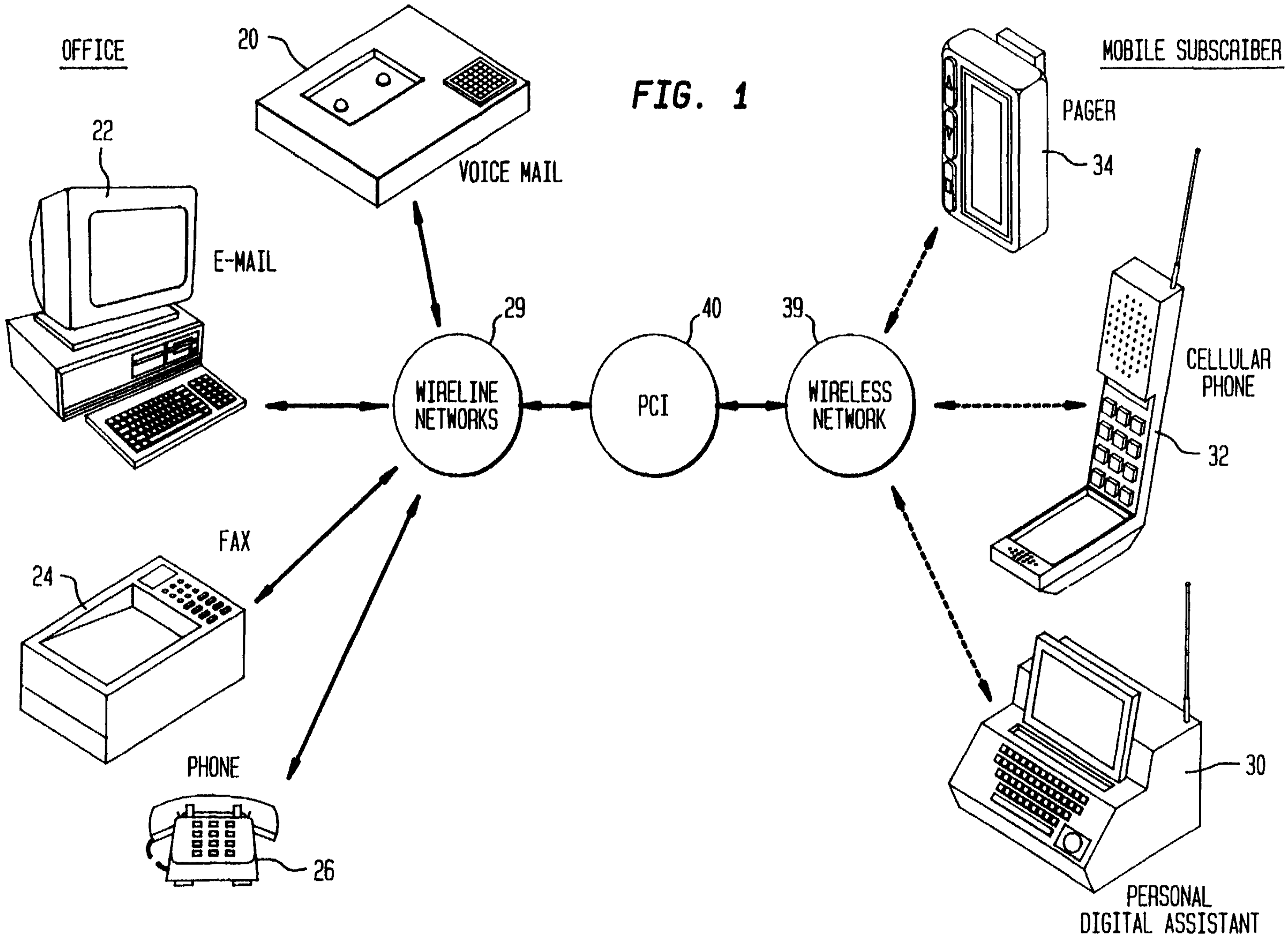

OFFICE
20
VOICE MAIL
22
E-MAIL
29
WIRELINE NETWORKS
40
PCI
39
WIRELESS NETWORK
FAX
24
PHONE
26
MOBILE SUBSCRIBER
PAGER
34
CELLULAR PHONE
32
30
PERSONAL DIGITAL ASSISTANT

FIG. 2

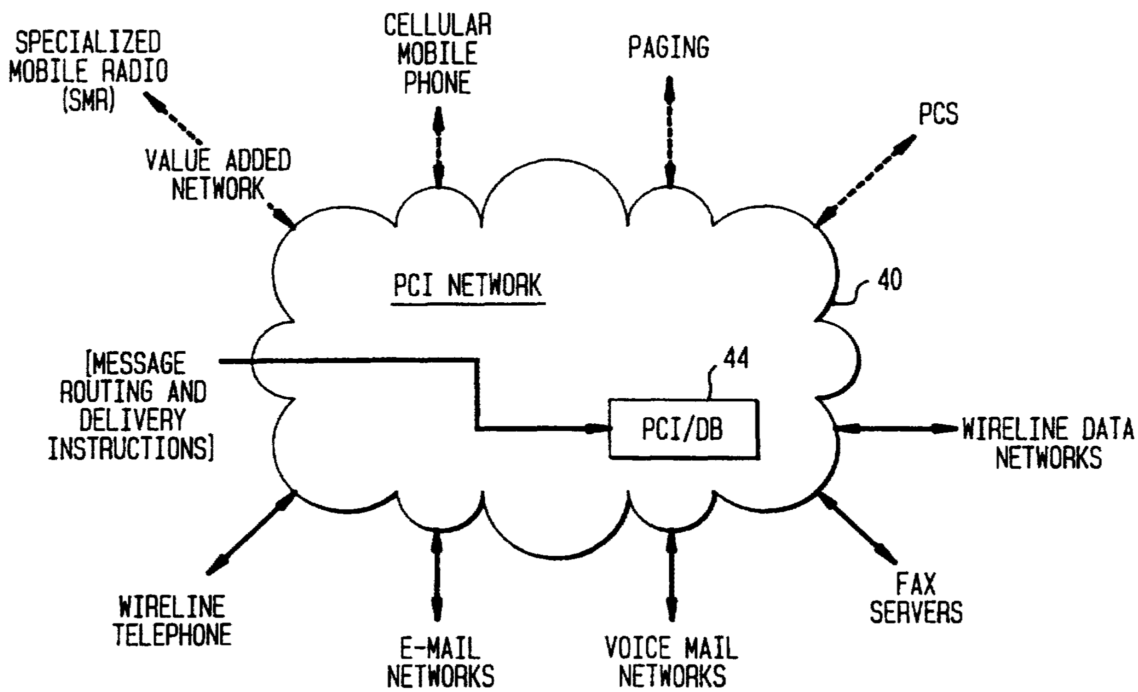

SPECIALIZED MOBILE RADIO (SMR)
CELLULAR MOBILE PHONE
PAGING
PCS
VALUE ADDED NETWORK
PCI NETWORK
40
44
[MESSAGE ROUTING AND DELIVERY INSTRUCTIONS]
PCI/DB
WIRELINE DATA NETWORKS
WIRELINE TELEPHONE
E-MAIL NETWORKS
VOICE MAIL NETWORKS
FAX SERVERS

FIG. 3

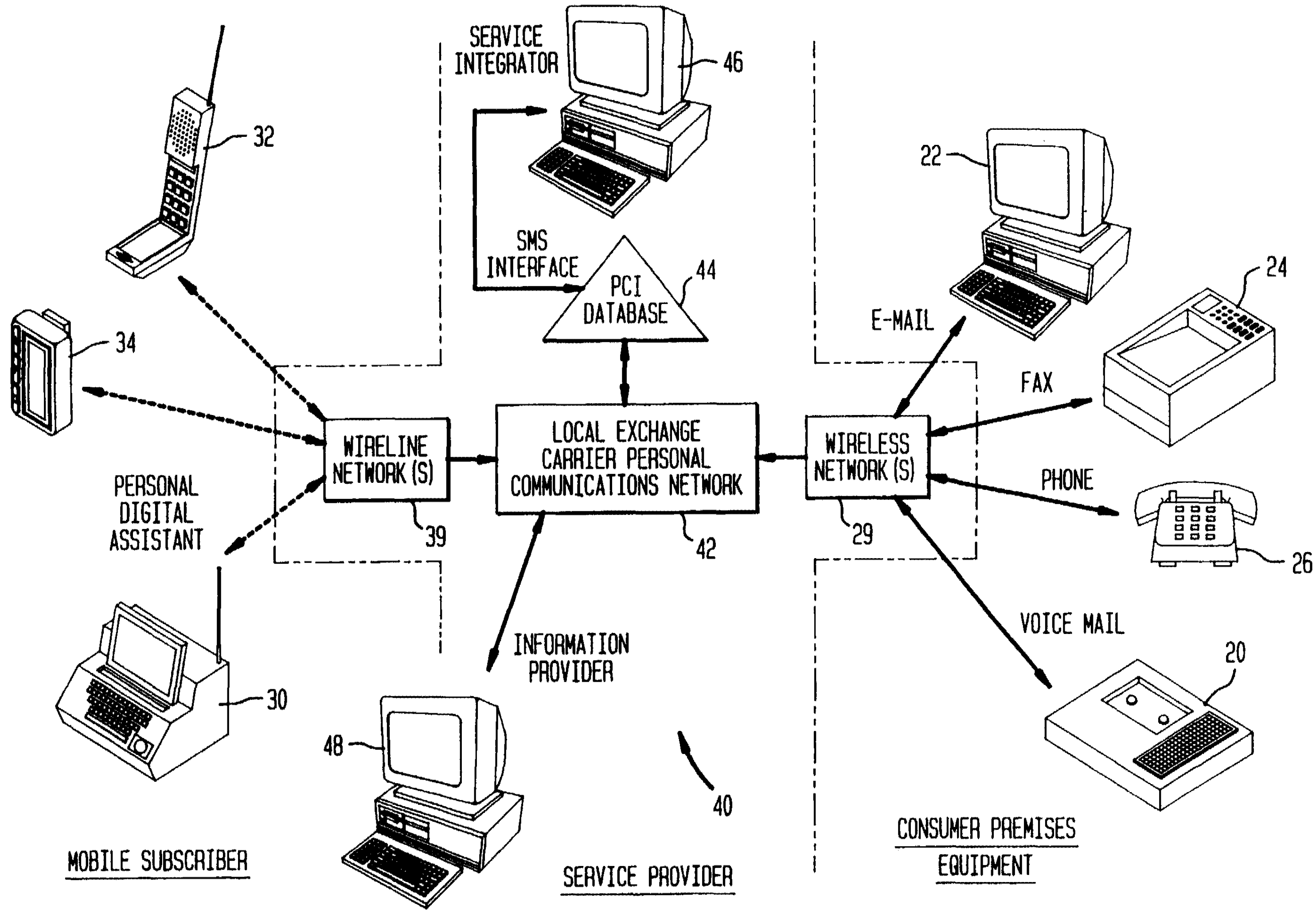

SERVICE INTEGRATOR
46
32
22
SMS INTERFACE
PCI DATABASE
44
24
34
E-MAIL
FAX
WIRELINE NETWORK (S)
LOCAL EXCHANGE CARRIER PERSONAL COMMUNICATIONS NETWORK
WIRELESS NETWORK (S)
PHONE
PERSONAL DIGITAL ASSISTANT
39
42
29
26
INFORMATION PROVIDER
VOICE MAIL
20
30
48
40
MOBILE SUBSCRIBER
SERVICE PROVIDER
CONSUMER PREMISES EQUIPMENT

FIG. 4

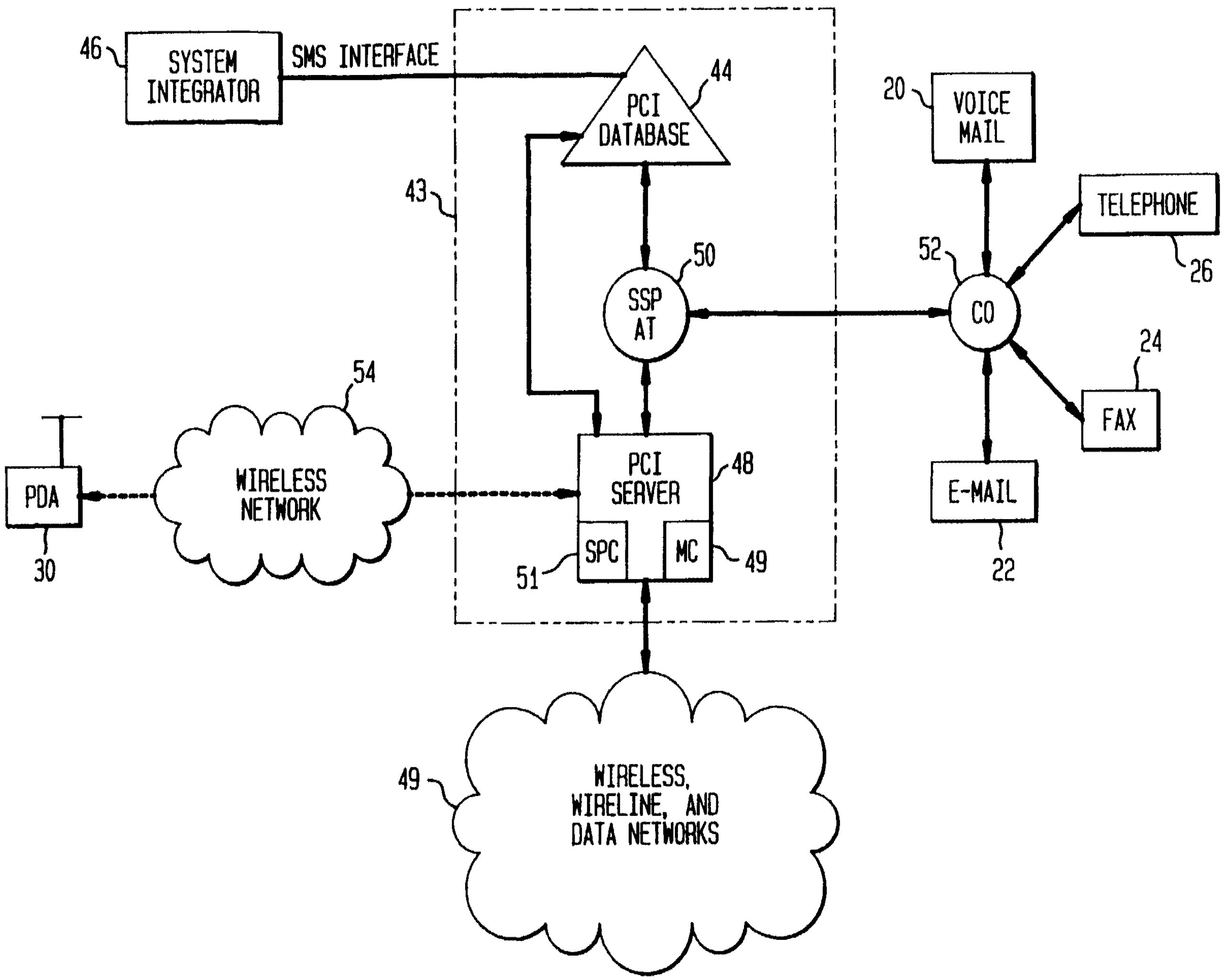

46
SYSTEM INTEGRATOR
SMS INTERFACE
PCI DATABASE
44
43
50
SSP AT
48
PCI SERVER
SPC
MC
51
49
54
WIRELESS NETWORK
PDA
30
49
WIRELESS, WIRELINE, AND DATA NETWORKS
20
VOICE MAIL
TELEPHONE
26
52
CO
24
FAX
E-MAIL
22

FIG. 5

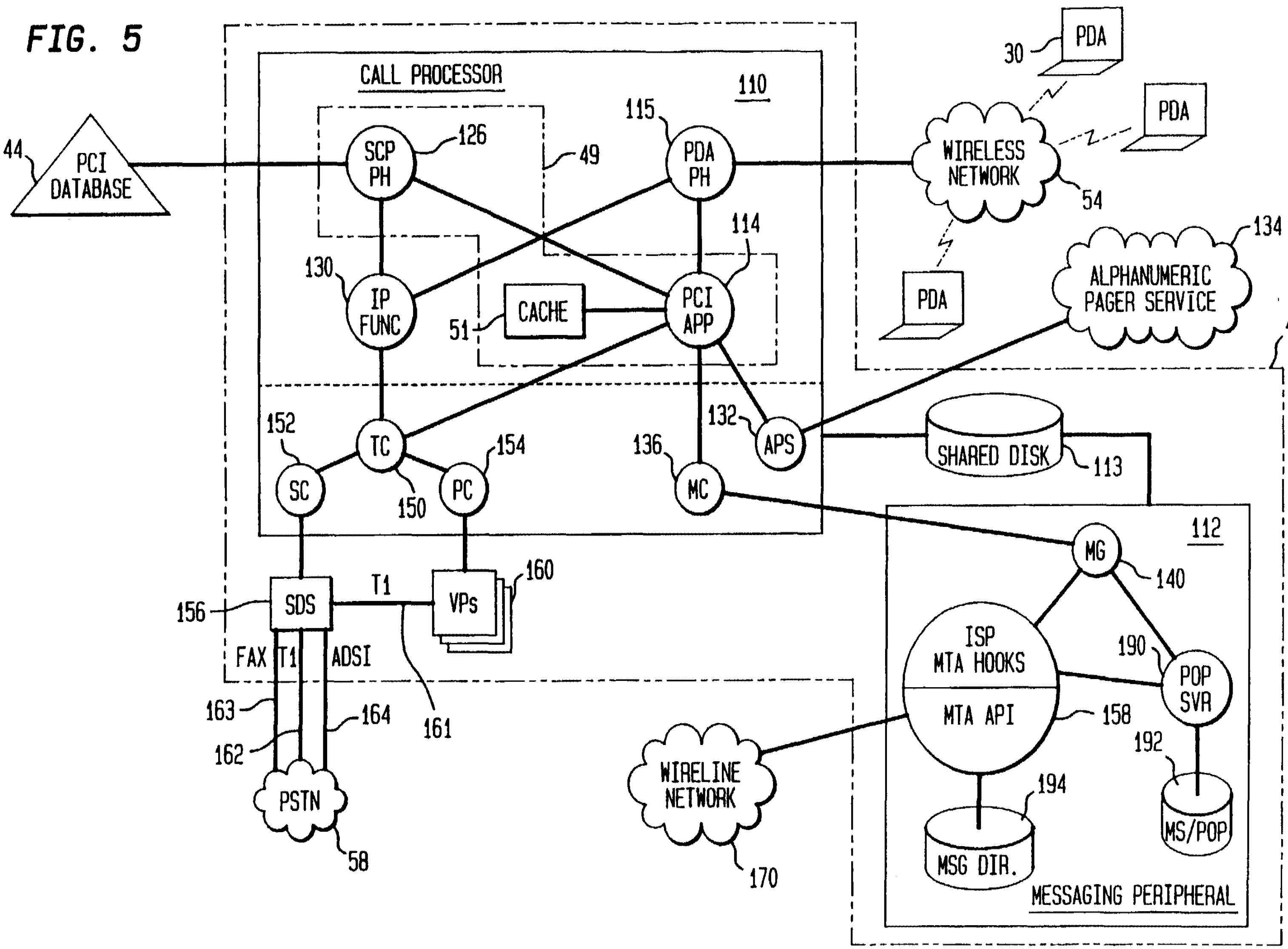

CALL PROCESSOR
110
44
PCI DATABASE
SCP PH
126
49
115
PDA PH
30
PDA
PDA
WIRELESS NETWORK
54
PDA
134
ALPHANUMERIC PAGER SERVICE
48
114
130
IP FUNC
51
CACHE
PCI APP
152
TC
154
136
132
APS
SHARED DISK
113
SC
150
PC
MC
112
MG
140
160
156
SDS
T1
VPs
ISP MTA HOOKS
190
POP SVR
FAX
T1
ADSI
MTA API
158
163
164
161
192
162
PSTN
58
WIRELINE NETWORK
170
194
MSG DIR.
MS/POP
MESSAGING PERIPHERAL

FIG. 6

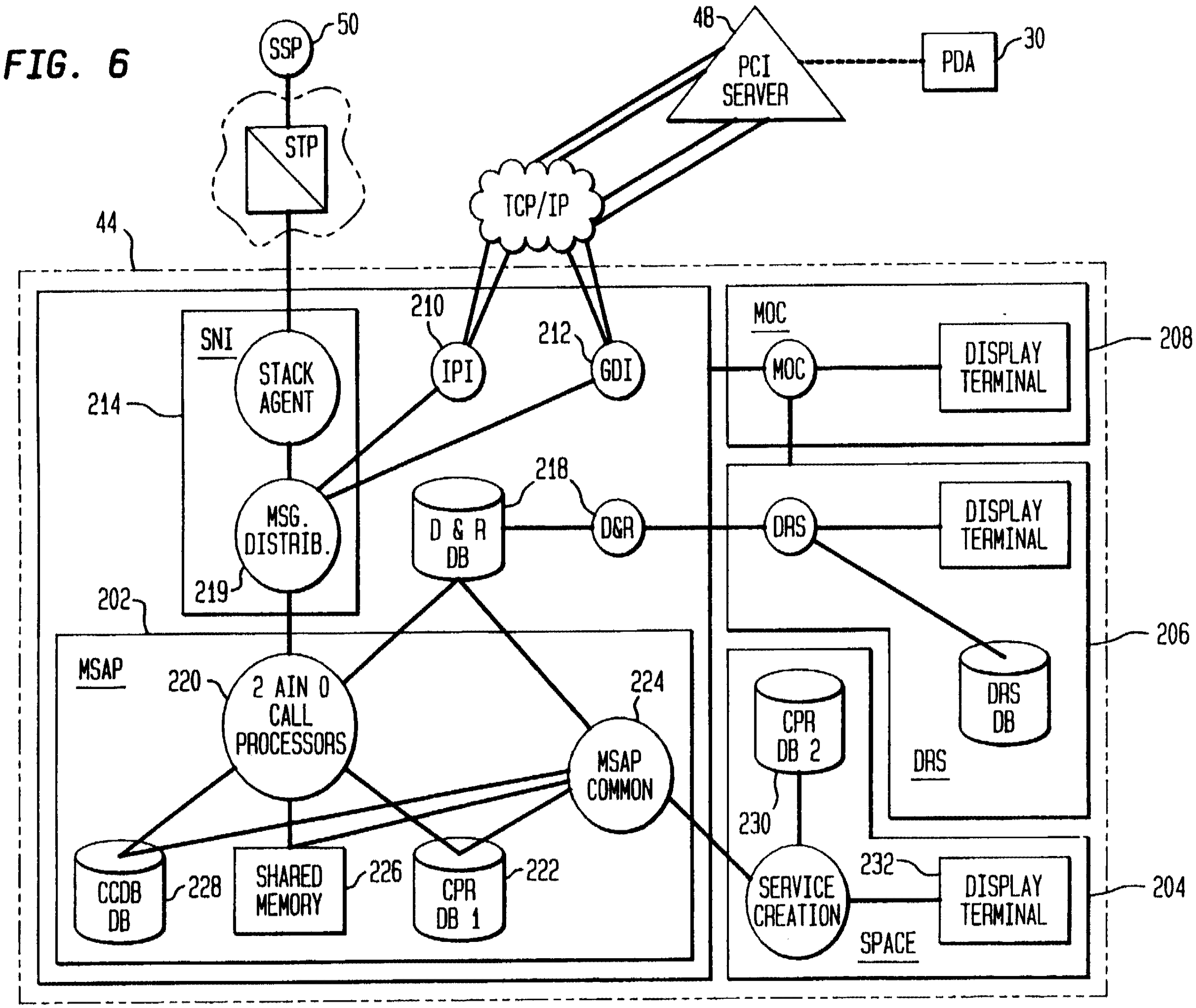

SSP
50
STP
44
48
PCI SERVER
PDA
30
TCP/IP
210
IPI
212
GDI
SNI
STACK AGENT
214
MSG. DISTRIB.
219
218
D & R DB
D&R
202
MSAP
220
2 AIN 0 CALL PROCESSORS
224
MSAP COMMON
CCDB DB
228
SHARED MEMORY
226
CPR DB 1
222
MOC
MOC
DISPLAY TERMINAL
208
DRS
DISPLAY TERMINAL
206
DRS DB
DRS
CPR DB 2
230
SERVICE CREATION
232
DISPLAY TERMINAL
204
SPACE

FIG. 7

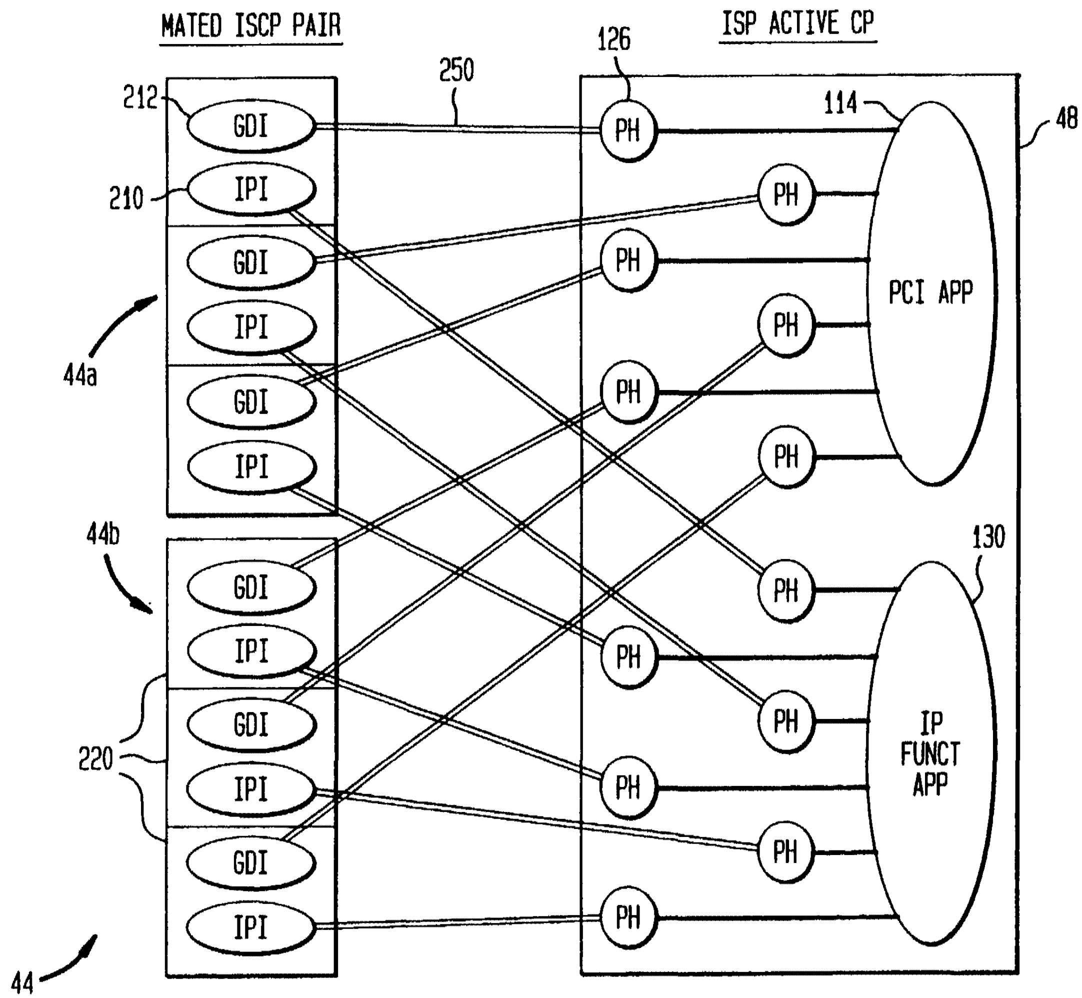

MATED ISCP PAIR
ISP ACTIVE CP
126
250
212
GDI
210
IPI
114
48
PH
PCI APP
44a
44b
130
IP FUNCT APP
220
44

FIG. 8

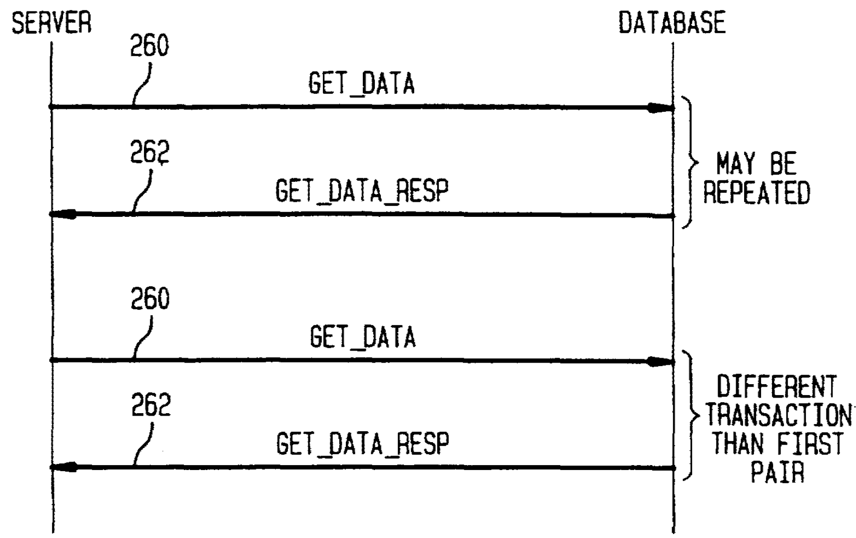

SERVER
DATABASE
260
GET_DATA
262
GET_DATA_RESP
MAY BE REPEATED
260
GET_DATA
262
GET_DATA_RESP
DIFFERENT TRANSACTION THAN FIRST PAIR

FIG. 9

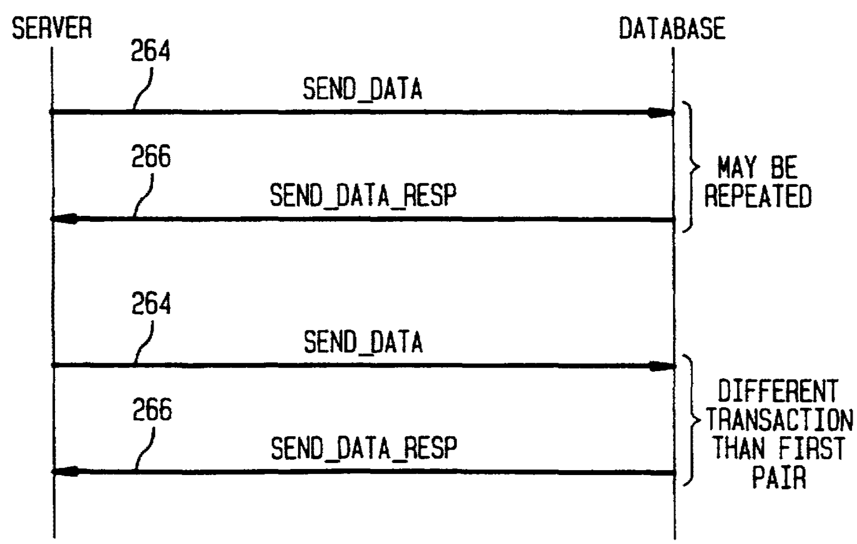

SERVER
DATABASE
264
SEND_DATA
266
SEND_DATA_RESP
MAY BE REPEATED
264
SEND_DATA
266
SEND_DATA_RESP
DIFFERENT TRANSACTION THAN FIRST PAIR

FIG. 10

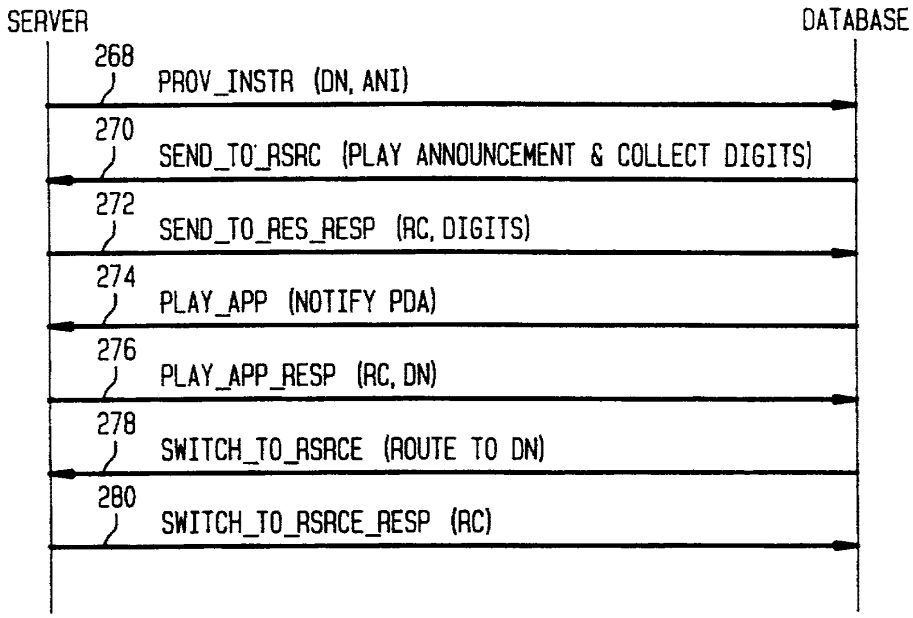

SERVER
DATABASE
268
PROV_INSTR (DN, ANI)
270
SEND_TO_RSRC (PLAY ANNOUNCEMENT & COLLECT DIGITS)
272
SEND_TO_RES_RESP (RC, DIGITS)
274
PLAY_APP (NOTIFY PDA)
276
PLAY_APP_RESP (RC, DN)
278
SWITCH_TO_RSRCE (ROUTE TO DN)
280
SWITCH_TO_RSRCE_RESP (RC)

FIG. 11

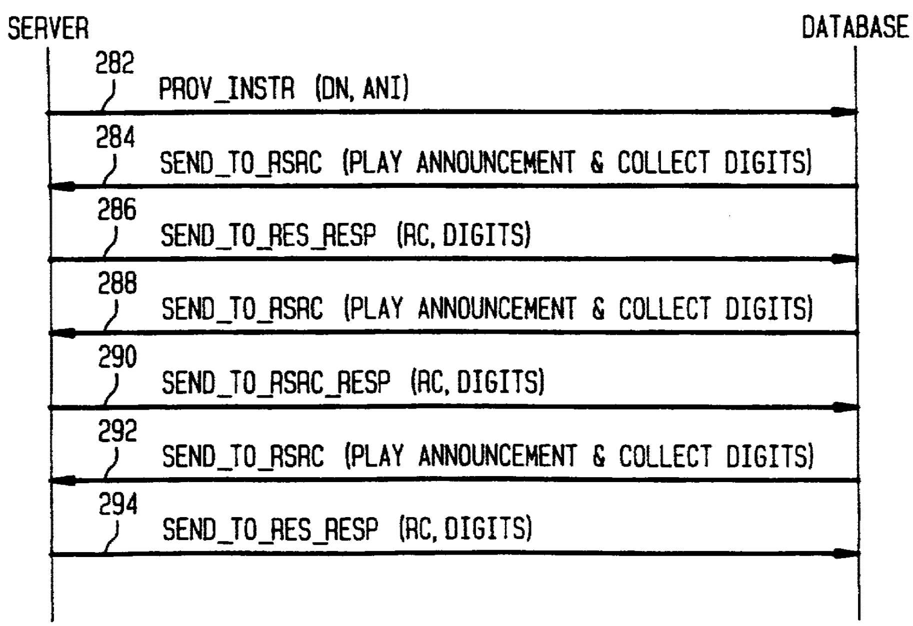

SERVER
DATABASE
282
PROV_INSTR (DN, ANI)
284
SEND_TO_RSRC (PLAY ANNOUNCEMENT & COLLECT DIGITS)
286
SEND_TO_RES_RESP (RC, DIGITS)
288
SEND_TO_RSRC (PLAY ANNOUNCEMENT & COLLECT DIGITS)
290
SEND_TO_RSRC_RESP (RC, DIGITS)
292
SEND_TO_RSRC (PLAY ANNOUNCEMENT & COLLECT DIGITS)
294
SEND_TO_RES_RESP (RC, DIGITS)

FIG. 12

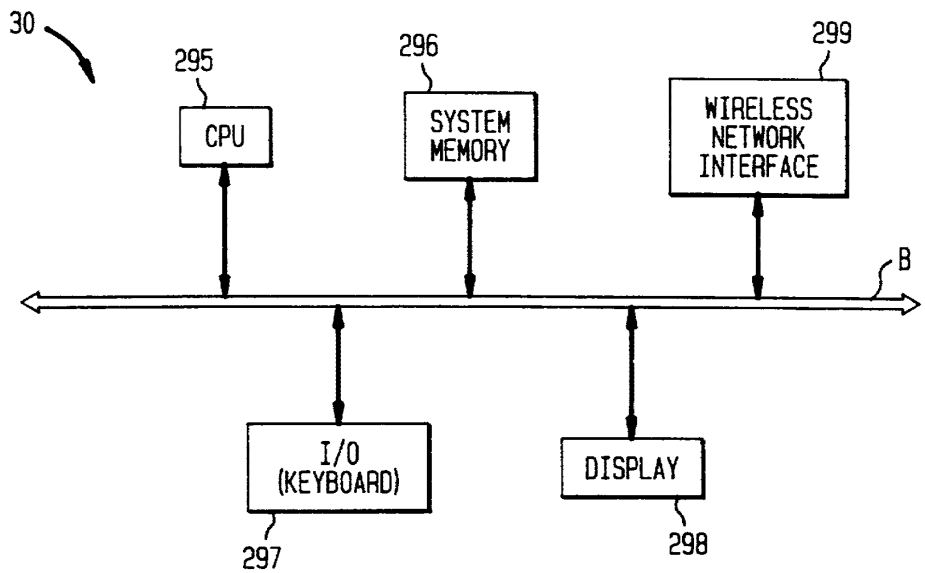


FIG. 13

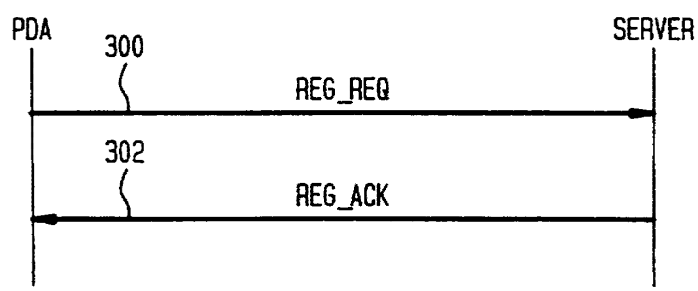


FIG. 14

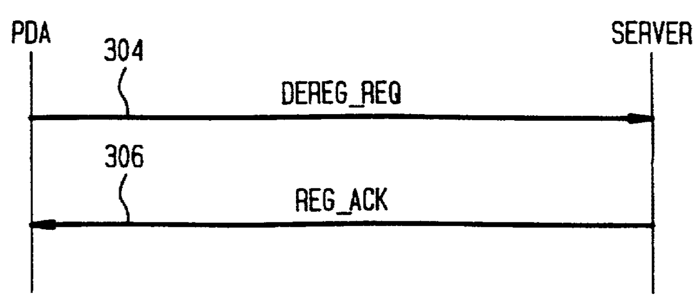


FIG. 15

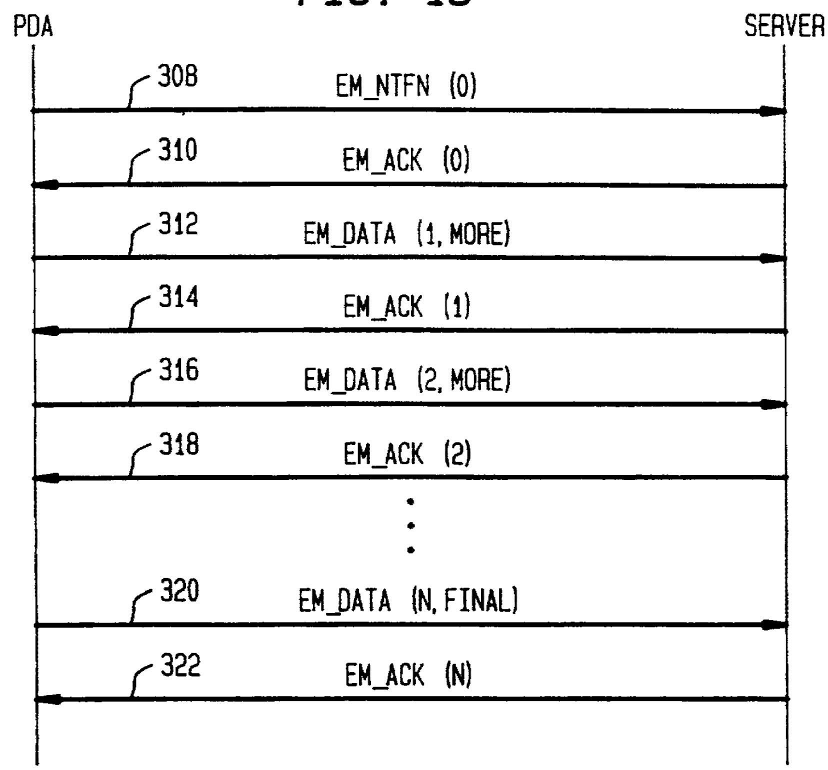


FIG. 16A

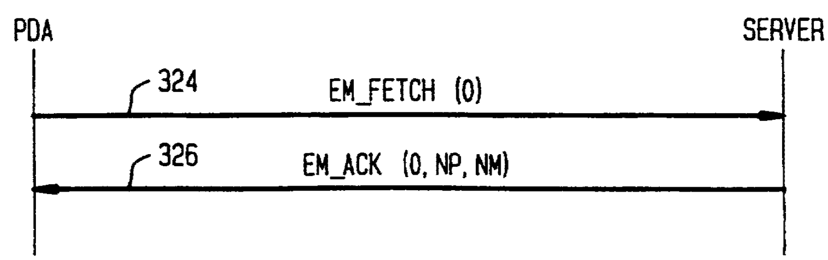


FIG. 16B

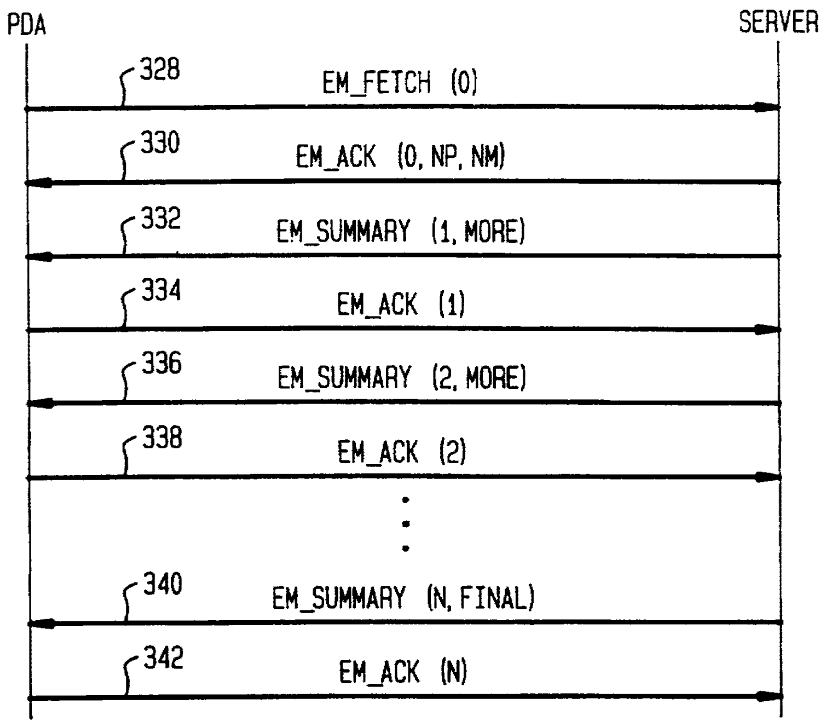


FIG. 17

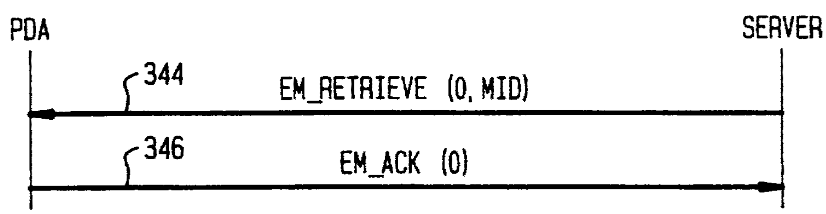


FIG. 18

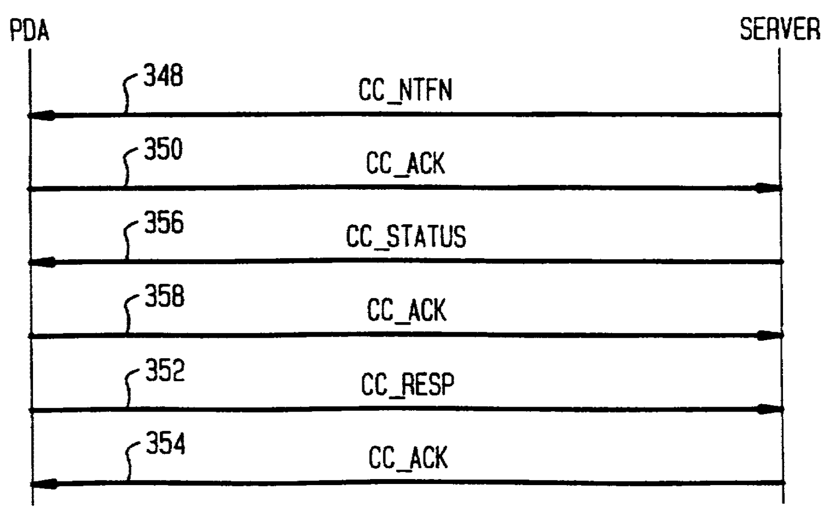


FIG. 19

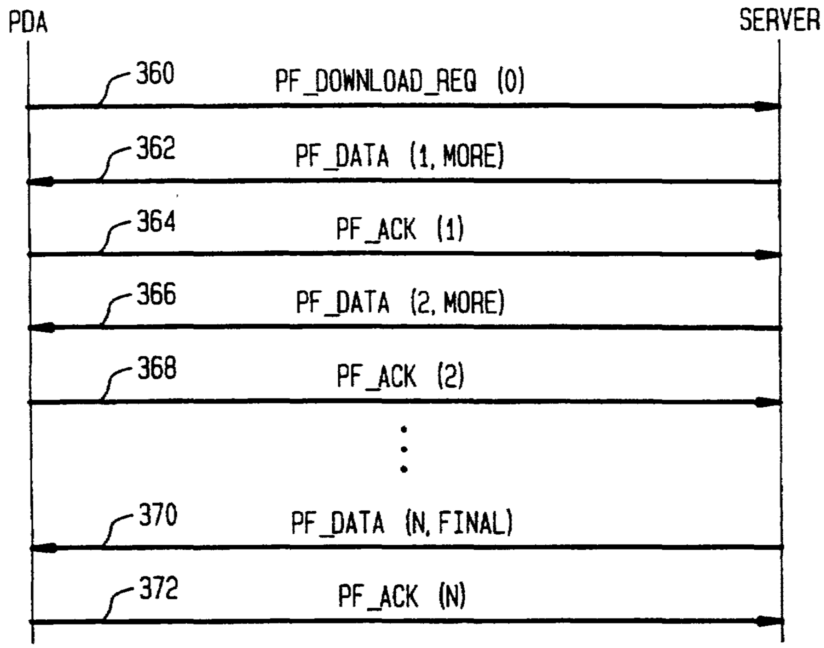


FIG. 20A

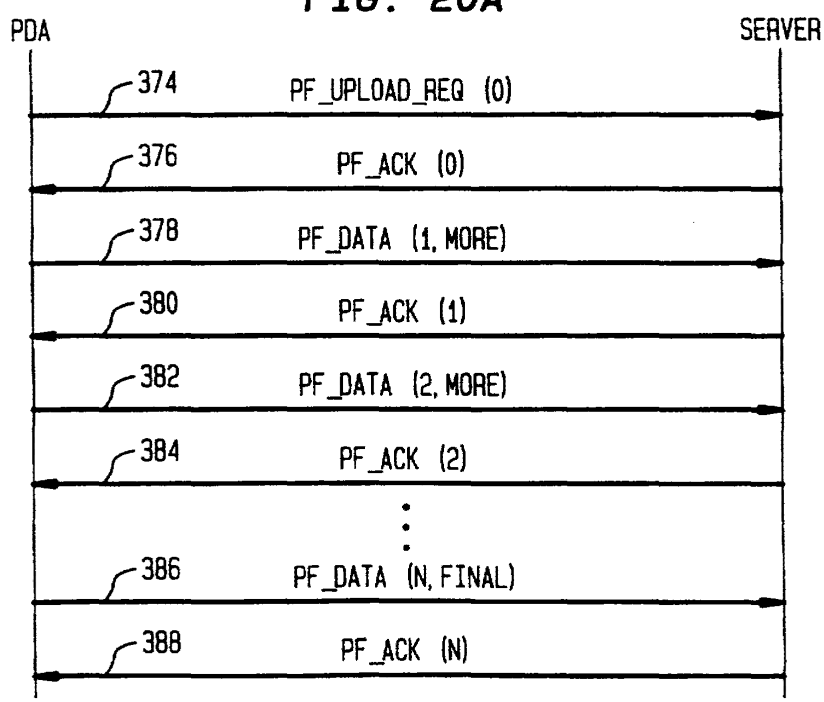


FIG. 20B

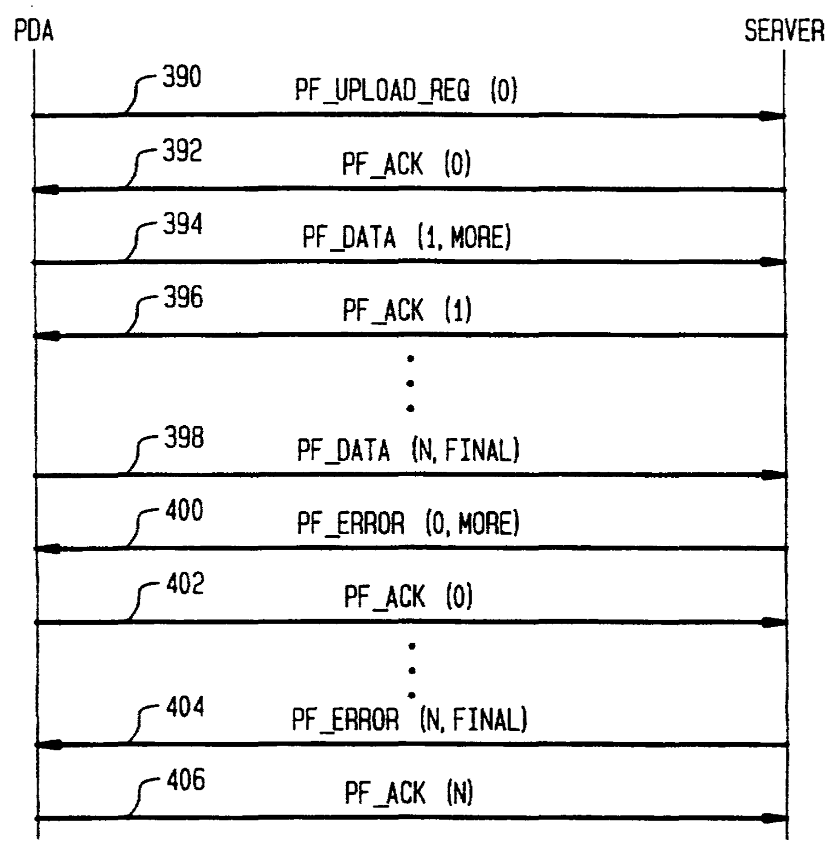

PDA
SERVER
390
PF_UPLOAD_REQ (0)
392
PF_ACK (0)
394
PF_DATA (1, MORE)
396
PF_ACK (1)
398
PF_DATA (N, FINAL)
400
PF_ERROR (0, MORE)
402
PF_ACK (0)
404
PF_ERROR (N, FINAL)
406
PF_ACK (N)

FIG. 21

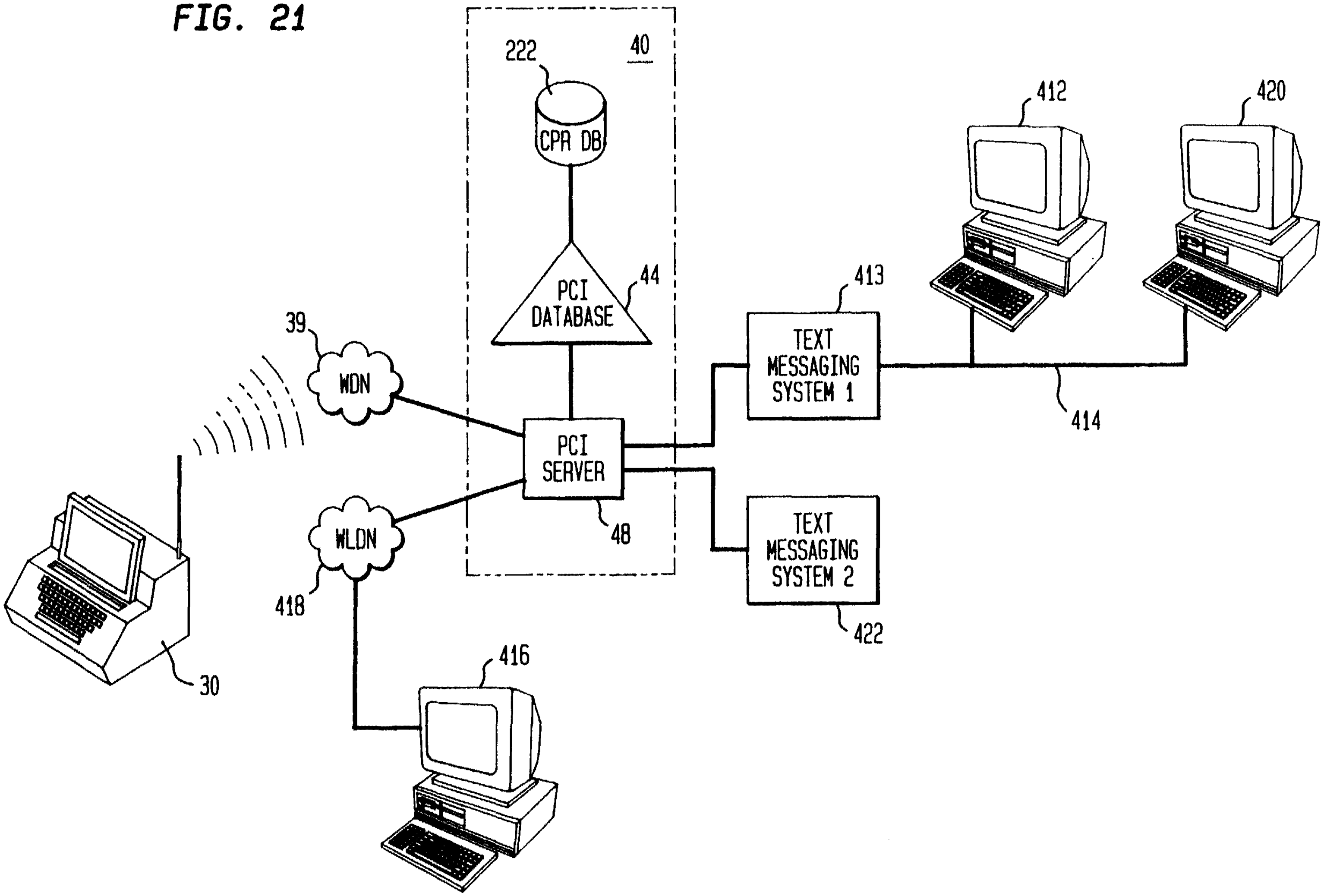

40
222
CPR DB
PCI DATABASE
44
39
WDN
PCI SERVER
48
WLDN
418
30
416
413
TEXT MESSAGING SYSTEM 1
412
420
414
TEXT MESSAGING SYSTEM 2
422

FIG. 22

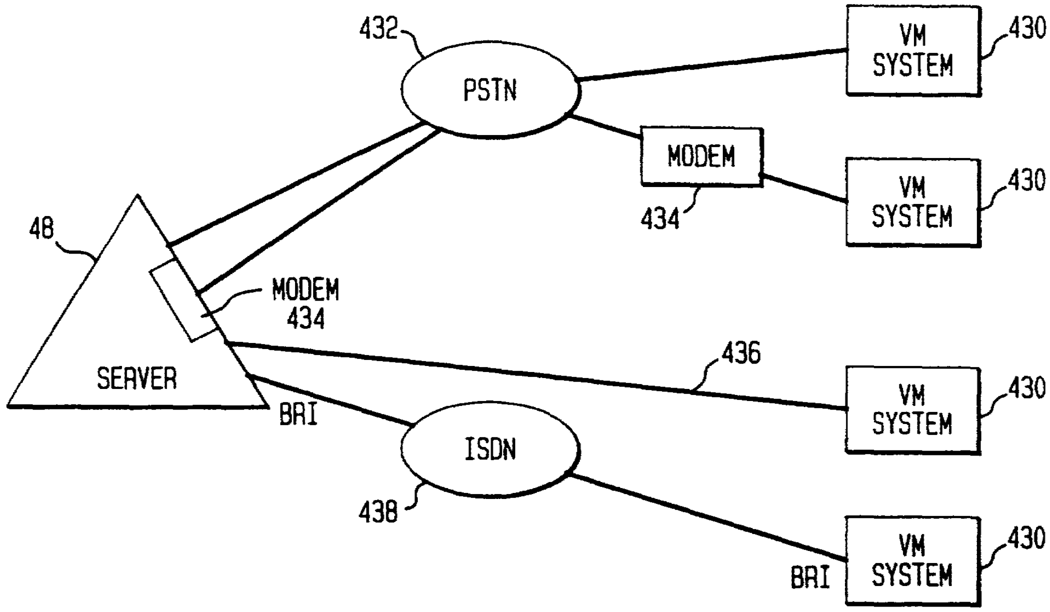

432
PSTN
VM SYSTEM
430
MODEM
VM SYSTEM
430
434
48
MODEM 434
SERVER
436
VM SYSTEM
430
BRI
ISDN
438
VM SYSTEM
430
BRI

FIG. 23

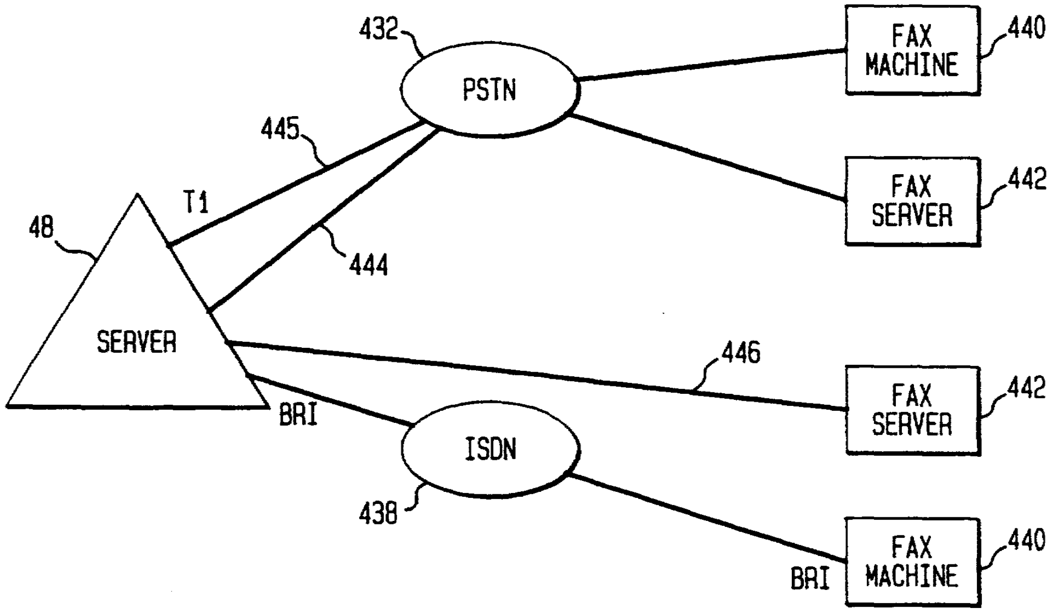

432
PSTN
FAX MACHINE
440
445
FAX SERVER
442
T1
48
444
SERVER
446
FAX SERVER
442
BRI
ISDN
438
FAX MACHINE
440
BRI

FIG. 24

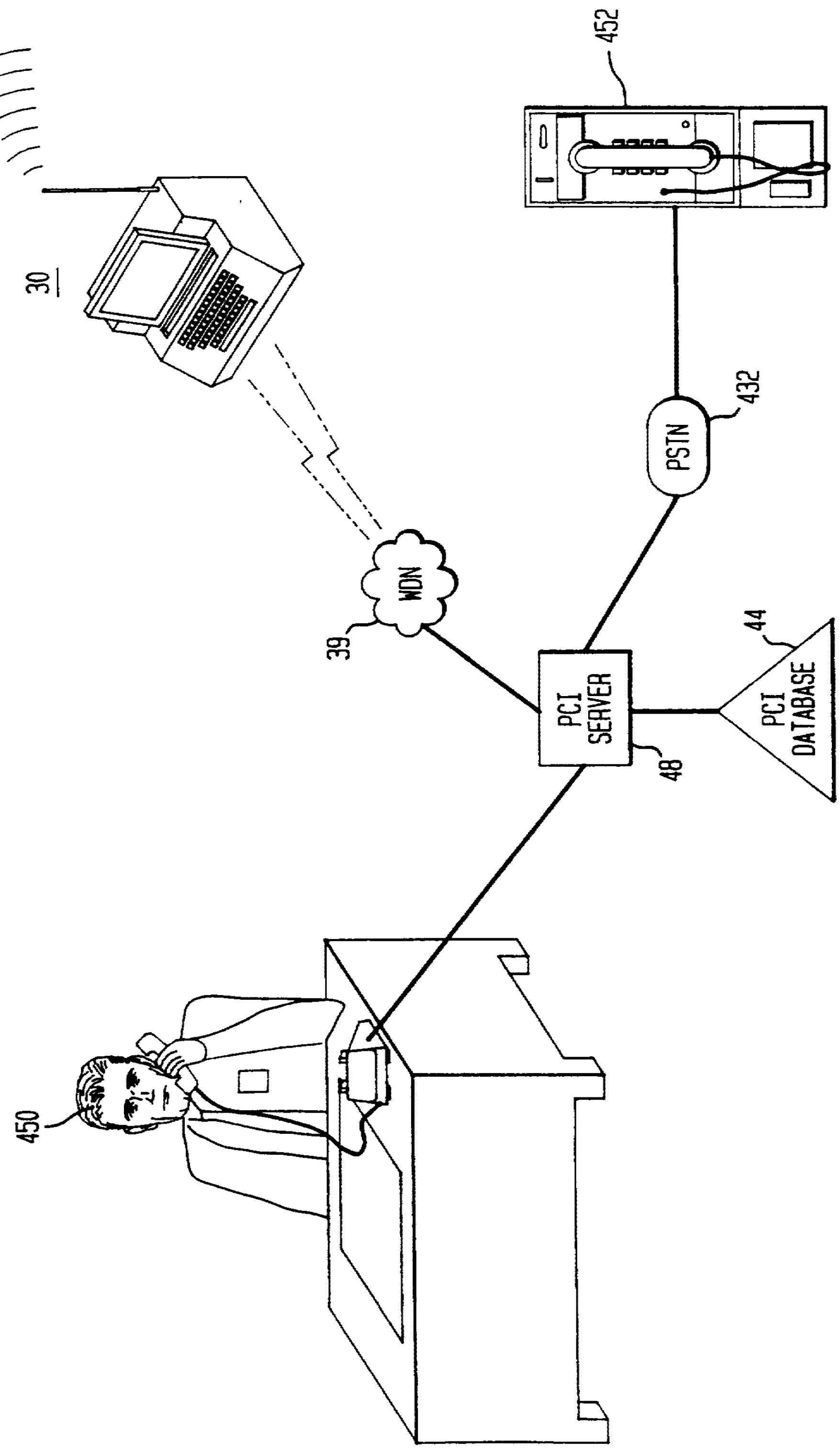


FIG. 25

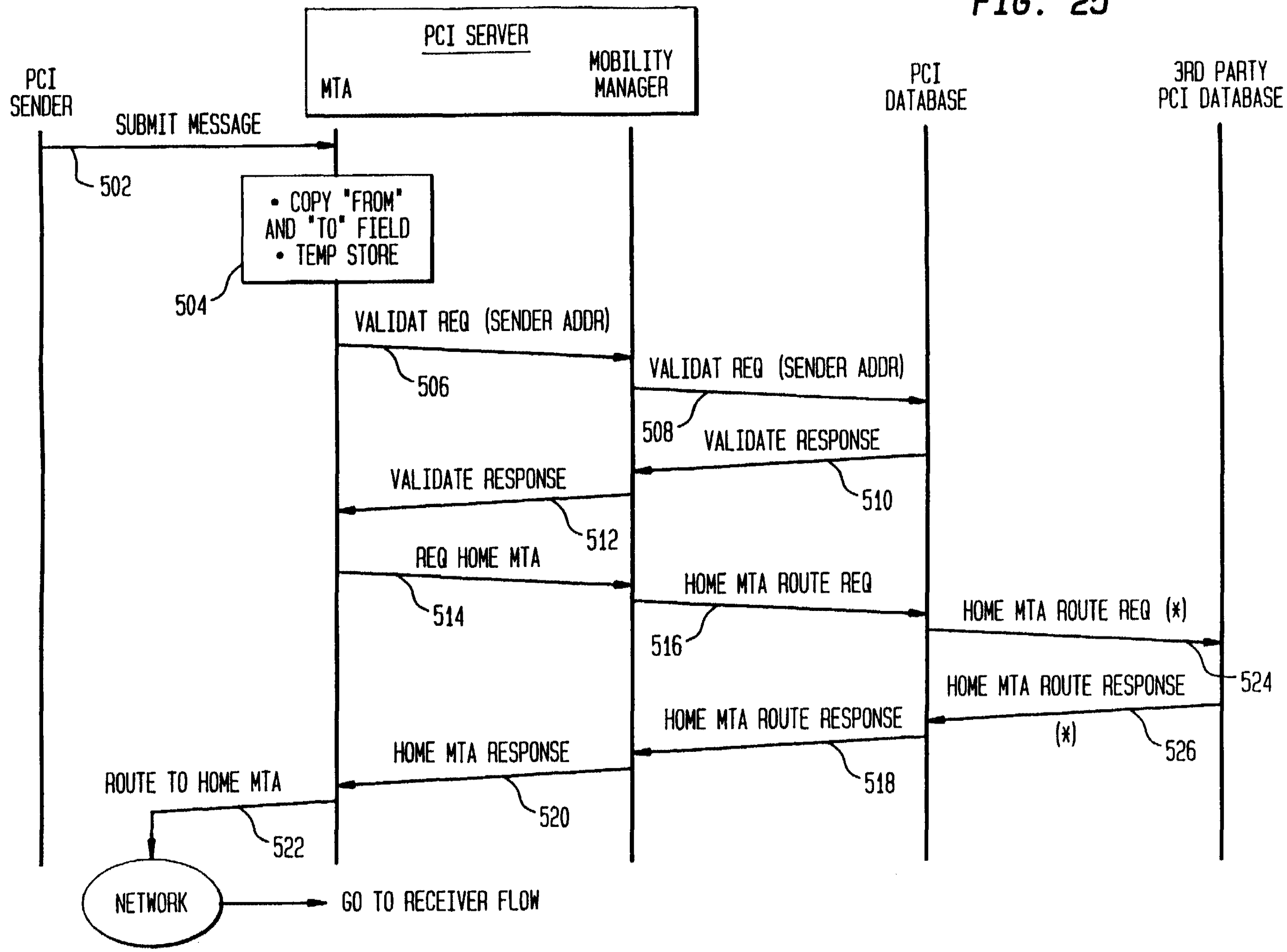

PCI SERVER
MTA
MOBILITY MANAGER
PCI SENDER
PCI DATABASE
3RD PARTY PCI DATABASE
SUBMIT MESSAGE
502
• COPY "FROM" AND "TO" FIELD
• TEMP STORE
504
VALIDAT REQ (SENDER ADDR)
506
VALIDAT REQ (SENDER ADDR)
508
VALIDATE RESPONSE
510
VALIDATE RESPONSE
512
REQ HOME MTA
514
HOME MTA ROUTE REQ
516
HOME MTA ROUTE REQ (*)
524
HOME MTA ROUTE RESPONSE
(*)
526
HOME MTA ROUTE RESPONSE
518
HOME MTA RESPONSE
520
ROUTE TO HOME MTA
522
NETWORK
GO TO RECEIVER FLOW

FIG. 26

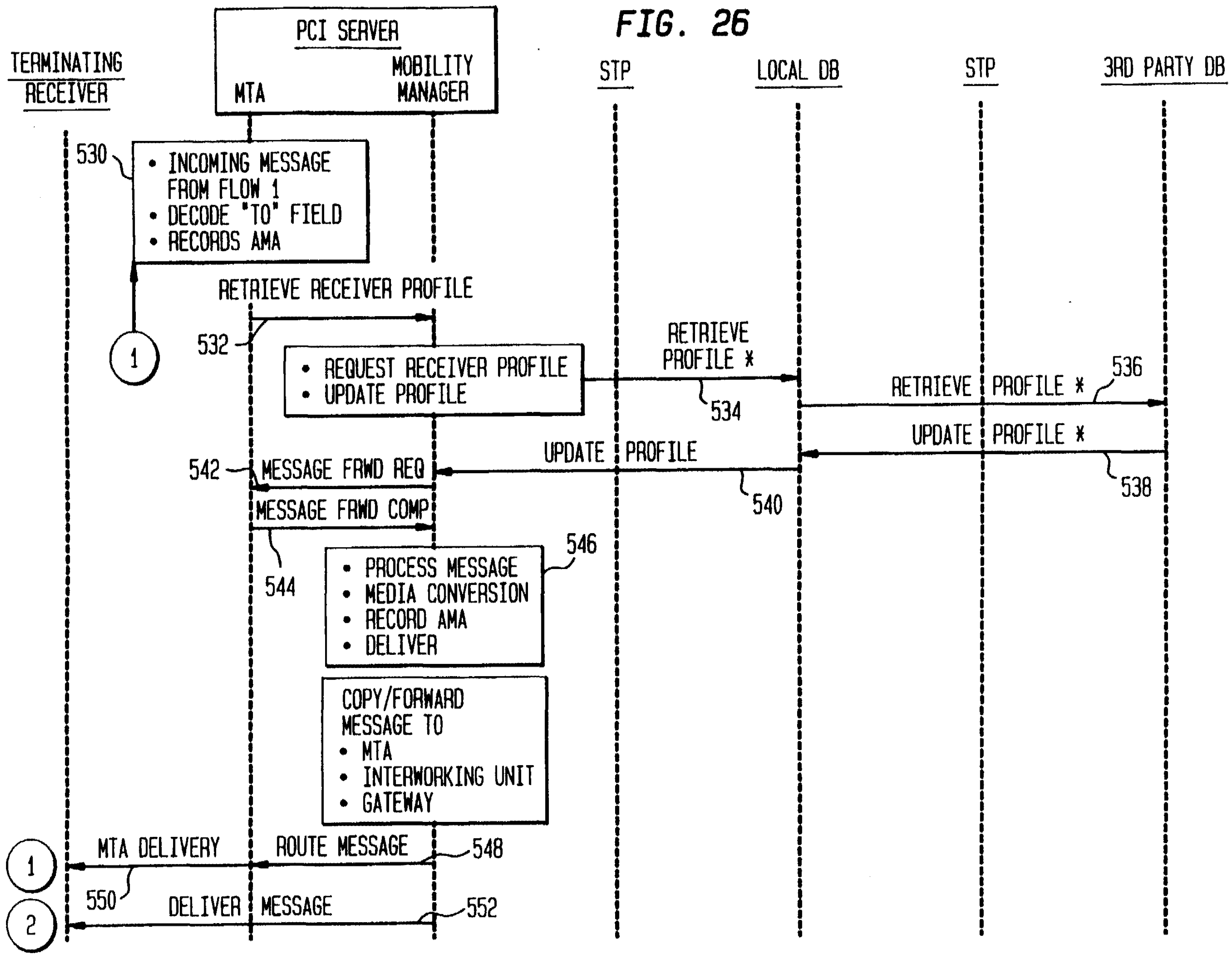

TERMINATING RECEIVER
PCI SERVER
MTA
MOBILITY MANAGER
STP
LOCAL DB
STP
3RD PARTY DB
530
• INCOMING MESSAGE FROM FLOW 1
• DECODE "TO" FIELD
• RECORDS AMA
1
RETRIEVE RECEIVER PROFILE
532
• REQUEST RECEIVER PROFILE
• UPDATE PROFILE
RETRIEVE PROFILE *
534
RETRIEVE PROFILE *
536
UPDATE PROFILE *
538
UPDATE PROFILE
540
542
MESSAGE FRWD REQ
MESSAGE FRWD COMP
544
546
• PROCESS MESSAGE
• MEDIA CONVERSION
• RECORD AMA
• DELIVER
COPY/FORWARD MESSAGE TO
• MTA
• INTERWORKING UNIT
• GATEWAY
1
MTA DELIVERY
ROUTE MESSAGE
548
550
2
DELIVER MESSAGE
552

FIG. 27

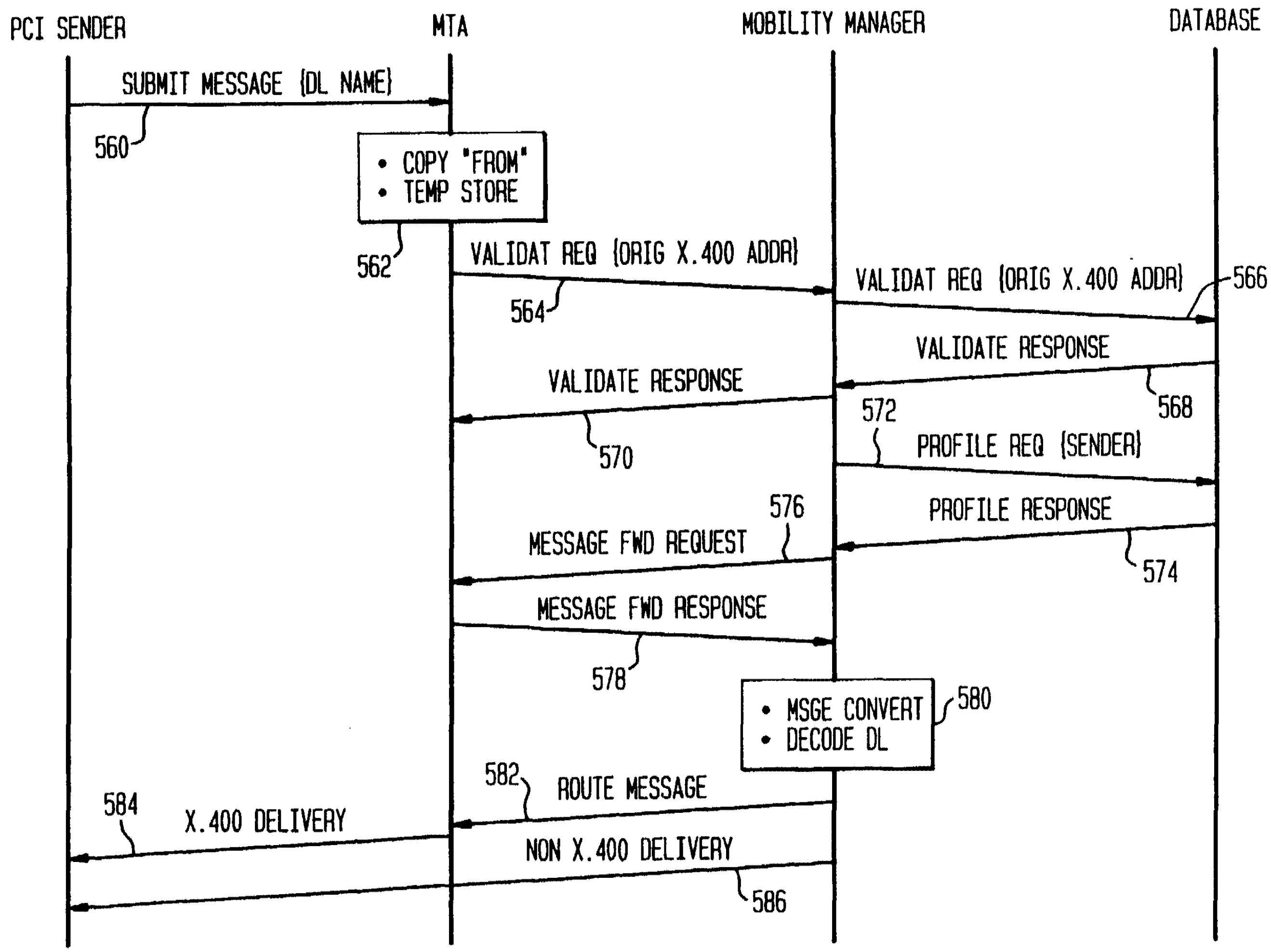

PCI SENDER
MTA
MOBILITY MANAGER
DATABASE
SUBMIT MESSAGE (DL NAME)
560
• COPY "FROM"
• TEMP STORE
562
VALIDAT REQ (ORIG X.400 ADDR)
564
VALIDAT REQ (ORIG X.400 ADDR)
566
VALIDATE RESPONSE
568
VALIDATE RESPONSE
570
572
PROFILE REQ (SENDER)
PROFILE RESPONSE
574
576
MESSAGE FWD REQUEST
MESSAGE FWD RESPONSE
578
• MSGE CONVERT
• DECODE DL
580
582
ROUTE MESSAGE
584
X.400 DELIVERY
NON X.400 DELIVERY
586

FIG. 28

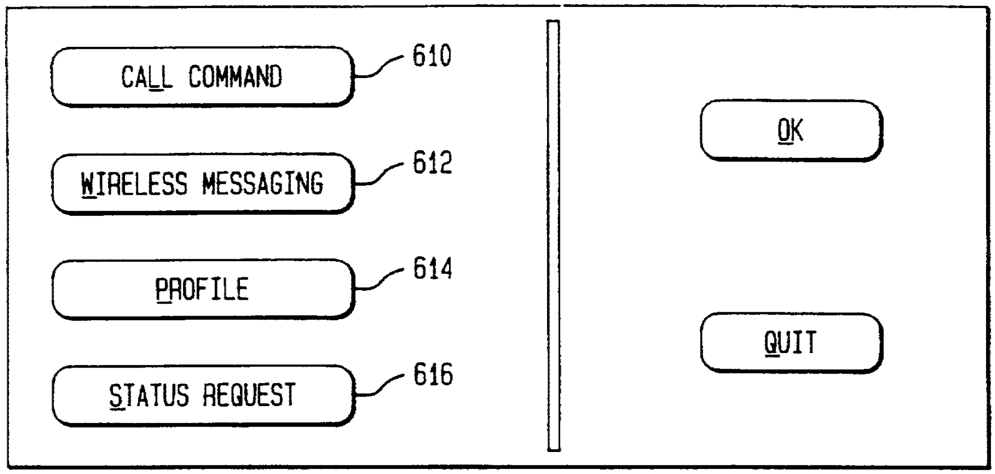


FIG. 29

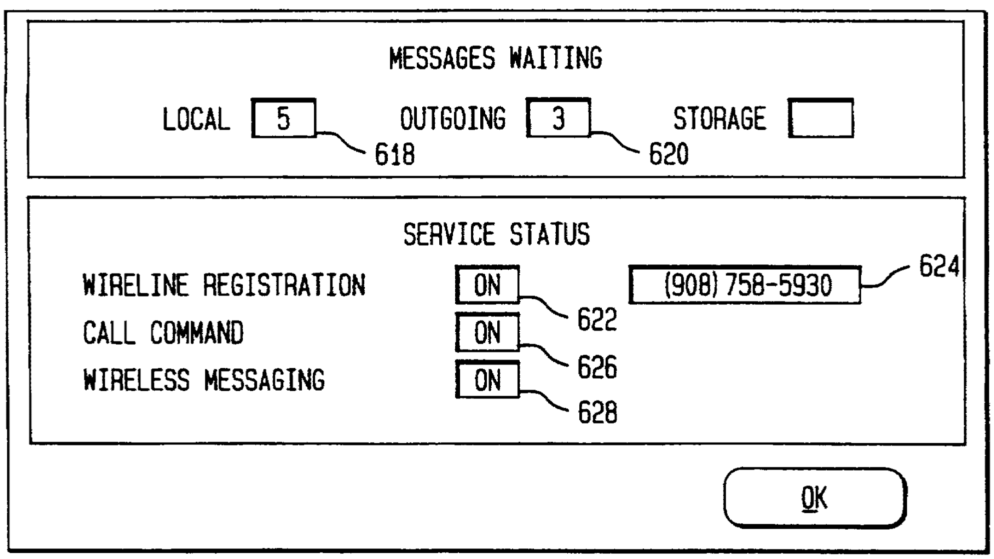


FIG. 30

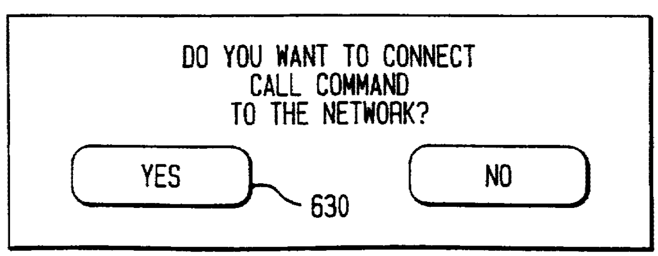


FIG. 31

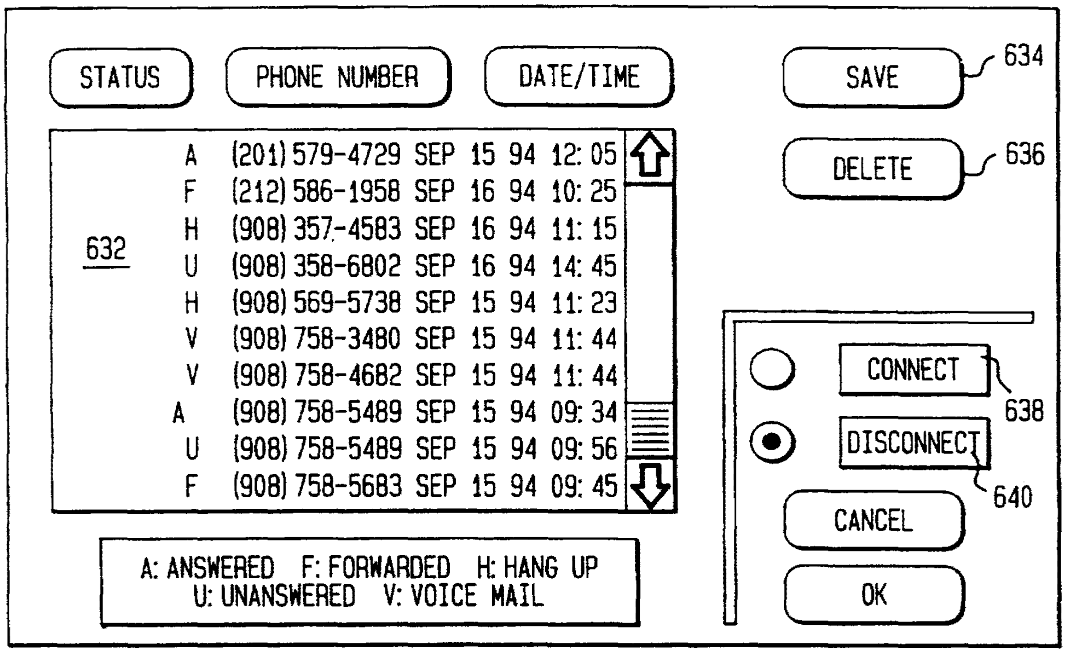


FIG. 33

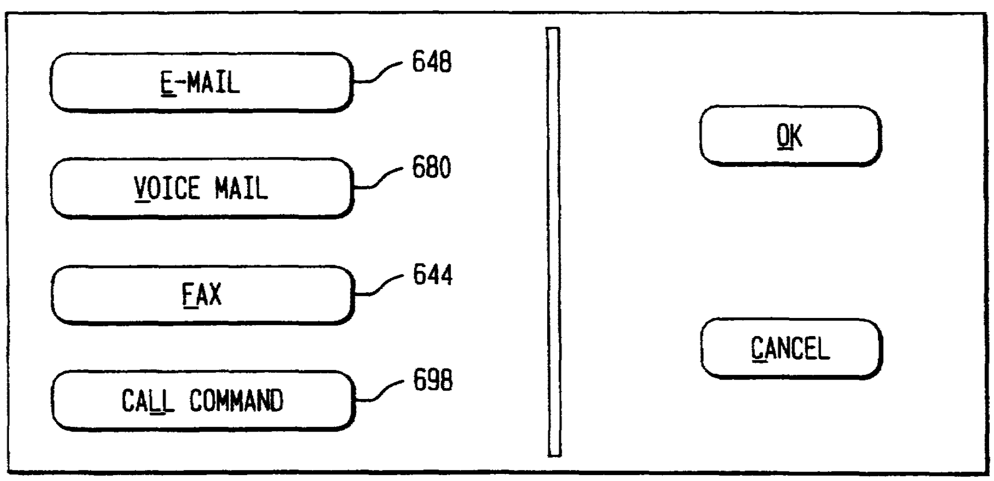


FIG. 32

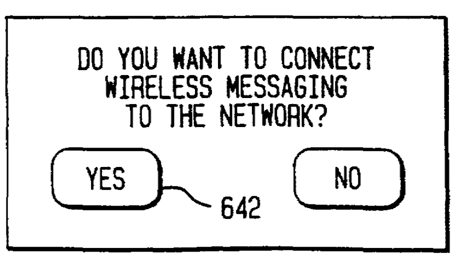


FIG. 34

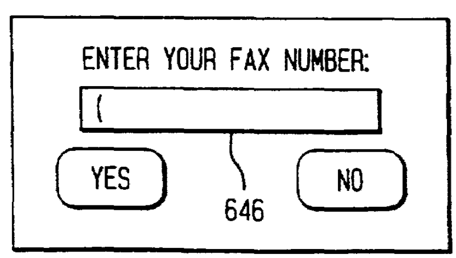


FIG. 35

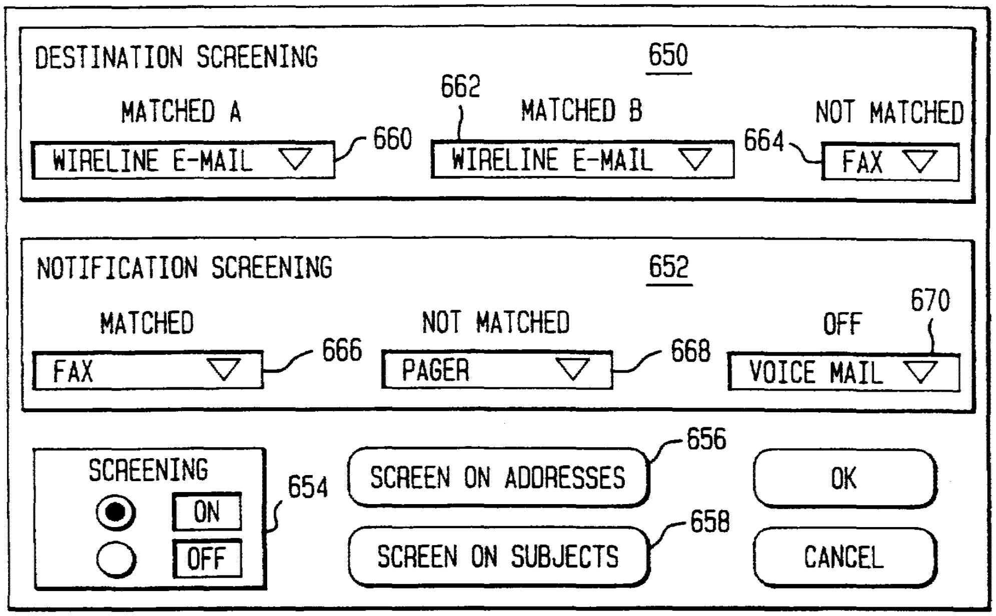


FIG. 36

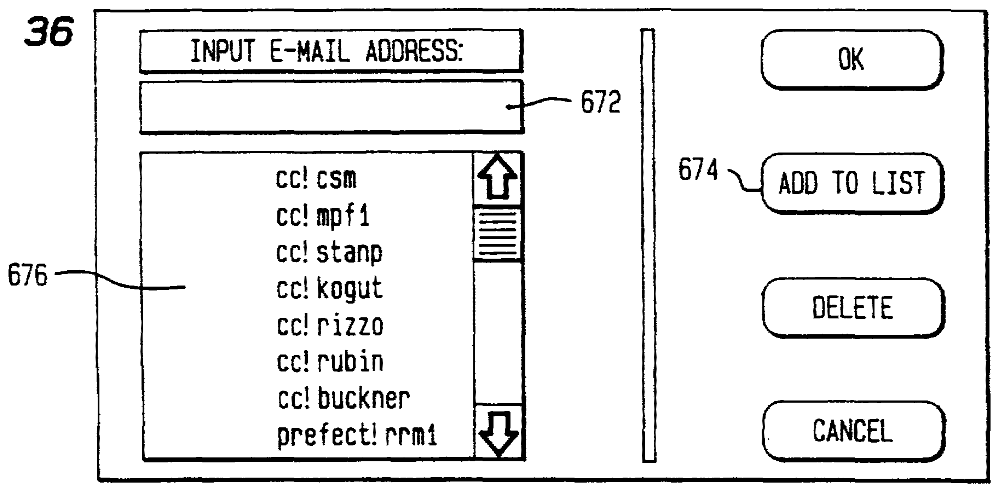


FIG. 37

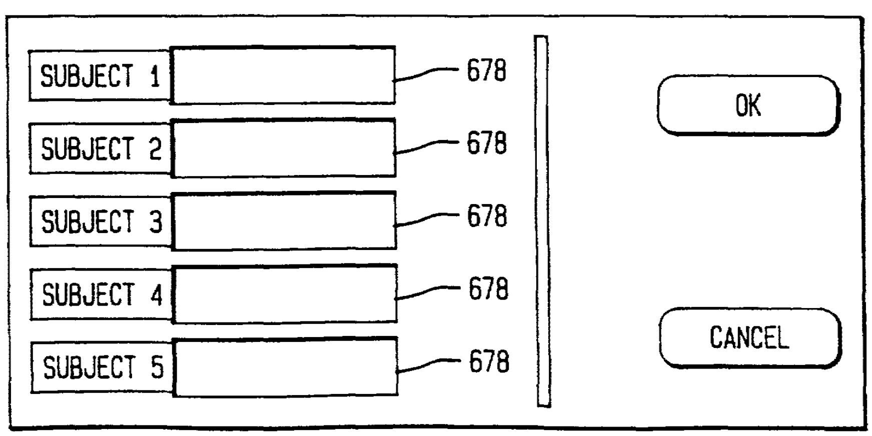


FIG. 38

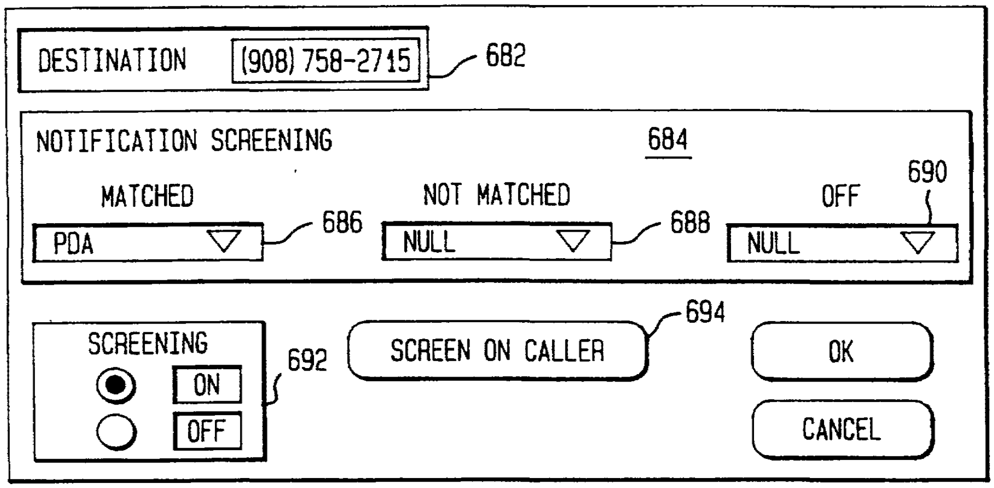


FIG. 39

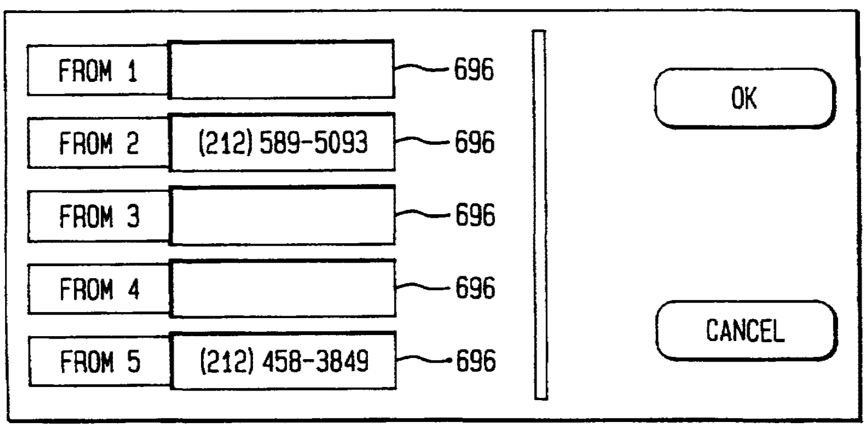


FIG. 40

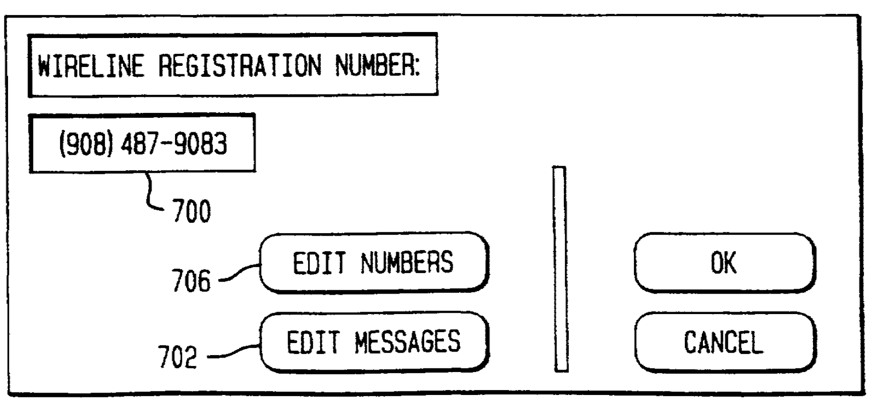


FIG. 41

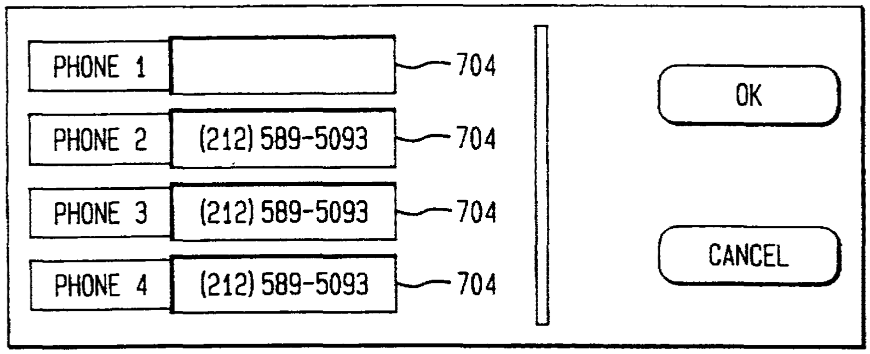


FIG. 42

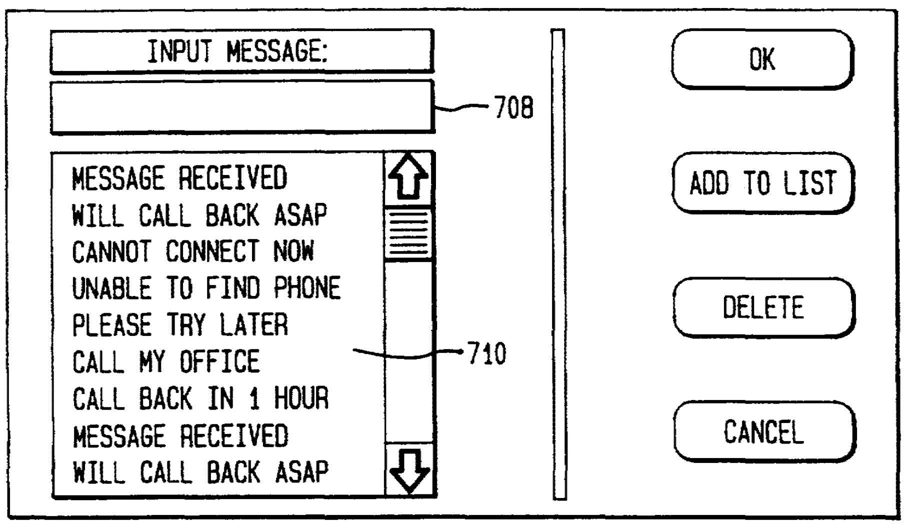


FIG. 43

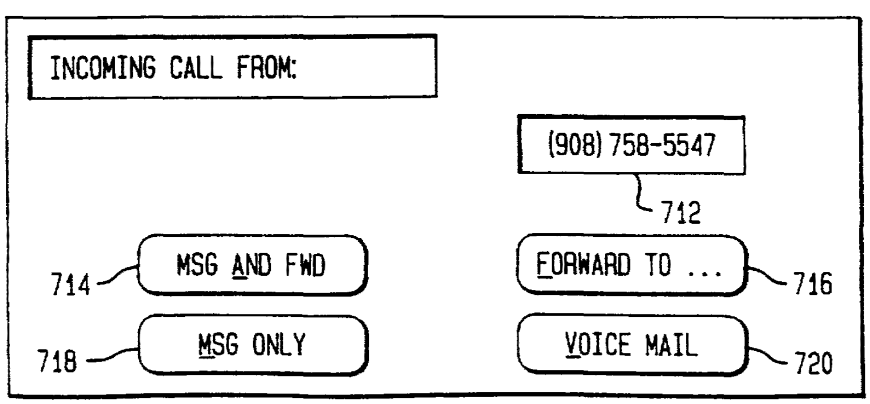


FIG. 44

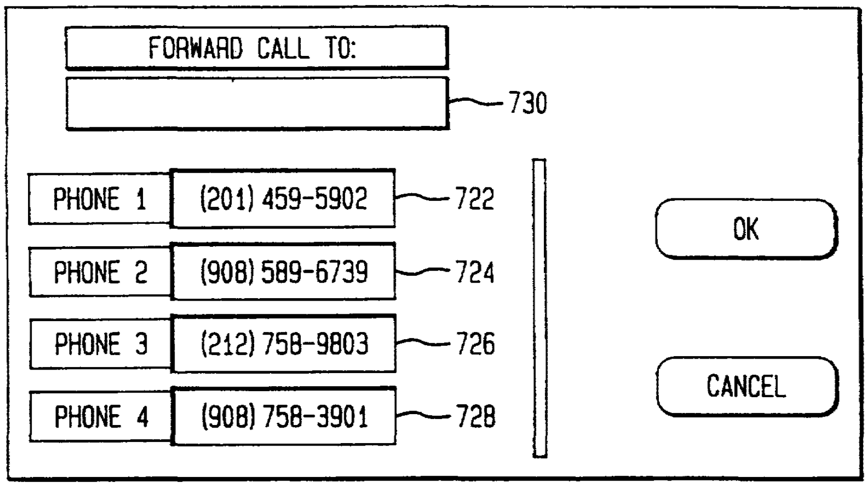
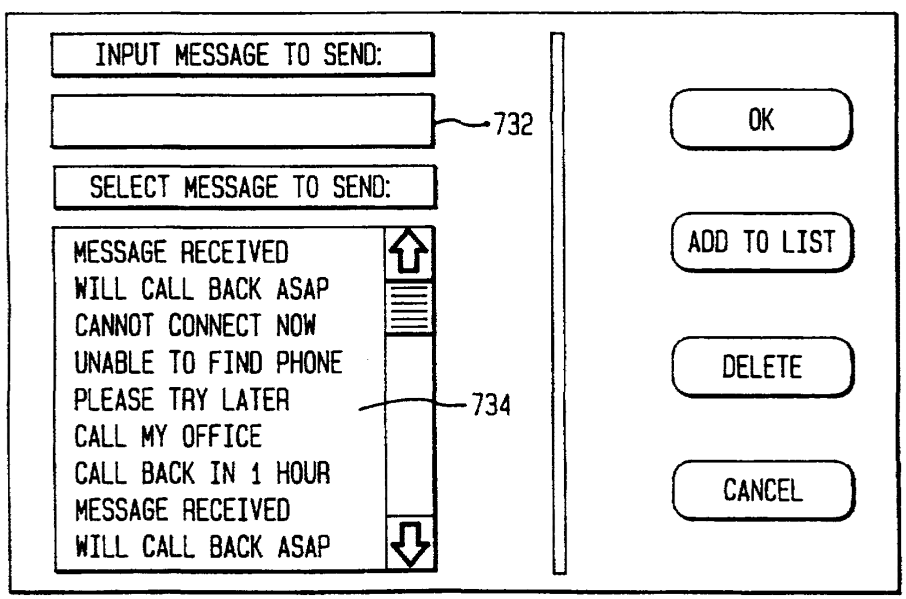

FORWARD CALL TO:
730
PHONE 1
(201) 459-5902
722
PHONE 2
(908) 589-6739
724
PHONE 3
(212) 758-9803
726
PHONE 4
(908) 758-3901
728
OK
CANCEL

FIG. 45


INPUT MESSAGE TO SEND:
732
SELECT MESSAGE TO SEND:
MESSAGE RECEIVED
WILL CALL BACK ASAP
CANNOT CONNECT NOW
UNABLE TO FIND PHONE
PLEASE TRY LATER
CALL MY OFFICE
CALL BACK IN 1 HOUR
MESSAGE RECEIVED
WILL CALL BACK ASAP
734
OK
ADD TO LIST
DELETE
CANCEL

INTERNATIONAL SEARCH REPORT

International application No. PCT/US96/03064

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04M 3/42
US CL :379/58, 211, 210, 212
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. : 379/58, 210, 211, 212

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)

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, 5,353,331, (EMERY ET AL) 04 OCTOBER 1994, ABSTRACT	1, 2, 35, 36, 38, 39
Y	US, A, 5,327,486, (WOLFF ET AL) 05 JULY 1994, col. 3, lines 38-40, col. 5, lines 1-6.	3, 4, 6, 22, 31 AND 34
Y	US, A, 5,479,472 (CAMPANA, Jr. ET AL) 26 DECEMBER 1995, ABSTRACT	47
Y	US, A, 5,329,578 (BRENNAN ET AL) 12 JULY 1994, Col. 4, Line 19- col. 13, line 56.	5, 7-21, 23-30, 33,37, 40-46, 48-52

☐ 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
17 MAY 1996	12 JUN 1996

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	LISA M. COWARD
Facsimile No. (703) 305-3230	Telephone No. (703) 305-4847

Form PCT/ISA/210 (second sheet)(July 1992)★

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
H04M 3/42

A1

(11) International Publication Number: WO 97/44943

(43) International Publication Date: 27 November 1997 (27.11.97)

(21) International Application Number: PCT/FI97/00299

(22) International Filing Date: 20 May 1997 (20.05.97)

(30) Priority Data:
962146 21 May 1996 (21.05.96) FI
964200 18 October 1996 (18.10.96) FI

(71) Applicant *(for all designated States except US)*: TELECOM FINLAND OY [FI/FI]; P.O. Box 106, FIN-00051 Tele (FI).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: SUOMINEN, Antti-Jussi [FI/FI]; Jaalaranta 9 B 39, FIN-00180 Helsinki (FI). MATTILA, Ari-Pekka [FI/FI]; Kukkumäenkuja 12 as, 4, FIN-02280 Espoo (FI). HOLMBERG, Andreas [FI/FI]; Gyldenintie 8 B 37, FIN-00200 Helsinki (FI). TÖHÖNEN, Harri [FI/FI]; Jääkärinkatu 8 A 11, FIN-00150 Helsinki (FI). HALME, Petri [FI/FI]; Sturenkatu 32-34 A 5, FIN-00550 Helsinki (FI). OLLIKAINEN, Jussi [FI/FI]; Vesakkotie 7 A 28, FIN-00630 Helsinki (FI).

(74) Agent: LAHTI, Heikki; Telecom Finland Oy, P.O. Box 106, FIN-00051 Tele (FI).

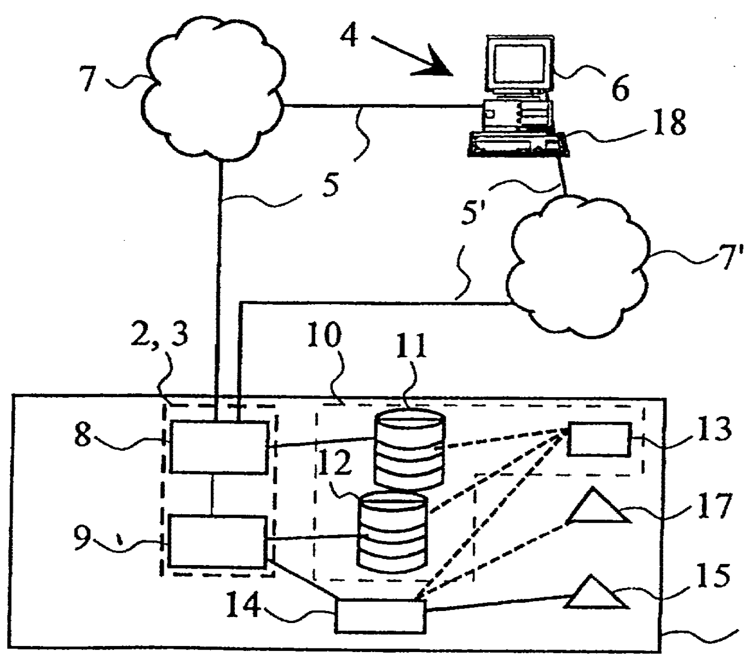
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), 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.
In English translation (filed in Finnish).

(54) Title: SYSTEM FOR MANAGING SUBSCRIBER RELATED SERVICES WITHIN A TELECOMMUNICATIONS NETWORK

(57) Abstract

The object of the invention is a novel system for changing and/or managing teleservices in the telenetwork. According to the invention with the server assembly controlled by a teleoperator an opportunity is arranged for the subscriber to change and browse for instance through Internet his own subscriber related coupled services. Because of the invention the control of services on one's own initiative by the subscriber's actions becomes easier than before. The invention also reduces and facilitates the work of the teleoperator.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

SYSTEM FOR MANAGING SUBSCRIBER RELATED SERVICES WITHIN A TELECOMMUNICATIONS NETWORK

The present invention relates to a novel system for modifying and/or managing teleservices within a telecommunications network.

Nowadays both in a fixed telephone network and in a mobile telephone network many service varieties are available relating to the possibilities offered by an operator of a wired or a wireless telephone. These services may include a fixed or a remote-controllable call diversion, knocking, blocking of the numerical display, advance noticing of the invoicing to the subscriber and the like. The use of these services is selective from the subscriber's point of view or the subscriber may decide, when he shall utilise each service. It is possible to couple the services for operation at least in two ways or by giving to the operator a commission to couple the service or by calling a certain number, which has a menu to be controlled by the keyboard of the telephone and a guiding voice.

At the present the subscriber may himself perform the control modes of his telecommunication services only in a very limited way through the telephone network (e.g. fixed call diversion programmed by the key combination *21 *... #). In configuration modifications that are even slightly more difficult one must call the teleoperator or service provider and ask him to make the desired change. In control solutions realised with the help of the voice frequency telephone (DTMF) and automatic telephone service systems (APJ) only telephone keys (=1, 2, ..., 0, #, *) and voice guides are available. By them it is difficult to carry out the control modes of complicated services so, that the final result would be ergonomic for the user. When the number of menus increases, the user often "drowns" among the menus and does not know any more (i.e. does not see) in which menu he/she is in any time, when the visual feedback from the location in the menu is lacking.

A further problem is that the teleoperator or service provider must bind resources to the customer service in order to be able to offer to the subscribers flexible control over their services.

The object of the present invention is to eliminate the above-mentioned drawbacks. The object of the present invention is particularly to set forth a novel method and system enabling coupling of the services related to the telephone by the subscriber's own actions. A further object of the invention is to facilitate by a graphical user interface the action of subscribers when selecting and guiding the services.

An object of the invention is further on to improve the possibilities of the customer to decide himself when and with what kind of configuration he wants to use his teleservices. At the same time the work load of the operator's customer service is reduced in simple configuration alterations.

An object of the invention is also to make it possible for a customer by a novel server platform implemented to a telecommunications network to get in contact with the teleservice library or -menu maintained by the teleoperator, and then with the help of a graphical user interface independently edit and control the desired teleservices.

The system according to the invention for managing subscriber related services, as call diversion or knocking by actions of a subscriber, includes according to the invention means for identifying the subscriber and means for forming a graphic or text-based presentation from the subscriber information on the grounds of the subscriber identification. In one preferable embodiment the server comprises a kind of a server platform, including a network server understanding the HTML-protocol, preferably an Internet-server and a changing and/or controlling server understanding also the HTML-protocol. The controlling server is preferably connected to the Internet-server, which is in connection to the teleoperator's database. In one advantageous embodiment the user interface of the changing and/or controlling server comprises a graphic operational connection of www-type. A subscriber register database is also preferably connected with the controlling server. In another advantageous embodiment both the teleoperator's database and the subscriber register database are in connection with the customer database transmitting the customer data to the adaptation server connected with the transforming and/or controlling server of teleservices.

The system includes also a terminal device according to the invention being connected by telecommunication connection, preferably Internet-network, to the server and to which device includes means to give a subscriber-related identification symbol to the server and a display to present subscriber-related information graphically or as text data. The telecommunication connection can be established also for example in the telephone network by a modem. The terminal device may comprise a computer, a portable mobile station or the like, and by it the control data given by the subscriber are transmitted to the server. Then the server relays to the subscriber according to the identification symbol given by the subscriber the menu of subscriber-related services, in which subscriber-related coupled services are presented, and a menu, from which the subscriber selects the service to be coupled.

An advantage of the present invention compared with the prior art is, that it is possible to offer to the user of the teleservice a control solution, by which the subscriber can be coupled to the operator's information systems and alter or check by himself the information included in his services in such a way, that the solution is sufficiently versatile, easy-to-use and economical for the user and on the other hand sufficiently flexible and safe for the operator.

Further because of the invention following advantages are obtained concerning the subscriber. The system according to the invention offers significantly more versatile alternatives to realise control solutions for complicated services including many qualities by the self-service principle, because the subscriber sees the respective configuration of his own services clearly in a visual way. A further advantage of the invention is that the subscriber may decide himself and select, when and what kind of service guiding he is going to use.

Additionally one advantage of the present invention considered from the operator's point of view is that there is no problem concerning the distribution and/or updating of the customer application, because this application is updated automatically for all users, when the operator updates the information of the concentrated server and the service routines integrated into it. Additionally because of the invention all the system components requiring the maintenance are in the operator's and service provider's own network and control. Thus also the service assortment visible to the subscriber can flexibly be altered.

Further on due to the invention the operator's work load is reduced in routine simple operations and the system is available from anywhere in the world through Internet. Additionally several services can flexibly be connected to the system and it can also be used as a marketing and advertising channel for new teleservices.

In the following the invention will be described with the help of enclosed performance examples with reference to the accompanying drawing, in which

figure 1 shows one system according to the present invention;

figure 2 shows diagrammatic plan of the operation of the system according to the invention; and

figure 3 shows as an example one graphical user interface according to the invention.

The system shown in Fig. 1 includes a computer 4 comprising the display 6 and the keyboard 18. The system comprises further the server platform 1, including the network server 8 and the control server 9. The computer 4 is associated through a telecommunication connection 5, 5' to the server 1. The telecommunication connection can be established to the Internet-network 7 or to any other corresponding network 7' transmitting the data. The server assembly 1 has been established advantageously by two server computers, of which one serves as a usual network server understanding the HTML-protocol for example in the Internet-network, and the other is also a control server understanding the HTML-protocol. In the computers 8, 9 suitable software 2, 3 has been arranged, by which the subscriber identification is established, when the subscriber is entering at the system, a graphic presentation is made for the services coupled to the subscriber and a service menu, from which the subscriber may couple for himself extra services. Such a graphic presentation comprises generally a WWW-page.

The system shown in Fig. 1 includes also database means 10, with which the teleoperator's database 11, the subscriber register database 12 and the customer database 13 are maintained. The database means are connected to the server 1, whereby it is possible to obtain subscriber-related information from the databases and the services coupled by the subscriber can be updated to them under the control of the server. In Fig. 1 it is shown an application server 15, which is coupled between the telephone network and the Internet-network. In Fig. 1 it is also set forth a service network element 17, with which an external service provider may connect his own service to the system.

In the following it is presented with reference to figure 2 and figure 3, in which one exemplary graphical user interface 16 is shown, one example of the subscriber's login procedure. In Fig. 2 in the block 19 the teleoperator's home page in Internet is described. From this home page the subscriber gets the connection to other WWW-services, block 21, and to the system according to the invention, block 20. In this way the subscriber may select a link from any start page to the system in question 20. According to the invention it is possible to connect different subscribers, as private and business customers, to the system. Different customers are described by the blocks shown by the arrow 22. The customer enters to the system in the block 24 and in association with the login the system checks the subscriber information from different databases. After the login, block 23, a subscriber-related service menu 16 is opened to the subscriber, which menu is shown in Fig. 3. The service menu 16 may include different kinds of optional services, blocks 25 - 31. In one example by selecting one block 25 - 31 and accepting the selection the subscriber may couple the service in question on or off depending the service status at that time. Based on this the control server 9 updates databases according to the need.

It is also pointed out that Internet is by no means the only possible operational environment, but that any other telecommunication network system is valid. It is not either required that a WWW- user interface compatible with the IP-protocol will necessarily be used as a graphical user interface, but any other graphical user interface, e.g. MS-WINDOWS, is valid for realising the principal idea of the present invention. It should be observed that it is possible to use a traditional text-based user interface to be offered via the terminal connection.

As a conclusion about the invention it is possible to state as follows. By the invention following problems will be solved. Firstly the user identification can automatically be made in association with the login. Further on the system according to the invention offers a user-related and dynamically changing graphical interface that the teleoperator may control. The subscriber is also connected by the user identifier to the information used by the telephone network and only limited operations are permitted and only limited information is presented to the user. The limitation can be made relating to the subscriber based on the user identification. Further on the access of the user to the information of other users is prevented in the system.

The invention is not limited only to the embodiment examples presented above, but many modifications are possible while staying within the inventive idea defined in the accompanying claims.

CLAIMS

1. A system for managing telephone network's subscriber related services, as call diversion, knocking and the like by actions of the subscriber, c h a r a c t e r i z e d in that the system includes:

a server (1), including means (2) for a subscriber identification and means (3) for establishing a graphic or text-based presentation from the subscriber-related information on the grounds of the subscriber identification; and

a terminal device (4), which is connected by a telecommunication connection (5) to the server and have means (18) for giving the subscriber related identification to the server and a display (6) for the presentation of the subscriber related information graphically or as text data in order to transmit the control information given by the subscriber to the server,

whereby the server transmits to the subscriber according to the identifier given by the subscriber a menu of subscriber related services, in which are presented the subscriber related coupled services, and a menu, from which the subscriber selects the service to be coupled.

2. A system according to claim 1, c h a r a c t e r i z e d in that the server (1) is realised in a telecommunication network (7); and that the server includes:

a network server (8) for establishing a telecommunication connection (5) to the telecommunication network and through this to the terminal device (4); and

a control server (9), which is connected to the network server for controlling subscriber related services in the telephone network, and to which has been arranged a graphical user interface.

3. A system according to claims 1 or 2, c h a r a c t e r i z e d in that the system includes database means (10) for maintaining teleoperator's database

(11), subscriber register database (12) and customer database (13).

4. A system according to any of the preceding claims 1 - 3, c h a r a c t e r i z e d in that the system includes an application server (14), which is arranged to combine together the telephone network and the telecommunication network (7).

5. A system according to claim 4, c h a r a c t e r i z e d in that the system includes a service network element (15) for coupling the services of a service provider to the system.

6. A system according to any of the preceding claims 1 - 5, c h a r a c t e r i z e d in that the graphical user interface includes a subscriber-related service menu (16).

7. A system according to any of the preceding claims 1 - 6, c h a r a c t e r i z e d in that the system includes a teleservice library (17), to which has been deposited the information concerning the service provided in the telephone network, and which is maintained by the teleoperator and/or the service provider; and that a connection is arranged from the server (1) to the teleservice library.

8. A system according to any of the preceding claims 1 - 7, c h a r a c t e r i z e d in that the telecommunication connection between the server (1) and the terminal device (5) has been established by a HTML-protocol.

9. A system according to any of the preceding claims 1 - 8, c h a r a c t e r i z e d in that the telecommunication network comprises the Internet-network or the like.

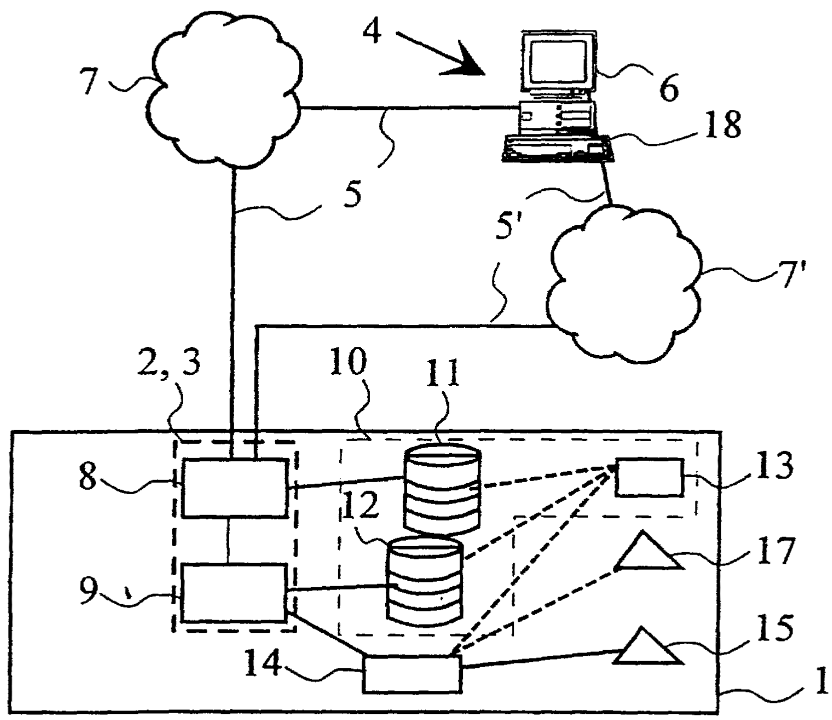


Fig 1

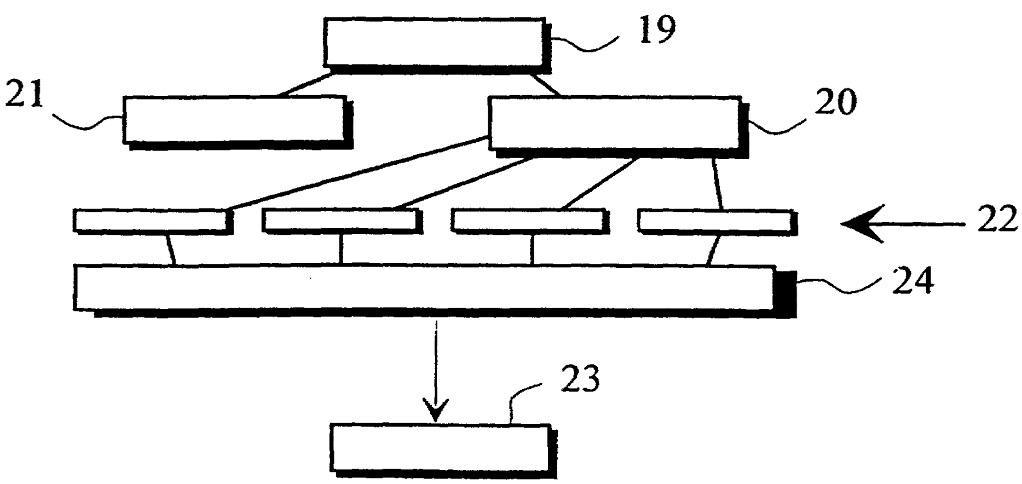


Fig 2

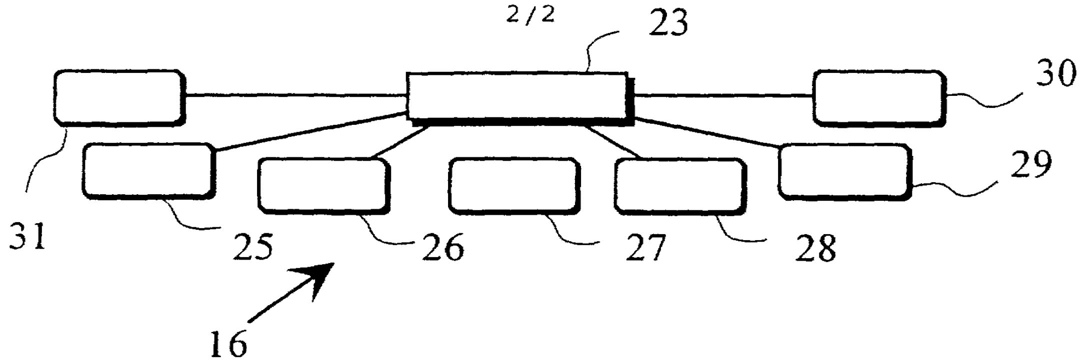


Fig 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 97/00299

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04M 3/42
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)

IPC6: H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, 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.
A	WO 9211724 A1 (BELL COMMUNICATIONS RESEARCH, INC.), 9 July 1997 (09.07.97) --	1-9
A	WO 9613927 A1 (TELEFONAKTIEBOLAGET LM ERICSSON), 9 May 1996 (09.05.96) --	1-9
A	US 5241588 A (BABSON, III ET AL), 31 August 1993 (31.08.93) --	1-9
A,P	WO 9631987 A1 (NOKIA TELECOMMUNICATIONS OY), 10 October 1996 (10.10.96) -- --------	1-9

☐ 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" erlier 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

Date of the actual completion of the international search	Date of mailing of the international search report
3 Sept 1997	04 -09- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Friedrich Kühn Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

06/08/97

International application No.
PCT/FI 97/00299

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9211724 A1	09/07/97	AU 9177791 A	22/07/92
		CA 2098607 A,C	19/06/92
		EP 0563319 A	06/10/93
		JP 6502752 T	24/03/94
		US 5323452 A	21/06/94
WO 9613927 A1	09/05/96	SE 9701566 A	25/06/97
US 5241588 A	31/08/93	AU 9173391 A	22/07/92
		CA 2098608 A,C	19/06/92
		CA 2190888 A	19/06/92
		CA 2190889 A	19/06/92
		CA 2190890 A	19/06/92
		EP 0572439 A	08/12/93
		JP 6502751 T	24/03/94
		WO 9211603 A	09/07/92
WO 9631987 A1	10/10/96	AU 5149696 A	23/10/96
		FI 951602 A	05/10/96

Form PCT/ISA/210 (patent family annex) (July 1992)

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04Q 7/22, 7/38	A2	(11) International Publication Number: **WO 98/00988** (43) International Publication Date: 8 January 1998 (08.01.98)

(21) International Application Number: PCT/US97/11656

(22) International Filing Date: 30 June 1997 (30.06.97)

(30) Priority Data:
08/677,048 1 July 1996 (01.07.96) US

(71) Applicant: ERICSSON INC. [US/US]; 7001 Development Drive, P.O. Box 13969, Research Triangle Park, NC 27709 (US).

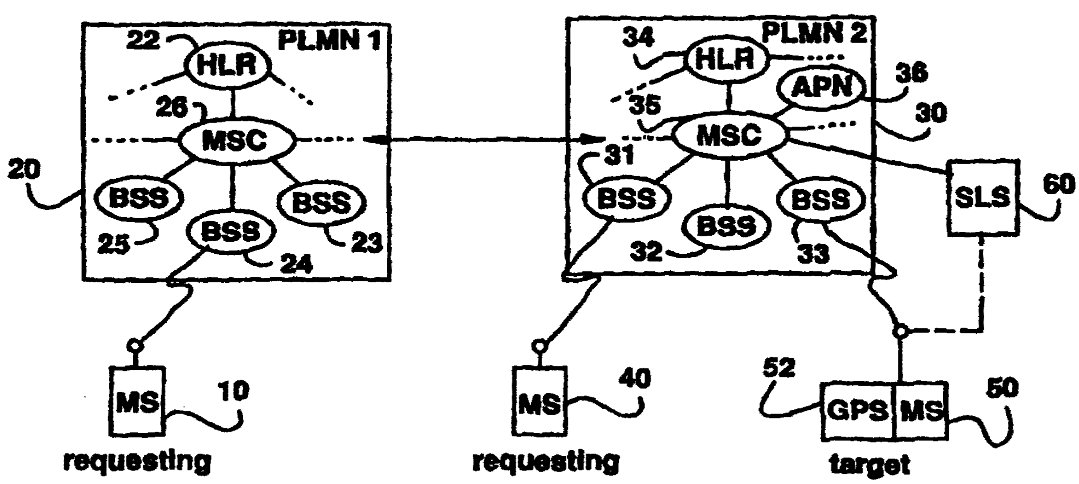
(72) Inventors: BOLTZ, David; 901 Loch Ness Lane, Garland, TX 75044 (US). MAUPIN, Alain, Guy; 1133 Lookout Drive, Richardson, TX 75080 (US). MAO, Xiaohong; 2400 Waterview Parkway #424, Richardson, TX 75080 (US).

(74) Agents: MOORE, Stanley, R. et al.; Jenkens & Gilchrist, P.C., Suite 3200, 1445 Ross Avenue, Dallas, TX 75202 (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, 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), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), 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
Without international search report and to be republished upon receipt of that report.

(54) Title: METHOD AND APPARATUS FOR COMMUNICATING INFORMATION ON MOBILE STATION POSITION WITHIN A CELLULAR TELEPHONE NETWORK



(57) Abstract

Position information regarding a mobile station is determined and provided upon request. In one situation, mobile station position is determined in response to a request from another mobile subscriber (10, 40) and displayed (226) on the requesting mobile station display. Mobile station position is also determined in response to a request from a land line user (70) and provided through either a synthesized voice communication (233), a data message (225) or a facsimile message (237). Mobile station positions are further provided in response to law enforcement (320) and other public service entity (422) requests. This information is useful in tracking a mobile station (312, 412) either during a call or when the mobile station is idle. In another instance mobile station location information is used to insure routing (434) of emergency (911) calls (424) to the proper public safety answering point (422). The system further has the capability of being programmed with certain response criteria applicable to the determination of mobile station position. Such criteria include accuracies, confidence factors, periods between location reports, and location determination technique.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania
AM	Armenia
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CU	Cuba
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GH	Ghana
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakstan
LC	Saint Lucia
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
MK	The former Yugoslav Republic of Macedonia
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam
YU	Yugoslavia
ZW	Zimbabwe

METHOD AND APPARATUS FOR COMMUNICATING INFORMATION ON MOBILE STATION POSITION WITHIN A CELLULAR TELEPHONE NETWORK

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates to locating the geographic position of a mobile station operating within a cellular telephone network and, in particular, to the provision of the determined geographic position information in response to requests from, for example, other subscribers and public service agencies, and further to the use of mobile station location information to direct the routing of emergency cellular telephone calls and the rendering of emergency assistance.

Description of Related Art

Cellular telephone networks typically include a plurality of base stations connected to a centrally-located switch commonly referred to as a mobile switching center. Base stations may be spaced apart from each other by distances of between one-half and twenty kilometers. Each base station is assigned a number of two-way voice channels and control channels. The voice channels are used to transmit voice signals to and from proximately located mobile stations. The control channels are used for the transmission of control information to and from those mobile stations, usually for the purpose of establishing a voice communications link.

The control channels used for transmissions from a base station to a mobile station are called the "forward" control channels. The forward control channel is generally a common channel, which means that any mobile station may access the channel and listen for messages transmitted by the base station. Conversely, the control channels used for transmissions from the mobile station to the base station are referred to as "reverse" control channels. The reverse control channels may be common, in which case there may be contention for access, or may be dedicated, which means that they are reserved or assigned for the use of a single mobile station in making a transmission to a base station.

Cellular telephone networks typically include a plurality of interconnected mobile switching centers, including a gateway mobile switching center through which the network interconnects with the conventional public switched telephone network. At least one home location register is included within a cellular telephone network. The home location register is used to store subscriber information including an identification of current mobile station location within the network.

In response to an incoming call dialed to a given mobile station, a signal is sent to the home location register requesting routing information through the network to the called mobile station. The home location register looks up the current location of the mobile station and contacts the currently serving mobile switching center to pre-route the call and retrieve a temporarily location directory number which is used to route the call through the network for delivery to the mobile station. The serving mobile switching center retrieves from a visitor location register an identification of the cell within which the called mobile station is currently located. The mobile switching center then instructs the base station associated with that cell to page the mobile station. Responding to the page, the mobile station requests assignment of a channel, and the network routes the call through the serving mobile switching center and over the assigned channel.

Conventional cellular telephone technology, by itself, does not include the capability of pinpointing, with any reasonable or useful degree of accuracy, the location of the mobile subscriber. For example, using a conventional cellular telephone network, the extent of the location precision typically available is to identify the cell within which a mobile station is located. Some cells, though, have a coverage radius in excess of one kilometer. Thus, cell location identification accordingly provides little, if any, assistance in actually locating the position of the subscriber. Accordingly, a number of systems have been proposed to assist in the location determination and provide more accurate position information. One system utilizes a triangulation or arcuation process to determine an approximate location of the caller through an analysis of signal strength measurements and/or propagation delay times of the cellular communications. Another system utilizes the existing Global Positioning System (GPS) with a GPS receiver attached to the cellular telephone to obtain geo-coordinates for the mobile station.

Although many systems have been proposed for more precisely identifying the location of a mobile station, it is equally important that the determined position information be provided to the persons or entities who need the information. Take first, for example, the cellular subscriber himself. It is not unusual for the subscriber to get lost and realize that they need to know their precise location in order to obtain directions. Absent the presence of landmarks or other location indicia (like street signs), the subscriber has no way of identifying their location without asking for help. In certain situations, like in rural areas, such help may not be available. It would be an advantage then if the cellular subscriber could use his or her mobile station to signal the cellular telephone network to make a position determination and relay that information to the subscriber for subsequent use in calling for directions.

In another example, consider the person who desires to know the location of a cellular subscribing family member or friend. The family member or friend may be late for an appointment and the person becomes concerned that they may be lost, injured or otherwise in need of assistance. Alternatively, the person may suspect that the family member is engaging in an undesirable activity and wish to monitor their location. In any case, it would be an advantage if that person could signal the cellular telephone network to make a position determination on a particular mobile station and relay that information back to the person for evaluation.

In yet another example, consider the situation where a law enforcement agency desires to know the location of either a mobile station or the person using the mobile station. Thus, for a mobile station located in a stolen vehicle, the law enforcement agency would want to monitor the location of the mobile station, and hence the stolen vehicle itself, to assist in apprehending the thief. Alternatively, a law enforcement agency may have an interest in monitoring not only the cellular telephone communications made by a cellular service subscripting suspect, but also the locations from which those calls are occurring. It would be an advantage, then, if the law enforcement agency could signal the cellular telephone network to make a position determination on a particular mobile station and relay that information back for use in tracking the suspect.

Cellular subscribers now frequently use their mobile stations to make emergency (911) calls. Unlike conventional land line telephones, mobile stations have no fixed address relating to a location which may be obtained by the public safety answering point (PSAP) when an emergency call is made. Accordingly, it would be an advantage, then, if the public safety answering point could signal the cellular telephone network to make a position determination on a particular mobile station from which an emergency call originates and relay that information back for use in dispatching emergency service aid.

Furthermore, knowing the location of the mobile station does not comprise the only concern in rendering emergency services in response to a cellular emergency call. It is also important that the emergency cellular call be routed through the network to the proper public safety answering point in those instances where the calling mobile station is roaming. In such cases, it would be an advantage if a switch handling the call could request location information on a particular roaming mobile station from which an emergency call is originated and use that information in determining which public safety answering point is the correct public safety answering point (based on proximity to the mobile station) to handle the call and dispatch the emergency service aid. It would further be an advantage if position information could be determined in response to that same request and provided to the correct public safety answering point for use in directing emergency services personnel to the aid of the subscriber.

SUMMARY OF THE INVENTION

The present invention comprises a system for selectively conveying mobile station position information to requesting entities. In a first embodiment, the system responds to a position request from another mobile station by routing the request to the serving switching node, processing location information to determine a mobile station position, and routing a return message identifying the determined position to the requesting mobile station. In another embodiment, the system responds to a position request from a land line telephone user by routing the request to the serving switching node, processing location information to determine a mobile station position, and routing a return message identifying the determined position to the requesting user for presentation in either a synthesized oral manner, as a data message, or as a facsimile message. In another embodiment, the requesting entity comprises a public service entity such as a law enforcement agency, and the system responds to a position request by routing the request to the serving base station controller, processing location information to determine a mobile station position, and routing a return message identifying the determined position to the requesting entity.

The present invention still further comprises a system for determining mobile station location, and processing location information to identify a proper public safety answering point to which an emergency call from that mobile station should be routed. In connection therewith, an anchor exchange recognizes that the mobile station is roaming and wants to place an emergency call, and requests from the serving exchange an identification of the mobile station location. This information is then used to route the call to the proper public safety answering point. Furthermore, either the anchor exchange or the public safety answering point to which the emergency call is routed may then make a request for the determination of mobile station position, with the returned information useful in directing the dispatch of emergency services aid.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be acquired by reference to the following Detailed Description when taken in conjunction with the accompanying Drawings wherein:

FIGURE 1 is a block diagram of a cellular telephone network in accordance with the present invention which supports responding to requests regarding mobile station position;

FIGURE 2 is a block diagram of a base station system like that used in the cellular telephone network of FIGURE 1;

FIGURE 3 is a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 1 in a first scenario for providing position information on a target mobile station;

FIGURE 4 is a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 1 in a second scenario for providing position information on a target mobile station;

FIGURE 5 is a block diagram of a telephone network in accordance with the present invention which supports responding to requests regarding mobile station position;

FIGURE 6 is a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 for providing position information on a target mobile station;

FIGURE 7 is a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 in delivering mobile station position information to a data terminal;

FIGURE 8 is a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 in delivering mobile station position information to a telephone;

FIGURE 9 is a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 in delivering mobile station position information to a facsimile machine;

FIGURE 10 is a block diagram of a cellular telephone network in accordance with the present invention which supports delivery of mobile station position information to public service entities;

FIGURE 11 is a signal flow and nodal operation diagram illustrating the operation of the cellular telephone network of FIGURE 10 in providing position information on a mobile station during an ongoing cellular voice/data communication;

FIGURE 12 is a signal flow and nodal operation diagram illustrating the operation of the cellular telephone network of FIGURE 10 in providing information on a mobile station while in an idle operating mode;

FIGURE 13 is a block diagram of a cellular telephone network in accordance with the present invention equipped to provide emergency situation caller assistance; and

FIGURE 14 is a signal flow and nodal operation diagram illustrating the operation of the cellular telephone network of FIGURE 13 in providing location information on a mobile station for purposes of properly routing an emergency cellular call.

DETAILED DESCRIPTION OF THE DRAWINGS

Reference is now made to FIGURE 1 wherein there is shown a block diagram of a cellular telephone network including a plurality of individual Public Land Mobile Networks (PLMNs) 20 and 30. The first Public Land Mobile Network 20 includes a mobile switching center 26 connected to a plurality of base station systems (BSSs) 23, 24 and 25. It will, of course, be understood that the Network 20 likely includes a plurality of mobile switching centers 26. The mobile switching center 26 is further connected to a home location register 22. The second Public Land Mobile Network 30 is similarly configured having a mobile switching center 35 connected to a plurality of base station systems 31, 32 and 33. Again, it is likely that the Network 30 includes a plurality of mobile switching centers 35. The mobile switching center 35 is further connected to a home location register 34. At least one mobile switching center 26 of the first Public Land Mobile Network 20 and at least one mobile switching center 35 of second Public Land Mobile Network 30 are interconnected for both voice/data communications and signaling transmissions in a manner well known to those skilled in the art.

Reference is now additionally made to FIGURE 2 wherein there is shown a block diagram of the base station systems 23, 24, 25, 31, 32 or 33. Each base station system comprises a base station controller (BSC) 108 connected to a plurality of base stations (BS) 102, 104 and 106. At least one base station is provided for each cell in the network. It is through the base stations 102, 104 and 106 that radio frequency communications with proximately located mobile stations (MS) are effectuated. The base station controller 108 is connected to the mobile switching center 26 or 35 shown in FIGURE 1. Operation of a Public Land Mobile Network 20 or 30 in providing cellular communications services to mobile stations through the base station controller 108 and base stations 102, 104 and 106 is well known to those skilled in the art.

Referring now again to FIGURE 1, instances often arise wherein a subscriber (not shown) having a mobile station 10 or 40 desires to know the geographic position/location of another (target) subscriber mobile station 50. The cellular telephone network of FIGURE 1 supports responding to mobile station 10 and 40 position requests by determining the position of the target mobile station 50 and responding to the requesting mobile station in an appropriate manner.

Take first the scenario where the requesting mobile station 10 is located in a different Public Land Mobile Network 20 than the target mobile station 50. Additional reference is now made to FIGURE 3 wherein there is shown a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 1 in a first scenario for providing position information on the target mobile station 50. Requesting mobile station 10 first (action 200) enters a service feature code, identifying a mobile station position request, along with the mobile station integrated service directory number (MSISDN) of the target mobile station 50. A signal 202 is then sent over a control channel by the requesting mobile station 10 to its serving base station system 24 using an Unstructured Supplementary Service Data (USSD) or Direct Transfer Access Point (DTAP) message. Responsive thereto, the base station system 24 routes (signal 204) the request to the mobile switching center 26. The mobile switching center 26 analyzes the directory number of the requesting mobile station 10 to determine its home location register 22. A query (signal 206) is then sent to the home location register 22 requesting confirmation that the requesting mobile station 10 is subscripted to the requested mobile station position service feature. A response (signal 208) is sent back to the mobile switching center 26. Alternatively, the requesting mobile station 10 subscription may be checked by the mobile switching center 26 itself (through its visitor location register), thus obviating the need for signals 206 and 208. If the response is affirmative, the mobile switching center 26 analyzes the directory number of the target mobile station 50, and sends a modified Mobile Application Part (MAP) message, referred to as a provide location information (PLI) request signal 210, to the home location register 34 for the target mobile station 50. The home location register 34 determines that mobile switching center 35 is currently serving the target mobile station 50. The provide location information request is then routed (signal 212) to mobile switching center 35. A location determination (action 214) with respect to the target mobile station 50 is then made in accordance with one of a number of known procedures. These procedures are briefly described later. The determined target mobile station 50 location information is then sent by the serving mobile switching center 35 to the home location register 34 again using a modified Mobile Application Part message signal 216. The information is then forwarded by signals 218, 220 and 222 through the mobile switching center 26 and base station system 24 to the requesting mobile station 10. The information is then processed (action 224) by the mobile station 10 and displayed (action 226) for subscriber review.

In a second scenario, the requesting mobile station 40 is located in the same Public Land Mobile Network 30 as the target mobile station 50. Additional reference is now made to FIGURE 4 wherein there is shown a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 1 in a second scenario for providing position information on a target mobile station 50. Requesting mobile station 40 first (action 200) enters a service feature code, identifying a mobile station position request, along with the mobile station integrated service directory number (MSISDN) of the target mobile station 50. A signal 202 is then sent over a control channel by the requesting mobile station 40 to its serving base station system 31 using an Unstructured Supplementary Service Data (USSD) or Direct Transfer Access Point (DTAP) signal. Responsive thereto, the base station system 31 routes (signal 204) the request to the mobile switching center 35. The mobile switching center 35 analyzes the directory number of the requesting mobile station 40 to determine its home location register 34. A query (signal 206) is then sent to the home location register 34 requesting confirmation that the requesting mobile station 40 is subscripted to the requested mobile station position service feature. A response (signal 208) is sent back to the mobile switching center 35. Again, subscription verification may be performed directly by the mobile switching center 35 obviating the need for signals 206 and 208. If the response is affirmative, the mobile switching center 35 analyzes the directory number of the target mobile station 50, and sends a modified Mobile Application Part (MAP) message, referred to as a provide location information (PLI) request signal 210, to the home location register 34 for the target mobile station 50. The home location register 34 determines that mobile switching center 35 is currently serving the target mobile station 50. The provide location information request is then routed (signal 212) back to mobile switching center 35. A location determination (action 214) with respect to the target mobile station 50 is then made in accordance with one of a number of known procedures. These procedures are briefly described herein. The determined target mobile station 50 location information is then sent by the serving mobile switching center 35 to the home location register 34 using a modified Mobile Application Part message signal 216. The information is then forwarded by signals 218, 220 and 222 back through the mobile switching center 35 and base station system 31 to the requesting mobile station 40. The information is then processed (action 224) by the mobile station 40 and displayed (action 226) for subscriber review.

Although mobile stations 40 and 50 are illustrated in FIGURE 1 as being served by the same mobile switching center 35 of the second Public Land Mobile Network 30, it will be understood that this need not necessarily be so. When different mobile switching centers 35 are involved, the signals 212 and 220 are routed to the correct one of the mobile switching centers in a manner well known in the art (and similarly to that illustrated in FIGURE 3).

Reference is now made to FIGURE 5 wherein there is shown a block diagram of a telephone network including a Public Switched Telephone Network 90 and a Public Land Mobile Network 30. The Public Land Mobile Network 30 is similar to that shown in FIGURES 1 and 2 to include a mobile switching center 35 connected to a plurality of base station systems 31, 32 and 33. The mobile switching center 35 is further connected to a home location register 34. The Public Switched Telephone Network 90 is not illustrated in detail, but does include, for purposes of the present invention, an end office exchange (EO) 82. Connected to the end office 82 are a telephone unit (TU) 70, data terminal equipment (DTE) 72 (comprising, perhaps, a personal computer), and a facsimile machine (FAX) 74. The mobile switching center 35 of the Public Land Mobile Network 30 and the end office 82 of the Public Switched Telephone Network 90 are interconnected for both voice/data communications and signaling transmissions in a manner well known to those skilled in the art.

Instances often arise wherein a person (not shown) having a telephone unit 70 desires to know the geographic position/location of a subscriber mobile station 50. The telephone network of FIGURE 5 supports responding to telephone unit 70 position requests by determining the position of the target mobile station 50 and responding to the requesting person in an appropriate manner.

Reference is now additionally made to FIGURE 6 wherein there is shown a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 for determining the position of a target mobile station 50. Requesting telephone unit 70 first (action 201) enters a service feature code, identifying a mobile station position request, along with the mobile station integrated service directory number (MSISDN) of the target mobile station 50. The manner of position information delivery (i.e., voice back to the telephone unit, or data to either the data terminal equipment 72 or facsimile machine 74) is also specified. A signal 203 is accordingly sent from the requesting telephone unit 70 to its serving end office 82. Responsive thereto, the Public Switched Telephone Network 90 then confirms (action 205) that the requesting telephone unit 70 is subscripted to the requested mobile station position service feature. If this is confirmed, the end office 82 analyzes the directory number of the target mobile station 50, and sends a modified Mobile Application Part (MAP) message or perhaps a Transaction Control Application Part (TCAP) message, referred to as a provide location information (PLI) request signal 207, to the home location register 34 for the target mobile station 50. The home location register 34 determines that mobile switching center 35 is currently serving the target mobile station 50. The provide location information request is then routed (signal 209) to mobile switching center 35. A location determination (action 211) with respect to the target mobile station 50 is then made in accordance with one of a number of known procedures. These procedures are briefly described later. The determined target mobile station 50 location information is then sent by the serving mobile switching center 35 to the home location register 34 using a modified Mobile Application Part message signal 213. The information is then forwarded by signals 215 and 217 through the end office 82 of the Public Switched Telephone Network 90 to an adjunct processing node (APN) 76. It will, of course, be understood that the adjunct processing node 76 functionality may be provided within the end office 82 itself. The manner of position information delivery input by the person at the telephone unit 70 is then processed (action 219) to determine whether the position information should be delivered to the telephone unit, data terminal equipment 72 or the facsimile machine 74.

Reference is now made to FIGURE 7 wherein there is shown a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 in delivering mobile station position information to the data terminal equipment 72. Following processing in action 219 to identify the data terminal equipment 72 as the delivery destination for the position information, the adjunct processing node 76 properly formats (action 221) the position information for data delivery, initiates a call (action 223) through the end office 82 to the data terminal equipment 72, and transmits the formatted position information over call connection 225.

Reference is now made to FIGURE 8 wherein there is shown a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 in delivering mobile station position information to the telephone unit 70. Following processing in action 219 to identify the telephone unit 70 as the delivery destination for the position information, the adjunct processing node

76 initiates a call (action 229) through the end office 82 to the telephone unit 70. Once a call connection 231 is established between the adjunct processing node 76 and telephone unit 70, the adjunct processing node synthesizes (action 233) a voice message relating the determined position information to the requesting person.

Reference is now made to FIGURE 9 wherein there is shown a signal flow and nodal operation diagram illustrating operation of the network of FIGURE 5 in delivering mobile station position information to a facsimile machine 74. Following processing in action 219 to identify the facsimile machine 74 as the delivery destination for the position information, the adjunct processing node 76 properly formats (action 221) the position information for facsimile delivery, initiates a call (action 235) through the end office 82 to the facsimile machine 74, and transmits the formatted position information over the established call connection 237.

With reference now again to FIGURES 1 and 5, a plurality of different mechanisms exist for determining the position of the mobile station 50 operating within the cellular telephone network. Although several location determination techniques are discussed below, it will be recognized that any suitable position determination mechanism may be used.

One way to determine position is to rely on information supplied from a Global Positioning System (GPS) transceiver 52 connected to the target mobile station 50. Responsive, perhaps, to requests from a base station system, or on a periodic basis, geo-coordinates are extracted by the target mobile station 50 and transmitted over a control channel of the air interface to the base station system. This information is then relayed to the serving mobile switching center, processed by an adjunct processing node (APN) 36 in the manner described above in connection with the location determination actions 211 and 214, and transmitted back through the network for presentation to the requesting entity.

A second way to determine position is to use the cell area where the target mobile station 50 is currently located. Identification information for the currently serving base station and cell is available to the network and in particular to the base station system. This information is relayed to the serving mobile switching center, processed by the adjunct processing node 36 in the manner described above in connection with the location determination actions 211 and 214, and transmitted back through the network for presentation to the requesting entity.

A third way to determine position is to use measurements (signal strength or timing advance) made by the base stations in the vicinity of the target mobile station 50. Responsive, perhaps, to requests from a base station system, or on a periodic basis, measurement information is acquired by the base station system serving the target mobile station 50 and relayed to the mobile switching center. This information is then processed by the adjunct processing node 36 in the manner described above in connection with the location determination actions 211 and 214, and transmitted back through the network for presentation to the requesting entity. In particular, the adjunct processing node 36 utilizes well known triangulation and arcuation processes to identify a position from the received measurement information.

A fourth way to determine position is to use measurements (signal strength or timing advance) made by the target mobile station 50 itself. Responsive, perhaps, to requests from a base station system, or on a periodic basis, measurement information is acquired by the target mobile station 50 and relayed to the mobile switching center through the serving base station system. This information is then processed by the adjunct processing node 36 in the manner described above in connection with the location determination actions 211 and 214, and transmitted back through the network for presentation to the requesting entity. In particular, the adjunct processing node 36 utilizes well known triangulation and arcuation processes to identify a position from the received measurement information.

A fifth way to determine position is to rely on a determination made by a separate location system (SLS) 60. The separate location system 60 utilizes a known location determination system, such as GPS, satellite Doppler, LORAN-C, direction finding, time or arrival triangulation (arcuation), or signal strength triangulation (arcuation). Responsive to a request, or perhaps on a periodic basis, the separate location system 60 sends position information to the mobile switching center. This information is then processed in the manner described above in connection with the location determination actions 211 and 214, and transmitted back through the network for presentation to the requesting entity.

Reference is now made to FIGURE 10 wherein there is shown a block diagram of a cellular telephone network 300 comprising a mobile switching center (MSC) 302, a base station controller (BSC) 304, and a plurality of base stations (BS) 306. The base station controller 304 and associated base stations 306 form a base station system (BSS) 308. Each base station 306 is configured to engage in radio frequency communications over an air interface 310 with proximately located mobile stations (MS) 312. The air interface 310 supports the transmission of both voice/data communications as well as signaling communications. In general, communications are effectuated with those mobile stations 312 located near or within the confines of a cell 314 associated with each base station 306. The mobile switching center 302 and base station controller 304 are connected via a communications link 316 which supports the transmission of both voice/data communications as well as signaling communications. The base station controller 304 and associated base stations 306 are connected via communications links 318 which, like the links 316, support the transmission of both voice/data communications as well as signaling communications. Operation of the cellular telephone network 300 in providing conventional cellular voice/data calling services to mobile station subscribers is well known to those skilled in the art, and accordingly will not be discussed herein.

A law enforcement agency is often authorized to monitor cellular telephone calls to obtain evidence for use in criminal investigations. To accomplish this goal, a monitoring center (MC) 320 is established which may include a tape recorder 322 for recording the voice conversation that is being monitored. The physical connection with the voice/data communications portion of the cellular telephone network 300 is made through a tap (generally shown at 324). The tap 324 may be made at any location within the cellular telephone network 300 in a manner well known to those skilled in the art, but is typically made at a selected one of the mobile switching centers 302 associated with the base station 306 and cell 314 where the mobile station 312 is currently located (roaming).

A number of instances may arise where the location of a mobile station 312 (or its possessing cellular subscriber) needs to be known by the law enforcement agency. One instance occurs in connection with the monitoring of an ongoing cellular telephone call. Another instance occurs when the mobile station 312 is idle, but the law enforcement agency desires to track its location.

Reference is now additionally made to FIGURE 11 wherein there is shown a signal flow and nodal operation diagram illustrating the operation of the cellular telephone network 300 of FIGURE 10 in providing position on a mobile station 312 during an ongoing cellular voice/data communication 330. It is assumed that all of the conventional, well known, cellular network operations preceding the establishment of the actual communication 330 (for example, authentication, ciphering, call set-up) have already occurred. The portion of the voice/data communication 330 carried over the air interface 310 utilizes a traffic channel (TCH). A control channel (CCH) is also provided over the air interface 310 for parallel mobile station 312 use during the ongoing call.

Suppose now that the law enforcement agency desires to know the location of the mobile station 312 which is engaging in the communication 330. From either its monitoring center 320 (as shown) or another selected location, the law enforcement agency signals 332 the network 300, and in particular the serving mobile switching center 302, to request location information. This request signal 332 includes not only the identification number (MIN, IMSI, IMEI, MSISDN, and/or MSID) of the mobile station 312 to be located, but also the degree of accuracy to be provided with the location determination. This degree of accuracy parameter specifies the precision with which the location determination is expected to be made (for example, actual location within one-hundred fifty meters radius of determined location).

Once the request signal 332 is received by the serving mobile switching center 302, the identification number of the mobile station 312 to be located is processed (action 334), and it is determined that the mobile station at issue is engaged in the communication 330. Thus, the network does not have to search (for example, page) for the mobile station 312 before making the location determination. A position request signal 336 is then sent by the mobile switching center 302 to the base station system 308 serving the mobile station 312 over the communications link 316 as a connection oriented signaling connection control part (SCCP) session. The position request signal 336 includes a plurality of parameters in addition to the parameters specified in the location request signal 332, including: the confidence factor with which the location position is to be reported; the expected method of reporting the location position; the periodicity with which reports are to be made; and, the kind of location determination that is to be made. The confidence factor parameter specifies the degree of confidence with which mobile station 312 location must be determined (for example, seventy percent in view of the specified accuracy parameter). The method of reporting parameter specifies that either: spontaneous position information is expected; single position information is expected; periodic position information is expected; or, no position information is expected. The periodicity parameter specifies how often (for example, every three minutes) mobile station 312 position is to be determined and reported to the requesting entity. The kind of location determination parameter specifies which one of a plural number of available determination methods (for example, signal strength analysis, timing advance analysis, or global positioning system determination) is to be used in determining mobile station 312 position.

Responsive to the position request signal 336, the base station system 308 serving the mobile station 312 makes the requested position request determination (action 338). The making of the position request determination in action 338 can take on one of several options. First, for example, if the mobile station 312 is equipped with a global positioning system (GPS) receiver 340, and if the mobile station has transmitted its geo-coordinates to the base station system 308 over the control channel (CCH) of the air interface 310, and further if the kind of location determination parameter specifies GPS, the action 338 merely comprises the capturing of the transmitted information, and the formatting of the position information for transmission back to the mobile switching center 302. Second, on the other hand, if the kind of location determination parameter specifies one of the measurement location methods (like, signal strength analysis or timing advance analysis) the action 338 primarily involves the capturing of the requisite measurement information. Then, if the base station system 308 is connected to a location processing device (LPD) 340, the action 338 further includes the processing of the measurement information to determine mobile station 312 position, and the formatting of the position information for transmission back to the mobile switching center 302. If no location processing device (LPD) 340 is immediately available to the base station system 308, the action 338 includes the collection of the measurement data, and the formatting of the position information for transmission back to the mobile switching center 302. In connection with the measurement location methods, if the measurement data is collected by the mobile station 312 itself (for example, during mobile assisted hand-off measurement), the data is transmitted to the base station system 308 over the control channel (CCH) of the air interface 310. Alternatively, the measurement data is collected by the base station 306 portion of the base station system 308 (for example, during hand-off determination or timing advance analysis).

Once the position request determination in action 338 is completed, a responsive position indication signal 342 is then sent by the base station system 308 serving the mobile station 312 to the mobile switching center 302 over the communications link 316 as a connection oriented signaling connection control part (SCCP) session. The method of reporting parameter within the position request signal 336 specifies the expected nature with which the position indication signal 342 is to be sent by the base station system 308. If the parameter specifies that spontaneous position information is expected, each time the position of the mobile station 312 is determined in action 338 with a confidence factor equal or superior to the factor specified in the confidence factor parameter of the position request signal 336, the position indication signal 342 is spontaneously sent. If the parameter specifies that single position information is expected, the action 338 implemented by the base station system 308 tries to achieve the position of the mobile station 312 within the preset confidence factor and respond with the position indication signal 342 within a preset time period. If the time period expires before the confidence factor is met, the base station system 308 then responds with the position indication signal 342 which includes an estimated confidence factor for the determined position. If the parameter specifies that periodic position information is expected, the action 338 implemented by the base station system 308 responds with the position indication signal 342 with or without meeting the preset confidence factor, and thereafter responds according to the periodicity specified by the periodicity parameter. If the parameter specifies that no position information is expected, the action 338 implemented by the base station system 308 responds with the position indication signal 342 which does not include any position information and stops any position information process related to that particular mobile station.

The location processing device 340 need not be directly connected to the base station system 308. Instead, or additionally, the device 340' may be directly connected to the mobile switching center 302. In such a case where the position determination is not made in association with the base station system 308 (i.e., the action 338 involves the collection of and the formatting of the measurement data), the measurement data is transmitted to the mobile switching center 302 in the position indication signal 342 and the requested position request determination (action 338') is thereafter made by the location processing device 340'.

Following receipt of each position indication signal 342 by the mobile switching center 302, the position information is processed and/or formatted (action 344), if necessary, and a request location information response signal 346 is transmitted from the mobile switching center to the monitoring center 320 (as shown) of the requesting law enforcement agency. It will, of course, be understood that the requesting entity need not necessarily be restricted to a law enforcement agency as shown. In fact, the position information provided by the network 300 is equally important to other public service agencies such as the fire department and emergency services department (ambulance and rescue squads). Furthermore, the position information is also valuable in fleet/delivery vehicle environments to track the locations of vehicles and personnel. As yet another alternative, the mobile station 312 itself may comprise the requesting entity.

Reference is now made to FIGURE 12 wherein there is shown a signal flow and nodal operation diagram illustrating the operation of the cellular telephone network 300 of FIGURE 10 in providing position information on a mobile station 312 while in an idle operating mode. Unlike the operation described in connection with FIGURE 11, when the request signal 332 is received, the serving mobile switching center 302 may not know where the mobile station 312 with the specified identification number operating in idle mode is located. Thus, the network 300 must search (for example, page) for the mobile station 312. Instead of sending the position request signal 336, the mobile switching center 302 sends a position/tracking request signal 350 to perhaps plural ones of the base station systems 308 (only one shown) over the communications link 316 as a connection-less signaling connection control part (SCCP) session. The position/tracking request signal 350 is sent to plural base station systems 308, rather than a single base station system as with the position request signal 336, in those instances where the location within the network 300 of the idle mobile station 312 is not known. This position/tracking request signal 350 includes the same parameters as the previously described position request signal 336 including Mobile Station Identification (MIN, IMSI, IMEI, MSISDN, and/or MSID).

Responsive to the position/tracking request signal 350, the base station system 308 builds a tracking group (action 352), analogous to a paging group, and broadcasts a tracking request signal 354, analogous to a paging request signal, through each of its associated base stations 308 (not shown), in an attempt to reach the idle mobile station 312. The tracking request signal 354 is transmitted by the base stations 306 using a common control channel (CCCH) over the air interface 310. If the idle mobile station 312 receives the tracking request signal 354, it transmits a channel request signal 356 to the base station system 308 using a dedicated control channel (DCCH) of the air interface 310. The base station system 308 responds with the assignment of a channel (signal 358), and the mobile station 312 replies by sending a tracking response signal 360, which is analogous to a paging response. This tracking response signal 360 may additionally include geo-coordinate and/or measurement information relating to mobile station 312 position determination.

The base station system 308 then forwards the tracking response signal 360 to the mobile switching center 302 over the communications link 316 as the responsive position indication signal 342, again analogous to the paging response, using a connection oriented signaling connection control part (SCCP) session. If the base station system 308 is connected to the location processing device (LPD) 340, the position request determination (action 338) is performed, and any received measurement information is processed to determine mobile station 312 position. The determined position information is then transmitted to the mobile switching center 302 using the responsive position indication signal 342. If no location processing device 340 is immediately available to the base station system 308, or if global positioning system geo-coordinates were received, the action 338 includes the collection and formatting of the measurement data (or geo-coordinates), and the responsive position indication signal 342 carries the formatted information to the mobile switching center 302. In a manner similar to that illustrated in FIGURE 11, the responsive position indication signal 342 is sent in accordance with the method of reporting parameter contained within the position/tracking request signal 350. Following receipt of the forwarded tracking response signal 360 in the form of the responsive position indication signal 342, the mobile switching center 302 sends a confirmation signal 362 to the base station system 308.

The network 300 then proceeds to authenticate (action 364) the mobile station 312 in a manner well known to those skilled in the art. If the authentication is successful, the mobile switching center 302 is then authorized (action 366) to report position information to the monitoring center 320 (as shown) of the requesting law enforcement agency using the request location information response signal 346. If position information was received in (or obtained from) the forwarded tracking response signal 360, this information is then reported following authorization to the requesting entity in accordance with the method of reporting parameter contained within the position/tracking request signal 350. If no position information was yet received, or if additional information is expected, completion of the authentication process 364 authorizes subsequent base station system 308 transmission of the responsive position indication signal 342 in accordance with the method of reporting parameter contained within the position/tracking request signal 350.

Again, the location processing device 340 need not be directly connected to the base station system 308. Instead, or additionally, the device 340' may be directly connected to the mobile switching center 302. In such a case where the position determination is not made in association with the base station system 308 (i.e., the action 338 involves the collection of the and formatting of the measurement data), the measurement data is transmitted to the mobile switching center 302 in the position indication signal 342 and the requested position request determination (action 338') is thereafter made by the location processing device 340'.

Reference is now made to FIGURE 13 wherein there is shown a block diagram of a cellular telephone network 400 equipped to provide emergency situation caller assistance. The cellular telephone network 400 includes a plurality of mobile switching centers (MSC) 402. Associated with each mobile switching center 402 is a base station controller (BSC) 404 connected to a plurality of base stations (BS) 406. Each base station controller 404 and its associated base stations 406 form a base station system (BSS) 408. Each base station 406 is configured to engage in radio frequency communications over an air interface 410 with proximately located mobile stations (MS) 412. The air interface 410 supports the transmission of both voice/data communications as well as signaling communications. In general, communications are effectuated with those mobile stations 412 located near or within the confines of a cell 414 associated with each base station 406. The mobile switching center 402 and base station controller 404 are connected via a communications link 416 which supports the transmission of both voice/data communications as well as signaling communications. The base station controller 404 and associated base stations 406 are connected via communications links 418 which, like the links 416, support the transmission of both voice/data communications as well as signaling communications. The mobile switching centers 402 are interconnected by communications links 420 which, like the links 416 and 418, also support the transmission of both voice/data communications as well as signaling communications. Operation of the cellular telephone network 400 in providing conventional cellular voice/data calling services to mobile station subscribers is well known to those skilled in the art, and accordingly will not be discussed herein.

Connected to the cellular telephone network 400 via routers 423 are a plurality of public safety answering point (PSAP) systems 422. Each public safety answering point system 422 is utilized by emergency service providers (such as the police department, fire department, or rescue department) as a central point for the reception of emergency services telephone calls (e.g., dial 911 calls) and the dispatching of emergency services personnel within an associated emergency service area. Certain mobile switching centers 402 are assigned to a certain public safety answering point system 422. In fact, it is possible that one mobile switching center 402 may be serviced by more than one public safety answering point system 422.

It is important that any cellular emergency call initiated from a mobile station 412 be handled by the proper public safety answering point system 422. Generally, this means the public safety answering point system 422 controlling the dispatching of proximately located emergency services personnel. If a cellular emergency call is misrouted, the dispatching and/or arrival of emergency aid could be delayed. Under normal cellular telephone system operating conditions, this is not a concern as the cellular emergency call is handled by the mobile switching center 402 for the service area where the emergency call is originated (the serving MSC) and routed through router 423 to the public safety answering point system 422 connected thereto. For those situations where a service area and its mobile switching center 402 are associated with plural public safety answering point systems 422, routing is made to the public safety answering point system 422 assigned to the cell 414 currently serving the mobile station 412. When the mobile subscriber is on-call, roaming and switches serving mobile switching centers 402, however, a communications link is maintained through the mobile switching center 402(1) for the service area where the first call was originated (the anchor MSC). Any cellular emergency call thereafter initiated (by placing the original call on hold) is then incorrectly, and perhaps undesirably, routed through the anchor mobile switching center 402(1) to its assigned (connected) public safety answering point system 422 via router 423 instead of to the public safety answering point system 422 for the serving mobile switching center 402(2).

Reference is now additionally made to FIGURE 14 wherein there is shown a signal flow and nodal operation diagram illustrating the operation of the cellular telephone network 400 of FIGURE 13 in providing location information on a mobile station 412 for purposes of routing an emergency cellular call to the proper public safety answering point system 422. In conjunction with anchor mobile switching center 402(1) receipt of a cellular emergency call 424 originated by a roaming mobile station 412 while maintaining an original call 425 (on hold), an identification is also provided of the cell 414 associated with base station 406 serving the mobile station. The data base 426(1) connected to the anchor mobile switching center 402(1) does not include translation information correlating the identified cell 414 with the routing identification number for its associated public safety answering point system 422. This is because this information is instead stored in the data base 426(2) connected to the serving mobile switching center 402(2). Thus, the anchor mobile switching center

402(1) does not possess sufficient information to properly route the call.

Recognizing then the situation of a roaming mobile station 412 making a cellular emergency call 424 with a prior call 425 on hold, the anchor mobile switching center 402(1) sends a position request with location number requested signal 428 to the serving mobile switching center 402(1) over the communications link 420 as a Mobile Application Part (MAP) message. This position request signal 428 optionally includes an identification of the cell 414 where the mobile station 412 is located, and a location type parameter which requests the return of a routing identification number for that cell. Responsive to receipt of the location number request signal 428, the serving mobile switching center 402(2) processes (action 430) the identified cell in its data base 426(2) which includes translation information correlating the identified cell 414 with the routing identification number for its associated public safety answering point system 422. The retrieved routing identification number is then included in a response signal 432 transmitted from the serving mobile switching center 402(2) to the anchor mobile switching center 402(1) over the communications link 420. Using the retrieved routing identification number, the anchor mobile switching center 402(1) forwards (action 434) the cellular emergency call 424 to the public safety answering point system 422 assigned to the cell 414 currently serving the mobile station 412.

Instances may arise where position information regarding the roaming, cellular emergency calling mobile station 412 is also needed to handle the call. One option is for the transmitted signal 428 to be treated by the network 400 as a position request signal 332 (see, FIGURE 11) as well. Responsive thereto, and via the maintained connection through the anchor mobile switching center 402(1), the serving mobile switching center 402(2) not only retrieves the routing identification number for the proper public safety answering point system 422 for delivery to the anchor mobile switching center, but also initiates the position determination procedure illustrated in FIGURE 11. Following receipt of each position indication signal 342 by the anchor mobile switching center 402(1), the position information is processed and/or formatted (action 344), if necessary, and a request position information response signal 346 is transmitted from the mobile switching center to the proper public safety answering point system 422 via the anchor mobile switching center 402(1). Alternatively, in response to the forwarding (action 434) of the cellular emergency call 424, the public safety answering point system 422 transmits a position request signal 332 (see, FIGURE 11) towards the serving mobile switching center 402(2) via the anchor mobile switching center 402(1). Following receipt of each position indication signal 342 by the serving mobile switching center 402(2), the position information is processed and/or formatted (action 344), if necessary, and a request position information response signal 346 is transmitted to the public safety answering point system 422 via the anchor mobile switching center 402(1).

Although a preferred embodiment of the method and apparatus of the present invention has been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiment disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

WHAT IS CLAIMED IS:

1. In a cellular telephone network including a first mobile switching center currently serving a target mobile station and a second mobile switching center currently serving a requesting mobile station, a method comprising the steps of:

routing a request for target mobile station position made by the requesting mobile station from the second mobile switching center to the first mobile switching center;

processing position indicative information to determine a position of the target mobile station; and

routing a response to the position request including target mobile station position from the first mobile switching center to the second mobile switching center.

2. The method as in claim 1 wherein the cellular telephone network includes a first public land mobile network having the first mobile switching center and a second public land mobile network having the second mobile switching center, and the steps of routing comprise the steps of routing the position request and response between the first and second public land mobile networks.

3. The method as in claim 2 wherein the first public land mobile network includes a home location register for the target mobile station, and the steps of routing further comprise the steps of routing the position request and response between the first and second mobile switching center through the home location register.

4. The method as in claim 1 wherein the cellular telephone network includes a public land mobile network having both the first and second mobile switching centers.

5. The method as in claim 1 further including the step of verifying requesting mobile station subscription

to a service feature supporting the request for target mobile station position.

6. The method as in claim 1 further including the steps of:

forwarding the response to the position request including target mobile station position from the second mobile switching center to the requesting mobile station;

processing of the included target mobile station position; and

displaying at the requesting mobile station of the target mobile station position.

7. In a telephone network including a public switched telephone network connected through an end office exchange to a requesting subscriber station and a cellular telephone network having a mobile switching center currently serving a target mobile station, a method comprising the steps of:

routing a request for target mobile station position made by the requesting subscriber station from the end office exchange to the mobile switching center;

processing position indicative information to determine a position of the target mobile station; and

routing a response to the position request including target mobile station position from the mobile switching center to the end office exchange.

8. The method as in claim 7 further including the step of verifying requesting subscriber station subscription to a service feature supporting the request for target mobile station position.

9. The method as in claim 7 further including the steps of:

placing a call through the end office exchange to the requesting subscriber station; and

delivering the target mobile station position to a requesting subscriber as a synthesized voice message.

10. The method as in claim 7 further including the steps of:

placing a call through the end office exchange to a facsimile machine associated with a requesting subscriber; and

delivering the target mobile station position to the requesting subscriber as a facsimile message.

11. The method as in claim 7 further including the steps of:

placing a call through the end office exchange to a data terminal associated with a requesting subscriber; and

delivering the target mobile station position to the requesting subscriber as a data message.

12. The method as in claim 7 wherein the mobile switching center is connected to a home location register of the target mobile station, and the steps of routing comprise the steps of routing the position request and response between the mobile switching center and end office exchange through the home location register.

13. In a cellular telephone network including mobile switching center connected to a base station system currently serving a target mobile station, a method comprising the steps of:

receiving at the mobile switching center a request from a requesting entity for target mobile station position;

routing the request for target mobile station position to the base station system currently serving the target mobile station;

collecting by the base station system of target mobile station position indicative information;

processing the position indicative information to determine a position of the target mobile station; and routing a response including the target mobile station position through the mobile switching center to the requesting entity.

14. The method as in claim 13 wherein the step of collecting comprises the step of obtaining position related measurement information collected by the target mobile station itself.

15. The method as in claim 14 wherein the position related measurement information comprises signal strength measurements.

16. The method as in claim 14 wherein the position related measurement information comprises timing advance measurements.

17. The method as in claim 13 wherein the step of collecting comprises the step of obtaining position related measurement information collected by the base station system itself.

18. The method as in claim 17 wherein the position related measurement information comprises signal strength measurements.

19. The method as in claim 17 wherein the position related measurement information comprises timing advance measurements.

20. The method as in claim 13 wherein the step of collecting comprises the step of obtaining geo-coordinate information collected by the target mobile station itself.

21. The method as in claim 13 wherein the position indicative information comprises position related measurement information, and the step of processing

comprises the step of arcuating the position related measurement information to determine the target mobile station position.

22. The method as in claim 13 wherein the position indicative information comprises position related measurement information, and the step of processing comprises the step of triangulating the position related measurement information to determine the target mobile station position.

23. The method as in claim 13 wherein the target mobile station is operating in an on-call mode, and wherein the step of routing comprises the step of routing the request to the base station system through which the target mobile station call is being handled.

24. The method as in claim 13 wherein the target mobile station is operating in an idle mode, and wherein the step of routing comprises the steps of:

paging for the target mobile station; and

routing the request to the base station system through which the target mobile station answers the page.

25. The method as in claim 13 further including the step of authenticating the target mobile station before allowing any target mobile station position response to be sent to the requesting entity.

26. A method, comprising the steps of:

responsive to mobile station hand-off during a first call from a first mobile switching center to a second mobile switching center, and further responsive to mobile station initiation of a second, emergency call while maintaining the first call, transmitting a request for mobile station location from the first mobile switching center to the second mobile switching center;

processing a current cell location for the mobile station to identify a public safety answering point serving the mobile station;

transmitting a response including the identified public safety answering point from the second mobile switching center to the first mobile switching center; and

routing the second, emergency call to the identified public safety answering point.

27. The method as in claim 26 further including the steps of:

collecting position indicative information for the mobile station;

processing the position indicative information to determine a position for the mobile station; and

routing the determined mobile station position to the identified public safety answering point.

28. The method as in claim 27 wherein the step of collecting comprises the step of obtaining position related measurement information collected by the target mobile station itself.

29. The method as in claim 28 wherein the position related measurement information comprises signal strength measurements.

30. The method as in claim 28 wherein the position related measurement information comprises timing advance measurements.

31. The method as in claim 27 wherein the step of collecting comprises the step of obtaining position related measurement information collected by the base station system itself.

32. The method as in claim 31 wherein the position related measurement information comprises signal strength measurements.

33. The method as in claim 31 wherein the position related measurement information comprises timing advance measurements.

34. The method as in claim 27 wherein the step of collecting comprises the step of obtaining geo-coordinate information collected by the target mobile station itself.

35. The method as in claim 27 wherein the position indicative information comprises position related measurement information, and the step of processing comprises the step of arcuating the position related measurement information to determine the target mobile station position.

36. The method as in claim 27 wherein the position indicative information comprises position related measurement information, and the step of processing comprises the step of triangulating the position related measurement information to determine the target mobile station position.

FIG.1

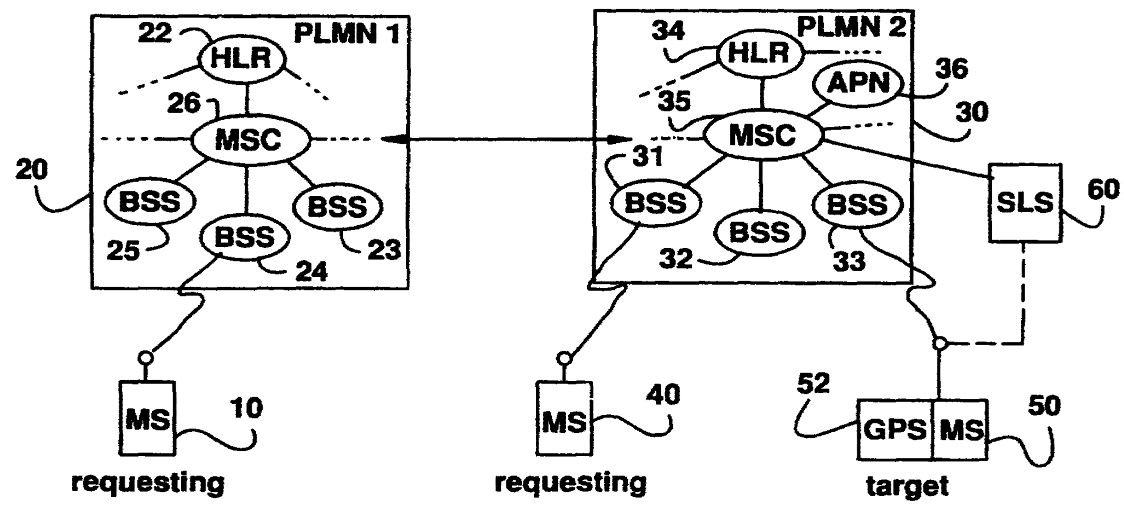


FIG.2

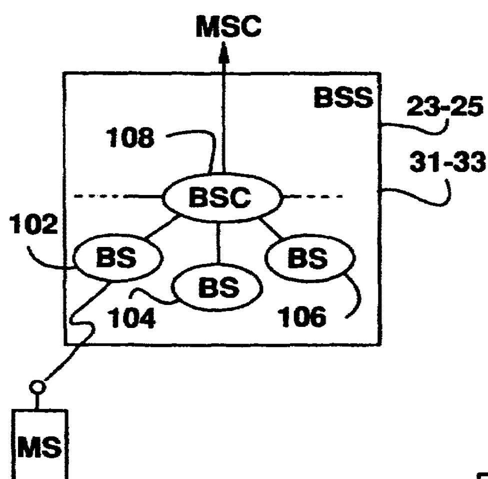


FIG.5

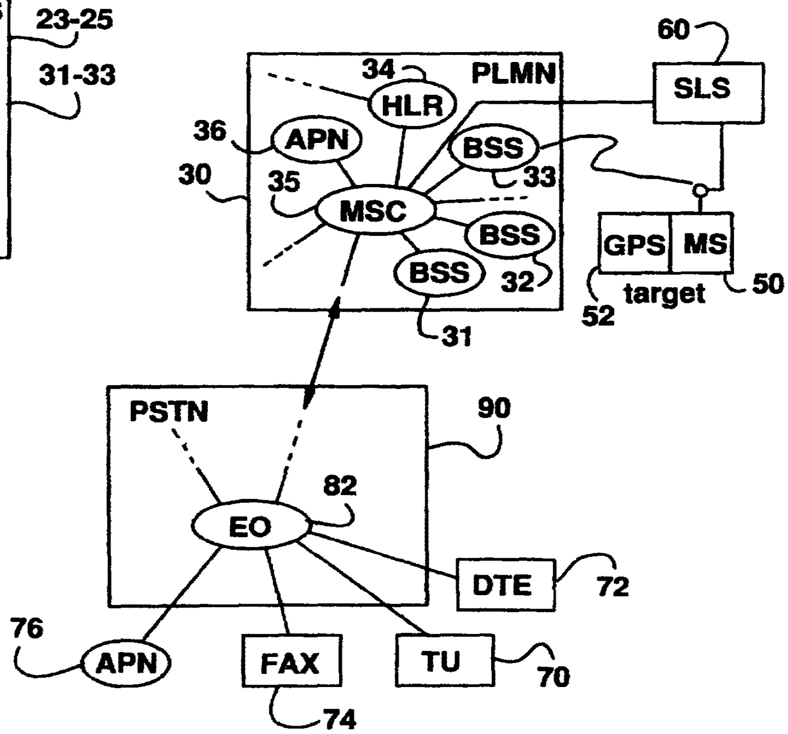


FIG.3

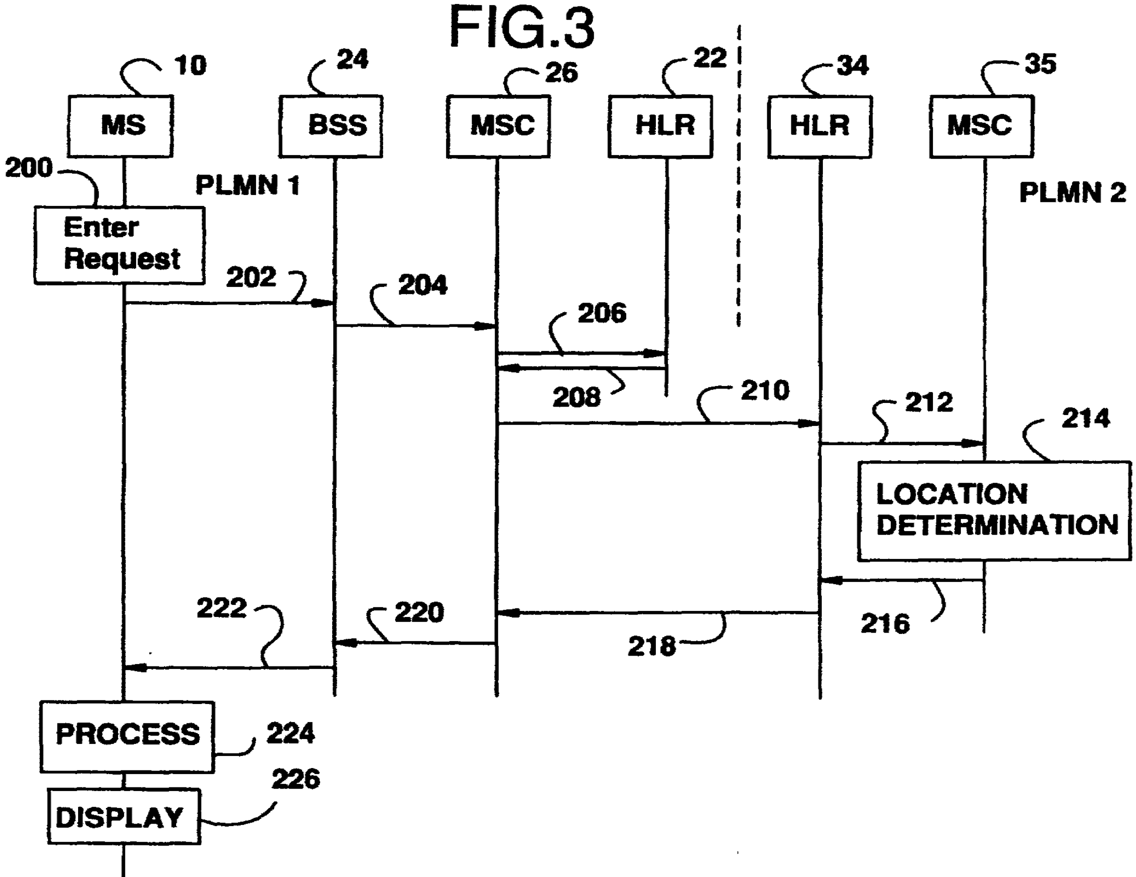

10
24
26
22
34
35
MS
BSS
MSC
HLR
HLR
MSC
200
PLMN 1
PLMN 2
Enter Request
202
204
206
208
210
212
214
LOCATION DETERMINATION
216
218
220
222
PROCESS
224
226
DISPLAY

FIG.4

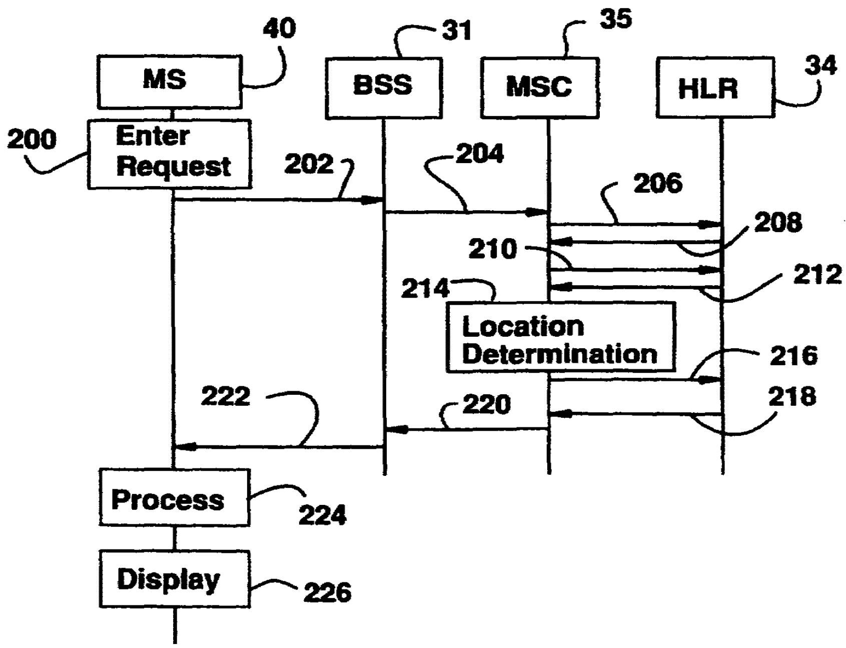

40
31
35
34
MS
BSS
MSC
HLR
200
Enter Request
202
204
206
208
210
212
214
Location Determination
216
218
220
222
Process
224
Display
226

FIG.6

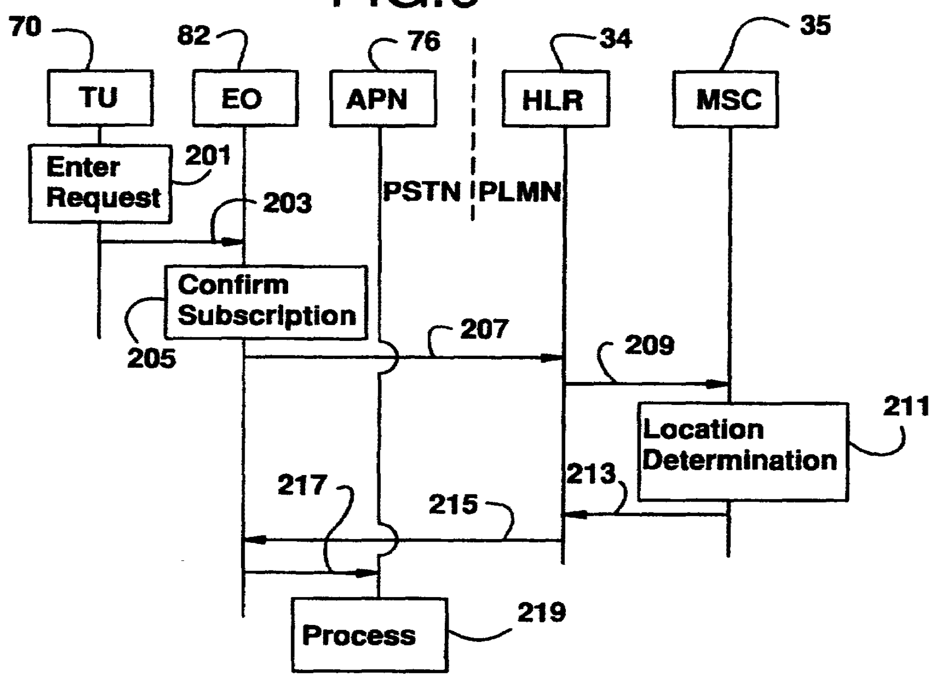


FIG.7

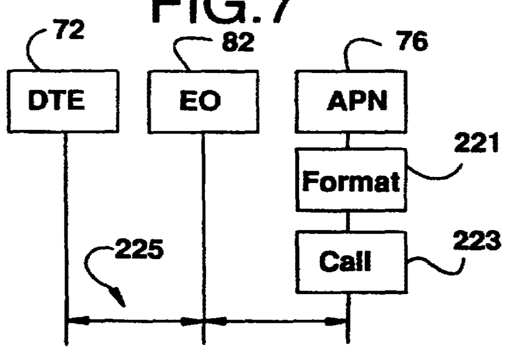


FIG.8

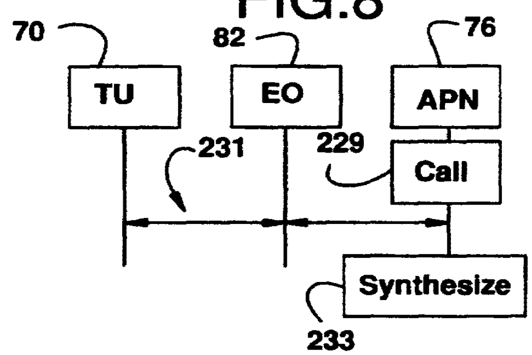


FIG.9

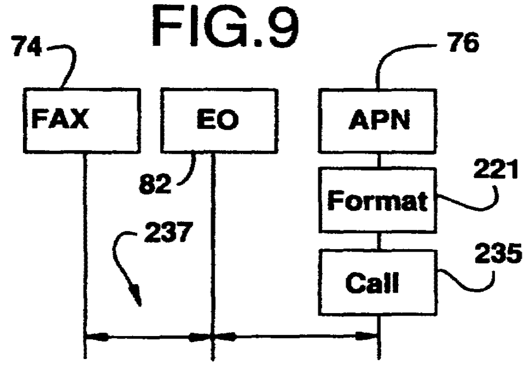


FIG.10

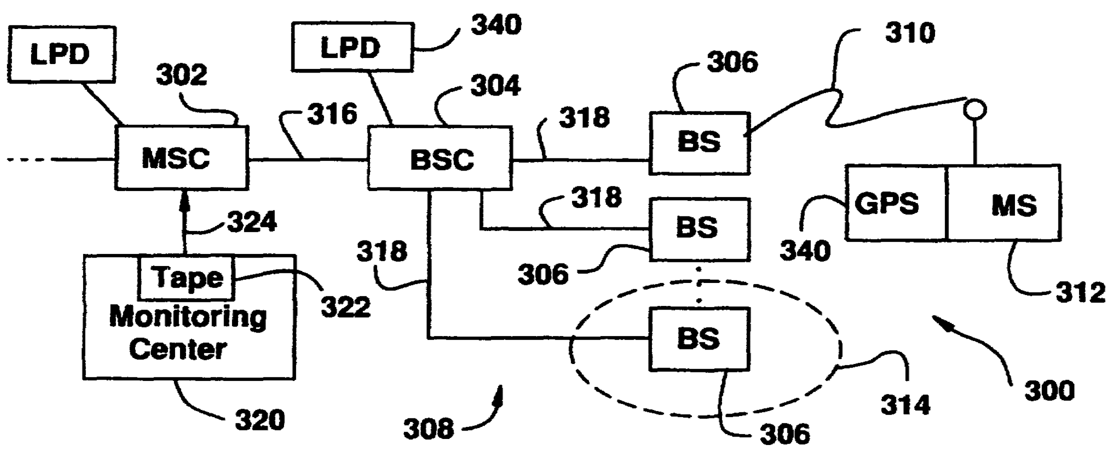

LPD
LPD
340
302
304
306
310
316
318
MSC
BSC
BS
318
GPS
MS
324
BS
Tape
Monitoring
Center
318
306
340
312
322
BS
300
314
320
308
306

FIG.13

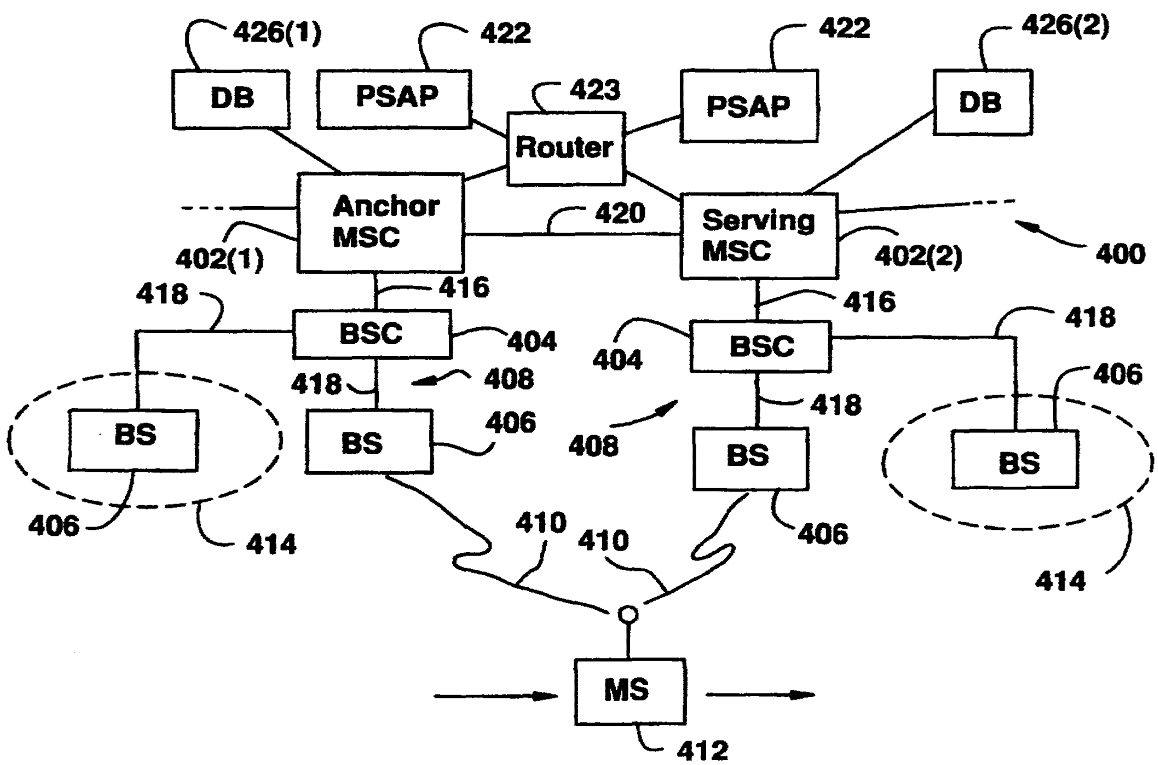

426(1)
422
422
426(2)
DB
PSAP
423
PSAP
DB
Router
Anchor
MSC
420
Serving
MSC
400
402(1)
402(2)
418
416
416
418
BSC
404
404
BSC
418
408
406
406
BS
BS
408
418
BS
BS
406
414
410
410
406
414
MS
412

FIG.11

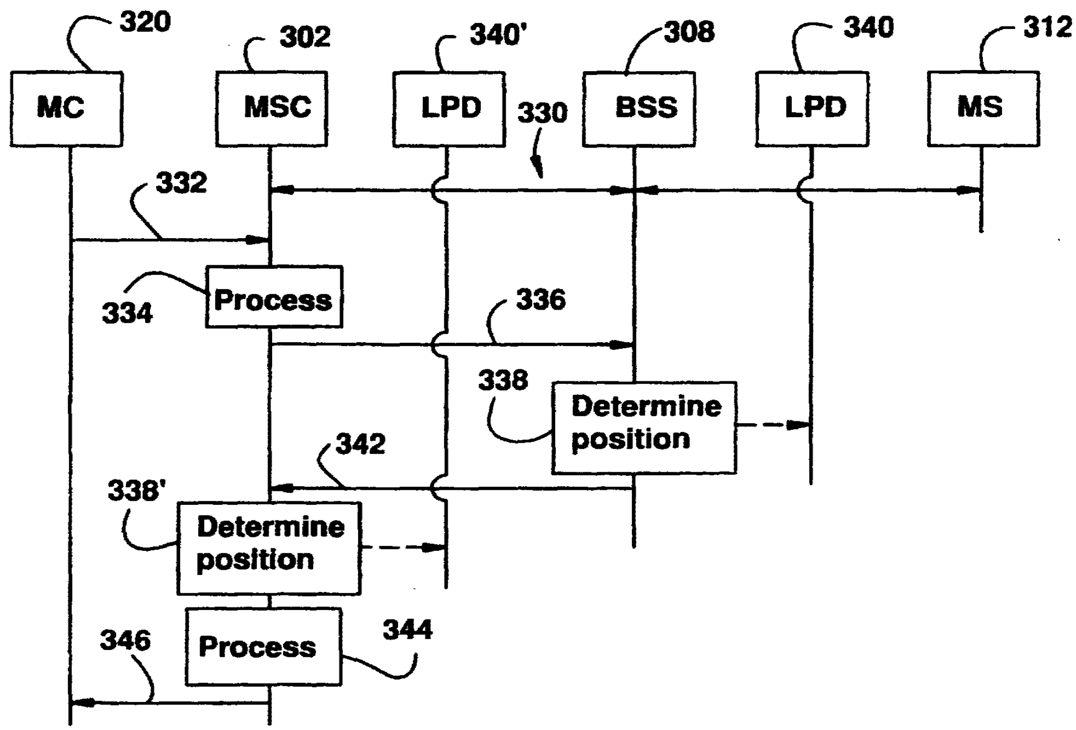

320
302
340'
308
340
312
MC
MSC
LPD
330
BSS
LPD
MS
332
Process
334
336
338
Determine position
342
338'
Determine position
346
Process
344

FIG.12

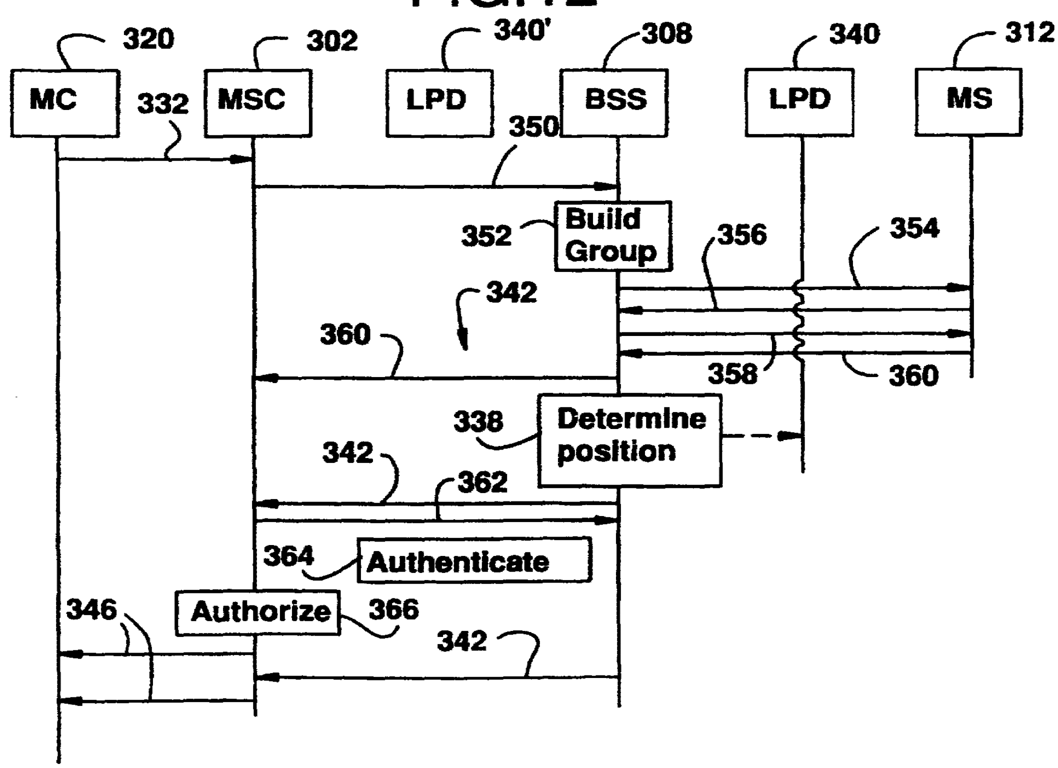
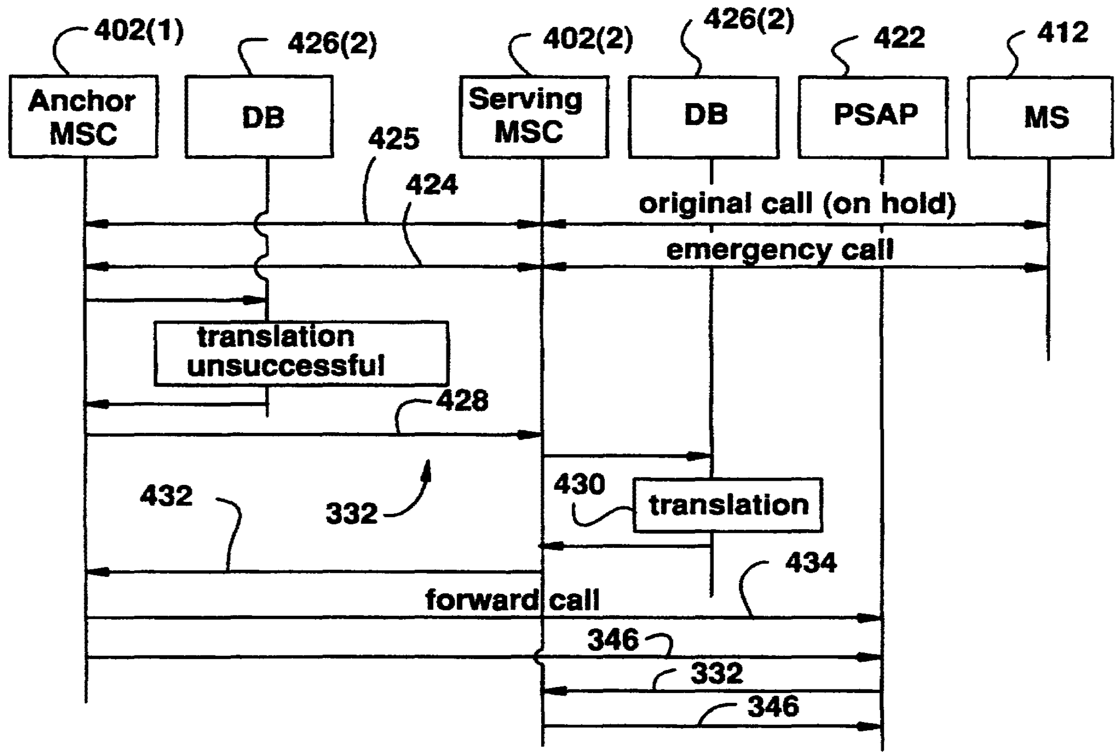

320
302
340'
308
340
312
MC
332
MSC
LPD
BSS
LPD
MS
350
352
Build Group
356
354
342
360
358
360
338
Determine position
342
362
364
Authenticate
346
Authorize
366
342

FIG.14



402(1)
426(2)
402(2)
426(2)
422
412
Anchor MSC
DB
Serving MSC
DB
PSAP
MS
425
424
original call (on hold)
emergency call
translation unsuccessful
428
432
332
430
translation
434
forward call
346
332
346

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04Q 7/38

A3

(11) International Publication Number: WO 98/00988

(43) International Publication Date: 8 January 1998 (08.01.98)

(21) International Application Number: PCT/US97/11656

(22) International Filing Date: 30 June 1997 (30.06.97)

(30) Priority Data:
08/677,048 1 July 1996 (01.07.96) US

(71) Applicant: ERICSSON INC. [US/US]; 7001 Development Drive, P.O. Box 13969, Research Triangle Park, NC 27709 (US).

(72) Inventors: BOLTZ, David; 901 Loch Ness Lane, Garland, TX 75044 (US). MAUPIN, Alain, Guy; 1133 Lookout Drive, Richardson, TX 75080 (US). MAO, Xiaohong; 2400 Waterview Parkway #424, Richardson, TX 75080 (US).

(74) Agents: MOORE, Stanley, R. et al.; Jenkens & Gilchrist, P.C., Suite 3200, 1445 Ross Avenue, Dallas, TX 75202 (US).

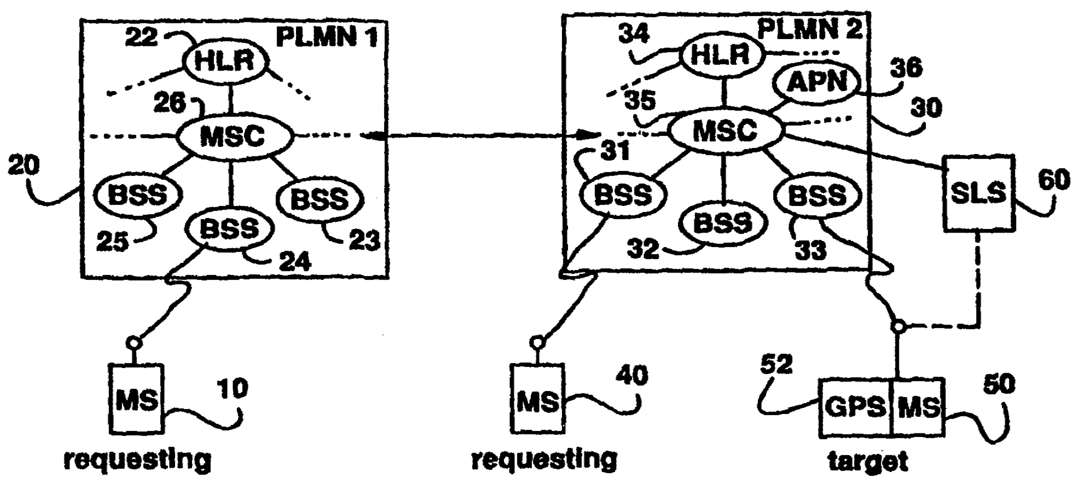
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), 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.

(88) Date of publication of the international search report: 7 May 1998 (07.05.98)

(54) Title: METHOD AND APPARATUS FOR COMMUNICATING INFORMATION ON MOBILE STATION POSITION WITHIN A CELLULAR TELEPHONE NETWORK



(57) Abstract

Position information regarding a mobile station is determined and provided upon request. In one situation, mobile station position is determined in response to a request from another mobile subscriber (10, 40) and displayed (226) on the requesting mobile station display. Mobile station position is also determined in response to a request from a land line user (70) and provided through either a synthesized voice communication (233), a data message (225) or a facsimile message (237). Mobile station positions are further provided in response to law enforcement (320) and other public service entity (422) requests. This information is useful in tracking a mobile station (312, 412) either during a call or when the mobile station is idle. In another instance mobile station location information is used to insure routing (434) of emergency (911) calls (424) to the proper public safety answering point (422). The system further has the capability of being programmed with certain response criteria applicable to the determination of mobile station position. Such criteria include accuracies, confidence factors, periods between location reports, and location determination technique.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

INTERNATIONAL SEARCH REPORT

Inter   onal Application No
PCT/US 97/11656

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q7/38

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 H04Q G08G

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.
X	DE 43 21 418 A (DEUTSCHE AEROSPACE) 5 January 1995 see page 4, line 68 - page 10, line 37 ---	1-25
X	WO 96 15643 A (ERICSSON TELEFON AB L M) 23 May 1996	13-25
A	see page 41, line 15 - page 44, line 24 ---	1-12
X	US 5 327 144 A (STILP LOUIS A ET AL) 5 July 1994	13-25
A	see column 5, line 56 - column 6, line 21 see column 8, line 23 - column 9; claims 1,12,13,22,23,25 ---	1-12
A	WO 94 01978 A (RIMER NEIL ALEXANDER ;GUTIERREZ PETER (GB); FIORENTINO MARCO ALBER) 20 January 1994 see page 13, line 7 - page 18, line 34 ---	1,9-11, 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

Date of the actual completion of the international search	Date of mailing of the international search report
17 February 1998	13/03/98

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	Janyszek, J-M

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/11656

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 5 208 756 A (SONG HAN L) 4 May 1993 see abstract see column 3, line 12 - column 5, line 34 ---	1,7, 13-24
A	EP 0 689 368 A (PTT GENERALDIREKTION) 27 December 1995 see column 6, line 347 - column 40 ---	5,8,9
A	WO 94 29995 A (MOTOROLA INC) 22 December 1994 see page 3, line 9 - page 5, line 11 see page 9, line 3 - page 10, line 31 see page 19, line 6 - page 20, line 20 ---	26
A	WO 96 19908 A (MOTOROLA INC) 27 June 1996 see page 5, line 32 - page 7, line 4 ---	26
P,X	WO 96 25830 A (EUROPOLITAN AB ;EKSTROEM TOMMY (SE)) 22 August 1996 see page 9, line 3 - page 16, line 6 ---	7-25
E	WO 97 24010 A (BELL COMMUNICATIONS RES) 3 July 1997 see page 6, line 10 - page 8, line 17 see page 15, line 14 - page 16, line 4 see page 20, line 8 - line 22 -----	1-25

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 97/11656

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. claims 1-25:
Method for routing position information on a target mobile subscriber roaming through a mobile network to and from a requesting second subscriber
2. claims 26-36:
Method for emergency call processing for a roaming mobile subscriber

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (1)) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 97/11656

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 4321418 A	05-01-95	AU 7185994 A	17-01-95
		WO 9501066 A	05-01-95
		EP 0705524 A	10-04-96
		FI 956181 A	21-12-95
		NO 955264 A	22-12-95
WO 9615643 A	23-05-96	AU 3942395 A	06-06-96
		CA 2204992 A	23-05-96
		SE 9701723 A	08-07-97
US 5327144 A	05-07-94	AU 677292 B	17-04-97
		AU 6094094 A	12-12-94
		AU 6820694 A	12-12-94
		BR 9406463 A	30-01-96
		CA 2161333 A	24-11-94
		EP 0700525 A	13-03-96
		JP 8508381 T	03-09-96
		WO 9427160 A	24-11-94
		WO 9427161 A	24-11-94
		US 5608410 A	04-03-97
		ZA 9401019 A	25-08-94
WO 9401978 A	20-01-94	US 5432841 A	11-07-95
		EP 0603390 A	29-06-94
US 5208756 A	04-05-93	AU 1343692 A	27-08-92
		WO 9213284 A	06-08-92
EP 0689368 A	27-12-95	AT 153206 T	15-05-97
		AU 2174595 A	04-01-96
		BR 9508091 A	12-08-97
		CA 2152215 A	21-12-95
		WO 9535635 A	28-12-95
		CN 1128476 A	07-08-96
		CZ 9603513 A	14-05-97
		DE 59402759 D	19-06-97
		FI 965078 A	17-12-96
		HU 76397 A	28-08-97
		JP 8265843 A	11-10-96
		NO 965315 A	18-02-97

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte onal Application No
PCT/US 97/11656

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0689368 A		PL 317643 A	14-04-97
		SG 34235 A	06-12-96
		SI 9520064 A	30-04-97
		SK 161396 A	05-11-97
		ZA 9505091 A	10-04-96
WO 9429995 A	22-12-94	AU 666279 B	01-02-96
		AU 7095594 A	03-01-95
		CA 2139514 A	22-12-94
		MX 9404431 A	31-01-95
WO 9619908 A	27-06-96	US 5602901 A	11-02-97
		AU 3895995 A	10-07-96
		EP 0799555 A	08-10-97
		FI 972614 A	18-06-97
		GB 2309617 A	30-07-97
		NO 972758 A	16-06-97
WO 9625830 A	22-08-96	AU 4737396 A	04-09-96
		CA 2210723 A	22-08-96
		EP 0809918 A	03-12-97
		FI 973342 A	14-08-97
		NO 973748 A	14-08-97
		SE 9500569 A	17-08-96
		SE 9502976 A	17-08-96
WO 9724010 A	03-07-97	AU 5252896 A	17-07-97

CORRECTED VERSION*

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 **:**
H04L 9/00, H04M 3/42, G06F 11/34, 19/00

A1

(11) International Publication Number: **WO 98/04065**

(43) International Publication Date: 29 January 1998 (29.01.98)

(21) International Application Number: PCT/US97/12792

(22) International Filing Date: 23 July 1997 (23.07.97)

(30) Priority Data:
08/690,253 24 July 1996 (24.07.96) US

(71) Applicant: BELL COMMUNICATIONS RESEARCH, INC. [US/US]; 445 South Street, Morristown, NJ 07960-6438 (US).

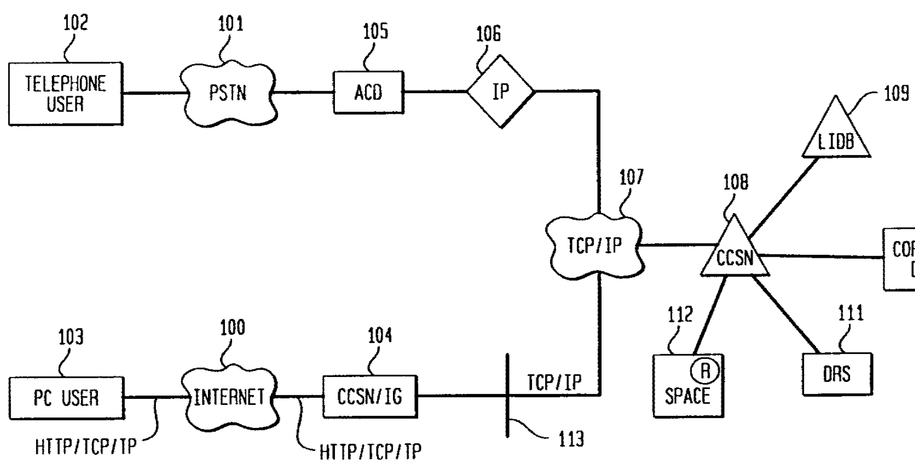
(72) Inventors: ELY, Thomas, Chambers; 1178 Delaware Drive, Bridgewater, NJ 08807 (US). MARTIN, Michael, A.; 1 Westbrook Avenue, Hillsborough, NJ 08876 (US). NOVAK, Thomas, S; 117 Hockenbury Drive, Glen Gardner, NJ 08826 (US). SMYK, Darek, A.; 15 Zirkel Avenue, Piscataway, NJ 08854 (US).

(74) Agents: YEADON, Loria, B. et al.; c/o International Coordinator, Room 1G112R, 445 South Street, Morristown, NJ 07960-6438 (US).

(81) Designated States: CA, CN, JP, KR, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: SYSTEM AND METHOD FOR PROVIDING CUSTOMER CONTACT SERVICES THROUGH A CUSTOMER CONTACT SERVICES NODE/INTERNET GATEWAY



(57) Abstract

A customer contact service node/Internet gateway (CCSN/IG) (104) connects a user (103) to the services and to information from a provider (108) via Internet (100). The user (103) can thereby get information about the services and can initiate service changes and can get user-specific information.

*(Referred to in PCT Gazette No. 21/1998, Section II)

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece	**ML**	Mali	**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**MN**	Mongolia	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MR**	Mauritania	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MW**	Malawi	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MX**	Mexico	**US**	United States of America
CA	Canada	**IT**	Italy	**NE**	Niger	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NL**	Netherlands	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NO**	Norway	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NZ**	New Zealand	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**PL**	Poland		
CM	Cameroon	**KR**	Republic of Korea	**PT**	Portugal		
CN	China	**KZ**	Kazakstan	**RO**	Romania		
CU	Cuba	**LC**	Saint Lucia	**RU**	Russian Federation		
CZ	Czech Republic	**LI**	Liechtenstein	**SD**	Sudan		
DE	Germany	**LK**	Sri Lanka	**SE**	Sweden		
DK	Denmark	**LR**	Liberia	**SG**	Singapore		
EE	Estonia						

SYSTEM AND METHOD FOR PROVIDING CUSTOMER CONTACT SERVICES THROUGH A CUSTOMER CONTACT SERVICES NODE/INTERNET GATEWAY

Cross Reference to Related Application

This application is related to U.S. Patent Application 08/594,749, entitled "System and Method for Integrating ISCP and Internet Services," filed January 31, 1996 by Darek A. Smyk, the contents of which are incorporated by reference.

Background of the Invention

The present invention relates generally to telecommunication networks and more particularly to the Internet and Internet services.

Currently, many companies provide call center automation systems and services, such as automatic call distributors, interactive voice response (IVR) systems, coordinated voice and data delivery, and voice mail. Growth in the use of such systems and services is expected to continue. While these technologies provide successful solutions to certain customer demands, they do have some limitations. For instance, callers interacting with an IVR self-service system can only be given a limited set of options at any point because of the tendency of people to become frustrated by long lists of options. Also, effectively communicating large amounts of data over the telephone can be difficult. For example, providing a customer with a line-by-line billing record over the telephone is typically not feasible. Additionally, communicating certain types of common data, such as names and addresses, or other alphanumeric data, requires specialized hardware to perform speech recognition and speech synthesis.

The recent explosion in the use of the Internet provides many new business opportunities and presents significant opportunities to providers of traditional network services. The number of Internet users is growing exponentially, stimulating network service providers to create new services to capture this new market. It is estimated that by 1999, 14 million households will subscribe to Internet access services. This number, however, reflects only a portion of the total number of Internet users because many people have access to the Internet through their school or place of employment. In fact, the current number of Internet users is estimated to be 30 million. The debut of the Microsoft Network service with full Internet access and the addition of Internet access to online services such as Prodigy, CompuServe, and America Online can be expected to bring even more potential customers online. It is projected that use of the Internet will continue to rise and therefore it is desired to provide customer services and access to information to Internet users.

One successful and widely publicized portion of the Internet is the World Wide Web (WWW or the Web). At a conceptual level, the WWW can be thought of as a vast, hyperlinked bank of data. To gain access to the WWW, a user must install on his/her computer WWW browser software and transmission control protocol/Internet protocol (TCP/IP) software and obtain a network connection from an Internet access provider. Once connected to the WWW, a user utilizes the browser to display "home pages"--graphical representations of information stored on WWW servers connected to the Internet.

WWW home pages include "hot links," which are usually represented by the browser as underlined text or as special graphical elements. When a user viewing a home page clicks on one of the hot links, the browser retrieves from the WWW network a home page associated with the selected link. Linked pages may be retrieved from the same or different servers. The sources of linked pages are transparent to the user. Thus, when navigating links between WWW pages, a user gets an impression of dealing with a single, interconnected "web" of information.

As currently implemented in the WWW, each hot link included in a Web document is assigned an address called a Uniform Resource Locator (URL). The URL includes: 1) a protocol indicator; 2) the address of the Internet server on which a particular document resides (generally this address is specified as the Internet domain name of the host or the host IP address); and 3) the address of the document on the server (this address generally consists of a full file name, including a directory path, of the file which contains the document). For example, in URL:*http://www.bellcore.com/aboutbell2.html*, "*http*," which stands for hypertext transfer protocol, identifies the protocol used between browsers and the Web servers; "*www.bellcore.com*" corresponds to the address of Bellcore's (the present assignee) Web server; and "*aboutbell2.html*" identifies the document.

Many companies have home pages that may be accessed in the above manner and that allow Internet users to get more information regarding companies. However, many corporate home pages are still in their infancy. Most provide only generic, non-customer specific information. Additionally most corporate home pages do not permit customers to make queries, get customer-specific information or to make changes to their service. Adding these capabilities would create a more personalized and dynamic exchange with existing or potential customers. Interactions could be custom tailored and product advertisements could be made user specific based on customer profiles or other data stored in corporate databases. Additionally, allowing Internet users to directly access information, products and services would allow for closing sales with customers who have become interested due to the product literature available from the home page. This potential may be lost when the home page is not integrated with the corporate systems that allow access to such products and services.

Some companies have started linking their home pages to their corporate systems. This is typically done by building point to point interfaces between the Web server and the corporate systems. This can be costly, however, particularly when compared to the potential for reuse of existing interface implementations currently in place in IVR systems. Such interfaces can also make it difficult to ensure consistency in customer interactions across a company's various channels, and make it difficult to obtain an overall view of the effectiveness of each channel.

Another current solution for linking home pages and corporate systems is electronic mail, or e-mail. However, e-mail normally requires staff to review the e-mail requests, apply business rules to determine if the requests are appropriate, input the request into the correct corporate system, and respond to the customer. These many steps restrict the advantages of automation.

Currently, Pacific Bell offers services over an agentless, telephone based Electronic Channel New Product Line (ECNPL). ECNPL call volume is projected to increase markedly. Such electronic interactions, as compared to interactions via traditional access methods, for example, over the telephone with an agent, emphasize improved operational efficiency, high availability, reliability, and security. Additionally, using ECNPL, it is often possible to decrease the activation interval or provide immediate activation for changes in service.

However, some self-service offerings are difficult to provide through a telephone interface such as ECNPL. Such offerings may become more feasible using the powerful graphical interface of the WWW. For instance, many advanced intelligent network (AIN) services, such as Do-Not-Disturb and Follow-Me services are cumbersome to instantiate and administer through a telephone channel.

It is therefore an object of the present invention to provide a customer contact services node Internet gateway (CCSN/IG) that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

It is desirable to provide a CCSN/IG by which a user can access a provider's information and services via the Internet.

It is additionally desirable to enhance a provider's existing Internet and home page capabilities to include more complex transactions.

It is also desirable to provide a common toolset for implementing business rules and data access which will leverage the equipment and experienced staff already involved in service creation via an ECNPL.

It is further desirable to provide a common toolset for tracking and reporting on various aspects of a company's customer care offerings including integrating data across the different channels.

Additional objectives, features, and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by means of the instrumentalities and combinations particularly pointed out in the written description and appended claims hereof, as well as the appended drawings.

Description of the Invention

According to the present invention, a provider's services and customer-specific information are easily and effectively marketed, provided, and administered off of the provider's home page. Wireless and broadband services may be provided as well.

The WWW-based "customer care" channel of the present invention is an effective complement to a telephony channel and the present invention envisions a set of WWW customer contact services similar to today's AIN customer contact services. In addition to providing a complement to a telephone-based self-service channel, such as ECNPL, according to the present invention, a customer contact service node Internet gateway (CCSN/IG) expands the capabilities available through a company's home page by allowing Internet users to not only get customer-specific information and information about available services, but to access and update customer-specific data. In that way, users, for example, access a company's home page and get user-specific information, order services, update or change existing services, or disconnect from services. At the same time, the company can get information about its customers and the services and information desired by its customers. In this way, the company could respond to its customers needs and offer new and different services and information as appropriate.

As an example, in the telephony industry, the CCSN/IG of the present invention allows users to access self-service offerings such as 900/976 call blocking, custom calling, custom local area signalling services (CLASS), inside wire repair plan, and residential optional calling plans. Additionally, the CCSN/IG allows for easy administration of personal identification number (PIN) changes and for the administration of complex services, such as Do Not Disturb and Follow Me. Users will also be able to access customer-specific information, such as billing data and services data. The CCSN/IG allows providers to get information about its customers by providing questionnaires and profiles and could receive customer complaints and/or comments in general.

The CCSN/IG of the present invention complements other telephone based ECNPL self-service offerings by providing similar services to other market segments while reusing the embedded base of systems and interfaces that are currently used in telephony-based self-service offerings. It is envisioned that companies will be able to leverage their existing operational systems that are utilized to provide ECNPL in providing a CCSN/IG. Thus, the overall cost and time of providing products and services to Internet users is small.

From a marketing perspective, providing access to services and information via the Internet makes the company's products and services more readily available and therefore will help promote those products and services, educate users and increase sales. Additionally, processing customer requests via a self-service channel costs significantly less as compared to processing such requests via an agent. Furthermore, compared to the relatively high costs associated with interactive voice recognition (IVR) ports, voice recognition boards, and the other components of a self-service channel with a telephone-based user interface, a self-service channel with an Internet-based user interface that is front-ended by the Internet can drive the cost per transaction significantly lower. Additionally, sizing telephony hardware resources to meet required service level objectives during peak demand periods makes cost of the telephone system higher. For example, at the beginning and the end of college semesters, the demand for telephone services may be great. Offering a software-based solution, such as Internet access, provides a cost-effective solution. This is particularly so in the example above because many of those requesting service connection or disconnection would have access to the Internet.

Additionally, new services and products can be offered to users without delay because the provider's home page can be easily changed to allow access to and selection of such new products and services.

Thus, the CCSN/IG of the present invention provides a gateway between a provider's WWW home page and its information and services and also provides a single platform for all customer care access methods. The present invention also advantageously provides the opportunity to immediately offer self-service options on the WWW that parallel those offered through an ECNPL.

Additionally, the CCSN/IG of the present invention advantageously provides an integrated platform for development, operations, administration and reporting as well as the ability to leverage previous investments in systems, interfaces, networks and staff. Specifically, the CCSN/IG of the present invention allows a provider to leverage its existing operations support systems (OSS) rather than incurring these costs again. As new OSS interfaces are incorporated into the CCSN architecture, the cost of developing these interfaces is incurred once, rather than being repeated for each customer care channel.

An additional benefit of the present invention is that the CCSN/IG of the present invention can be used with existing applications, such as Bellcore's proprietary SPACE® application and the data and reporting system (DRS) to provide an integrated view of the interactions taking place over the Internet and across the traditional telephone interface.

To achieve these and other advantages and in accordance with the purposes of the invention, as embodied and broadly described, the invention includes a customer contact services system comprising means for accessing the Internet, means for entering a request, means for displaying the request, customer contact services node Internet gateway (CCSN/IG) means, coupled to the display means and to the Internet, for accepting the request, network means, coupled to the CCSN/IG means, for providing access to a particular set of services and data, and customer contact services node (CCSN) means, coupled to the network means, for processing the request and for providing information about the request through the network means and the CCSN/IG means to the display means.

In accordance with the purposes of the invention, as embodied and broadly described, the invention also includes a method for user access to data and services of a provider comprising the steps of accessing a network, entering a request, displaying the request, accepting the request via a customer contact services node network gateway, providing access to a particular set of data and services of the provider, and processing the request and providing information about the request through the network and the customer contact services node network gateway.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred implementations of the invention and, together with the general description given above and the detailed description of the preferred implementations given below, serve to explain the principles of the invention.

In the Drawings:

Fig. 1 is a block diagram of a customer contact services system in accordance with one embodiment of the present invention;

Fig. 2 is a block diagram showing in greater detail the customer contact services system in accordance with one embodiment of the present invention;

Fig 3 is a block diagram showing in greater detail the corporate database and operations system shown in Fig. 2 in accordance with one embodiment of the present invention;

Figs. 4A-4E are exemplary screens illustrating how a user interfaces with a customer contact services system in accordance with one embodiment of the present invention;

Fig. 5 is a flow diagram showing how a service request is made using the customer contact services system in accordance with one embodiment of the present invention; and

Fig. 6 is a flow diagram illustrating exemplary steps taken during an interface with a customer contact services system in accordance with one embodiment of the present invention.

Best Mode For Carrying Out the Invention

Reference will now be made in detail to the construction and operation of preferred implementations of the present invention which are illustrated in the accompanying drawings. In those drawings, like elements and operations are designated with the same reference numbers where appropriate.

The following description of the preferred implementations of the present invention is only exemplary of the invention. The present invention is not limited to these implementations, but may be realized by other implementations.

Fig. 1 is a block diagram of an integrated Internet system in accordance with one embodiment of the present invention. As shown, a PC user 103 is connected to the Internet 100 via the HTTP/TCP/IP protocol. Although a PC user 103 is shown in Fig. 1, the present invention is not so limited. Instead of using a PC, a user could access the Internet via a Unix workstation, a wireless personal digital assistant, or any other type of device used to access the Internet. The Internet 100 communicates with the CCSN/IG 104 also via the HTTP/TCP/IP protocol. The CCSN/IG 104 provides a gateway interface between the PC user 103 and a provider's customer contact services node (CCSN) 108. The CCSN/IG 104 runs standard HTTP server software that accepts an HTTP request from the PC user 103 over the Internet 100. The CCSN/IG 104 communicates with a network 107 using the TCP/IP protocol. Interposed between the CCSN/IG 104 and the network 107 is a "firewall" 113, which prevents the PC user 103 from gaining unauthorized access to files and applications in the network 107.

The network 107 is also connected to the CCSN 108 via the TCP/IP protocol, or any other appropriate protocol. The CCSN 108 runs applications, such as Bellcore's proprietary SPACE® application 112. The SPACE® application 112 is used to create business rules for interacting with customers and has been successfully implemented in telephone service control points (SCP) to efficiently create and instantiate telephone services. The SPACE® application 112 generates call processing records (CPR) and stores them in a database, not shown, associated with the CCSN 108.

The CCSN 108 is also connected to the line information database (LIDB) 109. The LIDB 109 contains information regarding telephone service subscribers. It may be keyed by the billing telephone number of the user 103 and retrieves information about particular accounts. More specifically, the LIDB 109 contains information essential for making collect calls, calls billed to third numbers, and calls charged to calling cards. The LIDB 109 is used to automatically verify that the telephone number to which a person wants to bill a collect or third-number call has been assigned and can be charged for such calls. The LIDB 109 also validates the personal identification number (PIN) assigned to each calling card.

The CCSN 108 is also connected to the corporate database and operations system 110, which is used to support the operations and applications of the CCSN 108, such as interactions with customers and customer billing. The CCSN 108 is also connected to the data and reporting system (DRS) 111. The DRS 111 may be used to collect information on customer interactions taking place via the

CCSN 108. Thus, information gathered about a PC user 103 who accesses the CCSN 108 can be collected by the DRS 111. Additionally, information provided by such users, such as in response to questionnaires, can be stored and maintained in the DRS 111.

The integrated Internet system as shown in Fig. 1 also allows a telephone user 102 to access the network 107 and the CCSN 108. Access to the CCSN 108 for a telephone user 102 is accomplished via public switched telephone network (PSTN) 101, automated call distributor (ACD) 105 and intelligent peripheral (IP) 106. These elements comprise an IVR system by which a user can access information and services, made available through the CCSN 108, in a self-service or agentless fashion. Alternatively, a telephone user 102 can access the provider's services and products with the assistance of an agent, if necessary.

As illustrated in Fig. 1, the CCSN/IG 104 can be thought of as an add-on to existing systems that allow access to a CCSN 108 by a telephone user 102. In this manner, one customer contact system may be implemented for both access methodologies using the same set of rules and logic as well as using the systems previously in place for the telephone system.

Fig. 2 is a block diagram showing in greater detail the CCSN/IG system in accordance with one embodiment of the present invention.

As shown in Fig. 2, the CCSN/IG 104 comprises a Web server 201 and an integrated service control point (ISCP) gateway 202. The Web server 201 corresponds to a conventional Internet server, such as Webstar from Quarterdeck Corp. or Netscape Communications Server from Netscape Communications Corp. The Web server 201 communicates with the Internet 100 via the HTTP/TCP/IP protocol. To communicate on the Web, the PC user 103 must be running a Web browser application, such as Netscape's Navigator or Microsoft's Internet Explorer, which supports hyperlinks based retrieval of documents stored in Web files 203 any place on the Internet 100. The Web files 203 may include documents in hypertext markup language (HTML), that may contain graphics, video, and sound, and which may be linked to other documents.

The ISCP gateway 202 implements the application function of the gateway. In general, the ISCP gateway 202 responds to user queries forwarded by the Web server 201 by returning HTML templates augmented with the data retrieved from back-end systems, such as the ISCP and the systems that the ISCP interfaces with. The ISCP gateway 202 interacts with the Web server 201 utilizing the interface of the Web server 201. This interface may be, for example, the common gateway interface (CGI) 204, shown in Fig. 2. The CGI 204 is used to communicate between the Web server 201 and the applications that can service the PC user's 103 request. Instead of the CGI 204, the server interface can be NSAPI when the Netscape Web server is used or ISAPI when the Microsoft Web server is used.

Fig 3 is a block diagram showing in greater detail the elements of an exemplary corporate database and operations system 110 in accordance with one embodiment of the present invention. It should be noted that the elements of corporate database and operations system 110 will differ depending on the corporate system which the user 103 accesses. The elements of the corporate database and operations system 110 shown in Fig. 3 are exemplary of a telecommunications provider.

The CCSN 108 is connected to the elements of the corporate database and operations system 110 via a wide area network 310. The wide area network 310 is directly connected to various database and operations systems as described in greater detail below.

The AP 301, connected to the wide area network 310, is an operations system used to activate and or modify services for a user 103. Thus, when user 103 wants to modify his services, the service request is sent to the AP 301 operations system. The LMOS 302 is an operations system used to provide service assurance. Such service assurance can include, for example, trouble reporting, testing, and fault isolation. The BOSS 303 is an operations system used to maintain customer billing and payment information.

The CCPL 304 is a gateway system used to provide access to the various operations systems 306-309. The CCPL 304 also performs protocol conversions and maintains any local databases. The CCDL 305 is such a database within the CCPL 304 and is used to store temporary miscellaneous corporate data such as temporary pricing plans for current promotional campaigns.

The PBP 309 is an operations system that provides customer verification and authentication services. An exemplary service could be personal identification number (PIN) validation. The PREMIS system 308 is an operations system used to maintain and validate the location of customers. For instance, PREMIS 308 can be used to maintain the street addresses of customers. The AOG 307 is an operations system used to maintain information regarding pending customer service activation requests. Finally, the MI 306 is an operations system used to maintain for each customer a profile of the services used by that customer.

The corporate database and operations system 110 also may include an agent station 311. Instead of accessing any of the operations systems 301-303 or 306-309, the user 103 can, in alternative embodiments, interface with the agent station 311. The agent at the agent station 311 will work at an appropriate desktop device such as a PC, a workstation, a 3270 terminal, or any other appropriate device.

According to the present invention, an Internet interface through a CCSN/IG to a provider's home page could be used to allow customers to order or discontinue services or to get customer-specific information. For instance, in a telecommunications application, the CCSN/IG of the present invention could allow customers to order certain telephone services or disconnect from services over the Internet. By permitting service connection/disconnection in this manner, it is envisioned that backlogs or the need to use a greater than normal number of service operators during peak service connect/disconnect periods, such as the beginning and end of school years, would be eliminated. Figs. 4A-4E are exemplary screens illustrating how a user interfaces with the customer contact services system in accordance with one embodiment of the present invention.

Fig. 4A shows an example of a provider's home page according to the present invention. A PC user 103, shown in Figs. 1-3, could access this screen, or one like it, through the Internet 100 and the CCSN/IG 104 of the present invention. As shown in Fig. 4A, the user could first get information about the service features of the provider. For instance, where the provider is a telecommunications company, the user could access information about call forwarding 401, call screening 402, call waiting 403, select call forwarding 404, and speed calling wait 405. By selecting one of the options 401-405, the user can access information such as general information about the service, and the cost of the service. Selecting one of the options 401-405 will bring up another screen, not shown, which will display specific information about the requested service.

As also shown in Fig. 4A, the user can select to order or cancel any of the available service features 401-405 by selecting the order/cancel option 406. Selection of the order/cancel option 406, will cause the screen shown in Fig. 4B to be displayed. Fig. 4B is a verification screen and requires the user to enter certain information before any requested changes to a service can be made. First, in the case of a telecommunications provider, the user is prompted to enter his telephone number in box 407. After entering the telephone number, the user must enter a password which can be, for example, a certain number of digits of a calling card number 408, an account number 409, or a PIN number 410. After the telephone number and password have been entered, the user selects the submit key 411 and proceeds on to the service modification screen shown in Fig. 4C.

The service modification request screen in Fig. 4C can first display the account number and name of the person seeking to modify their service in box 412. Fig. 4C also shows table 413 showing service features that are available to the user. The service features can be different for different users, depending on the geographic availability of services for particular users. Table 413 indicates whether a particular service feature is currently subscribed to. For service features that are currently subscribed to, such as call waiting and speed calling eight, shown in table 413, the user can select to cancel such services, while for service features that are not currently subscribed to, the user can elect to order such services. Additionally, for all service features listed in the table 413, the user can elect no change to each current service feature. When the user is finished making his desired service modifications, he will depress the submit box 414. In addition, if the user wants to abort any of the service changes, he can select the cancel box 415. Instructional text may be inserted at the ellipses 420.

If the user selects to change his service, the order verification screen of Fig. 4D preferably appears. The order verification screen displays a subscription status table 416 which lists the subscription status of all of the available service features after any changes have been made. The order verification screen can also optionally display the service charges that will be billed to the user as well as any other appropriate messages about the user's account or services. Such information, or other instructions may appear at ellipses 420. After the user reviews the subscription status table 416 and any other information provided, the user will accept the service changes by selecting the confirm box 417. If, however, after reviewing the subscription status table 416 and the other information provided to the user, the user decides that the service modifications are not acceptable, the user can abort the changes to service by selecting the cancel box 418.

If the user selects the confirm box 417, a confirmation screen, such as that shown in Fig. 4E, may appear. The confirmation screen will, for example, inform the user that the service modifications have been accepted for processing and when the service changes will be made at ellipses 420. Additionally, the confirmation screen may advise the user that he will receive a separate confirmation by mail. The confirmation screen could also be configured to inform the user that a separate confirmation of the service modifications will be sent by e-mail. Also at the confirmation screen, the user can return to the provider's main page by selecting the main page box 419.

As described above, Figs. 4A-4E are exemplary screens that can be displayed when a user accesses a provider's services through the CCSN/IG of the present invention. The screens provided to the user will differ depending on the services made available by the provider. Additionally, the screens a specific provider makes available can differ depending on the particular users. For example, different screens can be made available to an individual account holder as opposed to a small business account.

Fig. 5 is a flow diagram showing how a request is made using the customer contact services system in accordance with one embodiment of the present invention. As shown in Fig. 5, a user first accesses the Internet in step 501. Included within step 501 is the step of accessing information about a particular service provider. This may be accomplished by accessing the home page of a service provider. Following access to information about the service provider, the user enters a request in step 502. As explained above, such a request could for example be a request to add an additional telephone service, or change a telephone service, or to receive customer-specific information. The present invention, however, is not so limited and also could include a request regarding ordering merchandise from a retailer, for example. After the request is entered in step 502, it is displayed to the user in step 503. The request is displayed so that the user can modify the request before it is sent to the provider. The request is then accepted by the provider in step 504. After the request is accepted, the provider provides information about the request to the user in step 505. The information provided to the user can be that a change in service, such as an addition or cancellation of service, has or will be processed by the provider, for example. Alternatively, the information could be the customer-specific information, such as billing data, requested by the user. In order for the provider to send such information to the user, it may be necessary for the provider to access its own databases and/or operations systems, as shown in Figs. 1-3.

Fig. 6 is a flow diagram illustrating exemplary steps taken during an interface with a customer contact services system in accordance with one embodiment of the present invention. In step 601, the user accesses the provider's services, and a home page screen, such as that shown in Fig. 4A, may appear. Next, in step 602, the user decides whether he wants to get any information about the provider's services. If yes, the information is provided in step 603. If the user does not want any additional information, then he proceeds to step 604 where he decides whether he wants to order or cancel any of the provider's services. If the user does not want to order or cancel any services, in step 605, the user decides if he wishes to exit from the provider's services, if not, the user is returned to step 602 and if so, the user is exited at step 606.

When the user wants to order or cancel services, at step 607 information identification, such as a user identification and a password, is inputted. At step 608, the user is verified if the correct identification information was entered. If not, the user is exited at step 606. If the user is verified, then at step 609 the user enters the desired service changes. The user confirms whether the entered service changes are correct at step 610. If the changes are not correct, the user can correct the changes at step 609. If the changes are correct, the changes are entered. Confirmation of the service changes is made at step 612. If the user is done accessing the provider's services, at step 613 he so indicates and is exited at step 606. If the user is not finished, he is returned to step 602.

It should be noted that the steps shown in Fig. 6 are exemplary only and can differ depending on the type of services provided by the provider and can also differ depending on the type of user.

Although previously discussed in terms of use over the Internet, the CCSN/IG of the present invention can also be used in an "intra-net" or internal Web server used exclusively to service the needs of an individual organization. Estimates indicate that more internal Web servers exist today than external Web servers. These internal Web servers provide a number of advantages when deploying applications for internal use. For instance, browsers already exist for a wide variety of end-user platforms, making the task of cross-platform development and support much easier. Additionally, in an intra-net situation, only the browser is distributed to each desktop while the application resides at a central location thereby making the administration of internal applications much easier. The same browser can be used for many different applications and therefore users do not have to become accustomed to the look and feel of multiple browsers. Also, the powerful presentation capabilities of today's Web browsers allow for creation of appealing and easy to use applications.

There are several additional advantages of such an intra-net system. First, the system administrator of an intra-net system has a great deal of control over who has access to the system and to the particular applications residing in the system. Additionally, there is no need to provide a firewall and the security risks of such a system are much lower than in an Internet system. These lower security risks make the engineering of such a system much easier than in an Internet system.

While there has been illustrated and described what are considered to be preferred embodiments and methods of the present invention, it will be understood by those skilled in the art that various changes and modifications may be made, and equivalents may be substituted for elements thereof without departing from the true scope of the invention.

In addition, many modifications may be made to adapt a particular element, technique or implementation to the teachings of the present invention without departing from the central scope of the invention. Therefore, it is intended that this invention not be limited to the particular embodiments and methods disclosed herein, but that the invention involve all embodiments falling within the scope of the appended claims.

Claims:

1. A customer contact services system comprising:

means for accessing the Internet;

means for entering a request;

means for displaying the request;

a customer contact services node Internet gateway (CCSN/IG), coupled to the display means and to the Internet, for accepting the request;

a network, coupled to the CCSN/IG, for providing access to a particular set of services and data; and

a customer contact services node (CCSN), coupled to the network, for processing the request and for providing information about the request through the network and the CCSN/IG to the display means.

2. The system according to claim 1, wherein the entering means may be responsive to the information provided by the CCSN means regarding the request.

3. The system according to claim 1, wherein the CCSN means comprises means for invoking at least one call processing record (CPR) in response to the request.

4. The system according to claim 1, further comprising interactive voice response (IVR) means, coupled to the network means, for providing telephone access to the network means and for permitting a request to be made over the telephone.

5. The system according to claim 1, wherein the CCSN/IG means further comprises:

a Web server for providing access to the World Wide Web (WWW); and an integrated services control point (ISCP) gateway, coupled to the Web server, for accessing the network means.

6. The system according to claim 5, further comprising a firewall disposed between the ISCP gateway and the network.

7. A method for user access to a services and data of a provider comprising:

accessing a network;

entering a request;

displaying the request;

accepting the request via a customer contact services node Internet (CCSN/IG) gateway;

providing access to a particular set of data and services of the provider; and

processing the request and providing information about the request through the network and the customer contact services node network gateway.

8. The method according to claim 7, wherein the accessing step comprises accessing the Internet.

9. The method according to claim 7, wherein the accessing step comprises accessing an intra-net.

FIG. 1

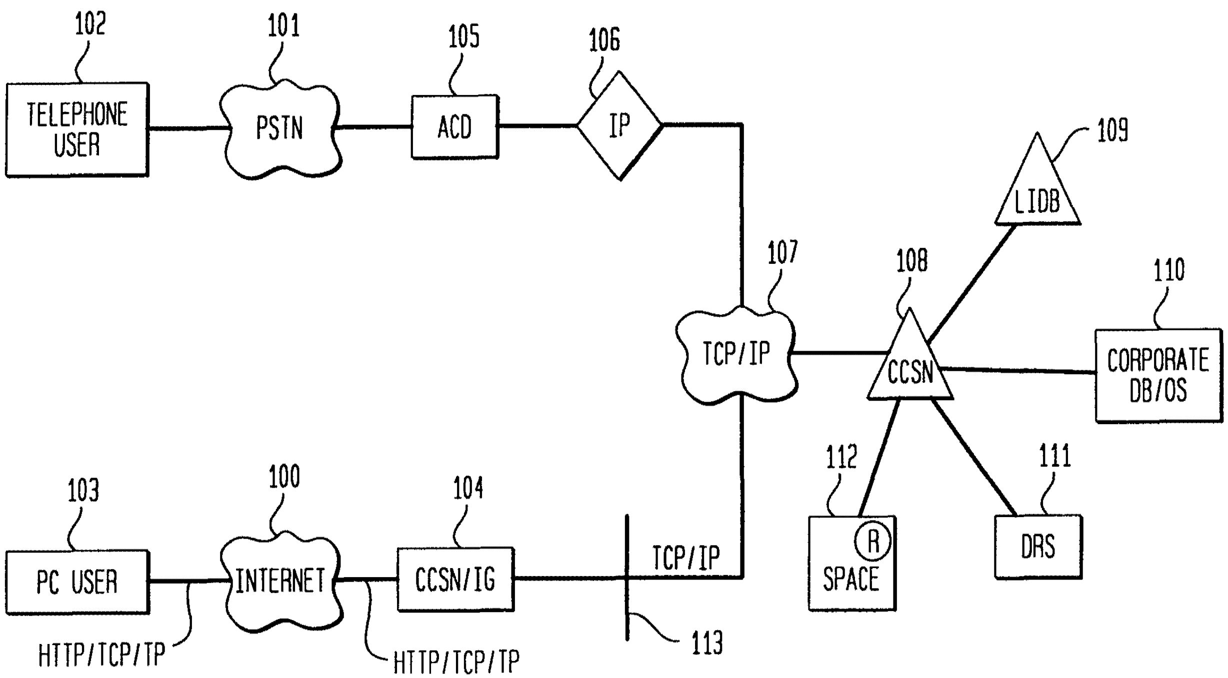

102
TELEPHONE USER
101
PSTN
105
ACD
106
IP
109
LIDB
107
TCP/IP
108
CCSN
110
CORPORATE DB/OS
103
PC USER
100
INTERNET
104
CCSN/IG
HTTP/TCP/TP
HTTP/TCP/TP
TCP/IP
113
112
R
SPACE
111
DRS

FIG. 2

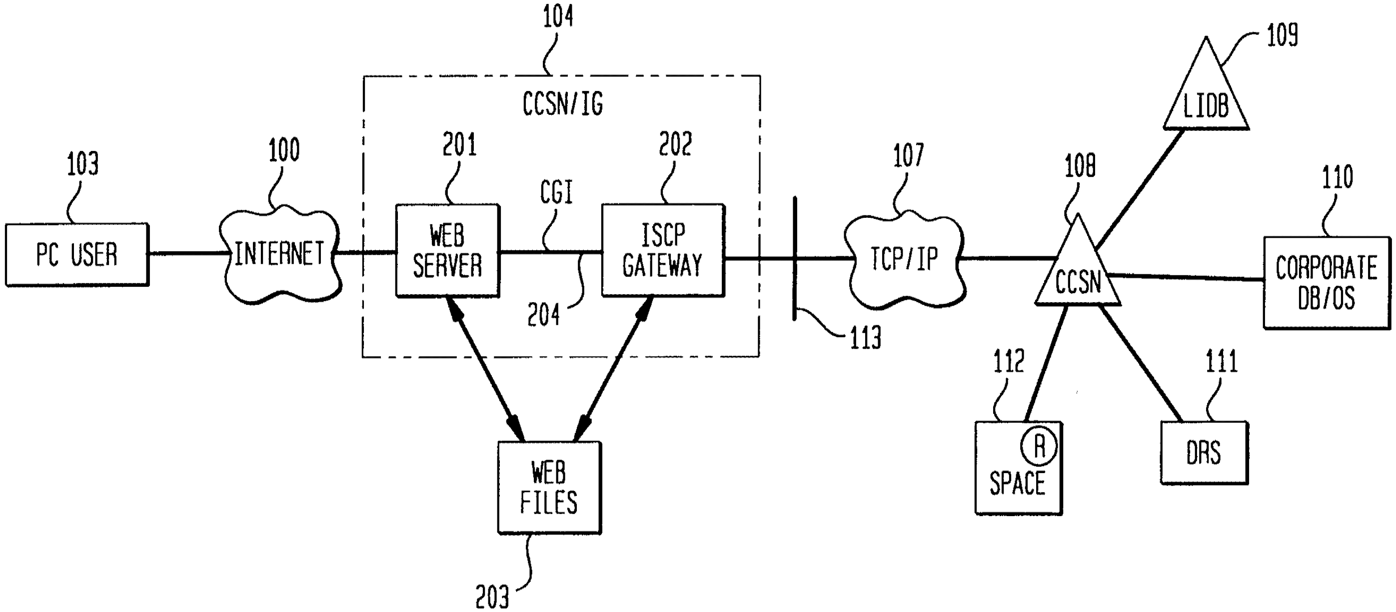

104
CCSN/IG
103
PC USER
100
INTERNET
201
WEB SERVER
CGI
202
ISCP GATEWAY
204
107
TCP/IP
113
108
CCSN
109
LIDB
110
CORPORATE DB/OS
112
SPACE
111
DRS
WEB FILES
203

FIG. 3

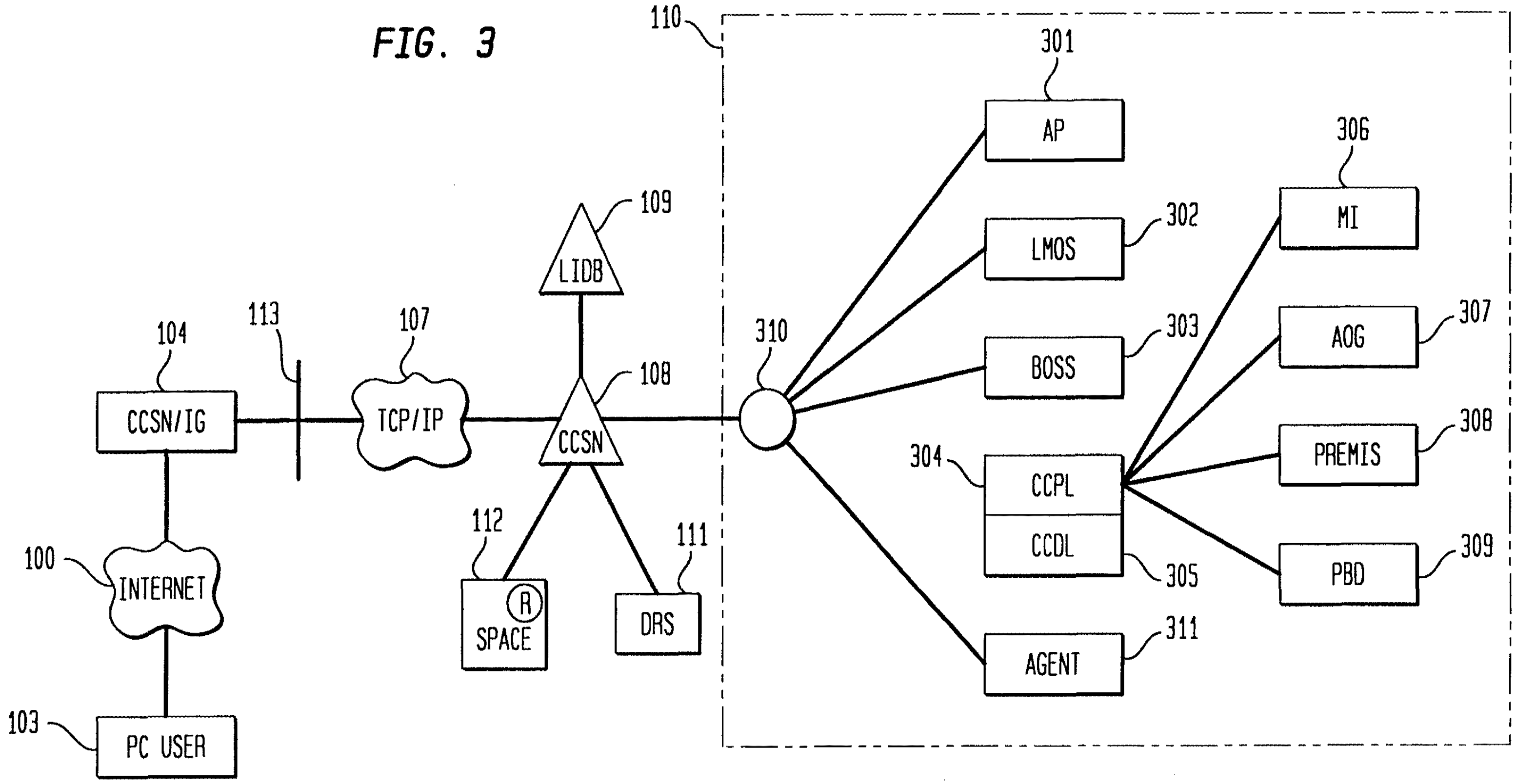

110
301
AP
302
LMOS
303
BOSS
304
CCPL
CCDL
305
311
AGENT
306
MI
307
AOG
308
PREMIS
309
PBD
310
109
LIDB
108
CCSN
107
TCP/IP
113
104
CCSN/IG
100
INTERNET
103
PC USER
112
R
SPACE
111
DRS

FIG. 4A

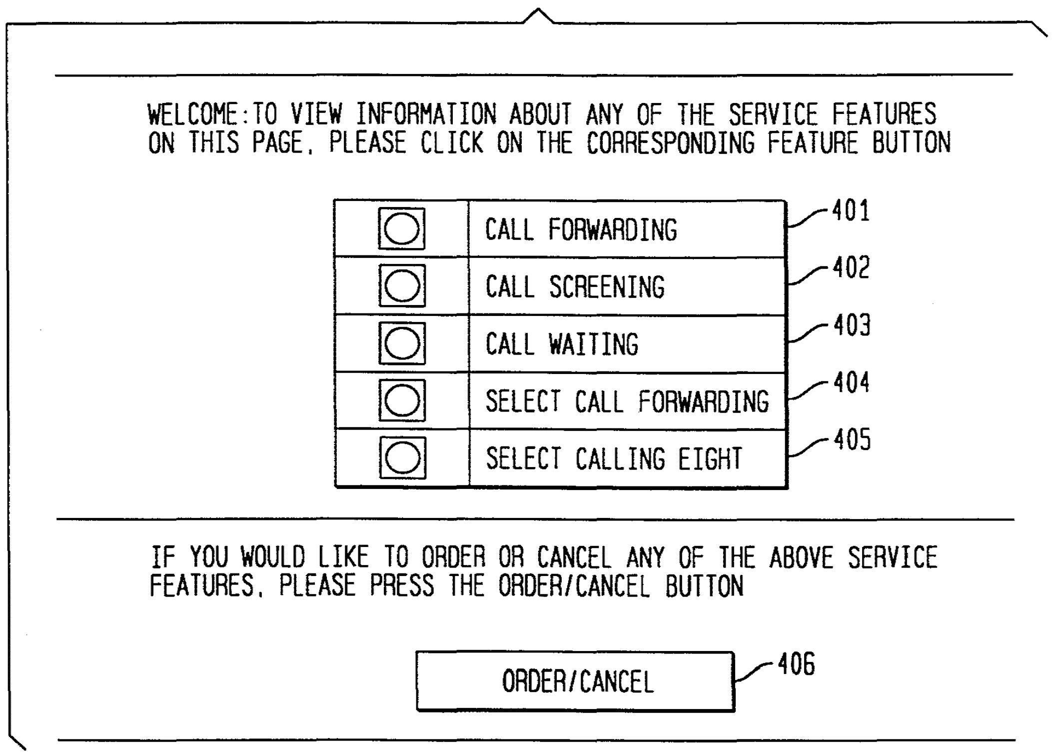

WELCOME:TO VIEW INFORMATION ABOUT ANY OF THE SERVICE FEATURES ON THIS PAGE, PLEASE CLICK ON THE CORRESPONDING FEATURE BUTTON
CALL FORWARDING
401
CALL SCREENING
402
CALL WAITING
403
SELECT CALL FORWARDING
404
SELECT CALLING EIGHT
405
IF YOU WOULD LIKE TO ORDER OR CANCEL ANY OF THE ABOVE SERVICE FEATURES, PLEASE PRESS THE ORDER/CANCEL BUTTON
ORDER/CANCEL
406

FIG. 4B

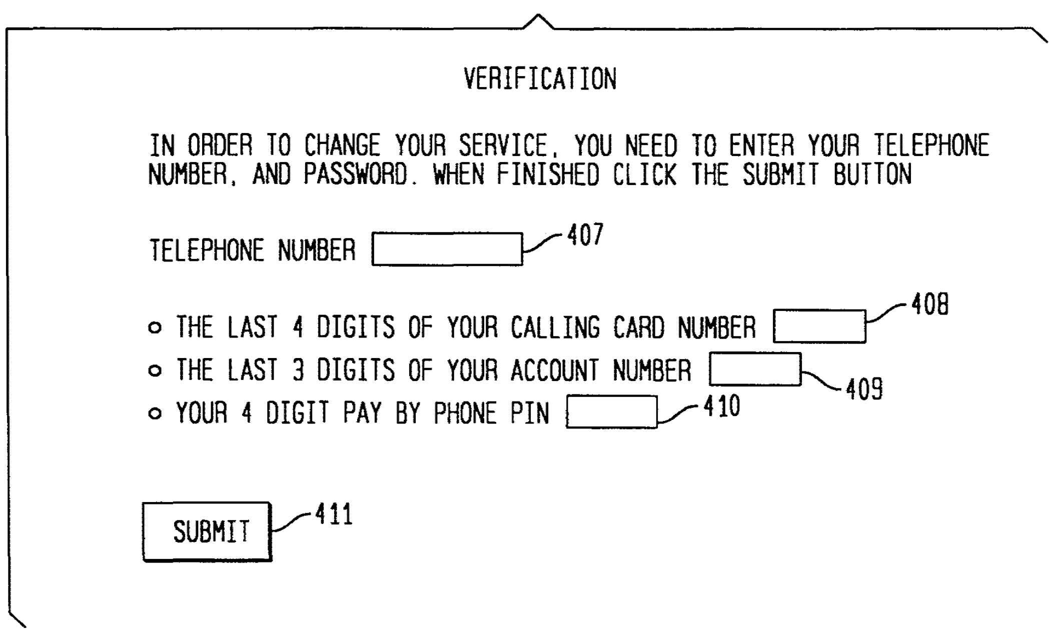

VERIFICATION
IN ORDER TO CHANGE YOUR SERVICE, YOU NEED TO ENTER YOUR TELEPHONE NUMBER, AND PASSWORD. WHEN FINISHED CLICK THE SUBMIT BUTTON
TELEPHONE NUMBER
407
THE LAST 4 DIGITS OF YOUR CALLING CARD NUMBER
408
THE LAST 3 DIGITS OF YOUR ACCOUNT NUMBER
409
YOUR 4 DIGIT PAY BY PHONE PIN
410
SUBMIT
411

FIG. 4C

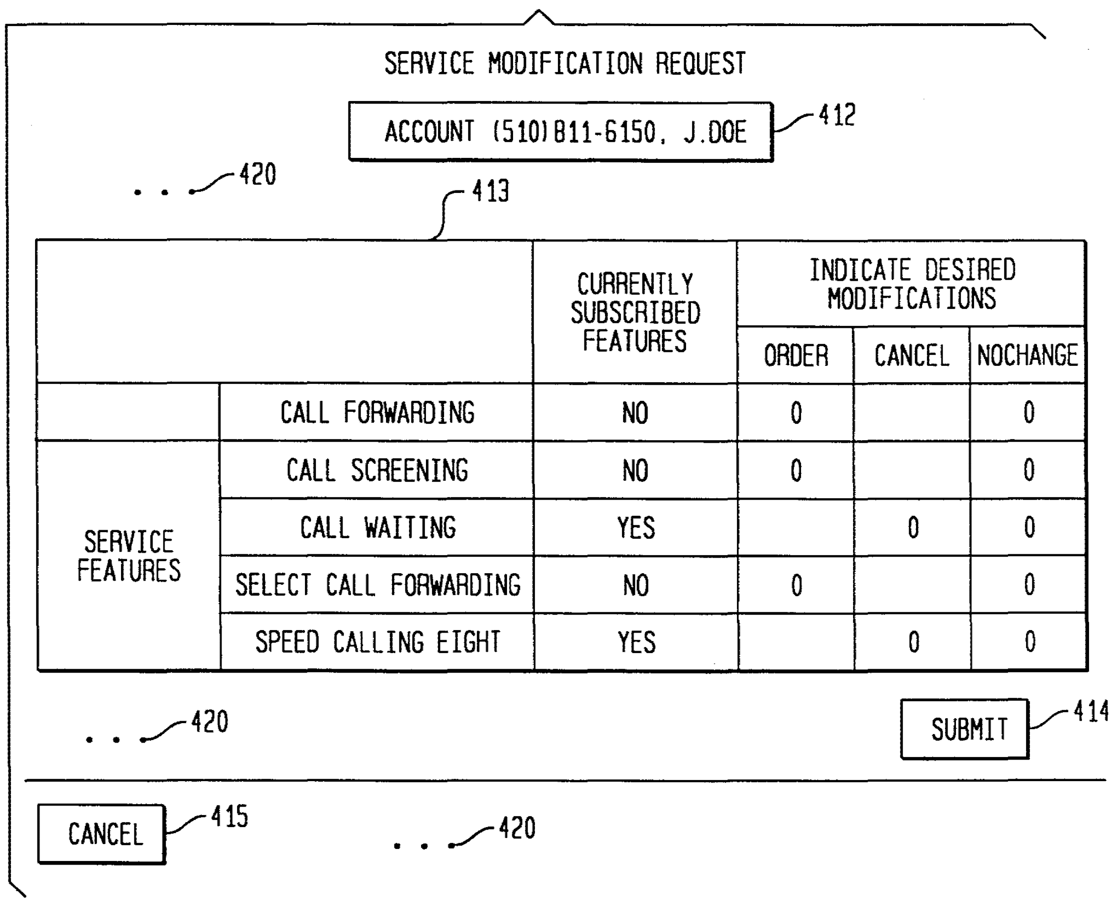
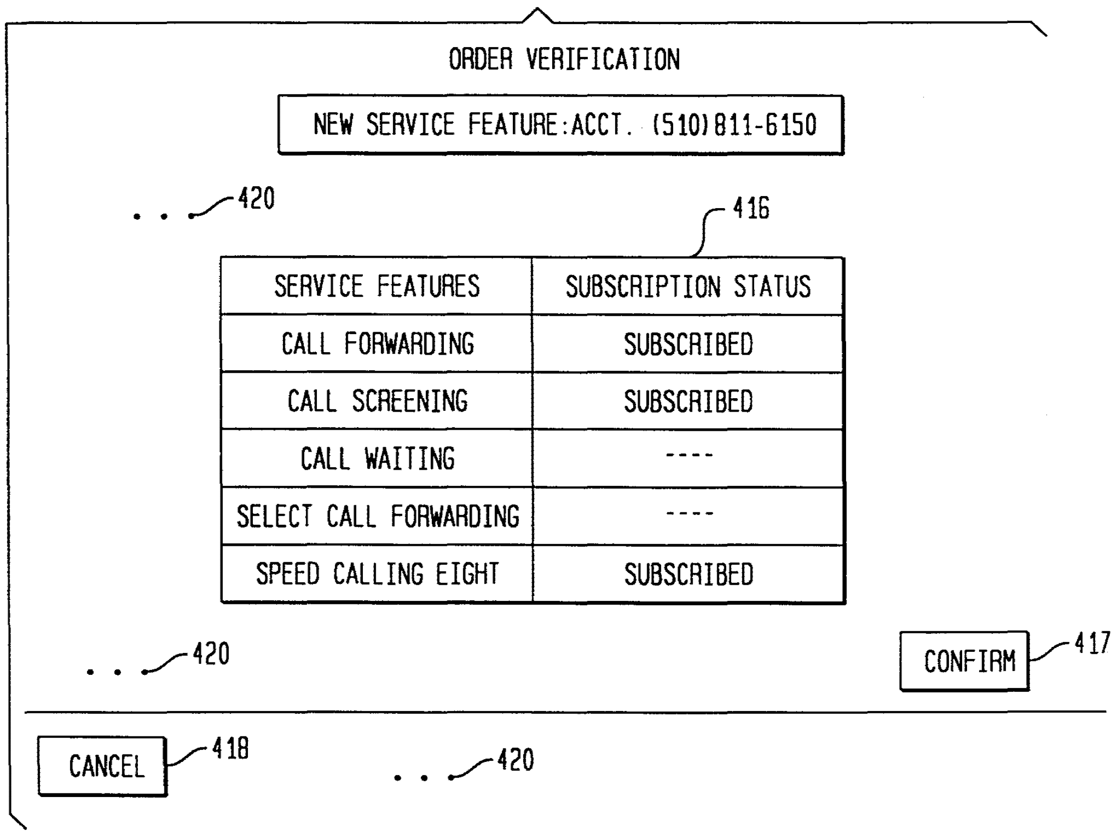

SERVICE MODIFICATION REQUEST
ACCOUNT (510)811-6150, J.DOE
412
420
413
CURRENTLY SUBSCRIBED FEATURES
INDICATE DESIRED MODIFICATIONS
ORDER
CANCEL
NOCHANGE
CALL FORWARDING
NO
0
0
SERVICE FEATURES
CALL SCREENING
NO
0
0
CALL WAITING
YES
0
0
SELECT CALL FORWARDING
NO
0
0
SPEED CALLING EIGHT
YES
0
0
420
SUBMIT
414
CANCEL
415
420

FIG. 4D


ORDER VERIFICATION
NEW SERVICE FEATURE:ACCT. (510)811-6150
420
416
SERVICE FEATURES
SUBSCRIPTION STATUS
CALL FORWARDING
SUBSCRIBED
CALL SCREENING
SUBSCRIBED
CALL WAITING

SELECT CALL FORWARDING

SPEED CALLING EIGHT
SUBSCRIBED
420
CONFIRM
417
CANCEL
418
420

FIG. 4E

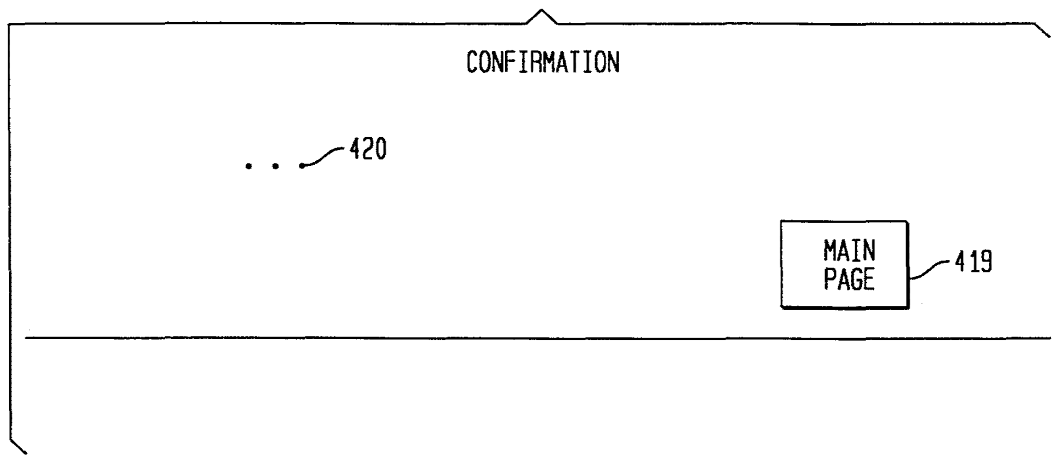

CONFIRMATION
...
420
MAIN PAGE
419

FIG. 5

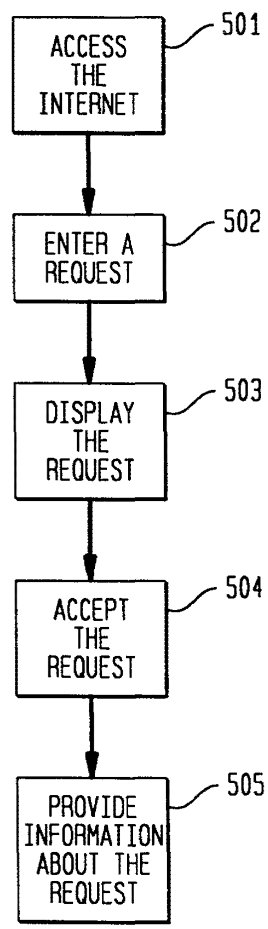
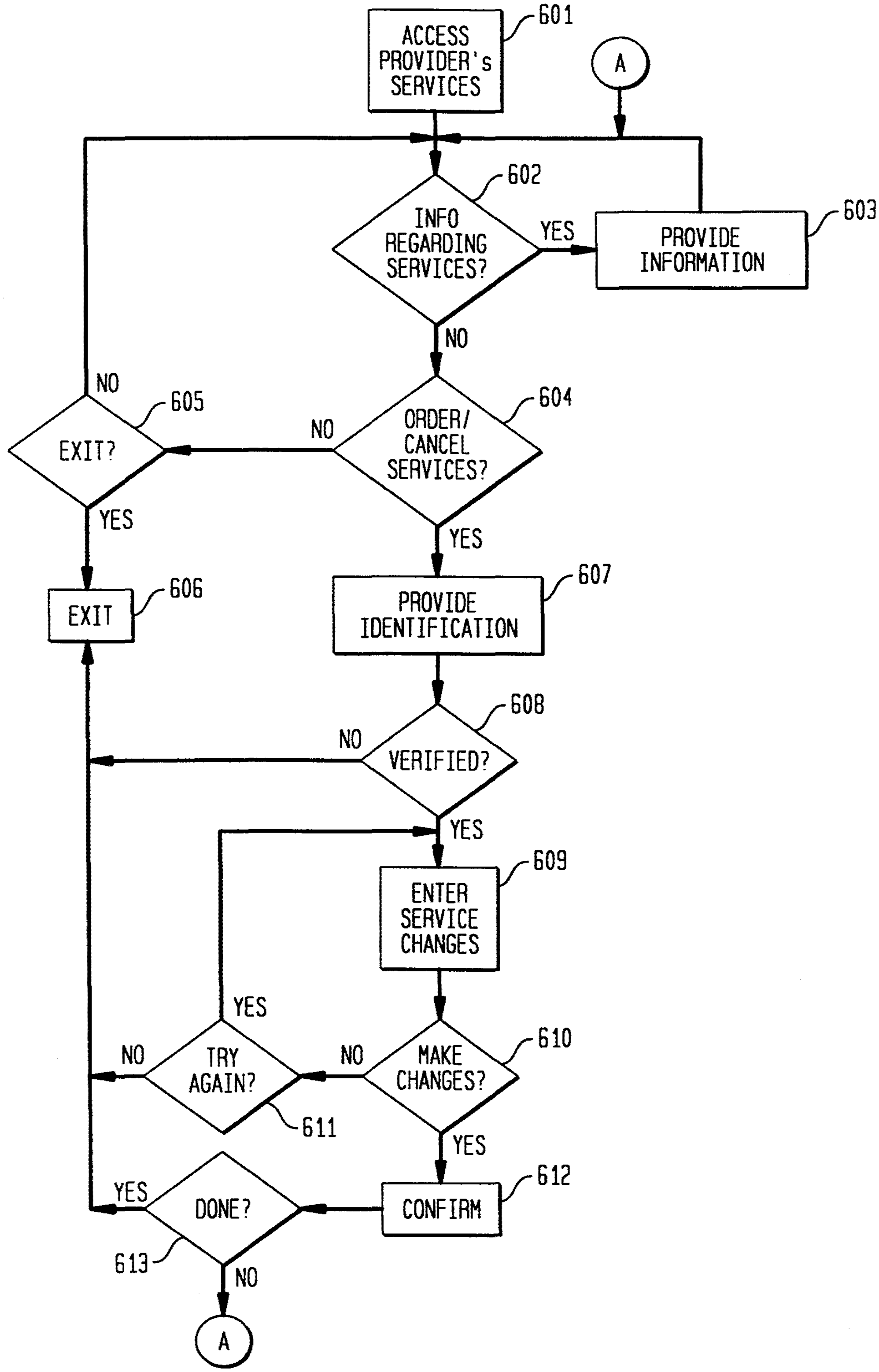

ACCESS THE INTERNET
501
ENTER A REQUEST
502
DISPLAY THE REQUEST
503
ACCEPT THE REQUEST
504
PROVIDE INFORMATION ABOUT THE REQUEST
505

FIG. 6



ACCESS PROVIDER's SERVICES
601
A
INFO REGARDING SERVICES?
602
YES
PROVIDE INFORMATION
603
NO
ORDER/ CANCEL SERVICES?
604
NO
EXIT?
605
NO
YES
EXIT
606
YES
PROVIDE IDENTIFICATION
607
VERIFIED?
608
NO
YES
ENTER SERVICE CHANGES
609
MAKE CHANGES?
610
NO
TRY AGAIN?
611
YES
NO
YES
CONFIRM
612
DONE?
613
YES
NO
A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/12792

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04L 9/00; H04M 3/42; G06F 11/34, 19/00
US CL :Please See Extra Sheet.
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)

APS SEARCH--> Search Terms : customer or client or user, server or provider, network, node, internet gateway (IG), world wide web (WWW), web server

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 5,590,197 A (CHEN ET AL) 31 December 1996, see figure 1, column 1 line 64 to column 2 line 7, column 2 lines 39-48, column 4 lines 43-62, column 5 lines 37-41, column 6 line 12 to column 7 line 8, and column 7 lines 38-41.	1-9
Y,P	US 5,572,643 A (JUDSON) 05 November 1996, see abstract, figures 2-3, column 4 lines 36-51, and column 5 line 41 to column 6 line 12.	1-9
A,P	US 5,572,581 A (SATTAR ET AL) 05 November 1996.	1-9
A,P	US 5,553,239 A (HEATH ET AL) 03 September 1996.	1-9

☐ 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
01 OCTOBER 1997	14 NOV 1997

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
PARSHOTAM LALL
Telephone No. (703) 305-9715

Form PCT/ISA/210 (second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/12792

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

395/200.3, 200.31, 200.47, 200.48, 200.55, 200.59, 187.01;
380/24, 25; 379/201, 207, 211, 212, 229

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

395/200.3, 200.31, 200.47, 200.48, 200.55, 200.59, 187.01;
380/24, 25; 379/201, 207, 211, 212, 229

Form PCT/ISA/210 (extra sheet)(July 1992)★

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
H04B 7/26, 17/00, H04Q 7/20, 7/22, 7/24, 7/26, G01S 3/02, H04M 11/00

A1

(11) International Publication Number: **WO 98/10538**

(43) International Publication Date: 12 March 1998 (12.03.98)

(21) International Application Number: PCT/US97/15933

(22) International Filing Date: 8 September 1997 (08.09.97)

(30) Priority Data:

60/025,855	9 September 1996 (09.09.96)	US
60/044,821	25 April 1997 (25.04.97)	US
Not furnished	20 August 1997 (20.08.97)	US

(71)(72) Applicants and Inventors: LEBLANC, Frederick, W. [US/US]; 7547 Braun Street, Arvada, CO 80005 (US). DuPRAY, Dennis, Jay [US/US]; 222 South Marion Parkway, Denver, CO 80209 (US). KARR, Charles, L. [US/US]; 400 Sandbrook Lane, Tuscaloosa, AL 35405 (US).

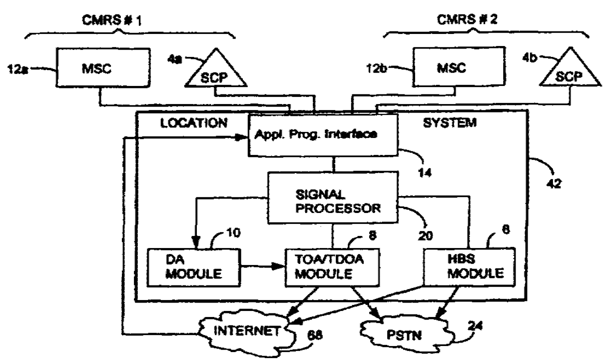
(74) Agents: DuPRAY, Dennis, J. et al.; Sheridan Ross P.C., Suite 3500, 1700 Lincoln Street, Denver, CO 80203-4501 (US).

(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, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), 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: LOCATION OF A MOBILE STATION USING A PLURALITY OF COMMERCIAL WIRELESS INFRASTRUCTURES



WIRELESS LOCATION USING MULTIPLE CMRSs

(57) Abstract

A location system for commercial wireless telecommunication infrastructures (CMRRs). The system is an end-to-end solution having one or more location systems (42) for outputting requested locations of commercially available hand sets or mobile stations (not shown) based on, e.g, AMPS, NAMPS, CDMA or TDMA communication standards, for processing both local mobile station location requests and more global mobile station location requests via, e.g., Internet communication between a distributed network of location systems. The system uses a plurality of mobile station locating technologies including those based on: two-way TOA and TDOA; home base stations and distributed antenna provisioning. 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 from certain areas.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

LOCATION OF A MOBILE STATION USING A PLURALITY OF COMMERCIAL WIRELESS INFRASTRUCTURES

RELATED 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 radio station in a macro base station, distributed antenna, or home base station environment.

BACKGROUND OF THE INVENTION

Wireless communications systems are becoming increasingly important worldwide. Wireless cellular telecommunications systems are rapidly replacing conventional wire-based telecommunications systems in many applications. Commercial mobile radio service provider networks, 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"). The Apsell patents disclose a system employing a "homing-in" scheme using radio signal strength, wherein the scheme detects radio signal strength transmitted from an unknown location. This signal strength is detected by nearby tracking vehicles, such as police cruisers using receivers with directional antennas. Alternatively, the Sheffer patent discloses a system using the FM analog cellular network. This system includes a mobile transmitter located on a vehicle to be located. The transmitter transmits an alarm signal upon activation to detectors located at base stations of the cellular network. These detectors receive the transmitted signal and transmit, to a central station, data indicating the signal strength of the received signal and the identity of the base stations receiving the signal. This data is processed to determine the distance between the vehicle and each of the base stations and, through trilateralization, the vehicle's position. 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 due, for example, to the limited reception of the satellite signals and the 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.

The behavior of a mobile radio signal in the general environment is unique and complicated. Efforts to perform correlation 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 geometry 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_0}) and are particular to various points in time and space domains.

Before discussing real world correlation 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.

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.

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.

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.

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.

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.

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.

However, a substantial difficulty with the two-ray model in practice is that it requires a substantial amount of data regarding building dimensions, geometry, 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 geometry and building heights are random. Moreover, data of sufficient detail is 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 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 correlation, 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 attenuation), 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 mobile station, 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).

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 $E_{b/No}$, 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})

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 this 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 a mobile station 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	
Ll_{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 log-normal slow fading PDF and allowing for a 1.4% slow fading margin overload, thus

$$_{slow} = 2\sigma = 14dB.$$

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 mobile station 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.

Although the acceptance of fuzzy logic has been generally more rapid in non-American countries, the principles of fuzzy logic can be applied in wireless location. Lotfi A. Zadeh's article, "Fuzzy Sets" published in 1965 in *Information and Control*, vol. 8, Pg 338-353, herein incorporated by reference, established the basic principles of fuzzy logic, among which a key thorem, the FAT theorem, suggests that a fuzzy system with a finite set of rules can uniformly approximate any continuous (or Borel-measureable) system. The system has a graph or curve in the space of all combinations of system inputs and outputs. Each fuzzy rule defines a patch in this space. The more uncertain the rule, the wider the patch. A finite number of small patches can always cover the curve. The fuzzy system averages patches that overlap. The Fat theorem was proven by Bart Kosko, in a paper entitled, "Fuzzy Systems as Universal Approximators", in *Proceedings of the First IEEE Conference on Fuzzy Systems*, Pages 1153-1162, in San Diego, on March, 1992, herein incorporated by reference.

Fuzzy relations map elements of one universe, say "X", to those of another universe, say "Y", through the Cartesian product of the two universes. However, the "strength" of the relation between ordered pairs of the two universes is not measured with the characteristic function (in which an element is either definitely reltated to another elemetn as indicated by a strength value of "1", or is definitely not related to another element as indicated by a strength value of "0", but rather with a membership function expressing various "degrees" of strength of the relation on the unit intergval [0,1]. Hence, a fuzzy relation **R** is a mapping from the Cartesian space **X** x **Y** to the interval [0,1], where the strength of the mapping is expressed by the membership function of the relation for ordered pairs from the two universes or $\mu_R(x,y)$.

Just as for crisp relations, the properties of commutativity, associativity, distributivity, involution and idempotency all hold for fuzzy relations. Moreover, DeMorgan's laws hold for fuzzy relations just as they do for crisp (classical) relations, and the null relations **O**, and the complete relation, **E**, are analogous to the null set and the whole set in set-theretic from, respectively. The properties that do not hold for fuzzy relations, as is the case for fuzzy sets in general, are the excluded middle laws. Since a fuzzy relation **R** is also a fuzzy set, there is overlap between a relation and its complement, hence.

$$\mathbf{R} \cup \mathbf{R}' \neq \mathbf{E}$$

$$\mathbf{R} \cap \mathbf{R}' \neq \mathbf{O}$$

As seen in the foregoing expression, the excluded middle laws for relation do not result in the null relation, O, or the complete relation, E. Because fuzzy relations in general are fuzzy sets, the Cartesian product can be defined as a relations between two or more fuzzy sets. Let A be a fuzzy set on universe X and B be a fuzzy set on universe Y; then the Cartesian product between fuzzy sets A and B will result in a fuzzy relation R, which is contained within the full Cartesian product space, or

$$\mathbf{A} \times \mathbf{B} = \mathbf{R} \subset \mathbf{X} \times \mathbf{Y}$$

where the fuzzy relation R has membership function:

$$\mu_R(x,y) = \mu_{AxB}(x,y) = \min(\mu_A(x),\mu_B(y))$$

Fuzzy composition can be defined just as it is for crisp (binary) relations. If **R** is a fuzzy relation on the Cartesian space **X** x **Y**, and **S** is a fuzzy relation on the Cartesian space **Y** x **Z**, and **T** is a fuzzy relation on the Cartesian space **X** x **Z**; then fuzzy max-min composition is defined in terms of the set-theoretic notation and membership function-theoretic notation in the following manner:

$$\mu_T(x,y) = \vee (\mu_R(x,y) \wedge \mu_S(x,y)) = \max \{ \min [\mu_R(x,y), \mu_S(y,z)] \}$$

The *fuzzy extension principle* allows for transforms or mappings of fuzzy concepts in the form y = f(x). This principle, combined with a *compositional rule of inference*, allows for a crisp input to be mapped through a fuzzy transform using membership functions into a crisp output. Additionally , in mapping a cariable x into a variale y, both x and y can be vector quantities.

SUMMARY OF THE INVENTION

OBJECTS OF THE INVENTION

It is an objective of the present invention to provide a system and method for determining wireless location using one or more commercial mobile radio telecommunication systems for accurately locating people and/or objects in a cost effective manner. Related objectives for the present invention include providing a system and method that:

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

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

(3) can be used for locating people and/or objects residing indoors.

Yet another objective is to provide a low cost location system and method, adaptable to wireless telephony systems, for using simultaneously a plurality of base stations owned and/or operated by competing commercial mobile radio service providers within a common radio coverage area, in order to achieve FCC phase 2 accuracy requirements, and for synergistically increasing mobile station location accuracy and consistency.

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

- time-of-arrival wireless signal processing techniques;
- time-difference-of-arrival wireless signal processing techniques;
- wireless signal processing techniques.

Yet another objective is to provide a system and method for flexible delivery of location information to Public Safety Answering Points, end users, centralized dispatchers, as well as to agents (either human or mechanized) associated with trigger-based inventory and tracking systems. Flexible delivery used here indicates providing location via various two dimensional closed-form shapes, such as polygons, ellipses, etc., which bound the location probabilities. In cases where height location information is known, the bounding shape may be three-dimensional.

Yet another objective is to provide a system and method for a variety of new location-based services for public and private group safety, including family support functions.

Yet another objective is to provide a system and method for National Scale Wireless Location capability. Although the primary focus of this patent is to provide wireless location with accuracy to meet the FCC phase two requirements, a system and method is provided that also utilizes roaming signaling to determine in which city is a particular wireless mobile station located.

Yet another objective is to provide and system and method for Parametric-driven, intelligent agent-based location services. Parameters may include time, location, and user-specific and/or group specific criteria.

Yet another objective is to provide a system and method for determining and/or enhancing wireless location using one or more of the following: (a.) CDMA-based Distributed Antenna technology; (b.) Home Base Stations and AIN technology.

Yet another objective is to provide notification messages and/or voice-synthesized call or text paging function to a plurality of other mobile station users when a mobile station user travel into, or away from, one or more zones or are within short distances of shopping malls, stores, merchandising dealers etc.

Yet another objective is to provide notification messages and/or voice-synthesized call or text paging functions to a plurality of other mobile station users when a mobile station dials a redefined telephone number, such as 911, or a type of "mild emergency cry for help' number.

Yet another objective is to provide notification messages and/or voice-synthesized call or text paging function to a plurality of other mobile station users when a mobile station user dials a predefined telephone number, such as 311, or a type of mild emergency cry for help number, wherein the plurality of other mobile station users are within a particular distance, or a minimum distance to the mobile station user who dialed the predefined number.

Yet another objective is to provide notification messages and/or voice-synthesized call or text paging function to a plurality of other mobile station users when a mobile station user dials a predefined telephone number, such as 311, or a type of mild emergency cry for help number, wherein the plurality of other mobile station users are within a particular distance, or a minimum distance to the mobile station user who dialed the predefined number, and wherein the other mobile station users are provided individualized directional or navigation information from their current locations, to reach to the mobile station user who dialed the predefined number.

Yet another objective is to provide automatic home office, vehicle and boat security functions, which are activated and deactivated based on a mobile station user's location to or away from a location associated with the security functions.

Yet another objective is to provide notifications (e.g., via fax, page, e-mail, text paging or voice synthesized call message), or to setup a group conference call capability to a plurality of predefined individuals, based on a mobile station user's call to 911, or based on a mobile station user's traveling into or away from a location zone or area, or based upon a sensor input signal to the user's mobile station, such as a sudden change in G forces, such as falling down, having the car hit another object suddenly, air bag deployment, etc.

Yet another objective is to provide location information to a 'searcher' mobile station user who then further refines or narrows the scope of the location/search for a 'target' mobile station, or the mobile station to be located, using a small microwave dish, in communication with, or to supplement/replace the searcher mobile station antenna, whose physical orientation is used to further determine the target mobile station location, relative to the searcher's mobile station position/orientation.

Yet another objective is to provide a means to allow more flexible storage, inventory and enhanced user accessibility of rental vehicles, by combining location technology of rental car driver carrying his/her own mobile station, along with a mobile station which remains always active and fixed to a rental car. By maintaining accurate location records of rental car locations and automatic, remote-control of rental cars (or smart cars) which use the mobile station to telemeter control data to and from the car, whose doors, doorlocks, and general accessibility are controlled by a centralized computer system, rental cars can be dropped off at convenient shopping center malls, airport parking lots, hotels and at other convenient locations.

Yet another objective is to provide location estimates to users carrying mobile stations, via voice synthesis, data circuit messaging or text paging.

Yet another objective is to provide a mechanism whereby mobile station users may access and control their subscriber profile for location purposes. The location subscriber profile is a persistent data store which contains logic regarding under what criteria will that mobile station user allow his/her location to be made known, and to whom. The mobile station user may access the location profile via several methods, including Internet means, and mobile station handset keypad entry and voice recognition circuits.

Yet another objective is to utilize signaling detection characteristics of other CDMA base stations and systems in a given area, owned and operated by a plurality another commercial mobile radio service provider (CMRS provider). By including other CMRS providers' infrastructure in the location estimation analysis process, improvements in location accuracy can be realized.

DEFINITIONS

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

(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, TDMA and GSM, as one skilled in the art will understand.

(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 mobile station, 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) 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, TDMA, and GSM wherein the base stations provide a network of cooperative communication channels with an air interface with the mobile station, 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., hand-offs) between the user's mobile station and these base stations in order to maintain effective

telephony service. The mobile switch center provides communications and control connectivity among base stations and the public telephone network.

(4) An example of a Parametric-driven intelligent agent-based location service follows: An intelligent agent software process monitors sets of Parametric conditions and location scenarios. When appropriate conditions and location criteria are satisfied, then a set of notifications or other actions are triggered to occur. A specific example follows: given that a certain child carrying a mobile station should be in a certain school between 8:00 A.M. and 3:00 P.M. on regular school days, then a wireless location request is invoked periodically, within the school day time frame. If a location request determines that the child's mobile station is located substantially outside of the general school area, then a parent/guardian is notified of that fact, and of the child's location via any of several methods, such as: (a.) a voice-synthesized telephone message, (b.) various extranet/internet means, such as electronic mail, netcasting, such as the product Castanet, by Marimba Software, Inc., (c.) fax to a pre-determined telephone number, or (d.) alpha-numeric text paging.

(5) Commercial mobile radio service (CMRS) service provider is the referenced name of the company that owns and/or operates a publicly accessible wireless system in the cellular or PCS spectrum radio bands.

SUMMARY DISCUSSION

The location system of the present invention accomplishes the above and other objectives by the following steps:

(1.) receiving signal data measurements corresponding to wireless communications between an mobile station to be located (herein also denoted the target mobile station) and a wireless telephony infrastructure, wherein the mobile station, BS and/or mobile switch center may be enhanced in certain novel and cost effective ways so as to provide an extended number of values characterizing the wireless signal communications between the target mobile station and the base station infrastructure, such infrastructure including multiple, distinct CMRS where base stations share a common coverage area;

(2.) organizing and processing the signal data measurements received from a given target mobile station and surrounding base stations so that composite wireless signal characteristic values may be obtained from which target mobile station location estimates may be derived. In particular, the signal data measurements are ensembles of samples from the wireless signals received from the target mobile station by the base station infrastructure, and from associated base stations wherein these samples are subsequently filtered using analog and digital spectral filtering. (3.) providing the resultant location estimation characteristic values to a mobile station location estimate module, wherein each such model subsequently determines the estimate of the location of the target mobile station based on, for example, the signal processing techniques 1. through 2. above.

Accordingly, steps (1.) and (2.) above are performed by a subsystem of the invention denoted the Signal Processing and Filtering Subsystem (or simply the Signal Processing Subsystem). In particular, this subsystem receives samples of wireless signal characteristic measurements such as a plurality of relative signal strengths and corresponding signal time delay value pairs, wherein such samples are used by this subsystem to produce the component with the least amount of multipath, as evidenced in the sample by the short time delay value, wherein each such value pair is associated with wireless signal transmissions between the target mobile station and a particular base station of a predetermined wireless base station infrastructure. Extremely transient signal anomalies such as signal reflection from tree leaves or the passing of a truck are likely to be filtered out by the Signal Processing Subsystem. For example, such an ensemble of data value pairs can be subjected to input cropping and various median filters employing filtering techniques such as convolution, median digital, Fast Fourier transform, Radon transform, Gabar transform, nearest neighbor, histogram equalization, input and output cropping, Sobel, Wiener, and the like.

It is a further aspect of the present invention that the wireless 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 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.

In another aspect of the present invention, in environments where a home base station capability exists, then wireless location can be provided under certain circumstances, wherein when a mobile station user is within a predetermined range of, for example, 1000 feet of his/her premises, the user's mobile station is detected through mobile station receiving electronics provided in, for example, cordless telephone units as being at home. Thus, the local public telephone switching network may be provided with such information for registering that user is at home, and therefore the mobile station may be allowed to function as a cordless home telephone utilizing the local public telephone switching network instead of the base station infrastructure. According to this aspect of the present invention, the location center of the present invention receives notification from the local public switched telephone network that the mobile station is at or near home and utilizes this notification in outputting a location estimate for the mobile station.

In yet another aspect, the present invention includes a capability for locating a target mobile station within areas of poor reception for infrastructure base stations by utilizing distributed antennas. A distributed antenna system as used herein is a collection of antennas attached in series to a reduced function base station, wherein the antennas are distributed throughout an area for improving telephony coverage. Such distributed antenna systems are typically used in indoor environments (e.g., high rise buildings) or other areas wherein the signal to noise ratio is too high for adequate communication with standard infrastructure base stations. Also a distributed antenna system may be located such that its coverage pattern overlaps the area of coverage of another distributed antenna system. In such cases each of the overlapping distributed antenna systems includes purposeful delay elements to provide different signal delays for each of the overlapping antenna systems and thereby provide multipath signals with sufficient delay spread for signal discrimination, as one skilled in the art will understand. Accordingly, the present invention receives and utilizes location information communicated from distributed antenna systems for locating a target mobile station. That is, the present invention may receive information from the base station infrastructure indicating that a target mobile station is communicating with such a distributed antenna system and provide distributed antenna signal characteristic values related to the distributed antenna system. Accordingly, to process such target mobile station location signal data, the present invention includes a distributed antenna system for generating target mobile station location estimate derived from the location signal data obtained from the distributed antenna system.

The location 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 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 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, 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 the exploitation of radio frequency spectral efficiency and isolation by (a) monitoring voice activity, (b) management of two-way power control, (c) provision 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.

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 location center modules may reside in remote locations and communicate their generated hypotheses via the Internet.

In an alternative embodiment of the present invention, the processing following the generation of location estimates by the modules may be such that this processing can be provided on Internet user nodes and the modules may reside at Internet server sites. In this configuration, an Internet user may request hypotheses from such remote modules and perform the remaining processing at his/her node.

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 modules may be object methods on an mobile station location estimator object, wherein the estimator object receives substantially all target mobile station location signal data output by the signal filtering subsystem 20. 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.

One embodiment of the present invention includes providing the location of a mobile station (MS) using the digital air interface voice channel and an automatic call distributor device. This embodiment provides location information to either the initiating caller who wishes to learn of his location, using the voice channel, and/or location information could be provided to another individual who has either a wireline or wireless telephone station.

Another embodiment of the present invention includes providing the location of a mobile station using the digital air interface voice channel and a hunt group provided from a central office or similar device. This embodiment provides location information to either the initiating caller who wishes to learn of his location, using the voice channel, and/or location information could be provided to another individual who has either a wireline or wireless telephone station.

Another embodiment of the present invention includes providing the location of a mobile station using the digital air interface text paging, or short message service channel and a hunt group provided from a central office or similar device. This embodiment provides location information to either the initiating caller who wishes to learn of his location, using the voice channel, and/or location information could be provided to another individual who has either a wireline or wireless telephone station.

Another embodiment of the present invention includes providing the location of a plurality of mobile stations using the public Internet or an intranet, with either having the ability to further use "push", or "netcasting" technology . This embodiment provides location information to either the initiating Internet/Intranet user who wishes to learn of one or more mobile station locations, using either the Internet or an intranet. Either the mobile station user to be located can initiate a request for the user to be located, or an Internet/intranet user may initiate the location request. Optionally the location information could be provided autonomously, or periodically, or in accordance with other logic criteria, to the recipient of the location information via the Internet or a intranet. As a further option, location information can be superimposed onto various maps (e.g., bit/raster, vector, digital photograph, etc.) for convenient display to the user.

Yet another embodiment of the present invention includes providing a multicast notification to a group of mobile station users, based on distress call from a particular mobile station, wherein the group of mobile station users are relatively nearby the distress caller. The multicast notification provides individual directions for each group mobile station user, to direct each user to the fastest route to reach the distressed caller.

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 an overall view of a wireless location system and method for using multiple commercial mobile radio service providers;

Fig. 2 shows is a high level wireless location architecture using the intelligent network, which illustrates aspects of the home base station and Internet connectivity for receiving location requests and for providing location estimates;

Fig. 3 illustrates how the signals from the base stations associated with various multiple commercial radio service providers can be shared with the wireless location system to provide an improved geometry and thus improved wireless location accuracy.

Fig. 4 shows how the mobile station database in the location system is updated via interfaces in communication with multiple commercial mobile radio service providers using customer care systems.

Fig. 5 shows a method of direct access to multiple CMRS base stations, from the location system perspective, thus avoiding the need to significantly modify network infrastructure systems.

Fig.6 illustrates physical components and the effects of predetermined signal delay, and total system delay in a distributed antenna environment for purposes of wireless location;

Fig. 7 shows the timing relationships among the signals within a distributed antenna system.

Fig. 8 shows a flowchart of the methods and procedures required to implement a DA database;

Fig. 9 illustrates an exemplary DA configuration with a direct antenna connection to the base stations;

Fig. 10 illustrates an alternative DA configuration using multipoint microwave;

Fig. 11 illustrates how multiple base stations could be used via a microwave circuit to provide PCS and location service to a multilevel building via virtual pilot channels;

Fig. 12 shows the DA delay spread ranges possible for a 500 microsecond guard zone;

Fig. 13 shows DA-cell layout a geometry and how location geometries can be constructed;

Fig.14 illustrates the realization of actual measurements and classification utilized within DA cell ranges to determine a percent range within each cell.

Fig. 15 shows the standard components of a CDMA MS.

Fig. 16 shows one embodiment for MS modification that facilities enhanced RF measurement telemetry.

Fig. 17 shows how the LC is used in a Home Base Station architecture.

Fig. 18 illustrates a typical case where signals from three base stations can be detected.

Fig. 19 illustrates a typical case where signals from four base stations (including remaining set information) can be detected.

Fig. 20 shows a MS detection scheme with a two base station geometry.

Fig. 21 illustrates a typical amorphous location area with only the signal detection of a single base station sector, by a MS.

Fig. 22 shows a series of typical reverse path CDMA RF measurements in a dense urban area.

Fig. 23 shows a series of typical reverse path CDMA RF measurements in a rural setting.

Fig. 24 shows a typical Location Center connection to a CTIA Model.

Fig. 25 shows a typical national Location Center and relevant network connections.

Fig. 26 illustrates a typical three dimensional delay spread profile.

Fig. 27 shows the magnifying effects of convoluting similar-property forward and reverse path three-dimensional images.

Fig. 28 illustrates an image and relief representation of a CDMA Delay Spread Profile.

Fig. 29 illustrates the main components of the Signal Processing Subsystem 20.

Fig. 30 illustrates an image based on an RF signal measurement sample set, before image histogram equalization filtering is applied.

Fig. 31 illustrates an image based on an RF signal measurement sample set, after image histogram equalization input cropping filtering is applied.

Fig. 32 illustrates an image sample grid before image filtering.

Fig. 33 shows a CDMA profile image after input cropping is used at a level of 50 percent.

Fig. 34 illustrates the results of combining input cropping at 40 percent, then performing four by four median filtering on the resultant.

Fig. 35 shows the results of combining input cropping at 50 percent with four by four median filtering.

Fig. 36 illustrates how location estimates can be provided using voice channel connections via an ACD and Internet technology.

Fig. 37 shows wireless Location of a MS using the Voice Channel from a Hunt Group.

Fig. 38 illustrates how location information can be provided via Text paging or short message service messaging.

Fig. 39 shows how location information of an MS can be provided via Internet via "Push" technology.

Fig. 40 illustrates how location directions can be provided to nearest members, regarding directions for each individual member to reach a distressed MS caller.

Fig.41 illustrates how traveling instructions from two different points can be provided to an initiator.

Fig.42 illustrates how wireless location services can be used to facilitate automotive rental car tracking and control.

Fig. 43 indicates the addition of a fuzzy logic module which discretizes the wireless location estimate output from the TOA/TDOA locaton estimator module.

DETAILED DESCRIPTION

Various digital wireless communication standards have been introduced such as 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 a mobile station. 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 mobile station 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 mobile station is located).

Fig. 1 illustrates a wireless location network using two commercial mobile radio service provider networks for the present invention. Accordingly, this figure illustrates the interconnections between the components of a typical wireless 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 network includes: (a) a mobile switching center (MSC) 12a; (b) generally a service control point 4a, and base stations (not shown) which are in communication with a mobile switch center 12a. Within a typical metropolitan area it is also common for a second commercial mobile radio service (CMRS) provider to offer wireless service within essentially similar coverage areas, such systems typically including an mobile switch center 12b, service control point 4b, and associated base stations (not shown). Added to this wireless network, the present invention provides the following additional components:

(1) a location system or center 42 which is required for determining a location of a target mobile station using signal characteristic values as measured by the target mobile station (not shown) and nearby base stations (not shown), further consisting of the following modules or subsystem components:

(1.1) an application programming interface 14, for physically interfacing with and controlling the messaging to and from each CMRS mobile switch center 12a, 12b, service control points 4a and 4b, receiving location requests from either the mobile switch center 12a, or 12b, or the Internet 68, and providing connection to the signal processing subsystem 20;

(1.2) a signal processing subsystem 20, which is in communication with the application programming interface (API) 14. The signal processor 20 receives, queues, filters and processes signal measurement messages into various formats suitable for the location estimate modules DA 10 and TOA/TDOA 8;

(1.3) a TOA/TDOA location estimate module 8, in communication with the signal processing subsystem 20. The TOA/TDOA module 8 provides a location estimate result, using a time of arrival or a time difference of arrival technique based on conditioned signals from the signal processing subsystem 20; in addition the TOA/TDOA module may also process signals from the distributed antenna module 10, in order to provide a location estimate within environments containing distributed antenna systems;

(1.4) a distributed antenna (DA) module 10, which receives signals related to distributed antennas, from the signal processor 20 in communication a location estimating capability for utilizing one or more distributed antenna systems 168 as shown in Fig. 2, wherein each such system 168 provides wireless location information for an MS 140 within the area in communication with one or more distributed antenna system 168.

(1.5) a home base station module (HBS) 6 in Fig. 1, which receives signals from the controller 14 and determines wireless location (i.e., providing a location estimate result) based on registration principles of the wireless user's mobile station when in communication with the user's home base station (not shown) in communications with a given service control point 4a or 4b, containing ahome base station application (not shown).

Since home base stations and distributed antenna systems can be located on potentially each floor of a multi-story building, in such cases where infrastructure is installed, the wireless location technology described herein can be used to perform location in terms of height as well as by Latitude and Longitude.

Referring to Fig. 2, additional detail is provided of typical base station coverage areas, sectorization, and high level components used in the present invention's scope, including the mobile switch center 112, a mobile station 140 in communication with a home base station 160, and communication between the location system 42 and the public Internet 468, via an Internet service provider interface 472. A novel aspect of this invention includes providing wireless location estimate information to various designated users via the public Internet. 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, such exemplary base stations (BSs) 122a through 122g are shown, each of which radiate referencing signals within their area of coverage to facilitate mobile station (MS) 140 radio frequency connectivity, and various timing and synchronization functions. A given base station may contain no sectors (not shown) , thus radiating and receiving signals in a 360 degree omnidirectional coverage area pattern, or the base station may contain "smart antennas" (not shown) which have specialized coverage area patterns.

Alternatively and generally most frequent are base stations having three sector coverage area patterns. Shown in Fig. 2, each sector for base station 122a through 122g contains three sectors, labeled a, b, and c, which represent antennas that 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 generally are designed to overlap to some extent, thus ensuring seamless coverage in a geographical area. Control electronics within each base station are used to communicate with a given mobile station 140. Further, during communication with the mobile station the exact base station identification and sector identification information are known and are provided to the location center 142.

The base stations located at their cell sites 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 the mobile station is powered on and in the idle state, it constantly monitors the pilot signal transmissions from each of the base stations located at nearby cell sites. As illustrated in Fig. 3, base station/sector coverage areas may often overlap both in the context of a single CMRS base station network, and also in the context of multiple CMRS base station networks, thus enabling mobile stations to detect, and, in the case of certain technologies, communicate simultaneously along both the forward and reverse paths, with multiple base stations/sectors, either with a single CMRS network or, in the case of hand-offs and roaming, multiple CMRS network equipment. In Fig. 3 the constantly radiating pilot signals from base station sectors 122a, 122b and 122c are detectable by mobile station 140 at its location. The mobile station 140 scans each pilot channel, which corresponds to a given base station/sector ID, and determines which cell it is in by comparing signals strengths of pilot signals transmitted from these particular cell-sites.

The mobile station 140 then initiates a registration request with the mobile switch center 112, via the base station controller 174. The mobile switch center 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 mobile switch center 112.

As shown in Fig. 2, the mobile switch center 112 communicates as appropriate, with a class 4/5 wireline telephony circuit switch or other central offices, with telephone trunks in communication with the public switch telephone network (PSTN) 24. Such central offices connect to wireline stations, such as telephones, or any communication device compatible with the line, such as a personal or home base station. The PSTN may also provide connections to long distance networks and other networks.

The mobile switch center 112 may also utilize IS/41 data circuits or trunks 522, which in turn connects to a service control point 104, using, for example, signaling system #7 (SS7) signaling link protocols for intelligent call processing, as one skilled in the art will understand. In the case of wireless advanced intelligent network (AIN) services such trunks and protocols are used for call routing instructions of calls interacting with the mobile switch center 112 or any switch capable of providing service switching point functions, and the public switched telephone network (PSTN) 24, with possible termination back to the wireless network. In the case of an mobile station 140 in communication with a corresponding home or office base station (HBS) 160, the HBS 160 controls, processes and interfaces the mobile station 140 to the PSTN 24, in a manner similar to a cordless telephone system, except that added AIN logic within, for example, the service control point (SCP) 104 is used to determine if the mobile station 140 is being controlled by the HBS 160 or a wireless base station 122. Regarding non-HBS calls, the mobile switch center 112 may direct calls between mobile stations 140 via the appropriate cell site base stations 122 a through 122h since such mobile stations 140 do not typically communicate directly with one another in such wireless standards as CDMA, TDMA NAMPS, AMPS and GSM.

Referring again to Fig. 2, the Location system 42 interfaces with the mobile switch center 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 24 (not shown). The location system 42 receives autonomous (e.g., unsolicited) autonomous or command/response messages regarding, for example: (a) the wireless network states, including for example, the fact that a base station has been taken in or out of service, (b) mobile station 140 and BS 122 radio frequency (RF) signal measurements, notifications from a SCP 104 indicating that an HBS 160 has detected and registered with the SCP 104 the mobile station 140 corresponding to the HBS 160, and (c) any distributed antenna systems 168. Conversely, the location system 42 provides data and control information to each of the above components in (a) - (c). Additionally, the Location system 42 may provide location information to an mobile station 140, via a BS 122, using, for example the short message service protocol, or any data communication protocol supported by the air interface baetween the base station and the mobile station. Interface 106 connecting the location system 42 with the service control point 104 may also be required in the event the home location register and/or the home base station AIN function is located in the SCP 104.

Assuming the wireless technology CDMA is used, each BS 122a, 122b, 122c, through 122g uses a time offset of the pilot PN sequence to identify a forward CDMA pilot channel. Furthermore, time offsets, in CDMA chip sizes, may be re-used within a PCS system, thus providing efficient use of pilot time offset chips, thus achieving spectrum efficiency.

The use of distributed antennas is another technique for improving or extending the RF coverage of a radio coverage area 120 of a wireless system. Such distributed antennas are typically used in buildings or other areas of dense clutter, such as numerous walls, partitions and/or similar structures causing substantial signal attenuation. As shown in Figs. 6, 9, 10, 11, and 13, distributed antennas 168 are typically connected together in a serial fashion for communicating with one or more infrastructure base stations 122. Distributed atennnas may be connected to the mobile switch center 112 via various air interfaces, as shown in Figs. 10 and 11, or alternatively distributed antennas may be connected to the MSC via a directed connection to a base station 122 as shown in Fig. 9, or via a private branch exchange (PBX) as shown in Fig. 13.

Referring to Fig. 11, distributed antennas 168 are useful particularly in wireless system configurations involving microcells, and potentially indoor environments, such as wireless systems in communication with private branch exchange systems (reference Fig. 13) in business offices, and in wireless local loop applications (not shown) as one skilled in the art will understand. Additionally, a distributed antenna embodiment can provide significant improvements in decreasing location error, as compared with an indoor mobile station 140 (reference Fig. 11) user with a wireless connection to an outdoor, infrastructure base station 122, as illustrated in Figs. 11, 12, 13 and 14.

MOBILE STATION DESCRIPTION

As an example of a mobile station 140, such a mobile station will be described using CDMA technology. Fig. 15 illustrates a typical block diagram of the functional components of a CDMA mobile station (MS) 140, based on the patent, "Diversity Receiver in a CDMA Cellular Telephone System", patent number 5,109,390. The MS 140 contains an antenna 510 coupled through diplexer 512 to analog receiver 514 and transmit power amplifier 516. Antenna 510 and diplexer 512 permit simultaneous transmission and reception of signals through an antenna 510. Antenna 510 collects transmitted signals and provides them through diplexer 512 to analog receiver 514. Receiver 514 receives the RF frequency signals, typically either in the 800-900 MHZ or 1.8-1.9 GHz band, from diplexer 512, for amplification and frequency down conversion to an intermediate frequency (IF). Translation is accomplished through the use of a frequency synthesizer of standard design which permits the receiver 514 to be tuned to any of the frequencies within the designated receive frequency band. The IF signal is passed through a surface acoustic wave bandpass filter, typically of 1.25 MHZ bandwidth, to match the waveform of the signal transmitted by a base station 122. Receiver 514 also provides an analog to digital converter (not shown) for converting the IF signal to a digital signal. The digital signal is provided to each of four or more data receivers (520, 522, 524, and 526), one of which is a searcher receiver (526) with the remainder being data receivers, as one skilled in the art will understand.

Analog receiver 514 also performs a open-loop type of power control function for adjusting the transmit power of the mobile station 140 on the reverse link channel. Receiver 514 measures the forward link signal strength of the signals from base stations 122, then generates an analog power control signal to circuitry in the transmit power amplifier 516, which can effect a range up to about 80 dB. The power control for the transmit power amplifier 516 is also supplemented by a closed-loop power control or mobile attenuation code (MAC) control parameter sent to the mobile station 140 via the air (i.e., wireless) interface from a BS 122, with either the CMAC or VMAC command (as one knowledgeable in CDMA standards will understand). The MAC can take on one of eight values 0 through 7, which effect a closed loop to raise or lower the power correction. The transmit amplifier 516 may utilize one of three transmit power classes when transmitting within a transmitted power control group in the 800-900 MHZ cellular band: class I (1 to 8 dBW), class II (-3 to 4 dBW), or class III (-7 to 0 dBW), for a closed-loop range of about " 32 dB. In the PCS 1.8-1.9 GHz band five classes are defined: class I (-2 to 3 dBW), class II (-7 to 0 dBW), class III (-12 to -3 dBW), class IV (-17 to -6 dBW), class V (-22 to -9 dBW), for a closed-loop range of about " 40 dB. The mobile station 140 power class and transmit power level for a communicating mobile station 140 is known to the wireless infrastructure network, and may be utilized for location estimation, as is described hereinbelow.

The digitized IF signal may contain the signals from several telephone calls together with the pilot channels and multipath delayed signals from each of several pilot channels. Searcher receiver 526, under control of control processor 534, continuously scans the time domain around the nominal time delay offsets of pilot channels contained within the active, candidate, neighboring and remaining sets of pilot channels. The initial sets of pilot channels and a defined search window size for each set are provided by a control message from a BS 122 via the air interface to the mobile station 140. The searcher receiver 526 measures the strength of any reception of a desired waveform at times other than the nominal time and measures each pilot channel's arrival time relative to each pilot's PN sequence offset value. Receiver 526 also compares signal strength in the received signals. Receiver 526 provides a signal strength signal to control processor 534 indicative of the strongest signals and relative time relationships.

Control processor 534 provides signals to control digital data receivers 520, 522 and 524 such that each of these receivers processes a different one of the strongest signals. Note, as one skilled in the art will understand, the strongest signal, or finger, may not be the signal of shortest arrival time, but rather may be a reflected, and therefore delayed, signal (such reflected denoted collectively as "multipath"). Data receivers 520, 522 and 524 may track and process multipath signals from the same forward channel pilot channel offset or from a different forward channel pilot offset. In the case where a different pilot channel offset signal is of greater strength than the current cell site (or more specifically the current base station 122) pilot channel offset, then control processor 534 generates a control message for transmission on a reverse channel from the mobile station 140 to the current BS 122, requesting a transfer of the call, or a soft hand-off, to the now strongest cell site Base station 122. Note that each of the four receivers 520, 522, 524 and 526 can be directed independently from each other. The three data receivers 520, 522, and 524 are capable of tracking and demodulating multipath signals from of the forward CDMA pilot channel. Thus data receivers 520, 522 and 524 may provide reception of information via separate multipath signals from one BS 122 (e.g., in particular, an antenna face of a sectored antenna at the BS 122, or reception of signals from a number of sectors at the same BS 122, or reception of signals from multiple BSs 122 or their antenna faces of sectored antennas. Upon receiving a CDMA pilot measurement request order command, or whenever: (a) the mobile station 140 detects a pilot signal of sufficient strength, not associated with any of the assigned forward traffic channels currently assigned, or (b) the mobile station 140 is in preparation for a soft or hard hand-off, then the searcher receiver 526 responds by measuring and reporting the strengths of received pilots and the receiver's definition of the pilot arrival time of the earliest useable multipath component of the pilot, in units of PN chips (one chip = 0.813802 microseconds). The receiver 526 computes the strength of a pilot by adding the ratios of received pilot energy per chip E_c, to total received spectral density, I_o, of at most k useable multipath components, where k is the number of data receivers supported in the mobile station 140.

The outputs of data receivers 520, 522, and 526 are provided to diversity combiner and decoder circuitry 538 (i.e., simply diversity combiner). The diversity combiner 538 performs the function of adjusting the timing of a plurality of streams of received signals into alignment and adds them together. In performing this function, the diversity combiner 538 may utilize a maximal ratio diversity combiner technique. The resulting combined signal stream is then decoded using a forward stream error detection contained within the diversity combiner. The decoded result is then passed on to the user digital baseband circuitry 542.

The user digital baseband circuitry 542 typically includes a digital vocoder which decodes the signals from diversity combiner 538, and then outputs the results to a digital to analog (D/A) converter (not shown). The output of the D/A serves as an interface with telephony circuitry for providing mobile station 140 user analog output information signals to the user corresponding to the information provided from diversity combiner 538.

User analog voice signals typically provided through an mobile station 140 are provided as an input to baseband circuitry 542. Baseband 542 serves as an interface with a handset or any other type of peripheral device, to the user for audio communication. Baseband circuitry 542 includes an analog to digital (A/D) converter which converts user information signals from analog form into a digital form. This digital form is then input to a vocoder (not shown) for encoding, which includes a forward error correction function. The resulting encoded signals are then output to transmit modulator 546.

Transmit modulator 546 modulates the encoded signal on a PN carrier signal whose PN sequence is based on the assigned address function for a wireless call. The PN sequence is determined by the control processor 534 from call setup information that was previously transmitted by a cell site BS 122 and decoded by the receivers 520, 522, 524 as one skilled in the art will understand. The output of transmit modulator 546 is provided to transmit power control circuitry 550. Note that signal transmission power is controlled partially by an open-loop analog power control signal provided from receiver 514. In addition, control bits are also transmitted by the controlling BS 122 in the form of a supplemental closed-loop power adjustment command and are processed by data receivers 520, 522,. In response to this command, control processor 534 generates a digital power control signal that is provided to the transmit power amplifier 516. Transmit power control 550 also provides the digitized and encoded user information signals in an IF format to output to the transmit power amplifier 516. The transmit power amplifier 516 converts the IF format signals into an RF frequency by mixing this signal with a frequency synthesizer (not shown) output signal for providing a corresponding signal at the proper output transmission frequency signal. Subsequently, transmit power amplifier 516 amplifies the signal to the final power output level. The transmission signal is then output from the transmit power amplifier 516 to the diplexer 512. The diplexer 512 then couples the transmission signal to antenna 510 for air interface transmission to the infrastructure base stations 122.

Additionally, note that control processor 534 is also responsive to various control and information request messages from the controlling BS 122, including for example, sync channel messages, the system parameters messages, in-traffic system parameters messages, paging/alert messages, registration messages, status requests, power control parameters messages and hand-off direction messages, as one skilled in the art will understand.

Referring still to a CDMA mobile station 140, in one embodiment of the present invention, the above-described standard CDMA mobile station architecture in an mobile station 140 is sufficient. However, in a second embodiment, this architecture may be modified in minor, cost effective ways so that additional information may be transmitted from an mobile station 140 to the BS 122. The modifications for this second embodiment will now be described. The following modifications, either together or in any combination, provide improvements in location accuracy from the perspective of capturing RF measurement data: (1) increasing measurement quantity, (2) improving measurement transmission, (3) extending the pilot set and search, (4) extending the pilot signal reporting capabilities, 5) decreasing the Quantization size of the units used to report the pilot PN phase arrival time, 6) improving the accuracy of the mobile and base station time reference, and 7) increasing the number of data receivers and related circuitry, for correlation tracking of a larger plurality of pilot channels and each of their multipath signals.

Using the standard system parameters overhead message in the paging channel as one method of reporting to the base station the signal strengths and delays of detectable pilot channels, a mobile station has various timers indicating the upper bounds of time needed to respond to a request, and to bid for access to the forward channel (if not already using it's assigned traffic channel). These timers restrict the frequency of measurement reporting and thus limit the aggregate amount of measurement data which can be sent in a given time period.

For example, CDMA standard timer T_{33_m} establishes the maximum time of a mobile station to enter the update overhead information substate of the system access state to respond to messages received while in the mobile station idle state, typically 0.3 seconds. Timer T_{58m}, the maximum time for the mobile station to respond to one service option request, is typically 0.2 seconds. Thus during a period of about five seconds, this measurement reporting method would provide for a maximum of about fifteen measurements.

However the same CDMA receiver design infrastructure, with slight circuitry modification can be used to support improved measurement transmission.

In order to collect a data ensemble of RF measurements that represents a statistically significant representation of data values in a geographical area of interest, it is the intention that the second (CDMA) mobile station 140 embodiment be capable of sending to the network base station infrastructure approximately 128 samples of each multipath peak signal strength and its relative delay, for each detectable pilot channel, in less than a preferred period of about five seconds. In order to transmit this amount of data, other means are needed to efficiently send the needed data to the network (i.e., from the mobile station to the base station, and then to forward data to the wireless switch, and then to forward data to the Location Center).

The CDMA air interface standard provides several means for transmitting data at higher rates. The Data Burst message can be used, or various blank-and-burst, dim-and-burst multiplex options can be used, and well as selecting various service options 2 through 9, through the setup of a normal voice or data telephone call. In one embodiment, , the user dials a speed number representing a data-type call to the Location Center 142, which initiates a command to the mobile station 140, responsive by the mobile station 140, which then provides the location center 142, via the base station 122, mobile switch center 112 with the needed measurement data.

Referring to Fig. 16, in one embodiment a software controllable data connection or path 49 is established between the control processor 46, and the user digital baseband 30 functional components in the mobile station, a much larger quantity of RF measurements, on the order of 128 data samples, can be transmitted as a data burst, multiplexed, or sent by other means such as a data circuit call, back to the network, and to the Location Center. Note that the existing connection between the control processor 534 and the transmit modulator 546 may also be used, as well via any other virtual path, such as software register-to-register move instructions, as long as sufficient signal measurement content and data samples can be sent to the wireless network and the location center 142 via the associated interfaces. Those skilled in the art will understand the wireless network consists of the base station, mobile switch center, and related infrastructure equipment, interfaces and facilities circuits to telemeter the measurement content and data samples to the location center 142. Additional design issues include, for example, the fact that existing memory in the mobile station must be allocated to the temporary storage of RF sample measurements, and new control means, such as selecting a future use control bit pattern in the CDMA air standard, are required to telemeter, preferably upon command, RF measurement sample data to the Location Center 142 in Fig. 1. In the case where a location request is received by the location engine 139 in the location center 142, the location engine 139 initiates a message to the mobile station 140 via a signal processing subsystem and the location center mobile switch center physical interface, the location applications programming interface 136 for the mobile switch center 112 and the wireless network infrastructure.

The addition of a controllable data connection or path 49 can be easily performed by CDMA application-specific integrated circuit (ASIC) manufacturers. In the case of one ASIC manufacturer known to the authors, the Qualcomm ASIC chip mobile station modem, model number MSM 2300, provides both the control processor function 534 and the user digital baseband 542 functions or the same chip, thus the external pinout physical configuration would not have to change to accommodate the wireless location software controllable data connection or path 49 modification.

If the mobile station 140 searcher receiver detects 4 pilots with 4 multipaths each, with each measurement consisting of a pilot index, finger identification, multipath signal strength, and multipath arrival time, then about 480 bytes are needed per measurement. Assuming the searcher receiver performs one measurement every 10 mS, about 1 second is needed to compile and buffer each sample of 128 measurements per sample, or about 48 kilobytes. Using a typical 9600 kbps CDMA data channel between the mobile station 140 and a BS 122, and assuming a 50 percent overhead, the mobile station can complete the collection and transmission of a location measurement sample in less than ten seconds, which is within a reasonable period for satisfying a location request.

The implementation of the data services required to telemeter the necessary signal measurements may be performed in any of several embodiments. In one embodiment the location signal measurements request-response application message set utilizes the air interface services provided by the spare bits and digital control words not currently in the air interface standards IS-95 and ANSI-J-STD-008. Such bits and control words can be reserved for the purpose of requesting and providing the required location signal measurements discussed herein. Using this embodiment the base station and mobile switch center must be modified to support the interworking function required between the location center and the mobile station. In a second embodiment the location signal measurements request-response application message set is implemented using service options 4 and 12, which provides asynchronous data transmission capability, as defined in *TR45 Data Standard, Async and Fax Section*, document number TIA/EIA/IS-DATA.4. Using this second embodiment, the mobile station control processor provides, or would interface with a function emulating mobile termination 0 or 2 services at the R_m network reference point. The L-API then provides, or would interface with a function emulating the physical interface connecting a data circuit-terminating equipment (DCE) to the PSTN at the W network reference point, in communication with the PSTN, which is also in communication with reference point Ai, which is in communication with reference point U_m, which is in turn in communication with reference point R_m. An advantage of this embodiment is that no ASIC or circuit board modifications are needed in the mobile station.

The ANSI standards J-008 and IS-95 provide several means for the base station 122 to establish and to extend the search window size that the mobile station 140 should use in its scanning process, and to identify further pilots. For location purposes, either existing standard parameters can be extended, or a location message request from the Base station can inform the searcher receiver of the mobile station to extend its search range, as necessary, to capture all relevant base station pilots and their multipath fingers, in order to complete the location measurement sample.

The search performance criteria defined in ANSI IS-98, Recommended Minimum Performance Standards for Dual Mode, can be increased as appropriate to accommodate a larger set of potentially detectable base stations, including Location Base stations and Mobile Base stations. Additionally the search window table size for various search window values must be increased to accommodate new pilot channel pn-offsets associated with Location Base Stations and Mobile Base stations.

Existing standard parameters include, for example using the In-traffic System Parameters Message, the values SRCH_WIN_A (for active and candidate set), SRCH_WIN_N (for neighboring set), and SRCH_SIN_R (for remaining set) can be used to cause the searcher receiver to increase its search area to detect and thus measure as many pilots as can be detected in the area. Extending the range of T_ADD and T_DROP parameters can also be used to facilitate the mobile to retain data on additional pilots in the area. The extended neighbor list message is used to inform the mobile station of the necessary characteristics of neighboring pilot signals. For example if location base stations are used on a different frequency assignment, and/or utilize unique, non-public pilot PN sequence offset indices, for example, in using increments other than 64 PN chips, then the extended neighbor list message can be used to instruct the mobile station to scan for those types of base stations, accordingly.

There can be several combinations of delay spread signal strength measurements made available to the location center, from the mobile station 140. In some cases the mobile station 140 may detect up to three to four pilot channels (representing 3-4 base stations), or as few as one signal from one pilot channel.

For each pilot channel detection case, multiple, up to three to four fingers, or multipath signals may be detected per pilot channel.

Note that multiple multipath signals, or multiple "fingers" could exist from a less-strong BS pilot signal, or in any of several combinations, which can depend widely upon the mobile station's location within the base station environment.

By modifying the CDMA Base station, mobile station and controller capabilities to provide the location center 142 with data that exceeds the 1:1 fingers to data receiver correspondence, additional information can be collected and processed in order to further improve the accuracy of the location estimate. A control message from the location center 142 and carried through the network, is sent to the control processor in the mobile station, requiring the searcher receiver in the mobile station o transmit to the location center 142 via the network, all detectable delay spread fingers related to each detectable pilot channel.

In one embodiment the control message is implemented in the CDMA receiver via a multiplexing technique, including appropriate manipulation of the hand-off parameters T_ADDs, T_DROPs, search window and the active, neighbor and remaining pilot sets held within the mobile station' memory.

Although the CDMA ANSI J-STD 008 requires reporting of the pilot channel arrival time in a time period of units of one chip size, or 813.802 nanoseconds, typical CDMA receivers contain an internal Quantization interval of one eighth chip size.

Within the mobile station, by modifying the time of arrival message response message to output the delay value in unit increments of one-eighth chip size, the precision of location accuracy can be increased from about 800 feet in radius to about 110 feet. At the base station the arrival time measurement is forwarded in one-eighth units to the Location Center. A multiplier function applied to the received measurement at the base station rescales the measurement for routine CDMA control and monitoring purposes, in order to be consistent with the CDMA standard. In order to distinguish among several mobile station models which report arrival time in either one-eighth chip units or one chip unit sizes, an encoding can be used in the mobile station's hardware or software identifications, telemetered to the base station and Location Center, in order to determine the arrival time measurement units. In one embodiment the analog receiver in the mobile station utilizes a clock signal which runs eight times faster than the clock originally disclosed in the Gilhousen patent, number 5,109,390. In this manner the digital signal provided to the data receivers and the searcher receiver will include an improved resolution in ability to detect delay spread signals, which are directly used to improve wireless location.

Although the CDMA air interface standard only requires a 1,000 nanosecond tolerance accuracy within respect to the base station, location accuracy can be improved if manufacturing calibration precision's are held to within tighter tolerances, such as less than 250 nanoseconds. However in any given location request, as long as the base station to base station tolerances are tuned properly to an amount less than 500 nanoseconds, then very good location estimates can be performed due to the self canceling time effect geometries typically present in multi pilot channel detection found in urban and suburban areas.

Increasing the typical number of data receivers in either the mobile station or base station provide added capabilities to lock and track more delay spread fingers and respective base station pilot channels. The resulting additional information, if available in a given radio coverage area 120 in Fig. 1, can be used for enhanced location estimate accuracy due to confluence or voting methods which can be deployed at the Location system 142.

In certain cases wireless location signals are received representing distributed antennas (or other base stations) across building floor boundaries being received from a specific floor on a multi-storied building. As a specific example, consider signals are being received from both the 40th and the 41th floor; the objective is to resolve the ambiguity of the situation. Fuzzy logic is used to resolve this ambiguity. The determination as to which floor the user of the mobile station is on is based on the strength of the signal, S, and the past reliability of the information associated with the two antennae, R. The spaces of S and R are discretized using fuzzy sets. The strength is defined as being: (1) VERY STRONG (VS), (2) STRONG (S), (3) WEAK (W), and (4) VERY WEAK (VW) as defined by membership functions. The reliability of information is defined as being: (1) VERY RELIABLE (VR), (2) RELIABLE (R), and (3) NOT RELIABLE (NR), again as defined by membership functions. A fuzzy relation or mapping is described which descretizes how confident it is that the signal is coming for a given floor, e.g., the 40th floor, using the following notation:

	VS	S	W	VW
VR	1.0	0.85	0.45	0.2
R	0.85	0.6	0.4	0.1
NR	0.6	0.4	0.3	0.0

The above relation matriz is read, for example, that when the signal information is RELIABLE and the strength is WEAK, then the confidence that the signal is coming from the 40th floor is 0.4. A similiar fuzzy relation matrix is established for the distributed antenna on the 41st floor, and thus the result would be a confidence factor associated with the mobile station being located on either floor. A single solution, that is, whether the mobile station is on the 40th or 41st floor is determined using a compositional rule of inference. The compositional rule of inference is a function that prescribes a mechanism for consolidating mambership function values into a single crisp function. This function can take a variety of forms including max-min composition, max-product composition. etc. The compositional rule of inference can be implemented, for example, by a summing junction which collects the results of each firing rule. The summing junction's output is then provided to a centroidal defuzzier which provides the discretized output.

Fig. 43 indicates the addition of a fuzzy logic module 41 which optionally discretizes the wireless location estimate output from the TOA/TDOA locaton estimator module 8. In the above case fuzzy logic rules related to the distributed antenna relation matrix would be fired or activated as a result of exmining the message header data structure that indicates that the location estimate was the result of a distributed antenna case around the 40th and 41st floor of a particular building within which such fuzzy relations exist or in any other localized case sherin such fuzzy relations have been predetermined. Otherwise, in cases where no such fuzzy rules apply, the location estimate is passed to the recipient without further discretization.

Note that the confidence associated with the location of the mobile station can be considered a function of several variables, not just the two (S and R) described above. For instance, it would not be unreasonable to segregate the reliability information by time signal delay as determined within this invention. The fuzzy relation is capable of handling a variety of such situations. Thus which floor the mobile station is on can be considered to be a function of numerous variables; the ultimate decision can be made based on a great deal of information.

LOCATION CENTER - NETWORK ELEMENTS API DESCRIPTION

A location application programming interface 14 (Fig. 1), or L-API, is required between the location system's 42 signal processor 20 and the mobile switch center 12 network element type, in order to send and receive various control, signals and data messages for wireless location purposes. The L-API is 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 mobile switch center 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 mobile switch center vendor. A minimum set of L-API message types include:

A first message type, an autonomous notification message from the mobile switch center 112 to the location system 42, is required in the event a wireless enhanced 9-1-1 call has been sent to the mobile switch center from an mobile station 140, including the mobile identification number (MIN), along with various CMRS identification and mobile station detected active, candidate, neighbor and remaining pilot set information, pilot strength measurements message;

A second message type, forward path request-response message, from location system 42 to mobile switch center 112, is required to request a mobile station (MS) for signal measurements and hand-off information, with a response message back from the mobile switch center 112 to the location system 42, along with various CMRS identification;

A third message type, Reverse path request-response message, from location system 42 to mobile switch center 112, to a BS for signal measurements received at the BS and hand-off information, for a given mobile station MIN, along with various CMRS identification. It is preferable for the received signal strength measurements performed at the mobile station along the forward path, and at the base station along the reverse path, to be reported in a variable-length data structure as follows: for each pilot channel offset, include the phase of the earliest arriving usable multipath component pilot PN sequence relative to the zero offset pilot PN sequence of this pilot, termed pilot PN phase or pilot arrival, in units of one-eighth PN chip, instead of units of one PN chip as stated in the standards. Furthermore, in accordance with the standards, the pilot strength shall be included, measured based on at most k usable components, where k is the number of demodulating elements supported by the receiver system. In addition the total number of each detectable multipath components shall be reported. In addition each multipath component, for a given pilot shall be identified by both its delay component and signal strength, for inclusion in the signal measurements to the location system 42. Regarding each individual multipath component, signal strength is expressed as is commonly known, by adding the ratios of received pilot-multhpath component energy per chip, E_c, to total received spectral density (noise and signals), i_c of at most that one mutipath component (i.e., k is equal to one).

A fourth message type, an autonomous notification message from the mobile switch center 112 to the location system 42 is required, in the event of an mobile station hand-off state change, along with various CMRS identification.

In order to implement additional location functions such as wide area location, wherein location is determined across roaming boundaries, out-of-coverage area conditions or mobile station 140 turned off, and home base station applications, the L-API must include access to and receive data from a data store contained in the home location register (HLR) network element type associated with the mobile switch center 112.

A fifth message type is required which provides the location system 42 with the mobile station MIN, hand-off, along with various CMRS identification information (e.g., old and new state changes, old and new BS identifications, and hand-offs to another CMRS), roaming location and status changes. A typical communications protocol such as Signaling System number 7, running on a V.35 communications channel could be used for implementation, but numerous other protocols (e.g., TCIP/IP, ROSE, CMISE, etc.) could be used to implement this capability. If the home location register is local to the mobile switch center 112 then the LC - mobile switch center communications link could be used, otherwise a separate communications link is used between the location system 42 and the home location register.

A sixth message type, an autonomous notification message type issued from the location system 42 to the home location register, is required for those location applications they rely on an alert from the home location register when ever a particular mobile station state change occurs, along with various CMRS identification. Consider the case wherein an mobile station 140 whose location is to be tracked constantly. In such cases a history of locations is maintained in the location system 42. Should the mobile station 140 user turn off the power, or exit from the coverage area, then by using previous location values a vector and approximate velocity can be determined. This sixth message type provides a notification message from the home location register to the location system 42 whenever a previously identified mobile station MIN has a state change. Examples of a state changes include cases where the base station 122 discovers the mobile station 140 has traveled to another base station, or that the current primary base station 122 can no longer communicate with the mobile station 140 (i.e., no power), or that a new registration has occurred. In general this message type should support the notification from the home location register to the location system 42 of all messaging and data associated with the nine types of registration, in the case of CDMA. Specifically these include power-up, power-down, timer-based, distance-based, zone-based, parameter-change, ordered, implicit and traffic channel registration. The location system 42 should also be informed of the registration enablement status of each type of registration, which can be provided to the location system 42 via a redirection of the systems parameters message. It should also be possible for the location system 42 to initiate an ordered registration through an order message, from the location system 42 to the mobile switch center 112. The mobile switch center 112 then shall route the message to the appropriate base station, and then to the mobile station. The location system 42 should also be able to receive the results of the message.

In order to implement additional location functions such as providing users with location information and routing instructions to certain locations via the wireless short message text paging service, an L-API is required between the location system 42 and the network element type used to implement the short message service. Such network elements may be termed an intelligent peripheral or a service node. A number of existing paging interfaces have been proposed in standards bodies, and one or more modifications can be made to accommodate L-API content. In any case, the following L-API addition is required: a seventh message type which allows the location system 42 to send a text message containing location information or instructions to a particular mobile station MIN, and a related message to verify response. Optionally another, ninth message type, an autonomous message may be provided to alert the location system 42 under conditions wherein a state change occurs on a previously pending text message. This last message type provides improved quality feedback to the initiating party regarding the acceptance situation of the attempted-to-send page.

UTILIZING MULTIPLE CMRS INFRASTRUCTURE IN A SHARED COVERAGE AREA

As a consequence in practical deployment situations that base stations are not placed in a uniform manner in a geographical area, and the fact that variable and fixed clutter introduce a variety of signal measurements which can result in the provision of an ambiguous location estimation, a novel aspect of this patent includes the utilization of the inherent ability of the wireless protocol and receiver design to request and receive signal measurements along the forward and reverse air interface communications path with a given mobile station and other commercial mobile radio service providers, in cases where multiple service providers share a common coverage area. Thus in a coverage area shared by two service providers A and B, utilization of received signal measurements from both service provider A and service provider B can be used by the location center as unique, orthogonal information to both resolve ambiguous location estimates and to further improve the location estimate accuracy.

The CDMA air interface, for example, provides a soft hand-off capability for the mobile station to hand-off a voice communication channel to another base station, and even to another CMRS provider, termed a hard hand-off.

Referring to Fig. 3, assume three sectored base stations 122a, 122b, and 122c, in communication with mobile switch center-A 112a, are owned and operated by CMRS provider A. Further, assume three sectored base stations 122d and 122e, in communication with mobile switch center-B 112b, are owned and operated by CMRS provider B, and that the coverage area with CMRS-A and CMRS-B substantially overlap. In order to locate a mobile station 140 whose subscriber normally does business with CMRS provider A, assume that the receiver of mobile station 140 can detect signals from base stations 122a, 122b, and 122c, as well as from base stations 122d and 122e, although normal mode use would preclude such measurements from being initiated. Assume further that the resulting location estimate 131, generated from the location center 120 contains either an ambiguous location estimate value pair, or otherwise cannot render a location estimate with the desired range of accuracy.

From an inspection of the overall base station geometry of base stations owned by CMRS A and CMRS B it is evident that a strong possibility exists that either 1.) the receivers in mobile station 140 have the possibility to detect the pilot channels associated with base stations 122d and 122e; 2.) the receivers in base stations 122d and 122e have the possibility to detect the transmitter signal from mobile station 140. The location system 142 contains a data store of both CMRS provider's base station geometeries and is in communication with each mobile switch center - A 112a and mobile switch center - B 112b. An application in the location system 142 sends a control message to the mobile station 140, instructing the mobile station to tune its searcher receiver to listen for and report back signal measurement data regarding the pilot channel information associated with base stations 122d and 122e, in addition to a request to report of pilot signals relative to base stations 122a, 122b, and 122c. Similarly the application in the location system 142 sends messages to each of base stations 122d and 122e, with instructions to take signal measurements and report back the resulting information regarding the mobile stations transmitter 140. Since the signaling information from base stations 122d and 122e are based on a substantially different location geometry, the resultant information is orthogonal and thus can be used by the location center to provide enhanced location estimates.

If appropriate, a variation of the above process includes a location center initiated forced hard hand-off of the mobile station from a primary base station, e.g., 122b associated with CMRS-A, to a new primary base station associated with CMRS-B, e.g., 122d. A forced hand-off will further provide improvements in reducing systemic timing errors which may be inherent among base stations owned by different CMRS. After the appropriate signal measurements have been reported the location system 142 can revert the hand-off back to the original CMRS. Other location system components shown in Fig. 3 include a controller 14 location applications programming interface 136 (L-API-MSC) for communications interface with multiple CMRS mobile switching centers, via physical interfaces 176a and 176b.

In order to provide the most economically efficient and accurate wireless location service capabilities among multiple CMRS providers in a shared coverage area, a common location applications programming interface (L-API) is highly desirable. A common interface also supports the natural competitive behaviors among wireless consumers and CMRS by providing flexible relationships among consumers who may want to switch service providers, yet retain consistent wireless location services for public safety. This approach minimizes the L-API design and deployment costs among infrastructure vendors and location service providers in a shared coverage area. Based on a L-API between a wireless location center and the mobile switch centers of multiple CMRS, a novel aspect of this invention further includes a method and process that provides account management clearing house and revenue settlement capability with appropriate security management controls. This capability is implemented as wireless location control, accounting and security mediation agent functions to compensate CMRS providers for providing various location-specific network services as described herein.

As wireless location requests are sent to the location center for a given CMRS, operated by a wireless location service provider (WLSP), this agent: 1.) assesses the appropriateness of soliciting additional signal and control measurements from another CMRS' base station in the same coverage area, in order to improve the quality of the location estimate, 2.) Accesses, requests and receives signal and control information with another CMRS base station infrastructure, 3.) provides as appropriate a record of compensation entitlement between or among multiple CRMS and WLSPs, and 4.) security management controls that protect the privacy needs of wireless customers and the unauthorized sharing of information between or among CMRS. Security controls also include audit trails and controls regarding customer access of their location subscriber profile and the administration of network security processes and related base station parameters and inventory.

Referring to Fig. 5, Location Center-base station access, multiple CMRS, an alternative embodiment is provided to extract the wireless location signal measurement data from each base station associated with each of multiple CMRS. Given base station 122i and 122j are operated by CMRS-A and base station 122k and 122m are operated by CMRS-B, a communication circuit provides connectivity with the location application programming interface - base station (L-API-BS) 109. The L-API-BS 109 is in communication with controller 14 in the location center 142. The communications circuit can be any of several conventional transport facilities, such as a private line circuit, a DS-1 or T-1 carrier circuit, frame relay circuit, microwave circuit, or other data communications circuit.

The advantage of this embodiment is that no modifications are required by the infrastructure vendor in terms of the embedded operations circuit, and related functions and systems which otherwise would be needed to telemeter wireless location signal measurement data from the base station to the location center 142. The termination equipment (not shown) in communication with the transport facilities, within each base station typically includes a small computer with an in-circuit connection, such as an ASIC clip-on device, with connections to the control processor circuitry with the base station in the receiver section. The small computer provides a conversion of the signals provided on the in-circuit connection to the ASIC chip, for serialization and transmission to the location center via the transport facilities.

HOME BASE STATION DESCRIPTION

The Home Base station (HBS) concept in the PCS wireless network environment allows a user's mobile station to be also used as a low cost cordless phone, whenever the mobile station is physically near (generally within 700-1,000 feet) of a Home Base station Device (HBSD). This enables the user to avoid the typically higher cost air time charges associated with traditional wireless service.

The HBSD is similar to ordinary cordless phone transceiver devices in current use today, but is modified to function with a PCS wireless mobile station. Although the HBSD has been typically used at a residential consumer's home, the HBSD could also be used in business settings and other environments.

When a mobile station (MS) is near the HBSD as shown in Fig. 17, and the HBSD detects the presence of a mobile station over the Cordless phone air interface, the HBSD signals the Home Location Register (HLR) software in the Service Control Point in the AIN network associated with the mobile station and mobile station's home mobile switch center. The home location register redirects mobile station terminating calls from the network away form the mobile station' mobile identification number in the mobile switch center, and to the AIN/SSP wireline class V switch which connects the wireline number associated with the HBSD. Similarly, the HBSD, upon detecting a mobile station call origination attempt, redirects the mobile station signal from a PCS network fixed base station, to the control of the HBSD. The HBSD redirects the mobile station originating call through the wireline network, similar to any other wireline network call.

A reverse scenario occurs whenever the mobile station and HBSD lose communication: the mobile station registers in a wireless PCS network fixed base station, causing redirection of calls to the wireless network. The cordless phone air interface may be of a vendor proprietary design, or it may be a similar design as the CDMA air interface.

In order to perform a location estimate in the HBS concept, a connection is used between the Location Center (LC) and the home location register/HBS application in the SCP. In addition, a new process, termed a Location Notification Process (LNP) within the home location register/SCP is used to send a message to the LC, autonomously whenever a state change occurs in the mobile station' (either via a specific list of mobile identification numbers or all mobile identification numbers) registration: registering either to a fixed Base station in the Wireless PCS network or to a HBSD.

Alternatively the process may respond to an on-demand message from the LC to the LNP within the home location register/HBS application. In either case a response message from the LNP to the LC provides the information regarding whether or not a mobile station is within range of its, or a designated HBSD. In either case the response message contains a message header information which provides the signal processing subsystem 20 (equivalently this may be known by signal filtering subsystem) with the ability to determine and distribute the information to the HBS First Order Location Estimate Model.

LOCATION USING DISTRIBUTED ANTENNAS DESCRIPTION

CDMA distributed antennas are useful particularly in system configurations involving microcells, and potentially indoor environments, such as CDMA PBX (private branch exchange) systems in business offices, and in wireless local loop applications. From a mobile station location perspective, the distributed antenna configuration can provide significant improvements in location error, as compared with an indoor mobile station user with a wireless connection to an outdoor, macrocell Base station. Wireless location can be achieved provided certain methods and procedures (M&Ps) are followed during the installation process. Data related to these M&Ps is then used by various location processes discussed elsewhere in this invention.

First, a general description of CDMA distributed antennas is presented, followed by the M&Ps necessary to support wireless location.

In the CDMA distributed antenna concept, a set of simple antennas, placed apart in a given area, similarly to any other cell placement arrangement for coverage objectives, are fed by a common radio signal. Antennas are usually placed such that their coverage patterns are substantially or completely overlapped in area of coverage. From a wireless location perspective, completely overlapping coverage is preferred (this approach also improves perceived signal quality by the end users).

The importance of understanding and characterizing the aggregate system delay elements is shown in Fig. 6: Distributed Antenna Delay Characterization. For any given Pilot Channel offset "I", additional delay is introduced by the microwave propagation channel (Point A) and any internal repeater/amplifier equipment (Point B). Each of four delay elements t_1 through t_4 introduce further delay. A mobile station detecting all four DA antennas' delayed signals would determine various sets of cumulative system propagation delays. Since each delay is essentially fixed in a location, such information can be used to determine the mobile station location within the building. Fig. 7 illustrates the effective system timing among the delay elements 324, relative to the GPA system time 336, along each point in the diagram shown in Fig. 6.

Fig. 9: One Exemplary DA Configuration, illustrates a typical configuration where the CDMA base station antenna is also directed connected to three delay elements and antenna radiators.

The CDMA Base station transmitter common output signal is fed through a distribution coaxial cable system, optical fibers or other means, to a string of two or more antennas. Each antenna is connected to the distribution cable via a transmission line tap or delay element, which may or may not provide further broadband gain. The transmission system normally consists of two media channels, one for transmit and one for receive signals. Fig. 10 illustrates an Alternative DA Configuration, using multi-point microwave antennas connected to individual delay elements and their respective radiating antennas.

Fig. 11: Serving Dense Multi-level buildings via Virtual Pilots, illustrates a typical application where a multi-level building is served by two base stations with pilot offsets "I" and "j". Pilot offset "I" serves floor X and pilot offset "j" serves floor Y. As shown, a microwave link, either active or passive, relays the base station signals between the distributed antennas within the building to the base stations.

The main concept is to introduce purposeful delay and multipath signals with sufficient delay spread for signal discrimination. Each antenna radiates a signal which is substantially delayed with respect to any other antenna in the area. If two or more paths are available for the mobile station receivers with greater than one eighth microsecond differential path delay (or whatever resolution is available in the CDMA mobile station receivers), then two or more PN receivers in the same mobile station can be employed to separately receive and combine these signals and thus achieve processing gains through path diversity. Antennas may be omni-directional or directional.

Delay elements may be simple delay lines such as lengths of coaxial cabling, or other active or passive delay elements, such that the combination of components provides the needed delay. The transmission line between the CDMA Base station/PBX and the distributed antennas may be via a pair of dedicated, beam-focused high gain antennas, and/or a repeater system. Provided sufficient delay exists between the multipath signals from separate distributed antennas exists, each Data Receiver within the mobile station tracks the timing of the received signal it is receiving. This is accomplished by the technique of correlating the received signal by a slightly earlier reference PN and correlating the received signal with a slightly late local reference PN. Further distributed antenna details can be seen from Gilhousen, et al, patent number 5,280,472, assigned to Qualcomm, Inc.

The total measured delay of both forward and reverse link signals between the BS and the mobile station are thus determined naturally by the CDMA radio receiver designs as a part of the multipath tracking process, and can be made available to a location entity for performing location estimates of the mobile station.

However, the measurements of delay between a particular distributed antenna and the mobile station will include the aggregate delay components of several mechanisms, beyond the BS pilot PN offset delay. In the case of distributed antenna configurations, the simple TOA or TDOA model which is based solely of the speed of light, must now be adjusted to account for the purposefully introduced delay.

The mobile station measures the arrival time T_i for each pilot /reported to the BS. The pilot arrival time is the time of occurrence, as measured at the mobile station antenna connection, of the earliest arriving usable multipath of the pilot. The arrival time is measured relative to the mobile station' time reference in units of PN chips. The mobile station computes the reported pilot PN phase f_i as:

$$f_i = (T_i + 64 \times \text{PILOT\_PN}) \bmod 2^{15},$$

where PILOT_PN is the PN sequence offset of the pilot.

Reference Fig. 6, which illustrates a typical distributed antenna configuration consisting of a repeater/amplifier and four distributed antennas. The total system delay, T_i is:

$$T_i = T_{offset} + T_0 + T_R + T_1 + T_2 + T_3 + T_4$$

During the installation phase of the high gain antenna (if required), repeater (if required) and the distributed antennas, if the system delay is measured at each distributed antenna and the values stored in a location database, including each antenna identification, and exact physical location (in three dimensions), then during a location request, all fixed delays will be known, thus the TP value can be determined by subtracting the fixed, known delay values from Ti, the measured time of arrival. The TP value can now be used to determine a TOA and or a TDOA value in a manner similar to the non-distributed antenna case, thus location can be determined based on these TOA/TDOA ranging values.

The required installation methods and procedures required to support wireless location are illustrated in Fig. 8: Methods and Procedures for DA Installation. By following these methods, the Location Center (LC) will contain a database populated with the necessary data values to perform accurate location estimates within the building containing the distributed antennas. Fig. DA-10: Exemplary DA Location Database, illustrates typically data element types and values required in the DA location estimate model database. Fig. DA-11 illustrates how a simple TOA location estimate model can be used to determine wireless location in a DA environment. Based on the known geometry and coverage areas of each DA cell, and the percentage of maximum radius, determined by the above classification, it is possible to construct radius-radius circles of the DA cells. The intersection of the three circles (in this case) provides the location estimate.

In order for the TOA and TDOA location calculations to be determined, it is a necessary condition that during distributed antenna installation, the minimum values of the Delay Elements be set to each exceed the maximum practical (i.e., within the coverage area) TP values be at least 1/2 of a PN chip duration (about 500 nanoseconds), to easily allow for the CDMA Data Receivers to be able to correlate between the delay element values and the TP delay values. Fig. 12: DA Delay Spread Ranges, illustrates typical maximum ranging variable delay values (e.g., up to 1,960 feet) if 500 nanosecond guard zones (t) are used. If larger ranging values are required, then guard zone delays must be increased proportionally.

Fig. 13: DA Cell Layout and Geometry, illustrates, for DA omnicell sizes with a radius of about 2,000 feet and guard zones of 500 nanoseconds, that the minimum required cumulative delay values for the delay elements are: $_{t2} = 2.46$ microseconds, $\mathbf{t_3} = 4.92$ mS, and $\mathbf{t_4} = 7.38$ mS, respectively.

It should also be noted that a maximum upper bound exists for the maximum amount of cumulative system propagation delay which can be tolerated by the CDMA mobile station. The total delay cannot exceed an amount that would interfere with the next pilot PN offset, or substantially delay the scanning time of the search receiver in the mobile station. In any case, 30 to 40 microseconds of total delay is acceptable, and would allow for a relatively large number of distributed antenna components to be included, thus no unusual impacts are required of the system to accommodate location methods.

By purposefully introducing a relatively large amount of delay in the distributed antenna delay elements, relative to the maximum permissible TP delay values, it is possible to utilize the large Delay Element values to uniquely identify the distributed antenna ID, and thus via the distributed antenna database, to determine the antennas' exact location. Knowing the antenna's location and TP value (last stage of propagation delay), TOA and TDOA ranging can be achieved, and thus mobile station location within a distributed antenna configuration, can be determined.

Fig. 14: Actual Measurements and Classification, illustrates how CDMA delay spread measurements are used in a DA configuration to form a relationship with the mobile station location with respect to the DA locations. Although the CDMA air interface standard only requires the signal strength and time of arrival of the first useable delay spread signal to be reported from the mobile station to the BS, assume here that the mobile station has the capability to provide the BS, and consequently the LC, with a list of all peak values of CDMA fingers.

Assume that the mobile station detects and telemeters three CDMA finger RF measurements, as shown in the table below, New Message Type Data Structure Content.

Signal Strength	Delay Time of Arrival
-77 dBm	1.68 microseconds
-66	3.98
-95	9.16

Table: New Message Type Data Structure Content.

Note that the measurements may be averaged over a sample space of 128 individual measurements. Referring now back to Fig. 14, it can be seen that the first finger is associated with the DA cell-1, range 0 to 1.96 microseconds, and DA cell-2, range 2.46 microseconds to 4.42 uS, and DA cell-4, range 7.38 to 9.34 uS. Since the DA cell antennas are fixed, with known locations, correlation's can be derived and established to relate actual measurements with locations. Any one of several location estimate modules may be used, as shown in Fig. DA-12: Location Estimate using the radius-radius method, or multiple invocations of different modules may alternatively be used to form a location estimate of the mobile station within the DA environment.

It is now possible to classify the above actual measurements as propagation delayed signals for the DA cells 1, 2, and 4, since each DA cell delay range is know, and sufficient guard zones exist between delay spread ranges to unambiguously classify the measurements, and thus to determine mobile station location. The following table illustrates a typical database containing the classification columns for each DA cell and their corresponding location in an x,y plane.

DA Cell ID	Location (X, Y) in feet)	DA Cell Radius	Low Range (microseconds)	High Range (In microseconds)
1	(0,0)	1.96	0	1.96
2	(-20, 3000)	1.96	2.46	4.42
3	(4000, 2800)	1.96	4.92	6.88
4	(1600, 2800)	1.96	7.38	9.34

Table: New Message Type Data Structure Content

Translating the actual delay measurements into a percentage of the maximum radius of each cell (i.e., cell 1 radius actual is 88 %, cell 2 radius actual is 78 %, and cell radius 4 actual is 91%) provides wireless location using familiar radius-radius calculations.

Depending upon the combinations of embodiments, the Location Center and Gateway may contain from one to three interfaces into the digital PCS network, shown as interfaces X, Y, and Z, in Fig. 24, Location and CTIA/TR45 Network Reference Model. Network interface reference points Um, A, Ai, B, C, D and H are part of the Cellular Telecommunications Industry of America (CTIA)/Technical Reference 45 standards, and are not discussed further.

Network interface reference point X provides a direct connection to the mobile switch center, used for transferring RF measurement signals from the mobile station and BS to the LC and for transferring location control between the LS and mobile station, and between the LC and BS. This interface can be implemented via any number of data communications circuit configurations and protocols in current use, such as a T-carrier data circuit, with DSU/CSUs at each end, using an intranet/internet protocol suite, such as TCP/IP, RPC messaging, or other middleware solutions, such as Pipes, IBM MQ series, world wide web protocols, such as JAVA/VRML scripts, hypertext markup language (HTML) links, and may also include various firewall schemes and data encryption mechanisms, etc., in order to communicate asynchronous messaging among the endpoints, and in particular, in reference to the final distribution of the location information to the desired end user.

Network interface reference point Y is used in the embodiment wherein a public switched telephone network interface is required or desired. This interface is a straightforward method to support location applications wherein, for example, a mobile station user dials a telephone number in order to initiate a location request, and could also be used to telemeter RF measurement and location control messages between the LC and the mobile station/BS. Alternatively a timer-initiated process internal to the LC may be used to start a location request, or via any number of events external to the network. Point Y also has the advantage of not requiring a direct connection to a commercial radio mobile service providers' network elements, thus affording a convenient interface for use by third party location service providers unrelated to the commercial radio mobile service provider.

NATIONAL SCALE WIRELESS LOCATION

By utilizing specific data items used in the Home Location Register in the Advanced Intelligent Network, it is possible to determine the mobile station location on a national scale, i.e., location within the context of a state, and in which city.

Network interface reference point Z is used in the embodiment wherein a gross location must be determined. A gross location is defined as an area associated with a particular mobile switch center coverage area. Mobile switch center coverage areas are typically bounded by a large metropolitan area, such as a city. The Home Location Register (HLR) contains gross location information. The Z interface allows the LC to query the home location register to determine if the user is in their "home area, or whether the user is roaming to another mobile switch center coverage area, such as another city. IS-41 Cellular Radio Telecommunications intersystem operations communications protocols provide mechanisms that allow a user to roam into authorized areas outside of their "home" area.

If the user is roaming in another area, then the LC can use that information to initiate location control messages toward the CDMA network currently hosting the mobile station user. Fig. 25 illustrates how a user based in Los Angeles, CA, for example, may roam to a CDMA system New York City, and be "located" within that metropolitan area, through a data communications network and a national Location Center Clearinghouse system.

SIGNAL PROCESSOR SUBSYSTEM

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 within the Location Center/System 42, shown in Fig. 3. In some cases the mobile station 140 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.

For each pilot channel detection case, multiple fingers (up to three or four) may be detected and thus reported to the Location system, as shown in Fig. 22 and 23, for dense urban and rural settings, respectively. From the mobile receiver's perspective, a number of combinations of measurements could be made available to the Location Center. Table SP-1 illustrates the available combinations for three and four receiver cases, respectively.

No. of Receivers	No. of BSs detected	No. of Fingers Detected	No. of Fingers, BS 1-S (first strongest)	No. of Fingers, BS 2-S (second strongest)	No. of Fingers, BS 3-S (third strongest)	No. of Fingers, 4-S (fourth Strongest
3	1	1	1	0	0	0
3	1	2	2	0	0	0

No. of Receivers	No. of BSs detected	No. of Fingers Detected	No. of Fingers, BS 1-S (first strongest)	No. of Fingers, BS 2-S (second strongest)	No. of Fingers, BS 3-S (third strongest)	No. of Fingers, 4-S (fourth Strongest
3	1	3	3	0	0	0
3	2	2	1	1	0	0
3	2	3	2	1	0	0
3	2	3	1	2	0	0
3	3	3	1	1	1	0
4	4	4	1	1	1	1
4	3	4	1	2	1	0
4	3	4	1	2	1	0
4	3	4	2	1	1	0
4	2	4	3	1	0	0
4	2	4	2	2	0	0
4	2	4	1	3	0	0
4	1	4	4	0	0	0

Table SP-1: Nominal CDMA Location Measurement Combinations

The above Table SP-1 scenario assumes that the mobile station design and data collection structure only permits a 1:1 correspondence to exist between the number of base stations detected and the number of data receivers reporting multipath CDMA fingers.

Table SP-1 illustrates the potential combinations of detected CDMA signals representing multipath fingers and total number of detectable base station pilot signals in a given location within the radio coverage area 120. 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.

The following diagrams illustrate a certain case from a location measurement perspective, of signals received for a three -data receiver and a four-data receiver configuration, in a nominal three sector honeycomb base station configuration. In Fig. 18, a mobile station at location "A" detects base stations 1b, 5c, and 4a. However although a triad of signals are received, if varying multipath signals are received from one or more base stations, then ambiguity can still result. Fig. 19 illustrates a mobile station located at position "A", detecting base stations 1b, 5c, 4a, and 2c. Although additional information is made available in this second case, traditional hyperbolic combinations taken three at a time, yield multiple location estimates. In certain cases the limit of the back-side of a "far-away"sectored antenna can be used to determine the limit of RF coverage in another base station sector area.

Fig. 20 shows that normally a delay spread in sector 1b would imply a range of a 120 degree solid angle. However by using the known fact that base station sector 2a contains a coverage limit, such negative logic can be used to further restrict the apparant coverage area in sector 1b, from 120 degrees to approximately 90 degrees as shown in the illustration, in order to locate the mobile station B. Such information regarding sector 2a can be determined by collecting the remaining set information from mobile station B.

Now consider more practical, less ideal cases. 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. Fig. 20 and 21 illustrate a typical relative error space wherein a mobile station detects only two base station pilot channels, and only one pilot channel, respectively. 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.

Base Station Cell site planning tools which utilize antenna gain radiation patterns, environmental clutter, such as buildings, dense forests, terrain heights, etc., can provide reasonable training data to bootstrap the initial operation of the LC.

An example of the types of data typically collected during field tests/runs is shown in the following database table SP-2 below:

Column Position	Mobile Data Test Set: Data Type Logged
1	CDMA Time (absolute, from GPS)
2	Vehicle Speed (in mph)
3	Vehicle Latitude (in deg. North)
4	Vehicle Longitude (in deg. East)
5	GPS Source (binary, e.g., GPS or Dead Reckoning)
6	GPS Data available indicator (binary states)
7	First BS-Mobile Received Power (in dBm, 1 second averages)
8	Mobile transmit Gain Adjust (in dBm, 1 second average)
9	First BS Mobile Rx Pilot E_c/I_o (dB, 1 second average)
10	First BS Mobile received Frame Counts (integers per measurement period)
11	Mobile Finger's Average Time Separation (in nano/microseconds)
12	Mobile Fingers' Maximum Time Separation (in nano/microseconds)
13	Mobile Fingers' Number of Pilots locked (per 1 second average)

Column Position	Mobile Data Test Set: Data Type Logged
14	Mobile finger Lock Counts
15	First BS Received Frame Counts
16	First BS Eb/No set Point (in dB, 1 second average)
17	First BS cell Rx Eb/No per antenna (in dB, 1 second average)
18	Hand-off State (relative to the First, or connected-to BS)
19	First BS Traffic Channel Gain
20	First BS Power Control Subchannel Gain
21	First BS Reverse Link full Frame Error Rate, over 500 frames
22	Forward Link full Frame Error Rate, over 500 frames
23	First BS Pilot Channel Delay Spread (in nanoseconds)
24	Second BS-Ranked Pilot Delay Spread (in nanoseconds)
25	Second BS-Ranked Pilot Relative Signal Strength (in dB)
26	Third BS-Ranked Pilot Delay Spread
27	Third BS-Ranked Pilot Relative Signal Strength (in dB)
28	Mobile Antenna Identification (in the case of a multi-sectored antenna)
29	Vehicle compass orientation (bearing or heading)
30	Mobile Station Power Class (an integer, 0-7, indicating max. power capabilities of the mobile station transmitter)

Table SP-2: Typical CDMA Field Test Measurements

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 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: 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. 1) within the Location system 42 (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 system 42 to the mobile switch center 12, and then to the base station(s) 122 (Fig. 2) 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 122, 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_s, T_DROP_s, 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.

Table SP-3 illustrates the resulting extended combinations of BS signals (pilot channels) and finger measurements potentially available, based on the above preferred conditions. The philosophy is to collect as much reasonable data as is practical, given the constraints of CDMA receivers, search times, receiver memory storage and available CPU and data transmission bandwidth, in order that sufficient orthogonal information can be processed to minimize location estimate error.

No. of Receivers	No. of BSs detected	No. of Fingers Detected	No. of Fingers, BS I-S (first strongest)	No. of Fingers, BS 2-S (second strongest)	No. of Fingers, BS 3-S (third strongest)	No. of Fingers, 4-S (fourth Strongest
3	1	1	1	0	0	0
3	1	2	2	0	0	0
3	1	3	3	0	0	0
3	2	2	1	1	0	0
3	2	3	2	1	0	0
3	2	3	1	2	0	0
3	2	4	2	2	0	0
3	2	5	2	3	0	0
3	2	5	3	2	0	0
3	2	4	3	1	0	0
3	2	4	1	3	0	0
4	2	5	4	1	0	0
4	2	5	1	4	0	0
3	3	3	1	1	1	0
3	2	6	3	3	0	0
3	3	3	1	1	1	0
3	3	4	2	1	1	0
3	3	4	1	2	1	0
3	3	4	1	1	2	0
3	3	5	2	2	1	0
3	3	5	2	1	2	0
3	3	5	1	2	2	0
3	3	6	2	2	2	0
3	3	6	3	2	1	0
3	3	6	2	3	1	0
3	3	6	1	2	3	0
3	3	6	1	3	2	0
4	4	4	1	1	1	1
4	4	5	2	1	1	1
4	4	5	1	2	1	1
4	4	5	1	1	2	1
4	4	5	1	1	1	2
4	4	6	2	2	1	1
4	4	6	2	1	2	1
4	4	6	1	1	2	2
4	4	6	1	2	2	1
4	4	6	1	2	1	2
4	4	6	2	1	1	2

4	4	7	3	2	1	1
4	4	7	3	1	2	1
4	4	7	2	3	1	1
4	4	7	2	1	3	1
4	4	7	2	1	1	3
4	4	7	1	3	2	1
4	4	7	1	2	3	1
4	4	7	1	1	2	3
4	4	7	1	1	3	2
4	4	7	3	1	1	2
4	4	<13	...	...	...	...

Table SP-3: Extended CDMA Location Measurement Combinations

As can be seen from the table, a much larger combination of measurements is potentially feasible using the extended data collection capability of the CDMA receivers. In the case of the last row shown, additional combinations are also possible using a similar scheme of allocating the number of CDMA fingers detected at the first or strongest BS, followed by the second strongest base station, then the third strongest base station, etc.

Fig. 29 illustrates the components of the Signal Processing Subsystem 20. 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 20 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 14 in Fig. 1. Detection is accomplished in the signal classifier 9 (Fig. 29) 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. 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 module 6 shown in Fig. 1. 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 module 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 68 location request message in Fig. 1, via the location application programming interface 14.

In addition the controller 15 receives autonomous messages from the MSC, via the location applications programming interface 14 (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 14 (Fig. 1), in communications with the MSC 12a and 12b in Fig.1, 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 MSC 12a and 12b in Fig. 1, 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 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 I 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 12a or 12b in Fig. 1. 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.1, to the appropriate MSC 12a and 12b, using the authorized communications port mentioned earlier. In a second case the controller 15 communicates directly with base stations as discussed above and shown in Fig. 5, Location Center-base station access, multiple CMRS, in this second case an alternative embodiment is provided to directly extract the wireless location signal measurement data from each base station associated with each of multiple CMRS networks within having to interface directly with the MSC for signal measurement extraction.

Upon receipt of the signal measurements, the signal classifier 9 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 or message location data related to a home base station), provided by the location applications programming interface (L-API) via the input queue 7 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 subsystem 20 in Fig. 1 contains a base station database table 13 (Fig. 29) which captures the maximum number of CDMA delay spread fingers for a given base station, containing information structures as shown in table SP-4 below:

Primary Base Station Identification	**Latitude, Longitude, elevation**	**Pilot Channel Offset**	**BS Identifier code**	**Maximum No. of CDMA Fingers**
DEN-001	x, y, z	5	CODENABC001	4
DEN-002	p, q, r	25	CODENABC002	4
DEN-003	s, t, u	20	CODENABC003	3
DEN-004	a, b, c	15	CODENABC004	4
BLD-005	d, e, f	45	COBLDABC005	4

Table SP-4: Base Station Characteristics

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.

Mobile Station Identification (MIN)	Manufact-urer	Model No.	Allowed S/W Revision Levels	Maximum No. of CDMA Fingers	Maxim um No. of Pilots Detecta ble	Transmit Power Class (Max)	Rec. Thermal Noise Floor (dBm)
3034561234567	Sony	5	R1.0	3	3	2	-114
3034561234568	Qualcomm	25	R2.01	4	4	4	-115
3034561234569	Panasonic	20	R1.1	3	3	5	-113
3034561234570	Fujutshu	15	R2.5	4	4	0	-116
3034561234571	Sony	45	R1.1	3	3	7	-115
Default	Default	Default	R1.0	3	3	3	-112

Table SP-5: Mobile Station Characteristics Table

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 on the SP-5 table data contained within the mobile station table 11, 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.

Fig. 4, Location Provisioning from Multiple CMRSs, illustrates a system architecture to enable the customer care systems belonging to different CMRSs, either on an autonomous or periodic basis, to update a provisionable signal processing database 26, containing the mobile station characteristics, in communication with the signal classifier/filter 9, input queue 7, and the location applications programming interface for customer casre systems (L-API-CCS) 139. 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. 2) is required. Referring to Fig. 29, 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.

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. 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.

Referring now to digital signal and image filter processing, by way of example, a forward-path CDMA mobile station delay spread RF measurement sample is illustrated in Fig. 22, for the mobile station reception of one sample of transmission signal related to BS-1, located at 16th and Stout Streets. In this sample three fingers or groups of RF energy (relative signal strength is indicated along the vertical axis) were detected. A first CDMA finger was found at a delay of about 3.4 microseconds, and relative signal strength of about -80 dBm. A second finger was found at a delay of about 5 microseconds, and peak strength of about -55 dBm, followed by a third finger at 6.5 microseconds and a strength of about -92 dBm. Two other base stations were detected, BS-5 and BS-2, along with their respective three CDMA delay spread fingers.

Refer now to the left image shown in Fig. 26: Delay Spread Profile Image. After 128 samples 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. Fig. 28 illustrates the result of image generation when a number of data samples, or an ensemble of signal strength, delay paris of values are added within a given bin area or matrix, to thus create a type of three-dimensional image, representing a particular RF signaling behavior at a given location.

Refer now to the right image shown in Fig. 26. 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.

The strongest signal technique has been discussed previously in the data filter section. Fig. 27: Convolution of Forward and Reverse Images, illustrates one method 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 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, as illustrated in Fig. 30 (before equalization) and 31 (after equalization) 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. Figs 32 and 33 illustrate the three dimensional grid images of the before and after input cropping filter example. As shown in Fig. 33, 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. Fig. 33 illustrate five "pencils" of CDMA finger energy that passed a simple 50 percent Input Crop filter. However, as shown in Fig. 34 when subjected to a 4X4 neighbor Median filter and 40 percent clipping, all five pencil-shaped fingers have been deleted. Fig. 35 illustrates the further simplified result of 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 estimators DA module 10, TOA/TDOA module 8 or the HBS module 6, in Fig. 1.

HOME BASE STATION MODULE

Upon receiving a message from the Data Capture Gateway or the signal processing subsystem 20, the HBS location estimate model examines a Home Base Station Table which defines relationships among a wireless MIN, and wireline telephone number, characteristics of the HBSD, and the possibility to use various signal types in order to further define the location within the address area of the fixed location HBSD. The following table, populated by the commercial mobile radio service provider at HBSD installation time, is used by the HBS model to determine location whenever the mobile station 140 is located within communication range of the HBSD:

Wireline MIN	Wireless MIN	HBSD Model	HBSD location Latitude, Longitude	Fixed HBSD Location	CDMA Strength/Delay Measurements ?
3035561234	3035661299	Sony Qx-9000, Rev. 1.1	52.619488 N, 112.4197601 W	727 Magnolia Drive, Boulder, CO	No
3035561236	3035661200	Panasonic PF-130, Rev. 5.0	52.645488 N, 112.4197601 W	1401 Digit Drive, Boulder, CO	Yes
3035561236	3035661240	Panasonic PF-130, Rev. 3.4	52.779488 N, 112.4197601 W	1698 Folsom St., Boulder, CO.	No
3035561284	3035661205	Panasonic PF-180, Rev. 5.0	51.619488 N, 111.9197601 W	990 Nutcracker Dr., Niwot, CO.	NO
3035561224	3035661266	Panasonic PF-5000, Rev. 1.0	52.619558 N, 112.4197601 W	5606 Bismark Circle, Denver, CO	Yes
...	...	...		...	...

Table HBS-1: HBSD Characteristics

In the event RF signals are available for telemetry from the HBSD to the location system, such information may be solicited from the location system to the HBSD, in the form of a request/response message scheme, using for example, a data-under-voice technique. In such cases the SSP provides a data connection with the location system 42 via the PSTN. The home base station may interact with the mobile station in the same manner as a cordless telephone transceiver interacts with a cordless telephone, when the mobile station is within an acceptable range.

The HBS module 6 in Fig. 1 outputs the Latitude and Longitude location estiamtes to either the PSTN 24 or to the Internet 68, dependending upon the source of the originating location request.

DISTRIBUTED ANTENNA MODULE

Upon receipt of one or more data ensemble messages from the signal processing subsystem 20 in Fig. 1, the distributed antenna (DA) module 10 queries a previously populated distributed antenna database to determine the locations of distributed antennas associated with the measured DA antenna "pilot delays" so that the detected signal measurement delay signal values received from the mobile station receivers and base station receivers can be input to the TOA/TDOA module. The TOA/TDOA module then utilizes the radius-radius method, or time difference method, in order to provide location estimates within the building or area containing the distributed antennas.

DAISEY CHAINING BASE STATIONS

As a practical matter it may be necessary in some network conditions to add base stations in areas to permit improved estimates to be achieved in wireless location. An aspect in this invention includes daisey chaining communication circuits or transport facilities between or among base stations, in order to simplify the installation and operation of such base stations. Base stations normally communicate with the mobile switch center using T-carrier transport facilities, in order to carry voice and data bearer traffic, and to transport bi-directional control signals. However for various economic or other reasons it may not be justifiable to install such transport facilities. At the base station, by essentially originating a plurality of mobile telephone calls using the data communications option, and terminating such calls at the mobile switch center appropriately, the outputs of the base station transport multiplex circuits are re-directed into the data communication circuits normally intended for use by mobile stations in establishing a data circuit communication call to the network. Circuits at the mobile switch center used to terminate these data calls, redirect the communication to those circuits normally used to terminate the T-carrier facilities from the base stations. In this manner, existing wireless channels can be used to provide transport via this daisy-chaining method between certain base stations and the mobile switch center, thus simplifying connectivity in cases where the installation of transport facilities would either be impossible or impractical.

DISTANCE FIRST ORDER MODULE (TOA/TDOA)

Particular distinctions over the current state of the art include utilizing essentially the native electronics, antennas and standards, and opposed to overlay solutions, supervisor functions which control a hybrid set of techniques, including Time Of Arrival (TOA), Time Difference of Arrival (TDOA) in both the forward and reverse paths, pilot signal strengths, power control, mobile stations (mobile station) state conditions, stochastic features of environmental clutter, multipath detection and mitigation, and robustness, supporting a variety of conditions including degraded/faulty equipment, distributed and SMART antennas, various registration modes, and various call processing conditions such as soft, hard and idle hand-off conditions, location during the idle state, traffic-bearing states, and location during cases of severe multipath, such as that experienced in urban canyon environments, as well as location in suburban and rural cases.

Since each base station is required to emit a constant signal-strength pilot pseudo-noise (PN) sequence on the forward link channel identified uniquely in a network system by a pilot sequence offset and frequency assignment, it is possible to use the pilot channels of active, candidate, neighboring and remaining sets of pilots, associated with neighboring base stations, stored in the mobile station, for TOA and TDOA measurements performed by the mobile station.

Based on the arrival time measurement estimates and the speed of propagation, ranges or range differences between the base stations and the mobile station can be calculated. TOA and/or TDOA measurements can then be input to either the radius-

radius multilateration or the time difference multilateration algorithms.

By utilizing the known base station positions, location of the mobile station can be determined. Since measurements and base station positions can be sent either to the network or the mobile station, location can be determined in either entity.

Since not all measurements can provide accurate location results at all times and conditions, a variety of supervisory logic processes can be invoked to resolve or litigate the problem area.

As those familiar with the EIA/TIA IS-95 and T1P1/JTC CDMA standards specifications know, mobile station call processing consists of four states:

1. *Initialization State* - where the mobile station selects and acquires a system, a network, and timing information. This state consists of four substates: *System Determination, Pilot Channel Acquisition, Sync Channel Acquisition*, and *Timing Change Substate*;
2. *Idle State* - where the mobile station monitors messages on the Paging Channel, and supports procedures such as Message Acknowledgment, nine modes of Registration, Idle Hand-off, Pilot Search, and response to Overhead Information, such as System and Access Parameters (which include BS Latitude and Longitude), mobile station Message Transmission Operation (i.e., Data Burst) and Neighboring List messages;
3. *System Access State* - where the mobile station sends messages to the base station on the Access Channel. This state consists of six substates: Update Overhead, Origination Attempt, Page Response, mobile station Order/Message Response, Registration Access; Message Transmission Operation/Data Burst);
4. *Mobile station Control on the Traffic Channel State* - where the mobile station communicates with the primary base station using the forward and Reverse Traffic Channels. This state consists of five substates: *TC initialization, Waiting for Order, Waiting for mobile station Answer, Conversation* (which includes hand-off procedures and earliest arriving usable multipath components of pilots), and *Release*.

At power-up an IS-95 or T1P1 PCS CDMA compliant mobile station enters *Initialization State*, as described in IS-95, section 6.6.1. During the *System Determination* substate, the mobile station refers to its internal memory to acquire preferences for system carrier (A or B), or the preferred carrier at 1.8-2.0 GHz, and for other types of service, including advanced mobile phone service, or AMPS, as well as narrow band advanced mobile phone service, or NAMPS.

A CDMA-preferred mobile station then transfers to the *Pilot Acquisition* Substate. The mobile station tunes to the CDMA Channel number equal to $CDMACH_S$ then sets its Walsh code (always W0) for the Pilot channel where it begins searching for pilot energy, in terms of energy per bit, per spectral density.

Once a sufficiently strong (as defined by the T_ADD threshold parameter) pilot channel has been identified within T_{20m} seconds, the mobile station enters the *Sync Channel Acquisition* Substate, where the mobile station receives a *Sync channel Message* that includes, among other information, system time and the unique PN offset index for that particular BS. In the *Timing Change* substate, the mobile station adjusts its internal timing to match the BS's CDMA system time. At the completion of the

Timing Change substate, the mobile station is completely synchronized to the CDMA system's BS time.

After satisfactory synchronization the mobile station then enters the stable *Idle* State, where the paging channel begins to be monitored.

At this point at least two alternatives are possible:

1. Perform Location determination without consumption of user-perceived air time via the introduction of a new call processing state, or
2. Perform Location determination via the traffic channel (requires air time)

In cases where Distributed Antennas (DAs), and/or Home Base Stations (HBS) are used, each location of these devices can be sent to the mobile station. There are at least three format-types possible in conveying this type of location information in the GeoLocation Message. First, A unique identifier can be assigned to each DA/HBS, such as a fully distinguished name. An example of location information could be: Within the USA, State of Colorado, city of Denver, with Service Provider xyz, BS ID 129, Distributed Antenna number 8. Or more compactly, the location string is structured as, "USA.CO.DEN.xyz.129.DA8". Secondly, an easy-to-understand human style data message can be sent, such as, "You are near the 30th floor of the Sears Tower building". Third, data values for Latitude, Longitude, and possibly altitude and accuracy could be sent from the BS or Location Center to the mobile station/LU ("LU" denoting . In order to be most easily useful to and end-user, in the first and third cases, a database would be needed within the mobile station or a Personal Digital Assistant device, which performs a translation of numerical data into a form useful for human understanding.

The mobile station thus maintains a list of location pilot offsets, where the list is ranked based on a weighted combination of received signal energy and BS location. The mobile station selects the best candidate BSs for location estimate purposes, which may be slightly different from the Active, candidate and remaining lists.

Additionally the mobile station may send a Data_Burst message back to the BS or Location Center, informing that no other Pilot Channels were detected. This "negative" Venn diagram information may be useful with various heuristics for location estimate deduction, for example, to note where the mobile station is not located.

It is the difference of system time values (as opposed to their absolute values) that is important. Note that for purposes of location, any communication back to a BS 122 would require re-synchronizing onto that BS's system time. Although not specified in either IS-95 or T1P1/JTC's PCS CDMA standards, most mobile station manufacturers build correlators with resolutions of approximately 1/8 PN chip, which is about 125 nS. A location equipped mobile station will provide +/- 125 nS. accuracy, which is about +/- 125 feet.

The mobile station or location entity can process the arrival time estimates in at least two ways. first the mobile station may difference the measurements (preferred) to form time-difference-of-arrivals (TDOA); or second, the mobile station may determine absolute time-of-arrival (TOA) by solving for the clock bias between the mobile station and other CDMA system time reports. TOA requires very well calibrated BS system clocks among each other.

The following procedure illustrates significant capabilities hidden in the CDMA standards, which provide a substantial enabling base with which to provide the measurements and data for this inventions' location methods.

First the BS sends the *Neighbor List Update Message*, containing a complete list of the neighboring pilot PN sequence offset indices (i.e., via the NGHBR_PN field) associated with candidate BSs in the area, with which the mobile station could possibly scan for detecting usable earliest arriving neighboring useable BS multipath components. This list should typically be a complete list, as opposed to the presumed candidate subset. If the mobile station is not already in the Traffic/Conversation State, it could invoke this state by calling a dialable telephone number in the network, e.g., a designed "Quiet Line" This approach also allows a billing record to be generated according to routine wireless telephony practice. If the network is to determine location, then the network pages the mobile station 140, connecting the mobile station to a Quiet Line/Voice message upon mobile station answer. Note that it may be desirable to suppress the mobile station ringer sounding for certain location applications. Other methods may also be possible.

During installation, each BS 122 in a particular area is provisioned with the locations of all possible neighboring BSs in its area. The BSs 122 use this information to populate a list of all Latitudes and Longitudes which can be sent to the LUs, using the *Neighbor List Update message*. Second, assuming that the mobile station does not currently have this data or if unknown, then the BS shall send a series of *Mobile Station Registered Messages*, each message containing the latitude and Longitude values (i.e., the BASE_LAT and BASE_LONG fields) associated with a neighboring BS pilot PN offset sent with the first message. Note that the constants N_{6m}, Supported Traffic Channel Candidate Active Set size, normally set to 6, and N_{7m}, Supported Traffic Channel Candidate Set size, normally set to 5, and N_{8m}, the Minimum Supported Neighbor Set size, normally set to 20, should be sufficient for most location purposes, however these constants could be changed if the need arises.

Third, the BS saves the current T_ADD and T_DROP values in the BS memory, associated with the In-Traffic LU, and sends the *In-Traffic System Parameters* Message, which includes reduced T_ADD and T_DROP parameter values, useable for location purposes. The value for T_ADD would typically be set to a value near the lower end of the IS-98 specification, possibly below the 80 dB dynamic range requirement, close to (but not including) the thermal noise power level of the LU receiver. Note that if the LU is using restricted battery, e.g., a portable, then the time for keeping T_ADD and T_DROP at a low value for location estimates purposes, should be kept short to conserve adverse consequences, such as increased current drain and noise.

Reduced T_ADD and T_DROP values sent to the mobile station will cause the LU to scan all conceivable neighboring BS pilots provided to it by the BS, and to measure the strengths of each received pilot, and to determine the pilot arrival time for each pilot offset. Note that the signal strengths now measured may not be sufficient for carrying traffic, but may be sufficient for location purposes.

Assuming the network is to determine location, then the mobile station reports the arrival time, PILOT_ARRIVAL, for each pilot reported to the base station. According to the standard the arrival time is measured relative to the mobile station's time reference (which was previously determined from the active BS), in units of PN chips (1/2288) microseconds, or about 814 nanoseconds, as follows:

$$PILOT\_PN\text{-}PHASE = (PILOT\_ARRIVAL + (64 \times PILOT\_PN)) \bmod 2^{15},$$

where PILOT_PN is the PN sequence offset index of the pilot associated with the BS pilot indices in the neighbor list.

In order to achieve location accuracy estimates on the order of a few hundred feet (or nanoseconds) a higher resolution than 1 PN chip is required. Although not specified directly in IS-95, most mobile manufacturers use correlators with resolutions of approximately 1/8 PN chip, or about 102 nS (suggesting that if no other systemic errors are present, about 102 feet of error is expected). Note that the search window size $SRCH\_WIN\_A_r$ for each pilot may need to be increased if there are substantial delays experienced from the environment. It is desirable for the mobile station to report the second and third arrival time (or the second and third fingers), and their relative signal strengths, corresponding to each detectable Pilot Channel.

If more than one PILOT_ARRIVAL is available then a basic TDOA multilateration algorithm may be invoked, at either the LU, or the network. In the network case, the active BS 122 must send a Pilot Request Order for Pilot Measurement Request Order (ORDER code 010001), which causes the mobile station 140 to forward its measurements to the BS (and consequently the network, as appropriate).

At this point a minimally sufficient number of measurements are available to perform a location estimate. Thus the BS should restore the original T_ADD and T_DROP values (previously saved in the BS memory) to the mobile station, via the *In-Traffic System Parameters* Message.

Additional information may be desirable, such as the active BS' TOA measurement, as well as associated BS measurements of the mobile station's TOA to their BS location. This added information may be sent to the mobile station if the mobile station is to perform location, via the *Data Burst Message* on the *Forward Traffic Channel*. Since 26 combinations of data burst types have been reserved for future use in the standard, dedication of several combinations could be used to telemeter location-related data. In cases where duplicate ranging or other information is available, various supervisor techniques mentioned elsewhere in this document, could be used to refine the location estimate.

Once the location estimate has been performed, any number of means could be used to provide the results to the end user.

The IS-95 and J-STD-008 CDMA specifications require that BSs should be synchronized to within +/- 3 microseconds of CDMA system time and shall be synchronized to within +/- 10 microseconds. This invention disclosure method assumes the cost of GPS receivers is relatively small, thus time calibration at a more precise calibration level at each location BS is recommended to be used by using the very accurate GPS time parameters. Preferably the absolute error deviation among surrounding or neighboring base stations should be less than 800 nanoseconds, however in most cases this should not be a fixed requirement, but rather a preference. In cases where absolute BS timing is prohibitively expensive, then the "Forced Hand-off" method discussed below can be used to overcome the preferred, or strict absolute BS timing requirements.

Three methods have been currently identified. Some of these techniques apply to other air interface types as well.

1. Use the first finger at BS (Absolute Ranging), and if detecteable, invoke a "Forced Hand-off" between the mobile station and a

neighboring BS, for a time sufficient to complete signal measurements between a mobile station transmitter and a BS receiver, and if possible, between a BS transmitter and a mobile station receiver, which gives access to as many BS's as can be detected either by the mobile station receiver or the surrounding BS receivers.

2. Use the first finger at mobile station (Differential Ranging) to obtain differential time readings of pilot channel from mobile station

3. Use the Pilot Power Level Measurements and Ground Clutter (Stochastic information)

Now in the general case where three or more BSs can either determine TDOA and/or the mobile station can telemeter such data to the location entity within the network, repeat this method for BS_2 and BS_3, and BS_3 and BS_1, in order to determine the remaining curves, thus yielding location within a 2D space. In the case of 3D geometry (such as a multi-story building with multi-floor pico BS cells), the process must be repeated a fourth time in order to determine altitude.

MATLAB MathWorks code to implement the above algorithms follows:

```
clear;hold off;
j = sqrt(-1);
step_size = 0.03;

# Set up BS variables
 theta = pi/3*ones(3,1);
 D = 10*ones(3,1);
 z(1) = 0;
 z(2) = D(1);
 z(3) = D(3)*exp(-j*theta(1));

# Define the distance parameters
 d = [0 6.4 -6.8]';
 location1 = [];
 location2 = [];
 location3 = [];

# Iterate and solve for the location with respect to the first BS (at (0,0) )
 t2 = -pi:0.05:0.05;
 for t1 = -pi/3:0.05:0.05,
  t1 = t1+0.001;
  r1 = 1./(exp(j*t1)-exp(j*t2)).*(D(1)-d(1)*exp(j*t2));
  r2 = 1./(exp(j*t1)-exp(j*t2)).*(D(1)-d(1)*exp(j*t1));
```

```
  temp = arg(r1);
  index = find(abs(temp) == min(abs(temp)));
  location1 = [location1;r1(index)*exp(j*t1)];
end;
for t1 = -pi/3:0.05:0.05
  t1 = t1+0.001;
  r1 = 1./(exp(j*t1)-exp(j*t2)).*(D(2)-d(2)*exp(j*t2));
  r2 = 1./(exp(j*t1)-exp(j*t2)).*(D(2)-d(2)*exp(j*t1));
  temp = arg(r1);
  index = find(abs(temp) == min(abs(temp)));
  location2 = [location2;r1(index)*exp(j*t1)];
end;
for t1 = -pi/3:0.05:0.05
  t1 = t1+0.001;
  r1 = 1./(exp(j*t1)-exp(j*t2)).*(D(1)-d(3)*exp(j*t2));
  r2 = 1./(exp(j*t1)-exp(j*t2)).*(D(1)-d(3)*exp(j*t1));
  temp = arg(r1);
  index = find(abs(temp) == min(abs(temp)));
  location3 = [location3;r1(index)*exp(j*t1)];
end;
location2 = location2*exp(j*arg(z(3)-z(2))) + z(2);
location3 = location3*exp(j*arg(z(1)-z(3))) + z(3);
set yrange [-10:1];
set xrange [-1:11];
plot([z;z(1)])
hold on
plot(location1)
plot(location2)
plot(location3)
```

WIRELESS LOCATION DATA COLLECTION

It is worthwhile to discuss techniques for both obtaining the initial collection of verified location data, as well as how additional location data can be obtained for updating the data in this data base in a straightforward cost-effective manner.

Regarding both the obtaining of the initial collection of verified location data as well as gathering data updates, it is believed that some of this data can be obtained from the initial and continued engineering of the base station infrastructure by the wireless telephony service provider(s) in the radio coverage area. Additional verified location data can be obtained by trained technicians driving and/or walking certain areas and periodically, at each of a plurality of locations: (a) determining a location estimate (using, for example, GPS if possible and/or offsets from GPS readings); and (b) using an mobile station 140 at the location to generate location data communication with the wireless base station infrastructure.

Alternatively, it is a novel aspect of the present invention that a straightforward method and system for gathering verified location data has been discovered, wherein a conventional mobile station 140 can be used without any additional electronics or circuit modifications. One embodiment of this method and system utilizes the personnel of businesses that travel predetermined routes through the radio coverage area (e.g., a delivery and/or pickup service) to generate such data using a conventional mobile station 140 while traversing their routes through the radio coverage area. One example of such personnel is the postal workers, and in particular, the mail carriers having predetermined (likely repetitive) routes for mail pickup and/or delivery at predetermined sites (denoted hereinafter as "mail pickup/delivery sites" or simply "mail sites"). By having such mail carriers each carry a conventional mobile station 140 and periodically generate location data communication with the wireless base station infrastructure at mail sites along their routes, additional verified location data can be added to the Location Data Base 1129 cost effectively.

To describe how this can be performed, a brief description of further features available in a typical mobile station 140 is needed. At least some modules of mobile station 140 have the following capabilities:

(27.2.1) a unique mobile station 140 identification number; in fact, every mobile station 140 must have such a number (its telephone number);

(27.2.2) the mobile station 140 has a display and a display memory for presenting stored data records having telephone numbers and related data to a user. Further, some portion of each data record is annotation and some portion is able to be transmitted to the wireless base station network. In particular, the mobile station 140 is able to store and recall data records of sufficient size such that each data record may include the following information for a corresponding mail pickup/delivery site along a mail route: (a) an address or other textual description data (e.g., an English-like description) of the mail pickup/delivery site; (b) a predetermined telephone number; and (c) a numerical code (denoted the "site code" hereinafter) associated with the mail pickup/delivery site, wherein the site code is at least unique within a set of site codes corresponding to the mail sites on the mail route. In one embodiment, the memory may store 99 or more such data records, and the display is scrollable through the data records;

(27.2.3) the mobile station 140 can have its display memory updated from either an RS232 port residing on the mobile station, or from an over-the-air activation capability of the wireless network;

(27.2.4) the mobile station 140 has a pause feature, wherein a telephone number can be dialed, and after some predetermined number of seconds, additional predetermined data can be transmitted either through additional explicit user request (e.g., a "hard pause"), or automatically (e.g., a "soft pause"). Moreover, the additional predetermined data can reside in the display memory.

Assuming these features, the following steps can be performed for acquiring additional verified location data:

(27.3.1) For (at least some of the) postal carriers having predetermined routes of addresses or locations visited, the postal carriers are each provided with an mobile station 140 having the capabilities described in (27.2.1) through (27.2.4) above, wherein the memory in each provided mobile station has a corresponding list of data records for the addresses visited on the route of the postal carrier having the mobile station. Moreover, each such list has the data records in the same sequence as the postal carrier visits the corresponding mail sites, and each data record includes the information as in (27.2.2) for a corresponding mail site the postal carrier visits on his/her mail route. More precisely, each of the data records has: (a) a description of the address or location of its corresponding mail pickup/delivery site, (b) a telephone number for dialing a data collection system for the location center 142 (or, alternatively, a reference to a memory area in the mobile station having this telephone number since it is likely to be the same number for most data records), and (c) a site code for the mail pickup/delivery site that is to be transmitted after a predetermined soft pause time-out. Note that the corresponding list of data records for a particular postal route may be downloaded from, for example, a computer at a post office (via the RS232 port of the mobile station 140), or alternatively, the list may be provided to the mobile station 140 by an over-the-air activation. Further, there are various embodiments of over-the-air activation that may be utilized by the present invention. In one embodiment, the postal carrier dials a particular telephone number associated with data collection system and identifies both him/herself by his/her personal identification number (PIN), and the postal route (via a route identifying code). Subsequently, the mail pickup and delivery sites along the identified route are downloaded into the memory of the mobile station 140 via wireless signals to the mobile station 140. However, additional over-the-air techniques are also within the scope of the present invention such as:

(a) If the postal carrier's route is already associated with the carrier's PIN for over-the-air activation, then the carrier may only need to enter his/her PIN.

(b) If the mobile station 140 is already associated with a particular route, then the carrier may only need to activate the mobile station 140, or alternatively, enter his/her PIN for obtaining an over-the-air download of the route.

(c) Regardless of how the initial download of mail sites is provided to the mobile station 140, it is also an aspect of the present invention that if there are more mail sites on a route than there is sufficient memory to store corresponding data records in the mobile station, then the data records may be downloaded in successive segments. For example, if there are 150 mail sites on a particular route and storage for only 99 data records in the mobile station, then in one embodiment, a first segment of 98 data records for the first 98 mail pickup/delivery sites on the route are downloaded together with a 99th data record for transmitting an encoding requesting a download of the next 52 data records for the remaining mail sites. (Alternatively, the data collection system may monitor mobile station 140 requests and automatically detect the last location capture request of a downloaded segment, and subsequently automatically download the next segment of mail site data records). Accordingly, when the data records of the first segment have been utilized, a second segment may be downloaded into the mobile station 140.

Moreover, at the end of the last segment, the data collection system may cause the first segment for the route to be automatically downloaded into the mobile station 140 in preparation for the next traversal of the route.

(27.3.2) Given that a download into the mobile station 140 of (at least a portion of) the data for a postal route has occurred , the postal carrier traversing the route then iteratively scrolls to the next data record on the list stored in the mobile station as he/she visits each corresponding mail pickup/delivery site, and activates the corresponding data record. That is, the following steps are performed at each mail pickup/delivery site:

(a) As the postal carrier arrives at each mail pickup/delivery site, he or she checks the scrollable mobile station 140 display to assure that the address or location of the mail pickup/delivery site is described by the data record in the portion of the mobile station display for activating associated data record instructions.

(b) The postal carrier then merely presses a button (typically a "send" button) on the mobile station 140 for concurrently dialing the telephone number of the data collection system, and initiating the timer for the soft pause (in the mobile station 140) associated with the site code for the mail pickup/delivery site currently being visited.

(c) Given that the soft pause is of sufficient length to allow for the data collection system call to be setup, the mobile station 140 then transmits the site code for the present mail pickup/delivery site.

(d) Upon receiving the telephone number of the mobile station 140 (via automatic number identification (AIN)), and the site code, the data collection system then performs the following steps:

(d1) A retrieval of an identifier identifying the route (route id). Note this may be accomplished by using the telephone number of the mobile station. That is, when the data collection system first detects that the mobile station 140 is to be used on a particular route, the telephone number of the mobile station and the route id may be associated in a data base so that the route id can be retrieved using the telephone number of the mobile station..

(d2) A retrieval of a iocation representation (e.g., latitude, longitude, and possibly height) of the mail pickup/delivery site identified by the combination of the route id and the site code is performed by accessing a data base having, for each mail site, the following associated data items: the route id for the mail site, the site code, the mail site address (or location description), and the mail site location representation (e.g., latitude, longitude, possibly height).

(d3) A request to the location center 142 is issued indicating that the location data for the mobile station 140 (resulting from, e.g., the call being maintained between the mobile station and the data collection system) is to be retrieved from the wireless network, temporarily saved, and a location estimate for the mobile station is to be performed. Accordingly, the data collection system request to the location center 142 the following:

(i) the telephone number of the mobile station 140;

(ii) the retrieved location of the mobile station 140 according to the route id and site code;

(iii) a request for the location center 142 to perform a location estimate on the mobile station 140 and return the location estimate to the data collection system;

(iv) a request that the location center 142 retain the location for the mobile station 140 and associate with it the location of the mobile station 140 received from the data collection system.

Regarding step (iii), the location estimate may also include the steps temporarily increasing the mobile station transmitter power level

(27.3.3) Subsequently, given that the location center 142 performs as requested, when the data collection system receives the mobile station 140 location estimate from the location center, the data collection system first associates the returned mobile station location estimate with the corresponding data collection system information regarding the mobile station, and secondly, performs "reasonability" tests on the information received from the mobile station 140 for detecting, filtering and/or alerting systems and personnel whenever the postal carrier appears to be transmitting (via the mobile station 140) from a location different from what the route id and site code indicate. The following are examples of such reasonability tests:

(a) If a threshold number of postal carrier transmittals disagree with the location center 142 estimate by a predetermined distance (likely dependent upon area type), then tag these particular transmittals as problematic and mark all transmittals from the mobile station 140 as suspect for "distance" inaccuracies.

(b) If there is less than a threshold amount of time between certain postal carrier transmittals, then tag these particular transmittals as problematic and mark all transmittals from the mobile station 140 as suspect for "time" inaccuracies.

(c) If an expected statistical deviation between a sampling of the postal carrier transmittals and the location estimates from the location center 142 vary by more than a threshold amount, then tag these particular transmittals as problematic and mark all transmittals from the mobile station 140 as suspect for "statistical" inaccuracies.

(d) If an expected statistical deviation between a sampling of the times of the postal carrier transmittals and an expected timing between these transmittals vary by more than a threshold amount, then tag these particular transmittals as problematic and mark all transmittals from the mobile station 140 as suspect for "statistical" inaccuracies.

(27.3.4) When suspect or problematic mobile station location information is detected (e.g., incorrect site code) in step (27.3.3), the data collection system may perform any of the following actions:

(a) Alert the postal carrier of problematic and/or suspected inaccuracies in real time, after a certain number of transmittals or at a later time. Note that such alerts as well as positive feedback at the end of the postal carrier's route (or segments thereof) may be advantageous in that it likely inhibits the postal carrier from experimenting with transmittals from locations that are purposefully inaccurate, but at the same time provides sufficiently timely feedback to encourage a conscientious postal carrier.

(b) Alert the Postal Service of perceived discrepancies in the mobile station 140 transmittals by the postal carrier.

(c) Dispatch location center technicians to the area to transmit duplicate signals.

(27.3.5) If the transmittal(s) from the mobile station 140 are not suspect, then the data collection system communicates with the location center 142 for requesting that each location received from the mobile station 140 be stored with its corresponding retrieved location (obtained in step (d2)) as a verified location value in the Location Data Base 1129. Alternatively, if the transmittals from the mobile station 140 are suspect, then the data collection system may communicate with the location center 142 for requesting that at least some of the location data from the mobile station 140 be discarded.

Note that a similar or identical procedure to the steps immediately above may be applied with other services/workers such as courier services, delivery services, meter readers, street sweepers, and bus drivers having predetermined routes.

WIRELESS LOCATION APPLICATIONS

After having determined wireless location from a base technology perspective, several applications are detailed below, which provide the results of the location information to a variety of users in various channels and presentation schemes, for a number of useful reasons and under various conditions. The following applications are addressed: (1.) providing wireless location to the originator or another, using either the digital air interface voice channel or a wireline channel, and an automatic call distributor; (2.) providing wireless location to the originator, or another, using either the digital air interface voice channel or a wireline channel, and a hunt group associated with the central office or a PBS group; (3.) providing wireless location to the originator or another, using either the digital air interface text paging, or short message service communications channel; (4.) providing wireless location to the originator or another, using the Internet, and in one embodiment, using netcasting or "Push" technology; (5.) selective group, multicast individualized directions with optional Conferencing; (6.) rental car inventory control and dispatch; (7.) vocalized directions and tracking; (8.) wireless location and court ruling/criminal incarceration validation; (9.) flexible delivery of wireless location information to public safety answering points; (10.) trigger-based inventory and tracking; (11.) group, e.g., family, safety and conditional notification; (12.) wireless location-based retail/merchandising services; (13.) location-based home/office/vehicle security management; (13.) infrastructure-supported wireless location using hand-actuated directional finding; (14.) infrastructure-supported intelligent traffic and highway management; (15.) Parametric-driven intelligent agent-based location services. Each of these wireless location applications is discussed in detail below.

Referring to Fig. 36, a user (the initiating caller) desiring the location of a target mobile station 140a, such as a user at a telephone station 162 which is in communication with a tandem switch 489 or a user of an mobile station 140b, or any other telephone station user, such as a computer program, dials a publicly dialable telephone number which terminates on the automatic call distributor 546 (ACD), associated with the location center 142. If the caller originated from an mobile station 102, then the call is processed via a base station 122 to a mobiles switch center 108. The mobile switch center recognizes the call is to be routed to the PSTN 124 via an interoffice trunk interface 600. The PSTN 124 completes the call to the ACD 546, via a trunk group interface 500. Note that the initiating caller could access the ACD 546 in any number of ways, including various Inter-LATA Carriers 492, via the public switched telephone network (PSTN) 124. The ACD 546 includes a plurality of telephone network interface cards 508 which provide telephony channel associated signaling functions, such as pulse dialing and detection, automatic number identification, winking, flash, off-hook voice synthesized answer, dual tone multi frequency (DTMF) detection, system intercept tones (i.e., busy, no-answer, out-of-service), disconnected, call progress, answer machine detection, text-to-speech and automatic speech recognition. Note that some of these functions may be implemented with associated digital signal processing cards connected to the network cards via an internal bus system. An assigned telephone network interface card 508 detects the incoming call, provides an off-hook (answer signal) to the calling party, then provides a text to speech (TTS) message, via an assigned text-to-speech card 512 indicating the nature of the call to the user, collects the automatic number identification information if available (or optionally prompts the caller for this information), then proceeds to collect the mobile identification number (MIN) to be located. MIN collection, which is provided by the initiating caller through keypad signaling tones, can be achieved in several methods. In one case the network card 508 can request a TTS message via text-to-speech card 512, which prompts the initiator to key in the MIN number by keypad DTMF signals, or an automatic speech recognition system can be used to collect the MIN digits. After the MIN digits have been collected, a location request message is sent to a location application 146. The location application 146, in concert with location application interface 135, in the location system 42, is in communication with the location engine 139. Note that the location engine 139 consists of the signal processing subsystem 20, and one or more location estimate modules, i.e., DA module 10, TOA/TDOA mocule 8 or HBS module 6. The location engine 139 initiates a series of messages, using the location application programming interface 136 to the mobile station 108. The location application programming interface 136 then communicates with one or more mobile switch centers 108, to determine whether or not the mobile station 140 to be located can be located. Conditions regarding the locateability of an mobile station 140 include, for example: mobile station 140 powered off, mobile station 140 not in communication range, mobile station 140 roaming state not known, mobile station 140 not provisioned for service, and related conditions. If the mobile station 140 cannot be located then an appropriate error response message is provided to the initiating caller, via e-mail, using the web server 464 in communications with the Internet 468 via an Internet access channel 472 or alternatively the error response message may be sent to a text to speech card 512, which is in communications with the initiating caller via the telephone interface card 508 and the ACD 546, which is in communication via telephony interface circuits 500 to the PSTN 124.

Note that in cases where rendering location estimate information is required on the Internet, the web server cna include the provision of a digital certificate key, thus enabling a secure, encrypted communication channel between the location web server and the receiving client. One such digital encryption key capability is a web server provided by Netscape Communications, Inc. and a digital certificate key provided by Verisign, Inc. both located in the state of California, U.S.A.

The PSTN 124 completes routing of the response message to the initiating caller via routine telephony principles, as one skilled in the art will understand. Otherwise the mobile station 140 is located using methods described in greater detail elsewhere herein. At a high level, the mobile switch center 112 is in communication with the appropriate base stations 122, and provides the location system 42 with the necessary signal and data results to enable a location estimation to be performed by the location engine 139. Once the location has been determined by the location engine 139 in terms of Latitude, Longitude and optionally height if known (in the form of a text string), the result is provided by to the initiator by inputting the location text string to a text-to-speech card 512, in communication with the assigned telephone interface card 508, via the automatic control distributor 546, completes the communication path and location response back to the initiating user via the telephone interface 500 to the PSTN

124, and from the PSTN 124 to the initiating user.

Alternatively the location results from the location application 146 could be provided to the initiating caller or Internet user via a web server 464 in communication with the Internet 468, via an Internet access channel 472 and a firewall 474. In another embodiment, the location results determined by the location application 146 may be presented in terms of street addresses, neighborhood areas, building names, and related means familiar to human users. The alternative location result can be achieved by previously storing a relationship between location descriptors familiar to humans and Latitude and Longitude range values in a map database 538. During the location request the location application 146 accesses the map database 538, providing it with the Latitude and Longitude information in the form of a primary key which is then used to retrieve the location descriptor familiar to humans. Note that to those skilled in the art, the map database 538 and associated messaging between the map database 538 and the location application 146 can be implemented in any number techniques. A straightforward approach includes defining a logical and physical data model using a relational database and designer environment, such as "ORACLE 2000" for the design and development, using a relational database, such as the "ORACLE 7.3" database.

In an alternative embodiment, the location application 146 may be internal to the location system 142, as one skilled in the art will understand.

Referring to Fig. 37, a user - the initiating caller, such as an mobile station 140b or desiring the location of an mobile station 140a, signals to the primary base station 122, in connection with the mobile switch center 108 via transport facilities 176, The mobile switch center 112 is connected to the PSTN 124, via interoffice trunks 600. The initiating user dials a publicly dialable telephone number which is then routed through an end office 496, to a telephone interface card 247, via a telephone hunt group 500. The hunt group 500 provides a telephony connection to the interface card 247 associated with the location system 228. The hunt group trunk interface 500 is provided from an end office telephone switch 496. Note that the initiating caller could access the telephony interface card 508, via hunt group trunk interface 500 in any number of ways, including an InterLATA Carrier 492, via the public switched telephone network (PSTN) 124. The hunt group trunk interface 500 is in communication with a plurality of telephone interface cards 508. The interface cards 247 provide telephony channel associated signaling functions, such as pulse dialing and detection, automatic number identification, winking, flash, off-hook voice synthesized answer, dual tone multi frequency (DTMF) detection, system intercept tones (i.e., busy, no-answer, out-of-service), disconnected, call progress, answer machine detection, text-to-speech and automatic speech recognition. An assigned network interface card 247 detects the incoming call, provides an off-hook (answer signal) to the calling party, then provides a text to speech (TTS) message indicating the nature of the call to the user, collects the automatic number identification information if available (or optionally prompts the caller for this information), then proceeds to collect the mobile identification number (MIN) to be located. MIN collection can be achieved in several methods. In one case the network card 247 can request a TTS message, generated by a voice synthesizer or text to speech card 512, which prompts the initiator to key in the MIN number by keypad tone signals, or an automatic speech recognition system can be used to collect the MIN digits. After the MIN digits have been collected, a location request message is sent to an application

146 in the location system 42. The application 146 in location system 42 initiates a series of messages to the mobile switch center 112, and optionally to the home location register 460, to determine whether or not the mobile station 140 to be located can be located. If the mobile station 140 cannot be located then an appropriate error response message is provided to the initiating caller, via e-mail, test to speech card 512, web server 464 in communications with the public Internet 468, or similar means. Alternatively the last known location can be provided, along with the time and date stamp of the last location, including an explanation that current location is not attainable. Otherwise the mobile station 140 is located using methods described in greater detail elsewhere in this patent. At a high level, the mobile switch center 112 is in communication with the appropriate base stations 122 and 122h, and provides the location system 42 with the necessary signal and data results to enable a location estimation to be performed by the location system 42. Once the location has been determined by the location system 42 in terms of Latitude, Longitude and optionally height if known (in the form of a text string), the result is provided back to the initiator by inputting the location text string to a text-to-speech card 512, in communication with the assigned telephone interface card 508. The interface card 508 then provides the audible, synthesized message containing the location estimate to the initiating caller. Alternatively the location results could be provided to the initiating caller via a web server 464 in communication with the Public Internet 468, using standard client request-response Internet protocols and technology. location system 42 access to a geographical information system or other mapping system could also be used to further enhance the user understanding of the location on a map or similar graphical display.

Referring to Fig. 38, a user (the initiating caller) desiring the location of an mobile station 140, such as a wireless user 140 who has text paging service provisioned, dials a publicly dialable telephone number, carried to the PSTN 124 which terminates on an end office 496 based hunt group interface 500, which in turn is in communication with the location system 142. The mobile switch center 112, local tandem 317 and interLATA Carrier tandem 362 are in communication with the PSTN 124, as those skilled in the art will understand. Note that the initiating caller could also be a wireline user with an ordinary telephone station 162 in communication with a local tandem 489, connected to the PSTN 124. The initiating location request user could access the telephony interface cards 512 via the hunt group 500. In other embodiments, including various Inter-LATA Carriers 492, via the public switched telephone network (PSTN) 124. The hunt group interface 500 is in communication with a plurality of telephone network interface cards 512, which are in communication with the location application 146 . The telephone interface cards 512 provide telephony channel associated signaling functions, such as pulse dialing and detection, automatic number identification, winking, flash, off-hook voice synthesized answer, dual tone multi frequency (DTMF) detection, system intercept tones (i.e., busy, no-answer, out-of-service), disconnected, call progress, answer machine detection, text-to-speech and automatic speech recognition. Note that some of these functions may be implemented with associated digital signal processing cards connected to the network cards via an internal bus system. An assigned telephony interface card 508 detects the incoming call, provides an off-hook (answer signal) to the calling party, then provides, if appropriate, a text to speech (TTS) message indicating the nature of the call to the user, collects the automatic number identification information if available (or optionally prompts the caller for this information), then proceeds to collect the mobile identification number (MIN) to be located by sending a location request message to an application 146 in the location system 42. The mobile station MIN collection, provided through the communications channel established, is sent by the initiating caller through keypad signaling tones. This MIN collection process can be achieved in several methods. In one case the telephony interface card 512 can request a text-to-speech message, generated by a text-to-speech card 512, which prompts the initiator to key in the MIN number by keypad tone signals. In another case an automatic speech recognition system can be used to collect the MIN digits. In either case after the MIN digits have been collected, a location request message is sent to the location system 142. The location system 42 initiates a series of messages to the mobile switch center 112, via the location applications programming interface (L-API) 366, and optionally to the home location register 360, to determine whether or not the mobile station 140 to be located can in fact be located. Alternatively the last known location can be provided, along with the time and date stamp of the last location, including an explanation that current location is not attainable. Conditions regarding the locateability of an mobile station include, for example: mobile station 140 powered off, mobile station not in communication range, mobile station roaming state not known, mobile station 140 not provisioned for service, and related conditions. If the mobile station 140 cannot be located then an appropriate error response message is provided to the initiating caller, via the service node for short messaging service 367. The service node is in communication with the location system 42 using a common text paging interface 369. The service node 107 accepts the location text paging message from the location system 42 and communicates a request to page the initiating caller via a typical signaling system 7 link for paging purposes, to the mobile switch center 112. The mobile switch center 112 forwards the location text page information to the initiating caller via the appropriate base stations 352 or 354, to the initiating mobile station 354. Otherwise the mobile station 140 is located using methods described in greater detail elsewhere in this patent. At a high level, the mobile switch center 112 is in communication with the appropriate base stations 352, 354, and provides the location system 42 with the necessary signal and data results to enable a location estimation to be performed by the location system 42. Once the location has been determined by the location system 42 in terms of Latitude, Longitude and optionally height if known (in the form of a text string). The location result is provided by to the initiator by inputting the location text string to the service node for short messaging service 367. The service node is in communication with the location system 42 using a common text paging interface 369. The service node 367 accepts the location text paging message from the location system 42 and communicates a request to page the initiating caller via a typical signaling system 7 link for paging purposes, to the mobile switch center 112. The mobile switch center 112 forwards the location text page information to the initiating caller via the appropriate-base stations 122a or 122b, to the initiating mobile station 140, via a text-to-speech card 512, in communication with the assigned telephone interface card 508.

Referring to Fig. 39, a user (the initiating user) desiring the location of an mobile station 140, who has a push technology tuner 484 associated with the user's client workstation 484, selects the location channel in the area, and further specifies the mobile station(s) to be located, with what frequency should the location estimate be provided, and other related parameters, such as billing information. The user's client workstation 482 is in communication with the Internet, optionally via and encrypted communications channel using, for example, Netscape's SSL 3 encryption/decryption technology. A push transmitter 472, connected to the Internet 468 via a web server 464, detects the client workstation 482 user's request. The transmitter 472 requests location update information for specified mobile identification numbers through a firewall 474 and a publisher 478, in communication with a location channel application 429 in the location system 42. The location system 42 initiates location requests for all mobile station mobile identification numbers for which location information has been subscribed to, then provides the location results to the location channel application 429.

The location system 42 initiates a series of messages to the mobile switch center 112, via the location applications programming interface (L-API) 136, and optionally to the home location register 460, to determine whether or not the mobile station 140 or others, to be located can in fact be located. Alternatively the last known location can be provided, along with the time and date stamp of the last location, including an explanation that current location is not attainable. Conditions regarding the locatability of an mobile station 140 include, for example: mobile station 140 powered off, mobile station not in communication range, mobile station 140 roaming state not known, mobile station 140 not provisioned for service, and related conditions. If the mobile station 140 cannot be located then an appropriate error response message is provided to the initiating client workstation, via the push technology components location channel application 429, publisher 478, firewall 474, transmitter 472, web server 464, public Internet 468, to the client workstation 482. A similar communication mechanism is used to provide the subscribed-to client's workstation 482 with attained location information.

Note that the location channel could in fact provide a collection of mobile station 140 mobile identification numbers for location purposes that are grouped by a particular market and/or customer organization segment. for example, location channel number 1 could provide enhanced wireless 9-1-1 service to specific public safety answering points, channel number 2 could provide periodic wireless location information of a fleet of taxi cabs belonging to a particular company, to their dispatch operator, channel 3 could provide wireless location to a control center of a military organization, channel 4 could provide wireless location information of vehicles carrying hazardous materials, to a control center, and so forth.

The location channel application 429 provides the location results to the publisher 478, which provides a method of adding the new location results to the transmitter, via firewall 474. The firewall 474, provides protection services between certain systems and the Internet, such as preventing malicious users from accessing critical computing systems.

The group multicast help, with individualized directions, are those whose are authorized and nearest, with text paging message instructions on how to drive or navigate, to reach the initiating distress caller. Alternatively optional voice synthesis technology could be used to aid one or more members to have spoken instruction giving directions and/or instructions for each member, to help them reach the distress caller.

Referring to Fig. 40, an individual having a mobile station desires to make a distress call for help, or for some other reason. The distress caller with mobile station 102 dials a special telephone number, received by base station 104, which then sends the originating call setup request to the mobile switch center 108. The mobile switch center 108 routes the originating call through the PSTN 112 to an automatic call distributor (ACD) 116. The ACD 116 selects an available telephony interface circuit 120, which answers the call and providing introductory information to the caller, such as a greeting message, progress of service, etc., using a voice synthesizer circuit card 124. Note that circuits 120 and 124 may be combined as voice response units. The telephony interface circuit 120 collects the automatic number identification information if available in the call setup message or optionally prompts the caller for this information. This MIN collection process can be achieved in several methods. In one case the network telephony interface card 120 can request a TTS message, generated by a voice synthesizer card 124, which prompts the initiator to key in their MIN number by keypad tone signals. In another case an automatic speech recognition system can be used to collect the MIN digits. In either case after the MIN digits have been collected, a location request message is sent to the location system 128. The location system or location system or center (LC) 128 initiates a series of messages to the mobile switch center 108, via the location applications programming interface (L-API) 166, to determine whether or not the mobile station 102 to be located can in fact be located. If the mobile station 102 cannot be located then an appropriate error response message is provided to the initiating caller. Otherwise the LC 128 determines the caller's location via methods discussed elsewhere in this patent. While this event is proceeding an application in the LS 128 references the initiating caller's location subscriber profile database 158 to determine if the caller allows others to locate him or her, and specifically which individuals are allowed to be informed of the caller's location.

Assuming the caller allows location information to be sent out to a select group, then the list of members mobile station identification numbers (MIN)s are extracted from the profile database 158, and an application in the LC 128 initiates a series of messages to the mobile switch center 108, via the location applications programming interface (L-API) 166, to determine the locations of each of the users' mobile station mobile identification numbers associated with the member list. Regarding those mobile station mobile identification numbers nearest the distress caller, each member mobile station is dialed via a control message sent from an application in the LC 128 to the telephony interface card 120. A voice synthesizer card 124 or text to speech circuit is also patched in the calling circuit path, to announce the purpose of the automated call to each member. The ACD 116 initiates the call request to each member via the PSTN 112, which connects to the mobile switch center 108, that ultimately rings the member mobile station 140 and 148 via base stations 132 and 152. An application in the LC 128 identifies a start and finish location destination location for a member, based on his/her current location as being the start location, and the finish location being the distress caller's location at mobile station MIN 102. The application in the LC 128 initiates a http or similar Internet compatible protocol universal resource locator (URL) request via the web server/client 162 to the public Internet 163, which terminates on a maps, directions web server 164. One such URL known to the authors is Lucent Technologies' http://www.mapsOnUs.com, which is provided for public use. The map/directions server 164 queries the map base 168 via a directions algorithm 170, and returns to the initiating http request, the location web server 162, with a list of instructions to enable a user to navigate between a start location and end location. Referring to Fig. 41, the information shown in the columns labeled "Turn #", "Directions", "And Go", and/or "Total Miles", can then be parsed from the http response information. Referring now to Fig. FIG. 40, this information can then be sent as a short text message, to the relevant mobile station 148 or 140 via the service node 182, using interface 557 to the mobile switch center 108, and relevant base stations 152 and 132, assuming each member mobile station has short message service provisioned. If this is not the case, the service node 182 will inform the application within the LS 128, which then initiates an alternative method of sending the start-finish location navigation instructions information via an appropriate voice synthesizer card 124 and associated telephony interface card 120. The interface card 120 initiates an automated call to each appropriate member's mobile station 148 and 140, via the telephony path including components ACD 116 in communication with the PSTN 112, which is in communication with the mobile switch center 108. The mobile switch center 108 completes the routing of the automated call to the appropriate mobile station 148 and 140 using base stations 152 and 132 respectively. The above process is repeated for each nearby member's mobile station, thus allowing all nearby members to be notified that the distress caller needs help, with navigation instructions to each member, which enables the member to reach the distressed caller. Variations of this application include putting each relevant party in communication with each other via a conference call capability in the ACD 116, with or without providing location information and/or start-finish navigation instructions.

An application in the location system utilizes periodic wireless location of appropriate rental cars, control circuits and control communications within the rental car, and secured transactions across the Internet, or similar means, in order to provide various tracking and control functions. Such functions allow rental car agencies to remotely control and operate their rental cars in order to reduce operating costs such as storage and maintenance, as well as provide additional conveniences and services to rental car agency customers.

Referring to Fig. 42, a vehicle 578 containing various sensors and actuators (not shown) used to, for example, lock and unlock car doors, sense door position, keypad depressions, sense the condition of the engine and various subsystems, such as brakes, electrical subsystems, sense the amount of various fluid levels, etc., is in communication with a vehicle-based local area network 572, which is in turn connected to a mobile station 140 containing asynchronous data communications capability. The vehicle-based local area network may optionally contain a computer (not shown) for control and interfacing functions. The mobile station 140 is always in communication, using the radio air interface with at least one base station 122g, and possibly other base stations 122h. The base stations 122g and 122h are in communication with the mobile switch center 112 via transport facilities 178. The mobile switch center 112 is in communication with the location system 142 and the public switched telephone network 126 via interoffice trunks 600. In addition the mobile switch center 112 is also in communication with the location system 142 via the location system - mobile switch center physical interface 178. The physical interface provides two-way connections to the location applications programming interface (L-API-MSC) 136, which is in communication with a location engine 139, which performs wireless location estimations for the mobile station, which is permanently mounted in the vehicle 578. The location engine represents key components within the location system which together comprise the capability to perform wireless location estimations. The rental car location application 146 is in communications wither the location engine 139 for purposes of initiating wireless location requests regarding the mobile station 140, as well as for receiving wireless location responses from the location engine 139. The application 146 is in communications with the automatic call distributor 546 for purposes of initiating and receiving telephone calls to and from the public switch telephone network 126, via hunt group interface 500. As one skilled in the art will appreciate, other interfaces (not shown) beyond hunt groups 500, can alternatively be used, such as ISDN interface circuits, T-carrier and the like. The application 146 is in communication with a web server and client 464, which in turn is in communication with the Internet 468 via an Internet access interface 472. As those in the art will understand, an Internet access interface is typically provided by an Internet service provider, also there are other methods which could be used to complete the Internet connection. The rental car agency contains a workstation or personal computer 582 with an Internet access interface 472 to the Internet 468. The application 146 requests of the location engine to perform a location request periodically regarding the mobile station 140, with the location response information provided the web server and client, 464. For each rental car or vehicle containing a mobile station 140, the location, as well as various information about the rental car or vehicle can be ascertained via the above described infrastructure.

An application in the location system operates in conjunction with an application in each public safety answering point (PSAP) that together provides various call handling functions to enable the PSAP to perform its work load efficiently and effectively toward unique emergency events unique to a given location. The application pair measures the number of emergency 9-1-1 wireless calls originating from a particular geographical area or location. Upon exceeding a provisional threshold value "X", the application pair traps the next incoming call from the same location and provides a call screening function via a play announcement and collect digits activity. This activity alerts the originating caller that if their call relates to an incident at a particular location, then they are the "X+1 th" caller who has already notified the PSAP, and that no further caller discussion is required. However, if the caller's intent does not relate to the incident described above, then the caller is requested to press or say "one", or some similar keypad number, which then is collected and causes the caller to be re-routed to the next available PSAP call taker. Alternatively if the originating caller does not respond within a short time period, then the call is also re-routed to the next available PSAP call taker. The voice announcement may either be synthesized by a text-to-speech card, or an PSAP operator may store a voice message which describes the incident at the above-referenced location.

Patent Claims

We claim:

1. An apparatus for locating a first mobile station for at least transmitting and receiving radio signals, wherein said radio signals are received on a forward radio bandwidth and said radio signals are transmitted on a different reverse radio bandwidth, comprising:

a first wireless network infrastructure for communicating with said first mobile station, said first wireless network infrastructure having:

(A1) a plurality of spaced apart base stations for communicating via said radio signals with said first mobile station, and

(A2) a mobile switching center for communicating with said first mobile station, via said radio signals with the base stations, wherein said mobile switching center also communicates with said plurality of base stations for receiving measurements of said radio signals, said measurements including: (i) first measurements of said radio signals received by said first mobile station in said forward radio bandwidth, and (ii) second measurements of said radio signals transmitted by said first mobile station in said reverse radio bandwidth;

a location determining means for locating said first mobile station, wherein said location determining means receives said first and second measurements from the mobile switching center for estimating a location of said first mobile station, wherein said estimate is a function of both said first measurements and said second measurements.

2. An apparatus for locating a mobile station as claimed in Claim 1, further including an interface means between said location determining means and said mobile switching center, wherein said interface means generates a location request for a primary one of said base stations to which said first mobile signaling means is in communication.

3. An apparatus for locating a mobile station as claimed in Claim 1, further including a means for requesting data related to additional radio signals between said first mobile station and at least a second wireless network infrastructure different from said first wireless network infrastructure.

4. An apparatus for locating a mobile station as claimed in Claim 1, wherein said first wireless network infrastructure is capable of communicating at least one of voice and visual information with said first mobile station.

5. An apparatus for locating a mobile station, comprising:

a wireless network infrastructure for communicating with a plurality of mobile stations, each said mobile station for transmitting and receiving wireless signals, wherein said wireless signals are received in a forward bandwidth and said wireless signals are transmitted in a different reverse bandwidth, and, said wireless network infrastructure having a plurality of spaced apart base stations for communicating via said wireless signals with said plurality of mobile stations;

a location determining means for communicating with said plurality of mobile stations, via said radio signals with the base stations, wherein said location determining means communicates with said plurality of base stations for receiving measurements related to said radio signals for estimating a location of at least a first of said plurality of mobile stations, said measurements including: (i) first measurements of said wireless signals received by said first mobile station in said forward radio bandwidth, and (ii) second measurements of said wireless signals transmitted by said first mobile station in said reverse radio bandwidth;

wherein said location determining means estimates a location of said first mobile station using both said first measurements and said second measurements.

6. An apparatus for locating a mobile station as claimed in Claim 5, wherein said second measurements are determined from said wireless signals being received by said base stations.

7. An apparatus for locating a mobile station as claimed in Claim 5, wherein said measurements include at least one of: a delay spread, a signal strength, a ratio of energy per bit versus signal to noise, a word error rate, a frame error rate, a mobile signaling means, a power control value, a pilot index, a finger identification, an arrival time, an identification of said first mobile station for communicating with the wireless network infrastructure, a make of said first mobile station, a revision of said first mobile station, a sector identification of one of the base stations receiving said radio signals transmitted from said first mobile station.

8. An apparatus for locating a mobile station as claimed in Claim 5, wherein said radio signals are communicated using one of: CDMA, W-CDMA, TDMA and advanced mobile phone service.

9. An apparatus for locating a mobile station as claimed in Claim 5, wherein said location determining means includes a location estimator using time difference of arrival data from said measurements.

10. An apparatus for locating a mobile station as claimed in Claim 9, wherein said location estimator receives said measurements from a distributed antenna system.

11. An apparatus for locating a mobile station as claimed in Claim 9, wherein said location estimator receives active, candidate and remaining set information from said first mobile signaling means.

12. An apparatus for locating a mobile station as claimed in Claim 1, wherein said location determining means includes:

a receiving means for receiving first data related to at least one of said first measurements and said second measurements between said first mobile station and said wireless network infrastructure;

activating a first location estimator for outputting a first estimate of a location of said first mobile station when supplied with location information from said receiving means, said location information related to the first data;

outputting said first estimate of the location of said first mobile station when said first estimate has an extent less than or equal to a predetermined size;

activating a second location estimator for outputting a second estimate of a location of said first mobile station when said first location estimator does not provide said first estimate having an extent less than or equal to a predetermined size;

outputting an estimate of the location of said first mobile station when said second location estimator provides said second estimate.

13. A method for locating a wireless mobile station, comprising: transmitting, by a first short range transceiver station, a status change related to whether the mobile station and said first short range transceiver station are able to wirelessly communicate through a telephony network to a predetermined storage; storing, in said predetermined storage, said status of a mobile station, wherein said status has a first value when the mobile station communicates with said short range transceiver station as a cordless telephone, and said status has a second value when the mobile station communicates with a network of base stations, wherein said base stations are cooperatively linked for providing wireless communication; detecting, by said first short range transceiver station, a change accessing said predetermined storage for determining a location of the mobile station.

14. A method for locating a wireless mobile station, as claimed in Claim 13, wherein said short range transceiver is a home base station.

15. A method for locating a wireless mobile station, as claimed in Claim 13, wherein said predetermined storage is accessible via one of: an autonomous notification message and a request-response message.

16. A method for locating a wireless mobile station, as claimed in Claim 13, wherein said predetermined storage is a home location register.

17. A method for locating a wireless mobile station, as claimed in Claim 13, wherein said predetermined storage includes one or more of the following data items related to said mobile station: mobile station identification number, short range transceiver identification and mobile switch center identification.

18. A method for locating a wireless mobile station, as claimed in Claim 13, wherein said step of accessing includes responding to a query of said predetermined storage location using an identification of the mobile station.

19. A method for locating a wireless mobile station, as claimed in Claim 13, further including providing said status from said predetermined storage together with an identification of the mobile station to a mobile station location estimator for estimating a location of the mobile station.

20. A method for location a wireless mobile station, as claimed in claim 17, wherein said step of transmitting further includes associating said change with a predetermined fixed location and said short range transceiver identification.

21. A method for location a wireless mobile station, as claimed in claim 13, wherein said step of accessing includes translating the mobile identification number and said short range transceiver identification into a predetermined location when the status has said first predetermined value.

22. A method for location a wireless mobile station, as claimed in claim 13, further including a prior step of provisioning a translating database from a customer care system containing the location of the short range transceiver.

23. A method for locating a wireless mobile station, comprising: receiving data of wireless signals communicated between

a mobile station and a wireless network; detecting, using said first data, that the mobile station is in wireless communication with a distributed antenna system having a plurality of antennas connected in series and distributed along a signal conducting line so that there is a predetermined signal time delay between said antennas and at predetermined locations; determining a plurality of signal time delay measurements for signals transmitted between the mobile station and a collection of some of said antennas, wherein said signals are also communicated through said line; estimating a location of the mobile station using said plurality of signal time delay measurements.

24. A method for locating a wireless mobile station as claimed in Claim 23, wherein said step of estimating includes correlating each measurement of said plurality of signal time delay measurements with a unique corresponding one of said antennas.

25. A method for locating a wireless mobile station as claimed in Claim 24, wherein said step of estimating includes: identifying a plurality of antennas in said collection using correlation obtained in said step of correlating; determining a corresponding signal time delay between the mobile station and each antenna in said collection; determining a location of each antenna in said collection; estimating a location of the mobile station using said corresponding signal time delays and said locations of each antenna in said collection.

26. A method for locating a wireless mobile station as claimed in Claim 23, wherein said step of estimating includes determining, for said signal time delay measurements, a common signal time delay corresponding to transmitting signals from said distributed antenna system to a receiver of the first wireless network.

27. A method for locating a wireless mobile station as claimed in Claim 23, wherein said step of estimating includes using an absolute delay time with respect to a pilot channel for a base station on the wireless network.

28. A method for locating a wireless mobile station as claimed in Claim 23, wherein said step of estimating includes performing a triangulation using values related to one of: a signal time of arrival, and a signal time difference of arrival for time difference of arrival corresponding to each antenna in said collection.

29. A method for locating a wireless mobile station, as claimed in Claim 23 wherein said step of estimating includes a step of computing a most likely location of said mobile station using a fuzzy logic computation.

30. A method for locating a wireless mobile station as claimed in Claim 23, wherein said step of activating includes activating one of:

(a) a location estimator for determining whether the mobile station is detected by a base station of the network, wherein said base station communicates with the mobile station as a cordless telephone;

(b) a location estimator for estimating a location of the mobile station using location information obtained from said distributed antenna system;

(c) a location estimator for estimating a location of the mobile station by one of: triangulation and trilateration.

31. A method for locating a wireless mobile station, comprising: first receiving first signal characteristic measurements of

wireless signals communicated between a mobile station and a first network of base stations, wherein said base stations in the first network are cooperatively linked by a first wireless service provider for providing wireless communication; instructing the mobile station to search for a wireless signal from a second network of base stations that are cooperatively linked by a second wireless service provider for providing wireless communication, wherein said first and second wireless service providers are different; second receiving second signal characteristic measurements of wireless signals communicated between the mobile station and said second network of base stations; estimating a location of the mobile station using said first and second signal characteristic measurements.

32. A method for locating a wireless mobile station as claimed in Claim 31, wherein the mobile station is registered for a wireless communication service with the first wireless service provider, and the mobile station is not registered for the wireless communication service with the second wireless service provider.

33. A method for locating a wireless mobile station as claimed in Claim 31, wherein said step of instructing includes transmitting a command to the mobile station for instructing the mobile station to search for a signal from a base station of said second wireless service provider in a frequency bandwidth different from a frequency bandwidth for communicating with the base stations of said first wireless service provider.

34. A method for locating a wireless mobile station as claimed in Claim 31, wherein said step of instructing includes transmitting a command to the mobile station for instructing the mobile station to hand-off from said first service provider to a base station associated with said second service provider, for purposes of performing additional signal measurements.

35. A method for locating a wireless mobile station as claimed in Claim 31, wherein said first signal characteristic measurements include measurements for time delay, signal strength pairs of signal communicated from at least one of:

(a) the base stations of said first network to the mobile station, and

(b) the mobile station to the base stations of said first network, and

wherein said second signal characteristic measurements include measurements for time delay, signal strength pairs of signals communicated from the base stations of said second network to the mobile station.

36. A method for locating a wireless mobile station, comprising: receiving first data related to wireless signals communicated between a mobile station and at least a first network of a plurality of commercial mobile service provider networks of base stations, wherein for each said network, there is a plurality of base stations for at least one of transmitting and receiving wireless signals with a plurality of mobile stations; instructing the mobile station to communicate with a second network of the plurality of networks for supplying second data; activating a mobile station location estimator, when said first and second data are obtained for providing an estimate of a location of the mobile station.

37. A method for locating a wireless mobile station, as claimed in Claim 36, wherein said second network includes a

second plurality of base stations, wherein a majority of base stations in said second plurality of base stations has a location different from the locations of base stations in said first network.

38. A method for locating a wireless mobile station, as claimed in Claim 36, wherein at least one of said first and second data includes signal characteristic measurements of communication with the mobile station for a time interval of less than 10 seconds.

39. A method for locating a wireless mobile station, comprising: first receiving first signal characteristic measurements of wireless signals communicated between a mobile station and a first network of base stations, wherein said base stations in the first network are cooperatively linked by a first wireless service provider for providing wireless communication; instructing a second network of base stations that are cooperatively linked by a second wireless service provider for providing wireless communication so that the second network searches for wireless signals from the mobile station, wherein said first and second wireless service providers are different; second receiving second signal characteristic measurements of wireless signals communicated between the mobile station and said second network of base stations; estimating a location of the mobile station using said first and second signal characteristic measurements.

40. A method for locating a wireless mobile station, as claimed in Claim 39, further including a step of requesting the mobile station to raise it's transmitter power level to a predetermined level, prior to said step of instructing.

41. A method for locating a wireless mobile station, comprising: receiving, by a receiving means, first data related to wireless signals communicated between a mobile station and at least a first network of a plurality of commercial mobile service provider networks, wherein for each said network, there are a plurality of communication stations for at least one of transmitting and receiving wireless signals with a plurality of mobile stations; first activating a location estimator for providing a first estimate of a location of the mobile station when supplied with first location information from said receiving means, said first location information related to the first data;

when one of: (a) said first estimate does not exist, and (b) said first estimate has an extent greater than or equal to a predetermined size, the steps (A1) and (A2) are performed:

(A1) instructing the mobile station to communicate with a second network of the plurality of networks for supplying second data to said receiving means, wherein said second data is related to wireless signals communicated between the mobile station and the second network;

(A2) second activating said location estimator a second time for providing a second estimate of a location of the mobile station when supplied with additional location information from said receiving means, said additional location information related to the second data;

outputting at least one of the estimates of the location of the mobile station provided by said location estimator when said location estimator provides at least one estimate of the location of the mobile station.

42. A method for locating a wireless mobile station as claimed in Claim 41, wherein said additional location information

and said first location information are utilized together by said location estimator.

43. A method of locating a wireless mobile station as claimed in Claim 41, wherein said communication stations include wireless base stations for one of CDMA, TDMA, and GSM.

44. A method of locating a wireless mobile station as claimed in Claim 43, wherein said communication stations include home base stations.

45. A method of locating a wireless mobile station as claimed in Claim41, wherein the mobile station includes one of: a CDMA transmitter, a TDMA transmitter, and a GSM transmitter, and a AMPS transmitter.

46. A method for locating a wireless mobile station as claimed in Claim 41, wherein one or more of said activating steps includes :

(a) said location estimator for determining whether the mobile station is detected by a communication station which communicates with the mobile station as a cordless telephone;

(b) said location estimator for estimating a location of the mobile station using location information related to data from a distributed antenna system;

(c) said location estimator for estimating a location of the mobile station by one of: triangulation and trilateration.

47. A method for locating a wireless mobile station as claimed in Claim 41, wherein said predetermined extent is less than one thousand feet.

48. A method for locating a wireless mobile station, comprising: receiving, by a receiving means, first data related to wireless signals communicated between a mobile station and at least a first network of one or more commercial mobile service provider networks, wherein for each said network, there is a different plurality of base stations for at least one of transmitting and receiving wireless signals with a plurality of mobile stations; activating a first location estimator for outputting a first estimate of a location of the mobile station when supplied with location information from said receiving means, said location information related to the first data; outputting said first estimate of the location of the mobile station when said first estimate has an extent less than or equal to a predetermined size; activating a second location estimator for outputting a second estimate of a location of the mobile station when said first location estimator does not provide said first estimate having an extent less than or equal to a predetermined size; outputting an estimate of the location of the mobile station when said second location estimator provides said second estimate.

49. A method for locating a wireless mobile station as claimed in Claim 48 further including a step of instructing the mobile station to communicate with a second network of the plurality of networks for supplying second data to said receiving means, wherein said second data is related to wireless signals communicated between the mobile station and the second network.

50. A method for locating a wireless mobile station as claimed in Claim 49, wherein said step of instructing includes a

step of instructing the mobile station to hand-off to said second network for synchronizing timing signals and performing measurements between the mobile station an said second network.

51. A method for locating a wireless mobile station as claimed in Claim 48, wherein one or more of said activating steps includes activating one of:

(a) a location estimator for determining whether the mobile station is detected by one of the base stations which communicates with the mobile station as a cordless telephone;

(b) a location estimator for estimating a location of the mobile station using location information related to data from a distributed antenna system;

(c) a location estimator for estimating a location of the mobile station by one of: triangulation and trilateration.

52. A method for locating a mobile station, comprising: receiving, by said mobile station, a request control message from one of a plurality of base stations, wherein said message is received by a receiving antenna of said mobile station; the control message providing information related to said message to at least one of a control processor and a searcher receiver in said mobile station; determining, using at least one of said control processor and said searcher receiver, a plurality of pairs of radio signal strength related values and corresponding signal time delays for a wireless communication between said mobile station and at least a first of the base stations, wherein for at least some of said pairs, said signal time delays are different, and for each pair, said signal strength related value for said pair is obtained using a signal strength of said communication at said corresponding signal time delay of said pair; transmitting signals for said pairs to one or more of the base stations via a transmitting antenna of said mobile station; routing data for at least one of said pairs from said one or more base stations to a mobile station location estimator for estimating a location of said mobile station.

53. A method for locating a mobile station, as claimed in Claim 52, wherein said step of receiving uses one of a CDMA, an AMPS, a NAMPS and a TDMA wireless standard.

54. A method for locating a mobile station, as claimed in Claim 52, wherein said step of determining is performed for a wireless communication between said mobile station and each of a plurality of the base stations.

55. A method for locating a mobile station, as claimed in Claim 52, wherein each of said signal time delays is included within a predetermined corresponding time delay spread.

56. A method for locating a mobile station, as claimed in Claim 52, wherein said step of determining includes a step of instructing, by said control processor, said searcher receiver to output a plurality of said radio signal strength related values for a plurality of fingers resulting from said communication from said first base station to said mobile station.

57. A method for locating a mobile station, as claimed in Claim 52, wherein said step of determining includes inputting data for said pairs to a modulator for modulating said data prior to said step of transmitting.

58. A method for locating a mobile station, as claimed in Claim 57, further including a step of establishing a software controllable data connection between said control processor and a mobile station component including at least one of: a user digital baseband component and said modulator, wherein said connection inputs said data to said component.

59. A method for locating a mobile station, as claimed in Claim 52 further including a step of providing said data for said pairs to a mobile station location estimating system having a first mobile station location estimating component using time difference of arrival measurements for locating said mobile station via one of trilateration and triangulation.

60. A method for locating a mobile station, as claimed in Claim 59, wherein said step of providing includes selecting one of: said first mobile station estimating component, a second mobile station estimating component using data obtained from a distributed antenna system, and a third mobile station estimating component for using data obtained from activation of a home base station.

61. A method for locating a mobile station, as claimed in Claim 60, further including a step of computing a most likely location of said mobile station using a fuzzy logic computation.

62. A method for locating a mobile station, as claimed in Claim 61, wherein said step of computing is performed by said second mobile station estimating component for determining a most likely floor that said mobile station resides in a multi-story building having a distributed antenna system.

63. A method for locating a mobile station, as claimed in Claim 59, further including a step of requesting data for additional pairs of radio signal strength related values and corresponding signal time delays for a wireless communication between said mobile station and at least a second base station of a commercial mobile radio service provider different from a commercial mobile service provider for said first base station.

64. A method for obtaining data related to wireless signal characteristics, comprising: providing a user with a mobile station for use when the user traverses a route having one or more predetermined route locations, wherein one or more of the route locations have a corresponding telephone number and a corresponding description stored in the mobile station; performing the following substeps when the user visits each of the route locations: activating a call to said corresponding telephone number; transmitting a code identifying the route location when the user is substantially at the route location; storing an association of:

(a) signal characteristic measurements for wireless communication between the mobile station and one or more base stations, and

(b) a unique identifier for the route location obtained using said code transmitted by said call;

Wherein said stored signal characteristic measurements are accessible using said unique identifier.

65. A method as claimed in Claim 64, wherein said unique identifier corresponds to one of: (a) an address for the route

location, and (b) a latitude and longitude of the route location.

66. A method as claimed in Claim 64, wherein said route is periodically traversed by a user having a mobile station for accomplishing said step of performing.

67. A method as claimed in Claim 64, wherein said step of storing includes retaining said signal characteristic measurements in a data storage for analyzing signal characteristic measurements of wireless communications between mobile stations and a wireless infrastructure of base stations.

68. A method as claimed in Claim 64, further including, prior to said step of activating, a step of determining, by the user, that a display on the mobile station uniquely identifies that said corresponding description of the route location is available for calling said corresponding telephone number and transmitting said identifying code.

69. A method as claimed in Claim 64, wherein said step of storing includes: obtaining a phone number identifying the mobile station; providing said phone number identifying the mobile station to a commercial mobile radio service provider in a request for said signal characteristic measurements.

70. A method as claimed in Claim 64, wherein said step of storing includes using a phone number identifying the mobile station in combination with said transmitted identifying code for determining said unique identifier.

71. A method as claimed in Claim 64, wherein said corresponding description includes at least one of: a textual description of its corresponding route location, and an address of its corresponding route location.

72. A method as claimed in Claim 64, further including steps of: associating said identifying code for the route location and said unique identifier in a data storage prior to performing said step of performing; accessing said data storage using said identifying code for obtaining said unique identifier in said step of storing.

73. A method as claimed in Claim 64, further including a step of accessing said stored signal characteristic measurements for enhancing a performance of a process for locating mobile stations.

74. A method as claimed in Claim 64, wherein at least two of said one or more base stations are in networks of different commercial mobile radio service providers.

75. A method as claimed in Claim 64, further including a step of filtering said signal characteristic measurements so that when said signal characteristic measurements are suspected of being transmitted from a location substantially different from the route location, said step of storing is one of: (a) not performed, and (b) performed so as to indicate that said signal characteristic measurements are suspect.

76. A method as claimed in Claim 75, wherein said step of filtering includes at least one of: (a) determining an amount by which an estimated location of the mobile station using said signal characteristic measurements differs from a location of the mobile station obtained from said unique identifier; (b) determining whether a predetermined amount of time has elapsed between successive performances of said step of activating.

77. A method for locating a wireless mobile station, comprising:

first receiving first signal characteristic measurements of wireless signals communicated between a mobile station and a first network of base stations, wherein said first signal characteristic measurements includes:

(a) one or more pairs of wireless signal strength related values and corresponding signal time delays for a wireless communication between the mobile station and at least a first of the base stations;

(b) data identifying operational characteristics of the mobile station including information related to a signal transmission power for the mobile station and information for determining a maximum transmission power level of the mobile station;

adjusting, for at least one of said pairs, its corresponding wireless signal strength, using said data, thereby obtaining corresponding adjusted pairs, wherein each adjusted pair has the corresponding adjusted signal strength, and wherein said adjusted signal strength is an expected signal strength of a predetermined standardized mobile station transmitter power level having a predetermined maximum transmission power and operating at a predetermined transmission power level;

outputting second signal characteristic information, obtained using said adjusted signal strength, to a mobile station location estimator for determining a location estimate of said first mobile station.

78. A method for locating a mobile station as claimed in Claim 77, further including applying sequence of one or more signal processing filters to one of: said pairs and said adjusted pairs.

79. A method for locating a mobile station as claimed in Claim 78, wherein said sequence of filters is dependent upon a corresponding mobile station location estimator.

80. A method for locating a mobile station as claimed in Claim 79, wherein said sequence of filters is pipelined so that for first and second filters of said sequence, an output of said first filter is an input to said second filter.

81. A method for locating a mobile station as claimed in Claim 79, wherein said filters include Sobel, Weiner, median and neighbor.

82. A method for locating a wireless mobile station, comprising:

first receiving first signal characteristic measurements of wireless signals communicated between a mobile station and a first network of base stations, wherein said first signal characteristic measurements includes one or more pairs of wireless signal strength related values and corresponding signal time delays for a wireless communication between the mobile station and at least a first of the base stations;

categorizing said pairs into categories according to ranges of signal strength related values and ranges of corresponding signal time delays for obtaining a representation of a frequency of occurrence of said one or more pairs in said categories;

applying one or more filters to said representation for one of: (a) reducing characteristics of said representation that are expected to be insufficiently repeatable for use in identifying a location of the mobile station, and (b) enhancing a signal to noise ratio;

supplying an output obtained from said step of applying to a mobile station location estimator;

estimating a location of the mobile station using said mobile station location estimator.

83. A method for locating a wireless mobile station as claimed in Claim 82, further including a step of requesting data for additional pairs of wireless signal strength related values and corresponding signal time delays for a wireless transmission between the mobile station and at least a second base station of a second network of base stations different from the base stations of the first network, wherein said first and second networks communicate with the mobile station in different signal bandwidths.

84. A method for locating a wireless mobile station as claimed in Claim 83, wherein the first network is operated by a first commercial mobile radio service provider and the second network is operated by a second commercial mobile radio service provider.

85. A method for locating a wireless mobile station as claimed in Claim 82, wherein said representation corresponds to a histogram.

86. A method for locating a wireless mobile station as claimed in Claim 82, further including a step of normalizing one of: (a) said pairs, and (b) values corresponding to said output.

87. A method for locating a wireless mobile station as claimed in Claim 23, wherein said step of activating further includes the step of applying a fuzzy logic module which further discretizes the location estimate provided from one of:

(a) a location estimator for estimating a location of the mobile station using location information obtained from said distributed antenna system;

(b) a location estimator for estimating a location of the mobile station by one of: triangulation and trilateration.

88. A method for contacting a telephony station, comprising: associating, by a user, a particular telephony number with a collection of one or more telephony station numbers of telephony stations with which the user desires to communicate when said particular telephony number is called from a predetermined telephony station; receiving said particular telephony number from the predetermined telephony station; determining a location of said predetermined telephony station and at least some of said telephony stations having telephony station numbers in said collection; selecting a first of said telephony stations having telephony station numbers in said collection, wherein said first telephony station is selected according to a location of said predetermined telephony station and a location of first telephony station; transmiting a user desired message to said first telephony station.

89. A method for locatin a mobile station, comprising: establishing, by a user of a particular mobile station, a collection of identities of one or more persons having permission to receive a location of said particular mobile station; receiving a request by a first of said persons for locating said particular mobile station; determining a location of said particular mobile station in response to said request, said location determined using measurements of wireless transmissions between said particular mobile station and a first wireless network of base stations, wherein said base stations are cooperatively linked for wireless communication; outputting said location to the first person.

90. A method as claimed in Claim89, wherein said step of determining includes using measurements of wireless tramsmissions between said particular mobile station and a second wireless network of base stations provided by a different commercial wireless service provider from a commercial wireless service provider for the first wireless network.

91. An apparatus for locating a mobile station as claimed in Claim 3, further including a means for providing a location estimate using the Internet.

92. An apparatus for locating a mobile station as claimed in Claim 3, further including a means for providing a location estimate using the Internet.

93. An apparatus for locating a mobile station as claimed in Claim 3, further including a means for providing a location estimate using digital certificate keys and the Internet.

94. An apparatus for locating a mobile station as claimed in Claim 91, further including a means for providing a location estimate using push technology on the Internet.

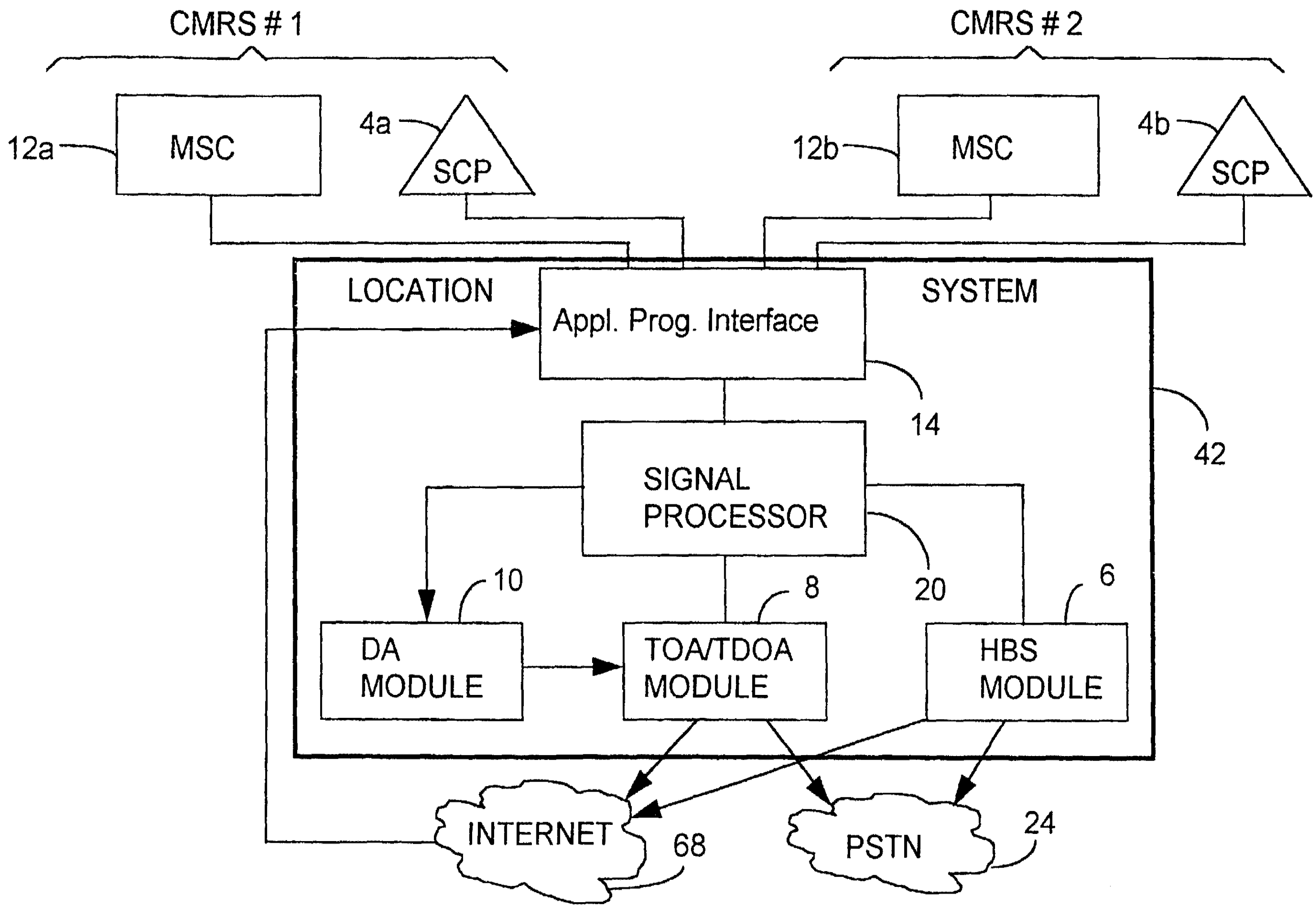


FIG. 1: WIRELESS LOCATION USING MULTIPLE CMRSs

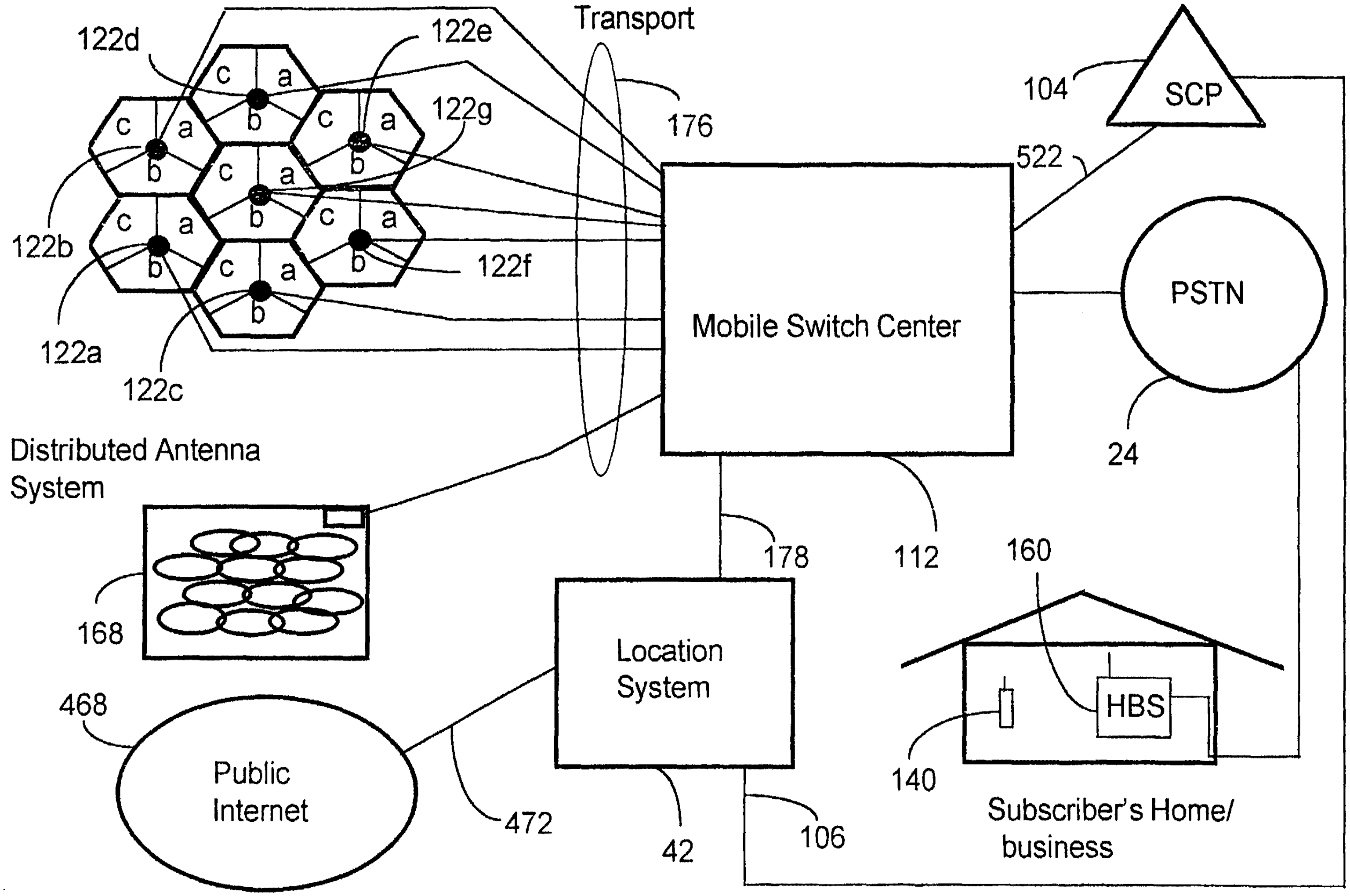


Fig. 2: WIRELESS LOCATION INTELLIGENT NETWORK ARCHITECTURE

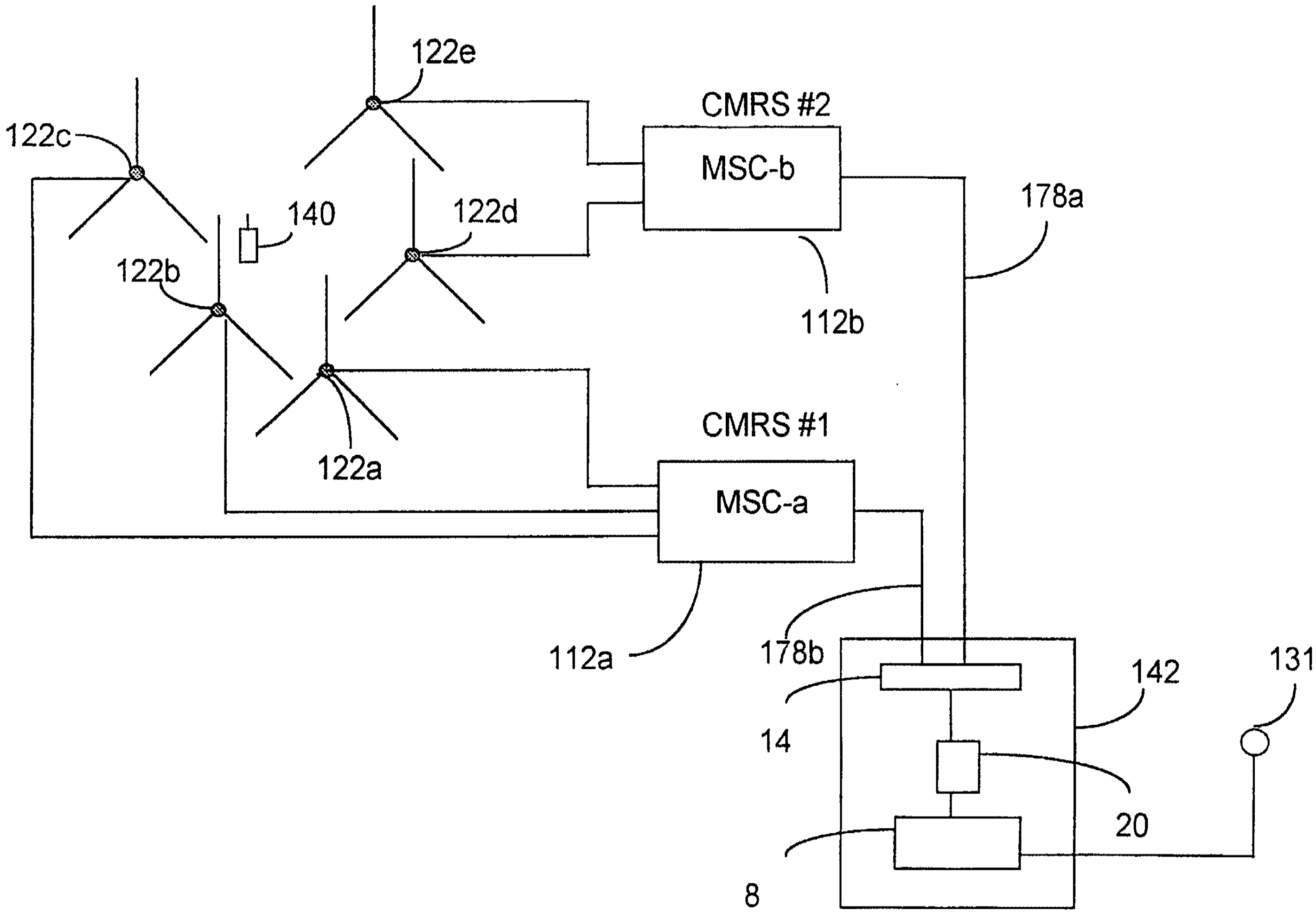


FIG. 3: SHARING CMRS BASE STATION INFRASTRUCTURE

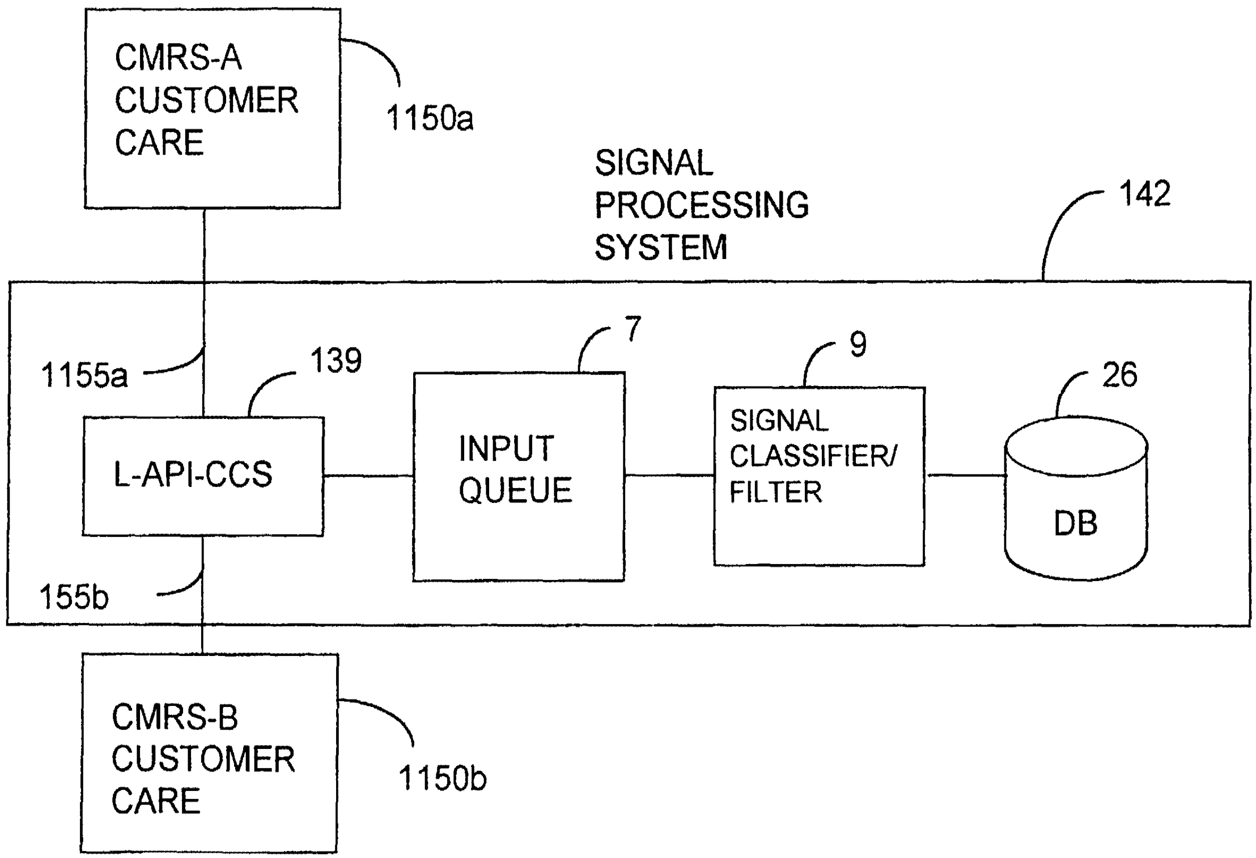


FIG. 4: LOCATION PROVISIONING VIA MULTIPLE CMRS

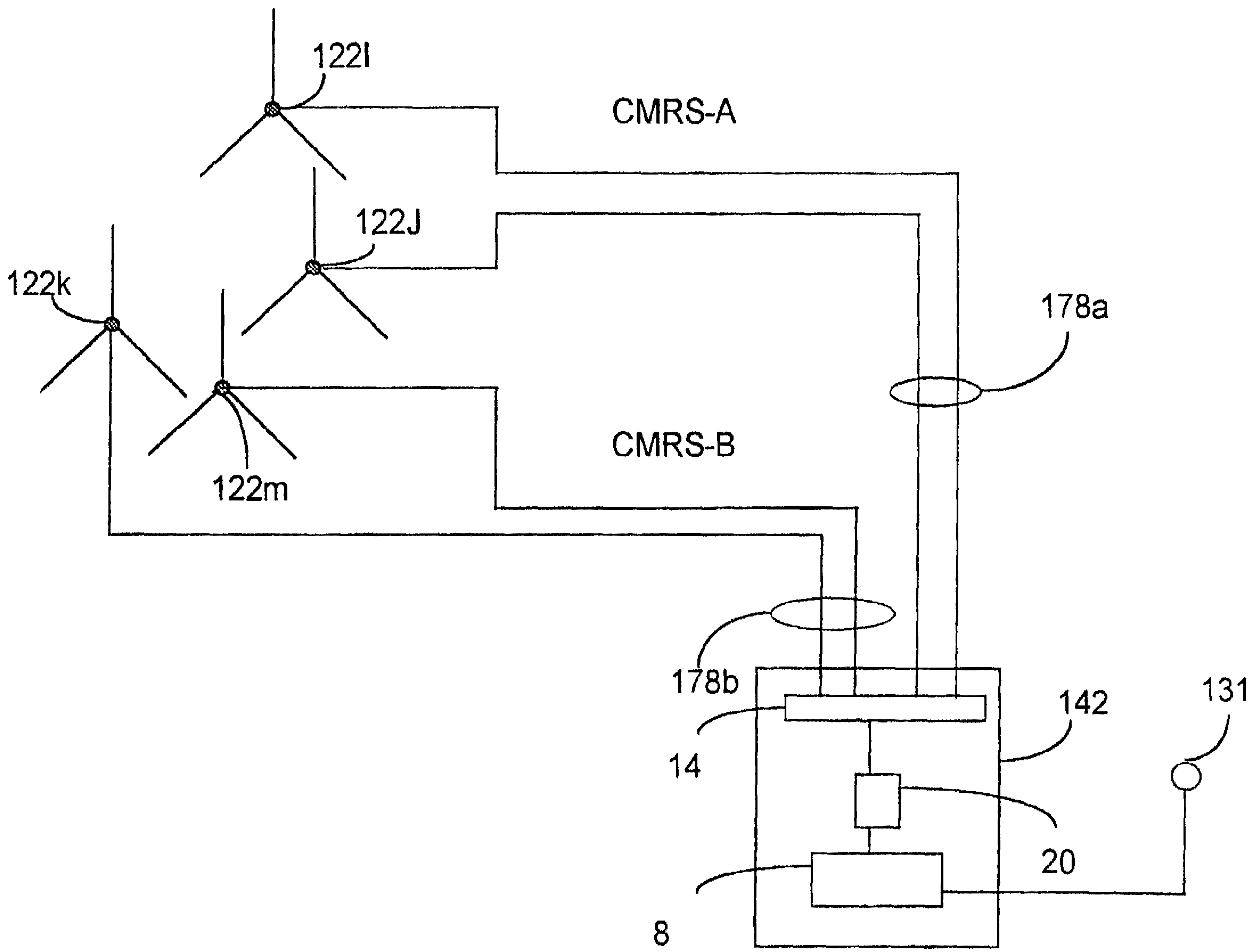


FIG. 5: LOCATION CENTER BASE STATION ACCESS, MULTIPLE CMRS

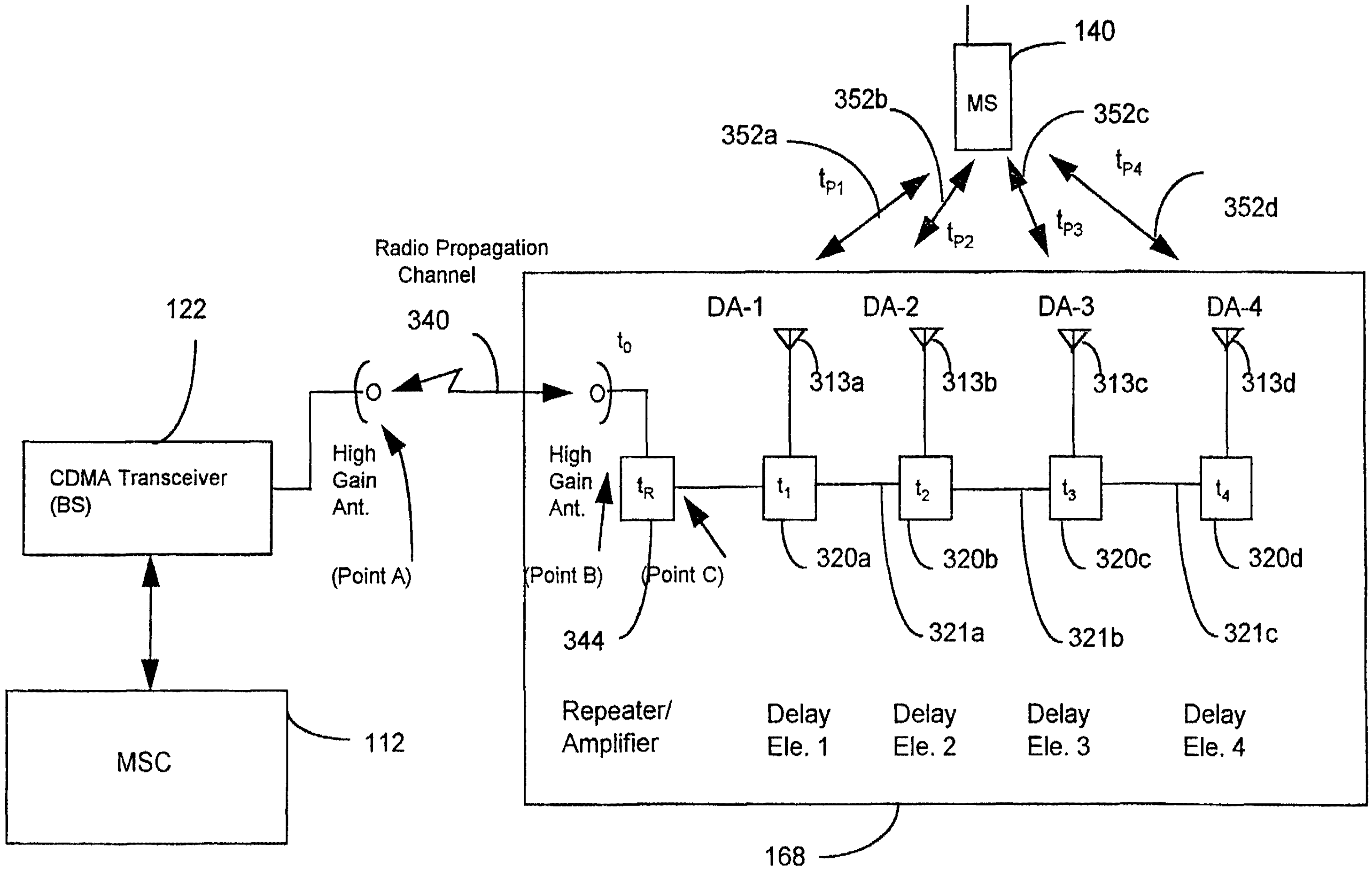


FIG. 6: DISTRIBUTED ANTENNA DELAY ChARACTERIZATION

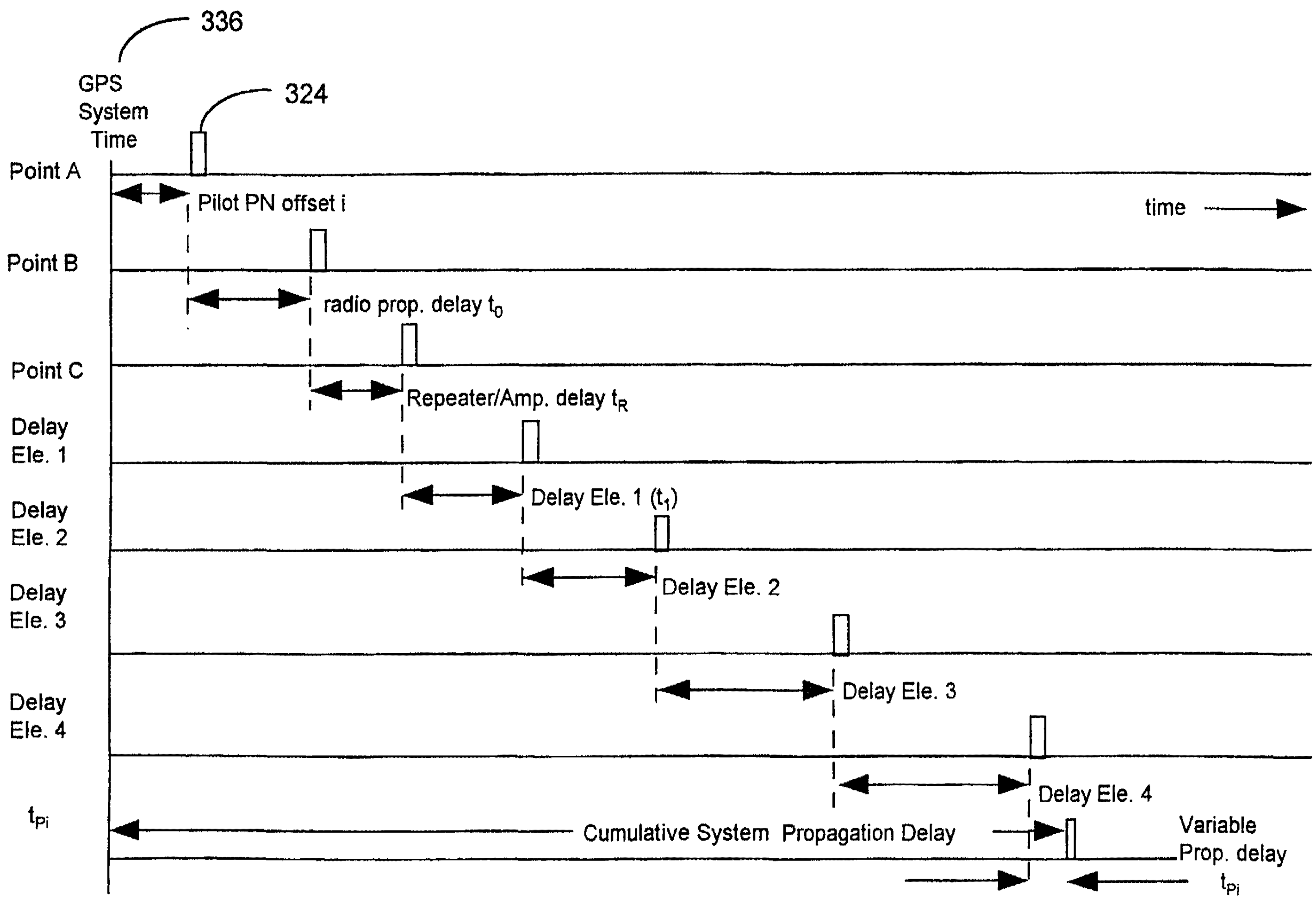


Fig. 7: DA System Timing Diagram

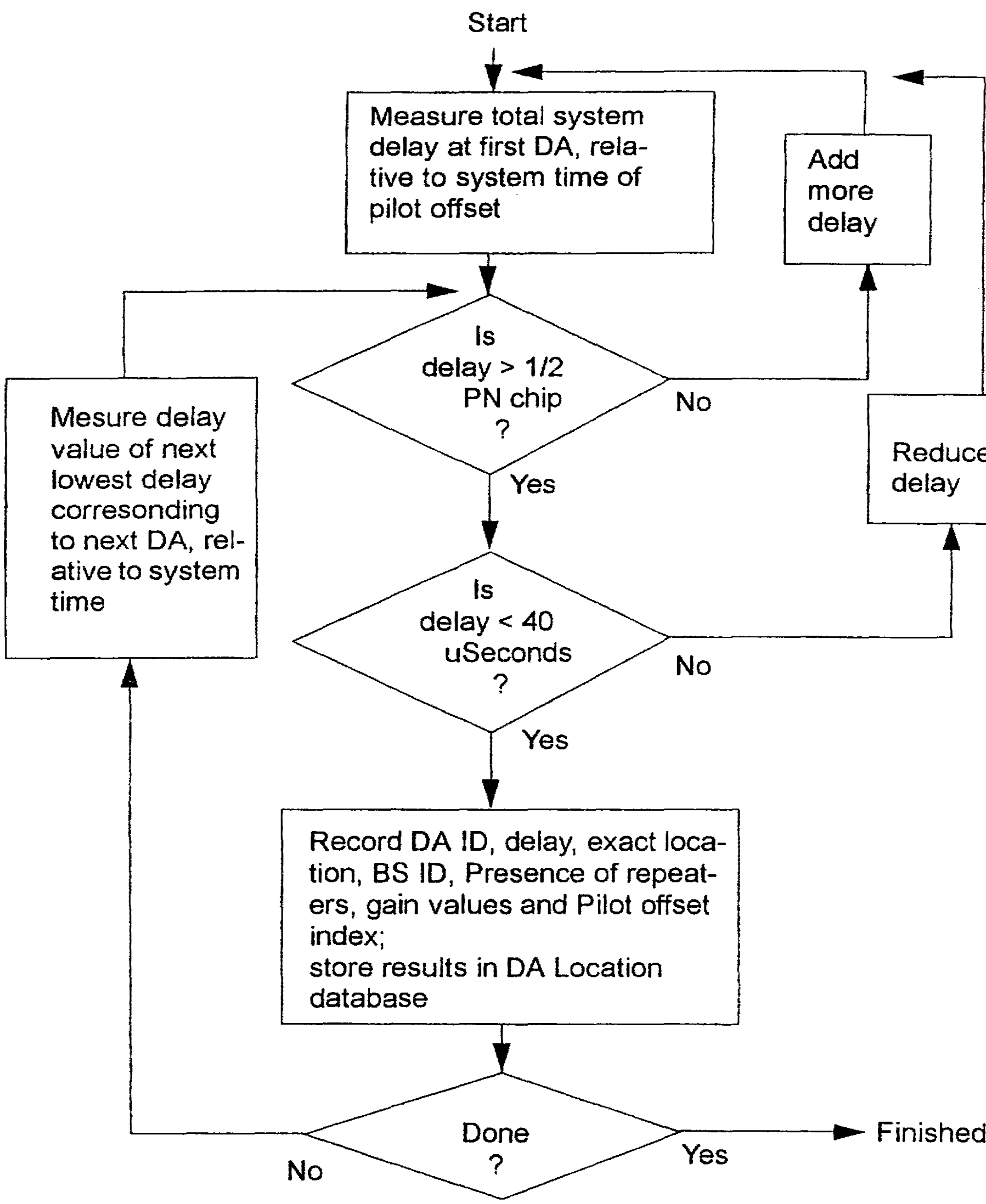


FIG. 8: DA Installation Procedure for Wireless Location

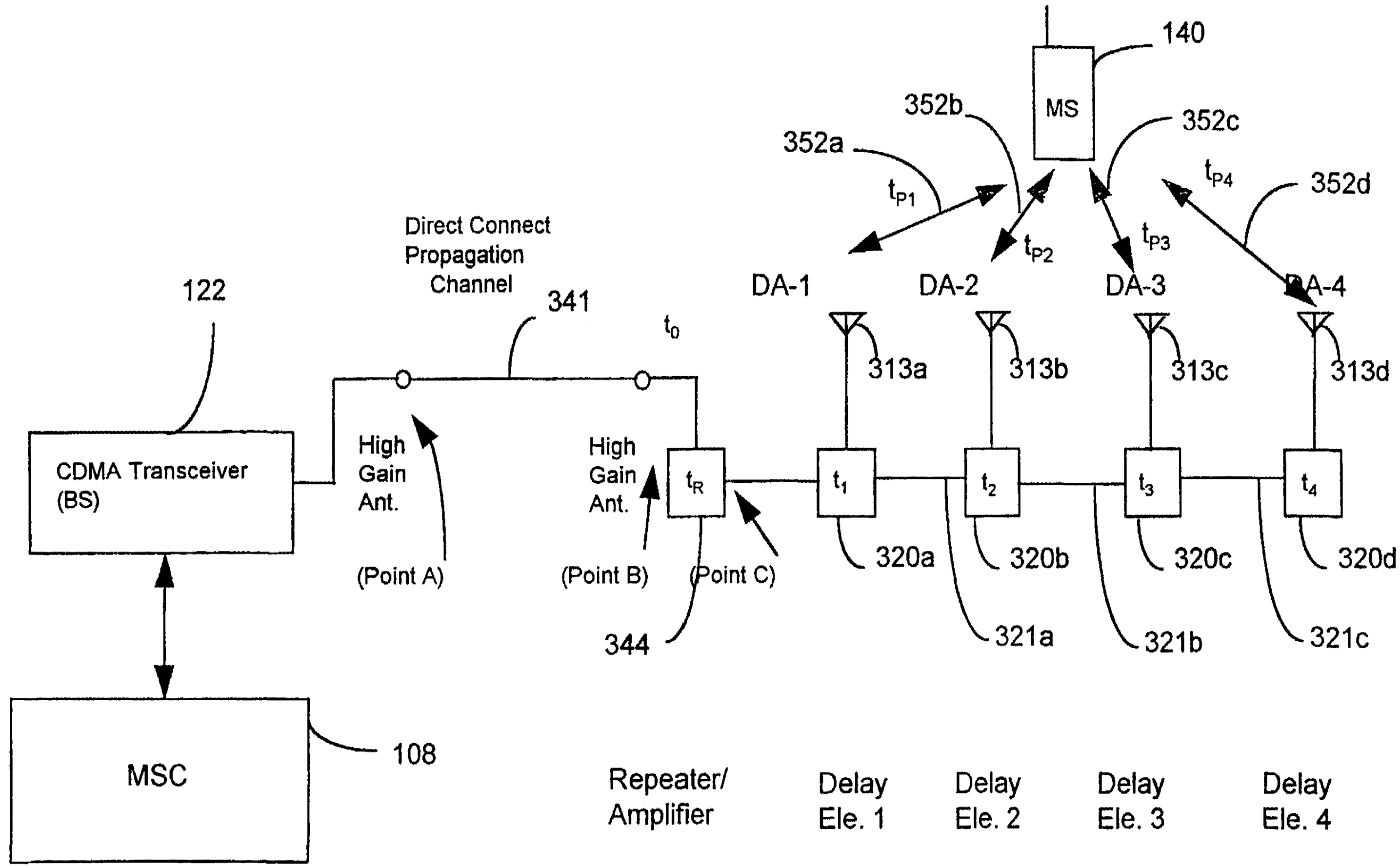


Figure 9: A Direct-Connect Distributed Antenna System

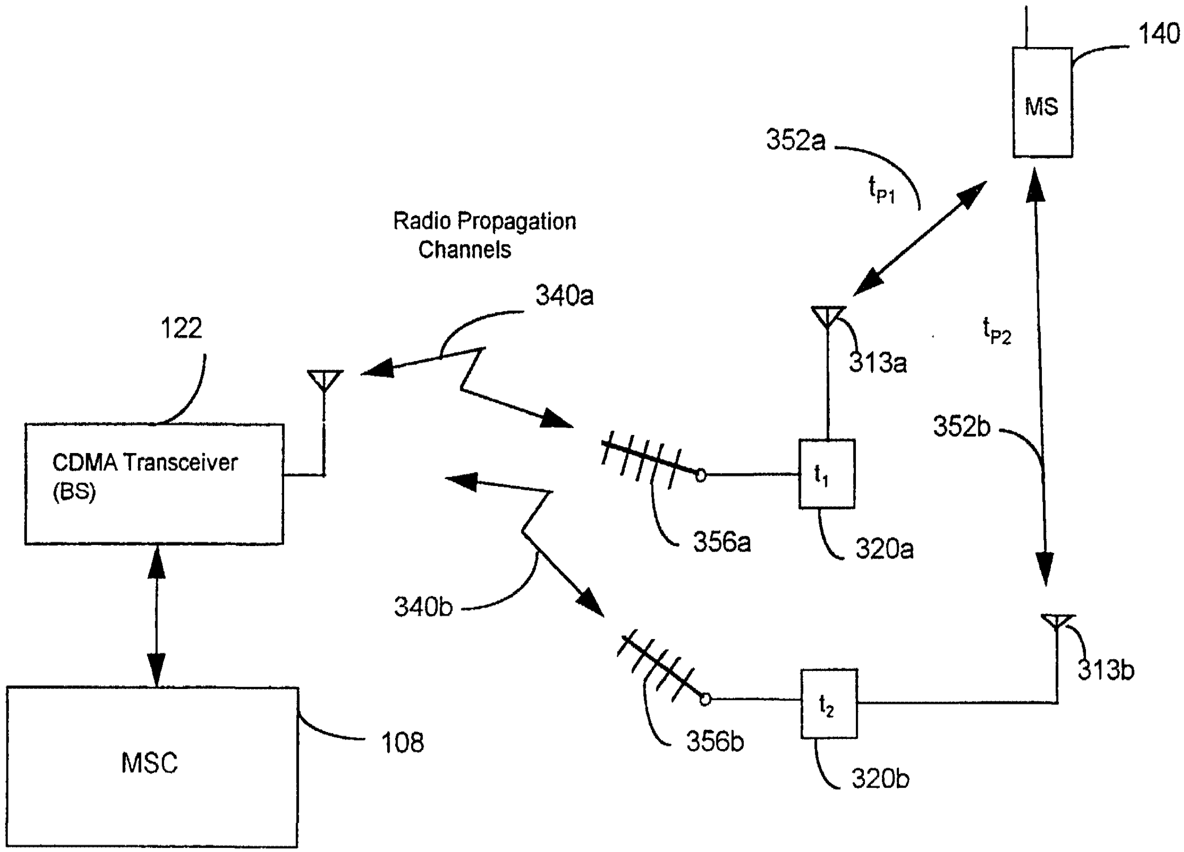


Figure 10: Multipoint Distributed Antenna System

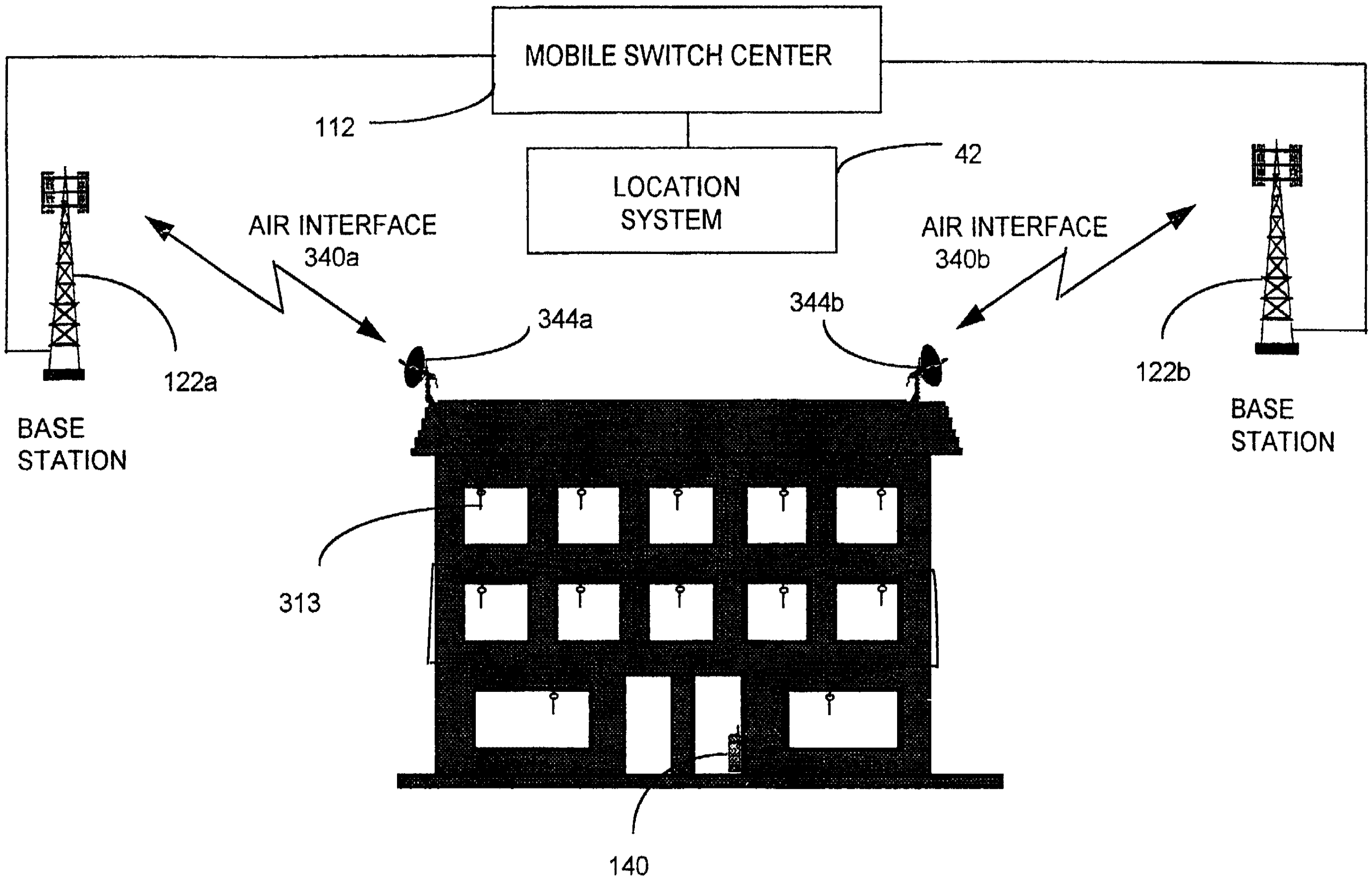


FIG. 11: Dual-Microwave Access Distributed Antenna Example

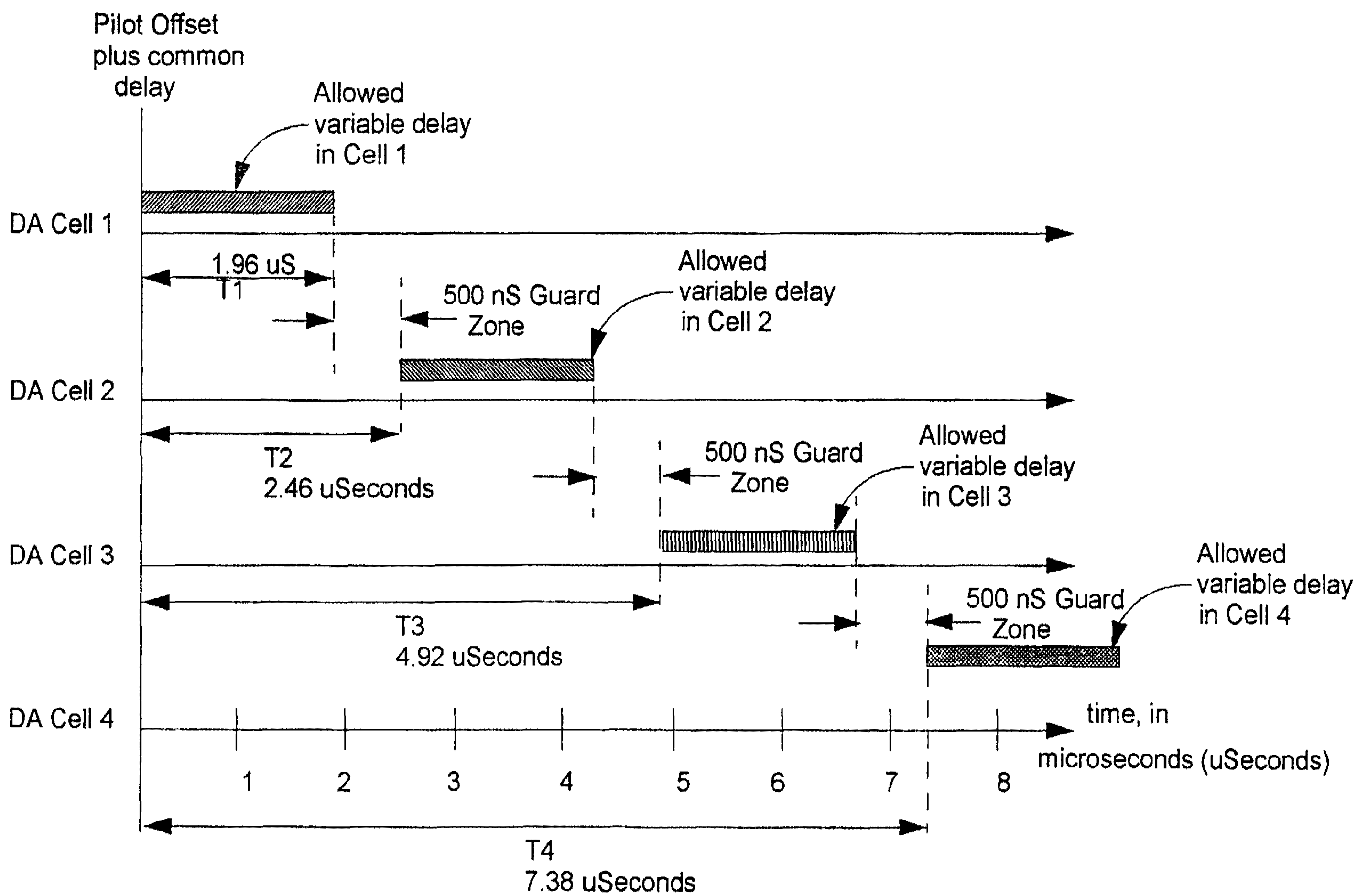
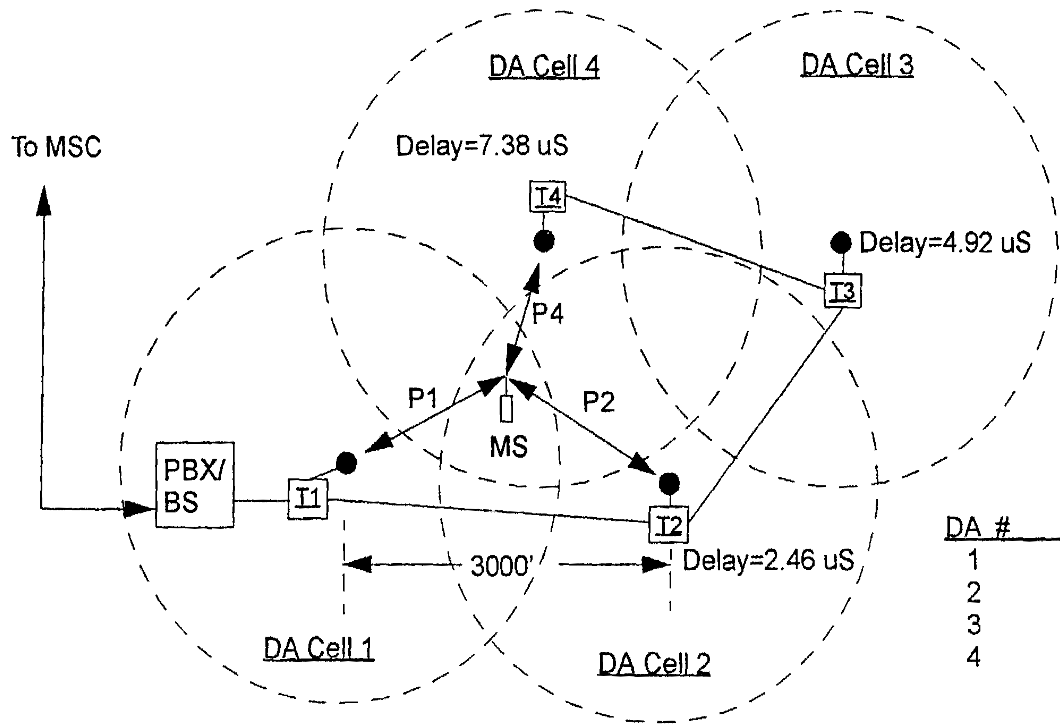


FIG. 12: ALLOWABLE DELAY SPREADS AMONG DA CELLS

All distributed omni antennas have a maximum coverage radius of 2,000 feet



DA #	X,Y Location
1	(0,0)
2	(3000, -20)
3	(1600, 2800)
4	(1600, 2800)

FIG. 13: DA Cell Geometry Illustration

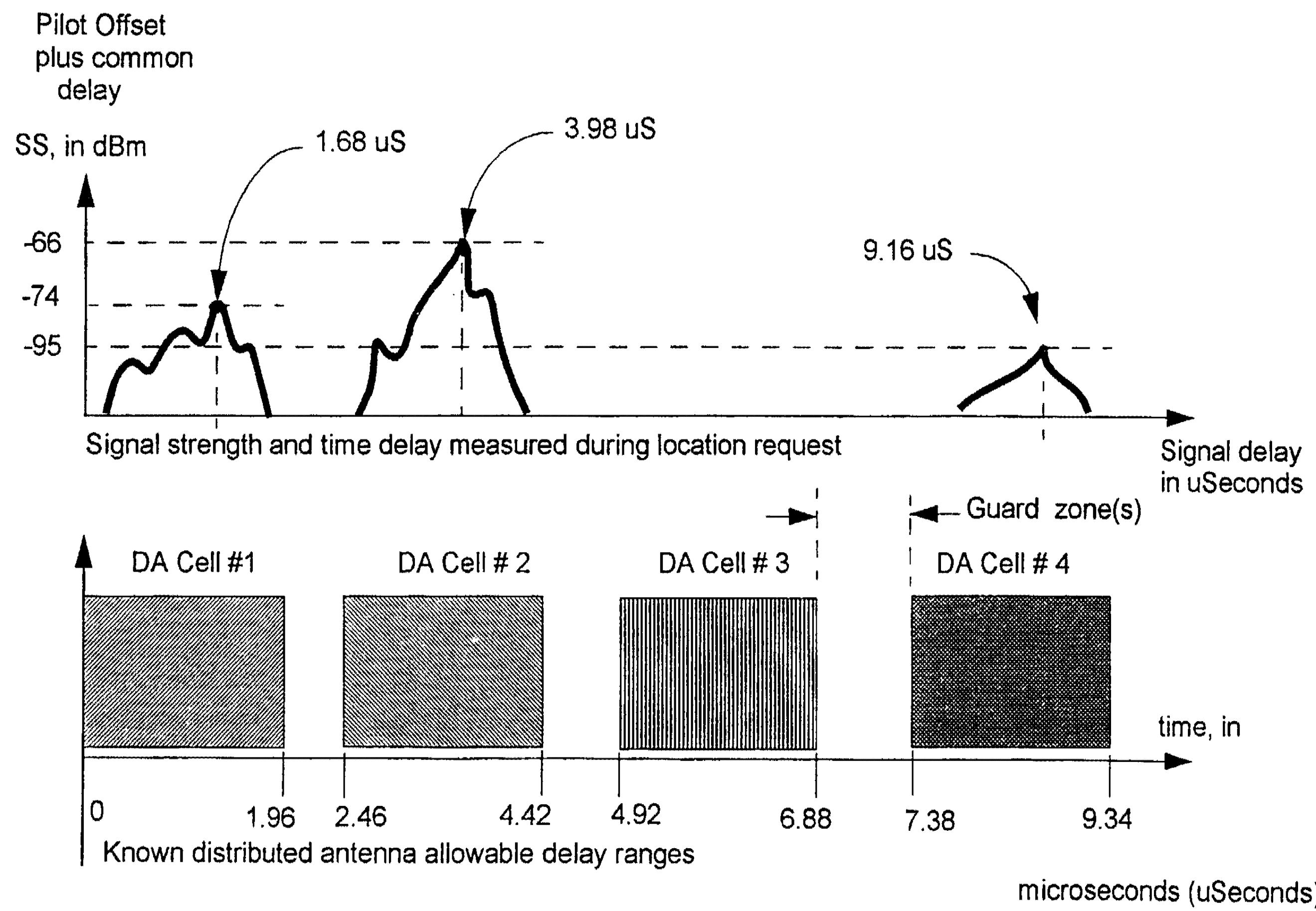


FIG. 14: LOCATION MEASUREMENTS ILLUSTRATION

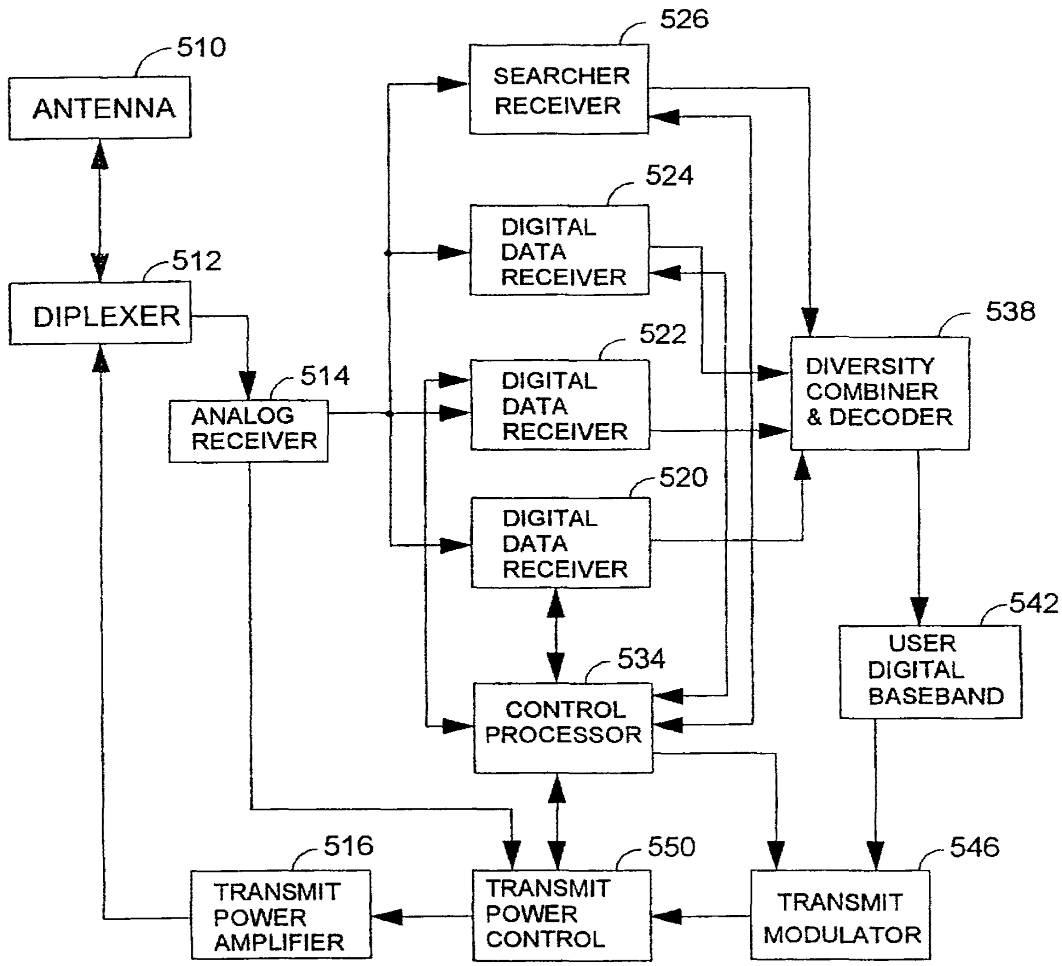


FIG. 15: CDMA Mobile Station Prior Art

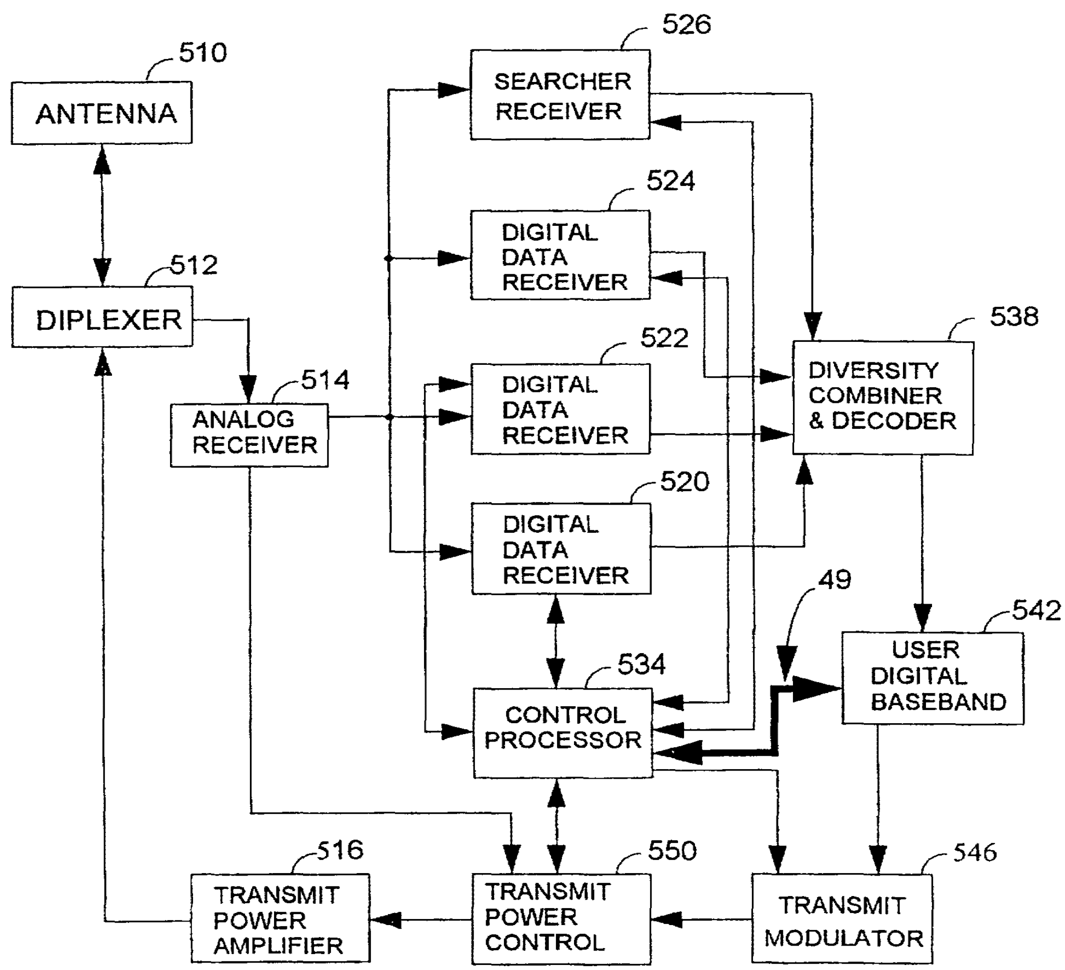


FIG. 16: MS Modification for RF Signal Telemetry

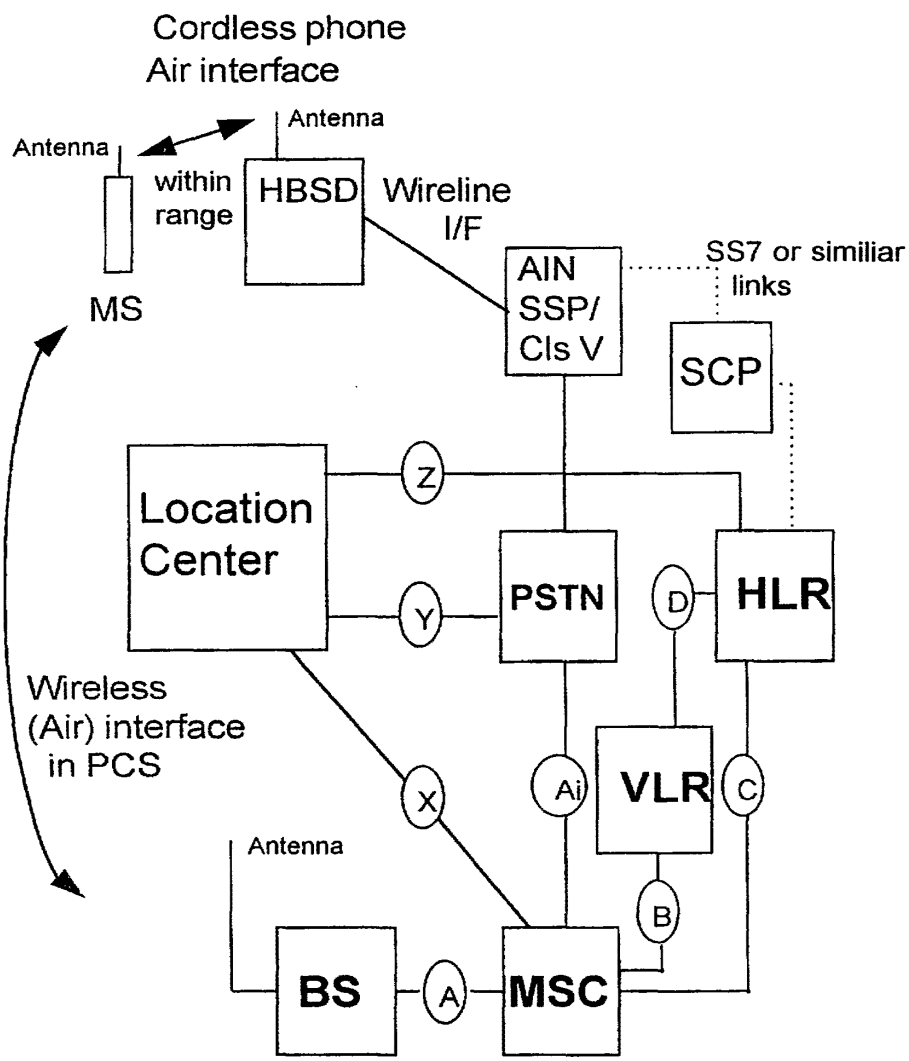


Figure 17: Location and a Home Base Station

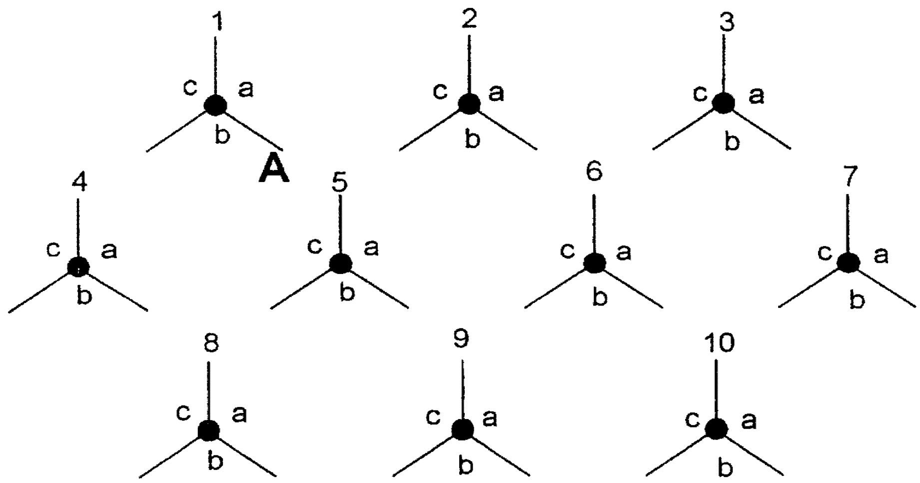


Fig. 18: MS at location A, detects BSs 1b, 5c and 4a

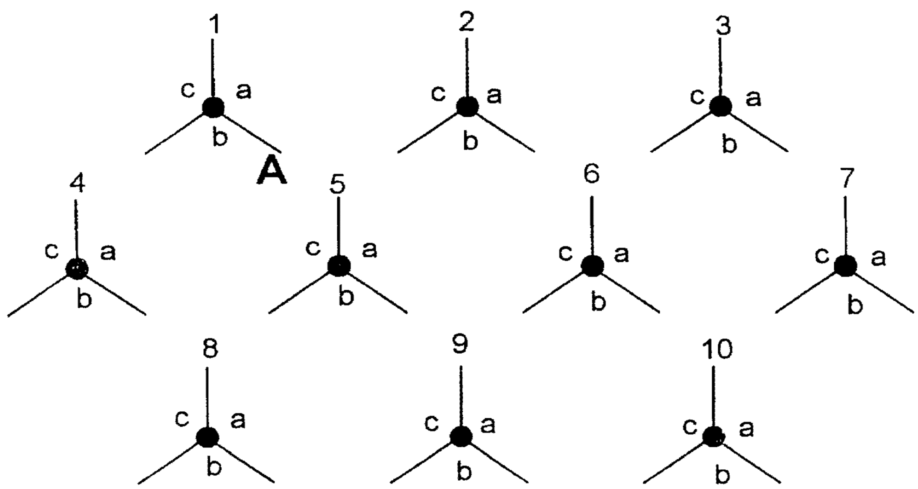


Fig. 19: MS at location A, detects BSs 1b, 5c, 2c and 4a

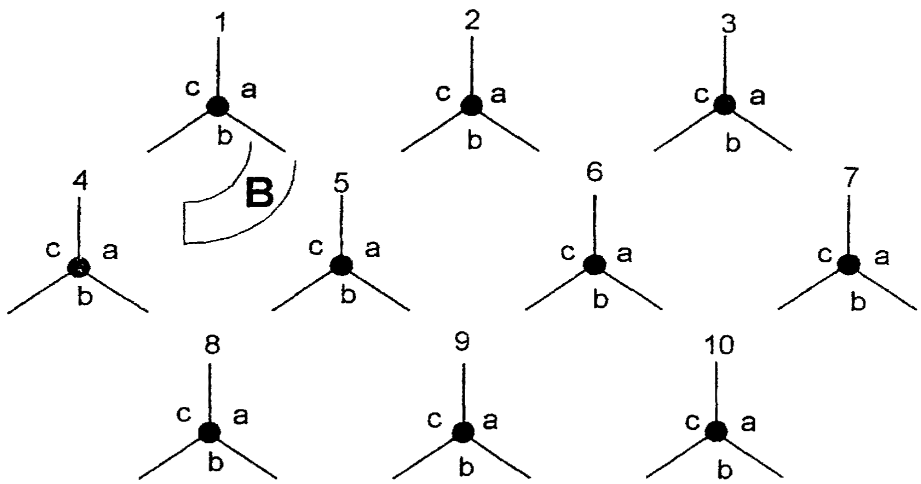


Fig. 20: MS at location B, detects BSs 1b and 2a

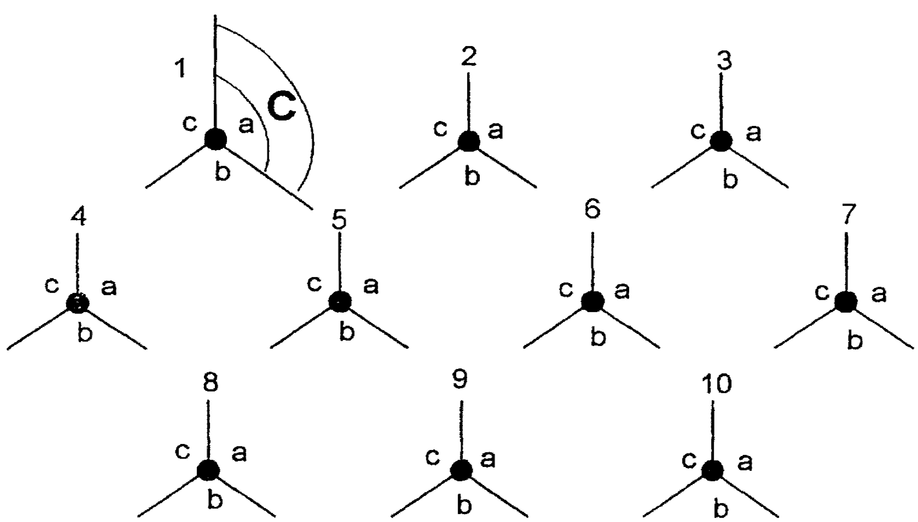
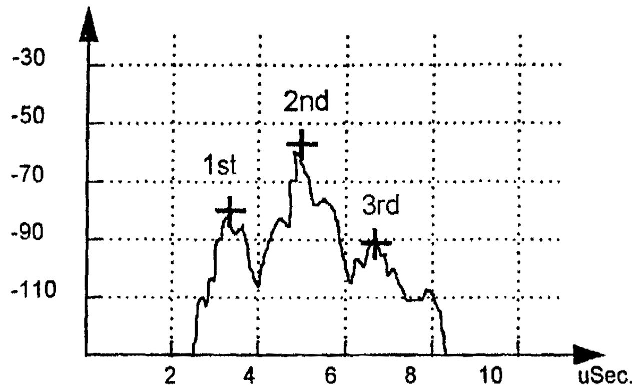
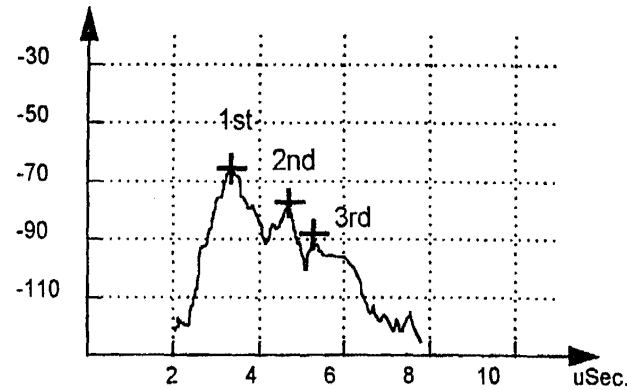


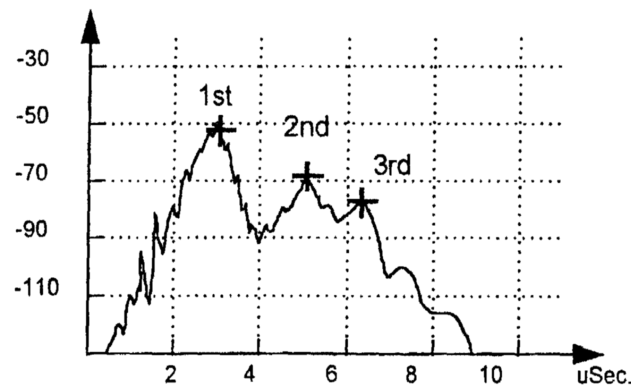
Fig. 21: MS at location C, detects only BS 1a



Delay Spread: MS RX of BS-1
(16th & Stout St.)

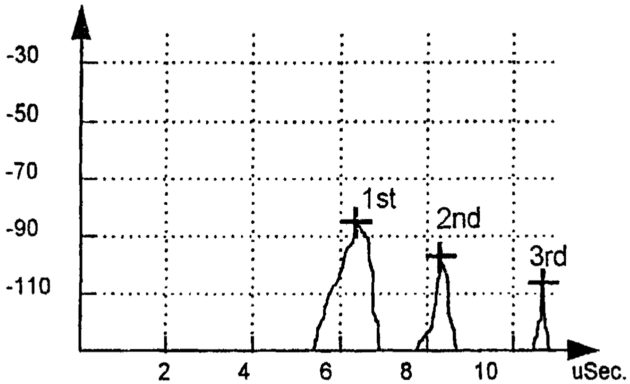


Delay Spread: MS RX of BS-5
(18th & Washington St.)

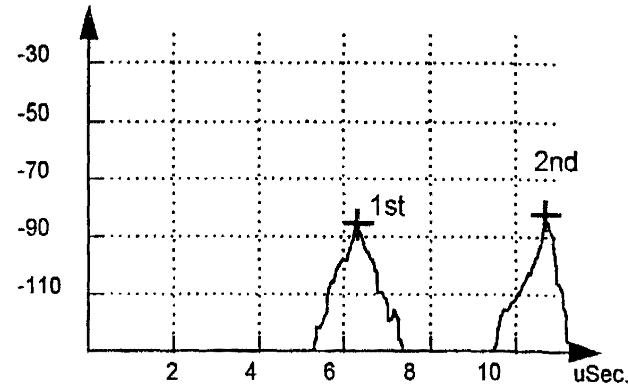


Delay Spread: MS RX of BS-2 (17th & Lincoln)

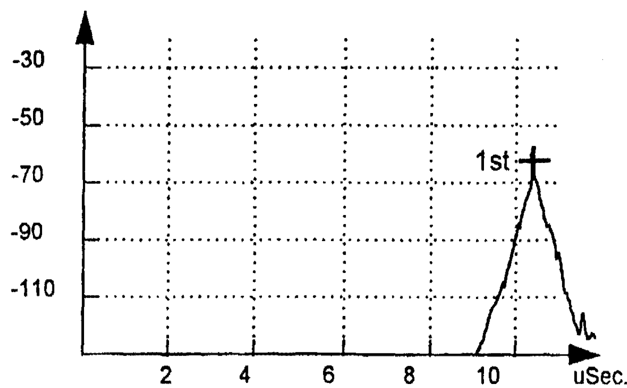
Figure 22: MS Received Delay Spreads of 3 Base Stations (Dense Urban Canyon)



Delay Spread: MS RX of BS-151
(South Table Mesa C.O.)



Delay Spread: MS RX of BS-152
(GC Miining Tower)



Delay Spread: MS RX of BS-154 (Hwy 91 & Rocky Flats)

Figure 23: MS Received Delay Spreads of 3 Base Stations (Rural Setting)

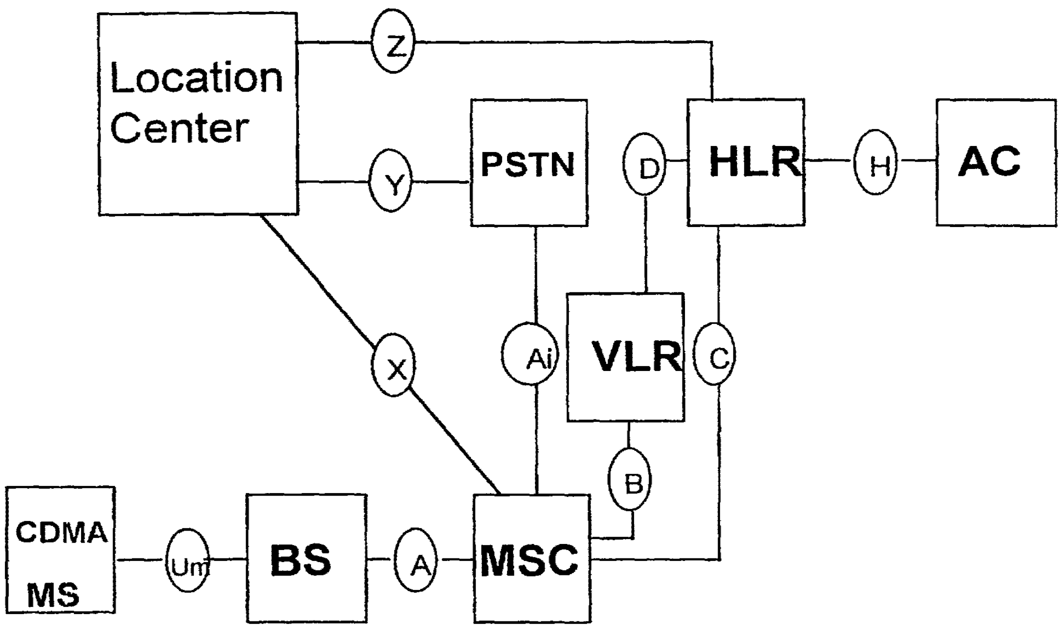


Figure 24: Location and CTIA/TR45 Network Reference Model

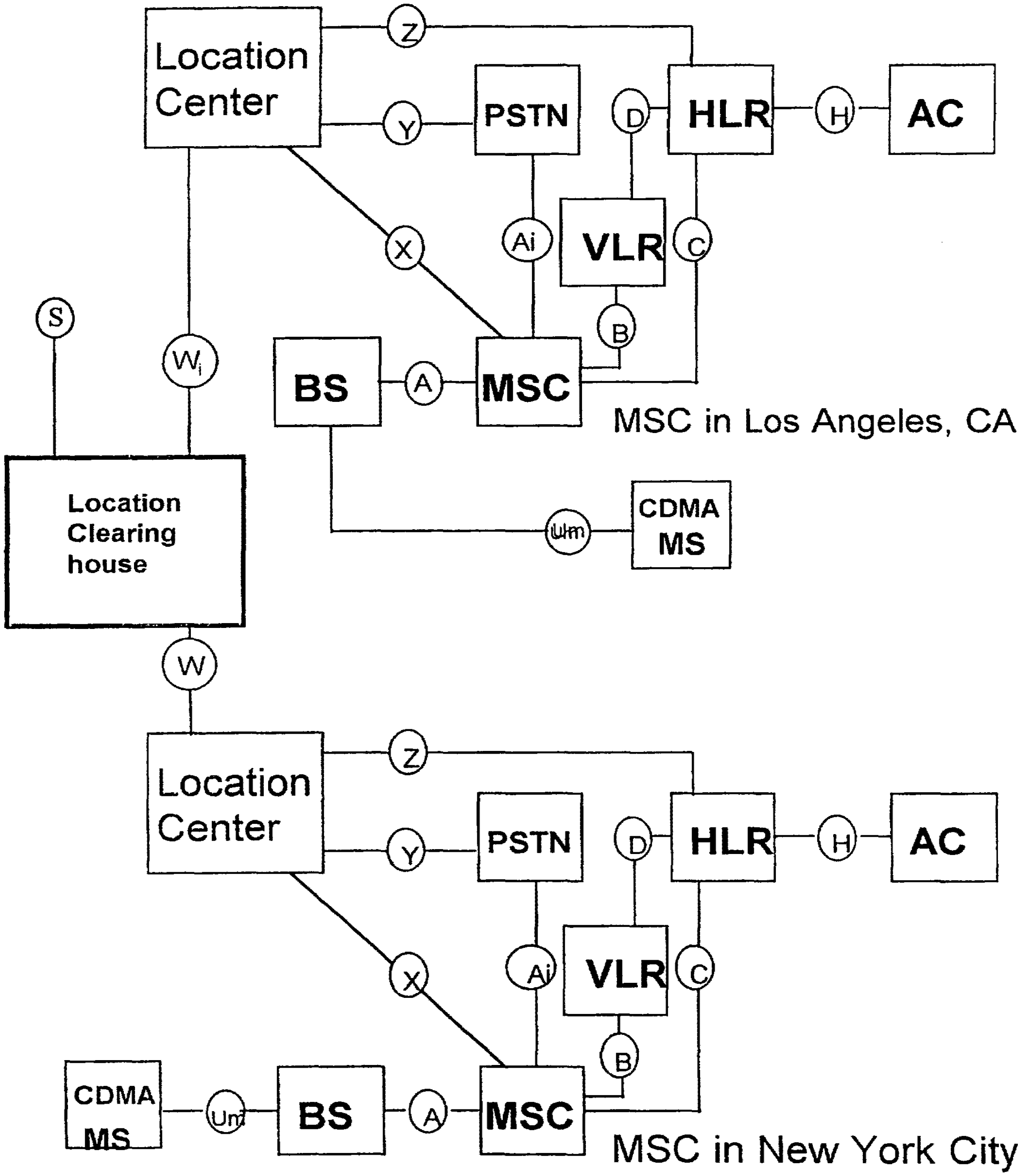
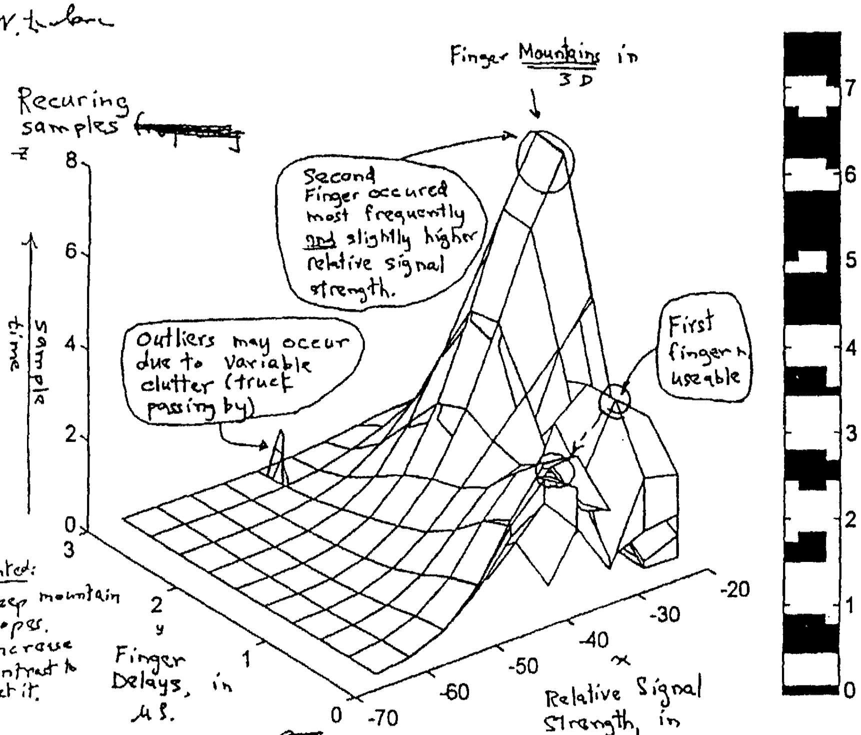


Figure 25: National Location Clearinghouse Structure



Power Control could be a 4th dimension.

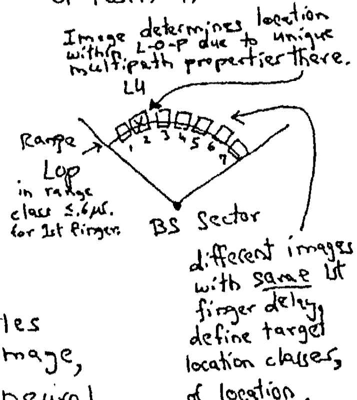
Figure : 26

MS Delay Spread Profile Image

Repeated samples of CDMA Delay Spread Profiles creates a histogram along the z-axis, or 3-D image, providing a more reliable input matrix to a neural net. Various image restoration techniques, such as median filtering, can be used to remove outliers (extreme, infrequent values) via sliding neighborhoods.

Location estimate with just one BS:

First finger provides general best range estimate, but entire image surface can provide further information to reduce other ambiguities such as determining a cartesian location along a ranging Line-of-Position.



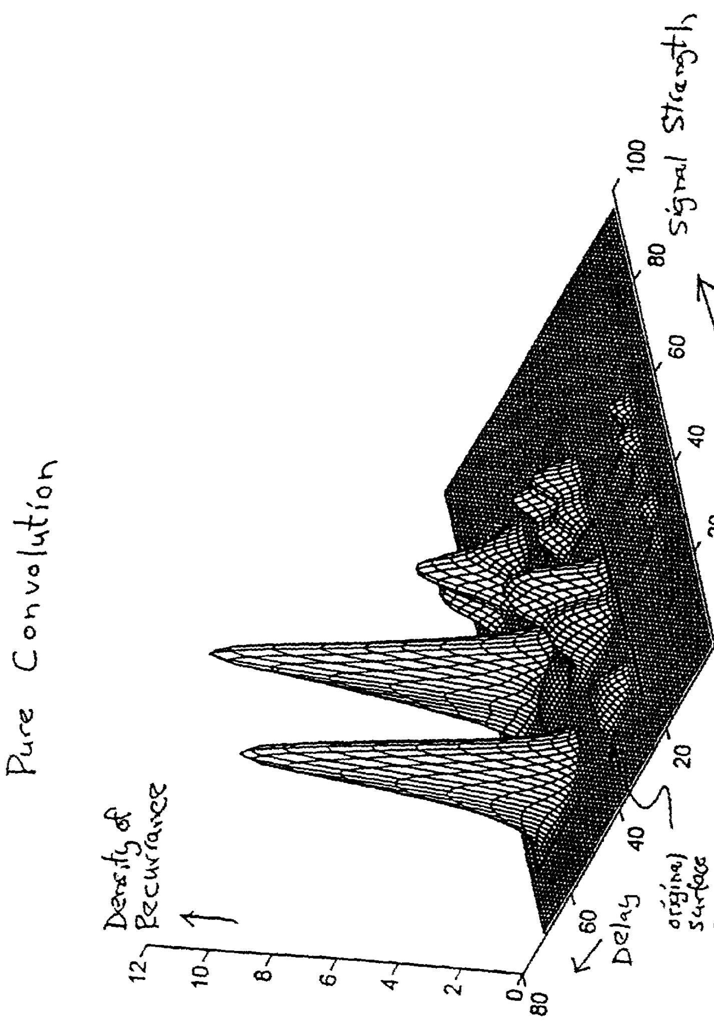


Figure 27: Convolution of Forward and Reverse Images

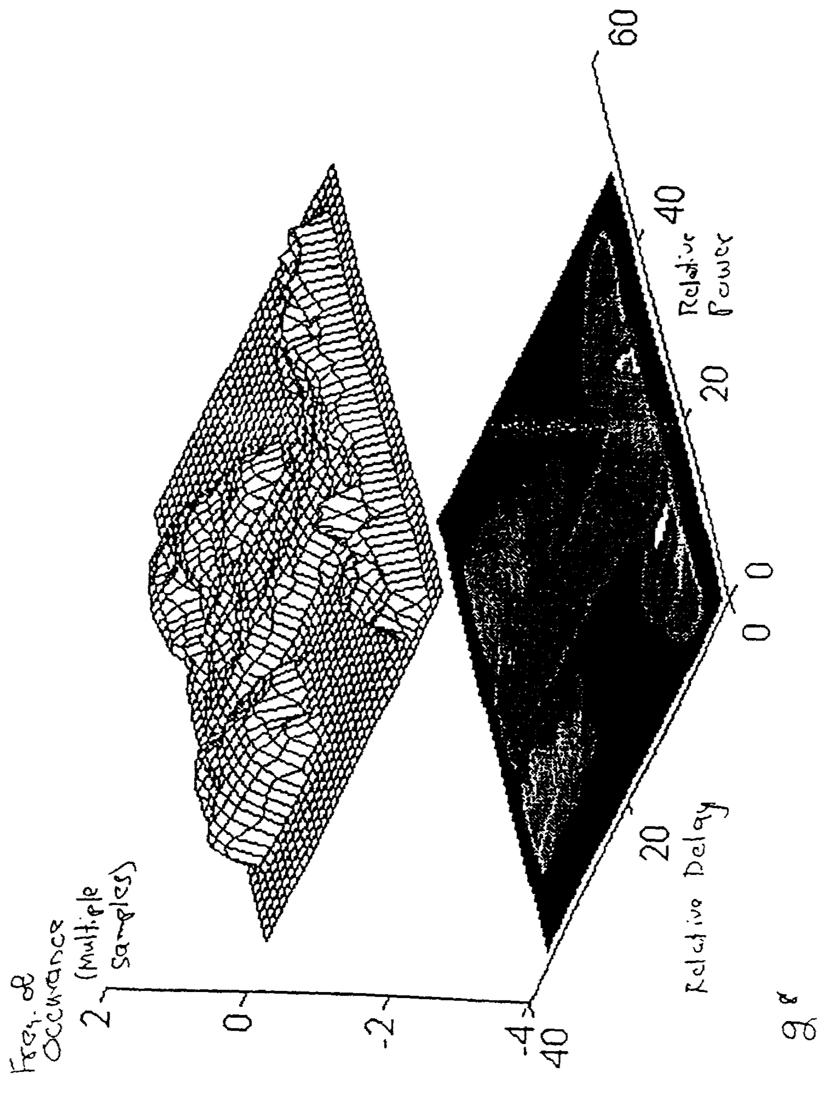


Figure [redacted] 9 : Image and Relief Representation of a CDMA Delay Spread Profile

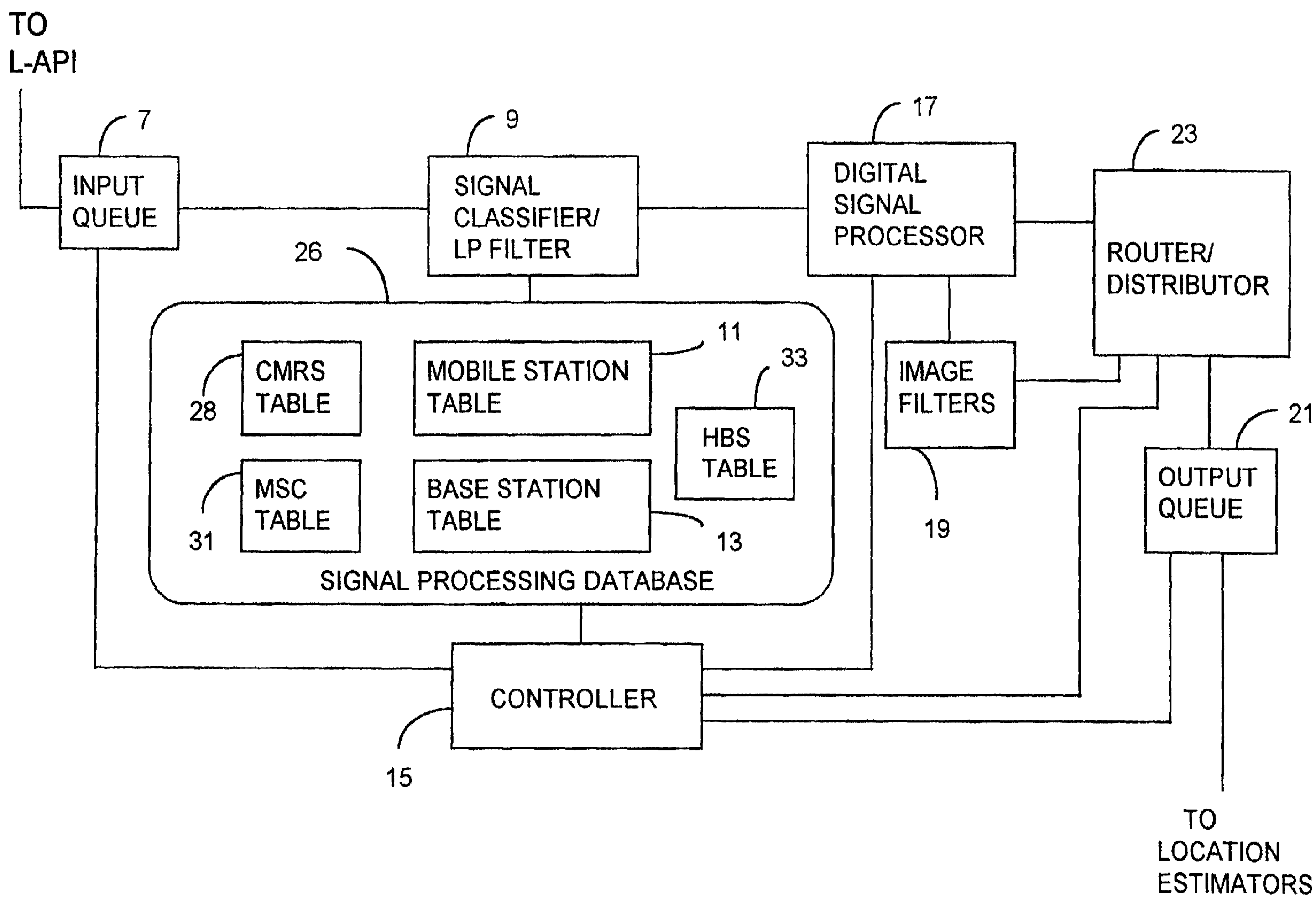


Fig. 29: Signal Processing Subsystem

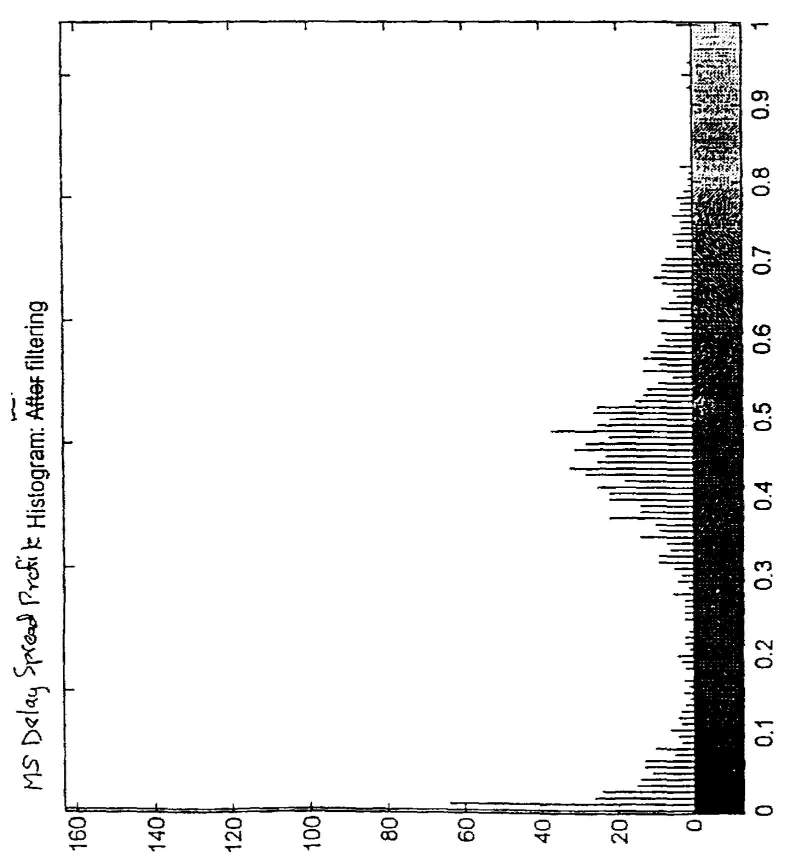


Figure 30: Image Sample Before Histogram Equalization

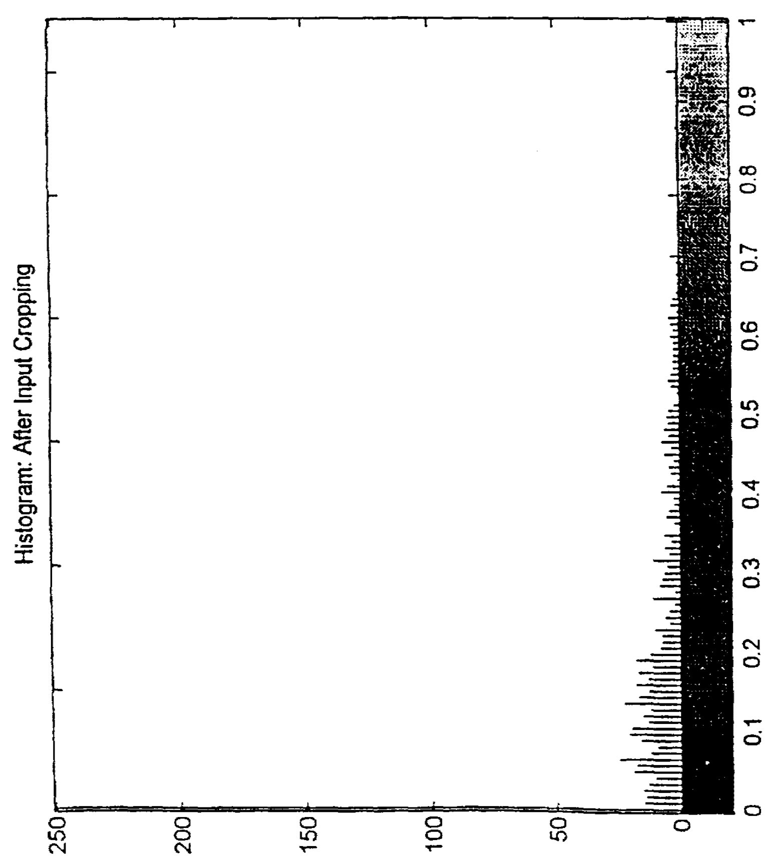


Figure [redacted] 31: Image Sample After Equalization and Input Cropping

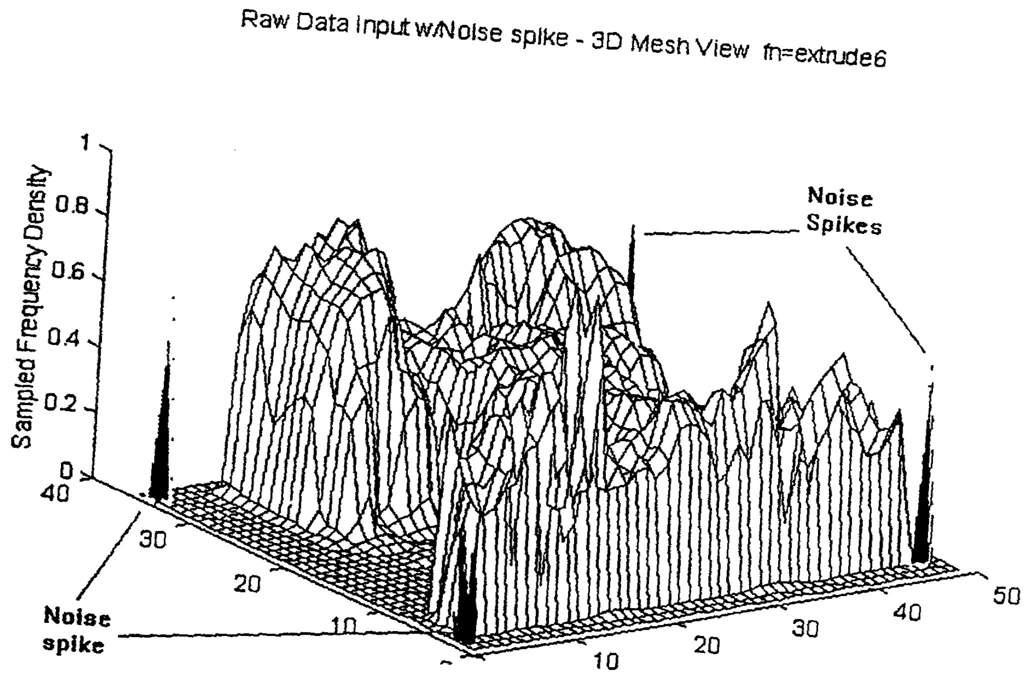
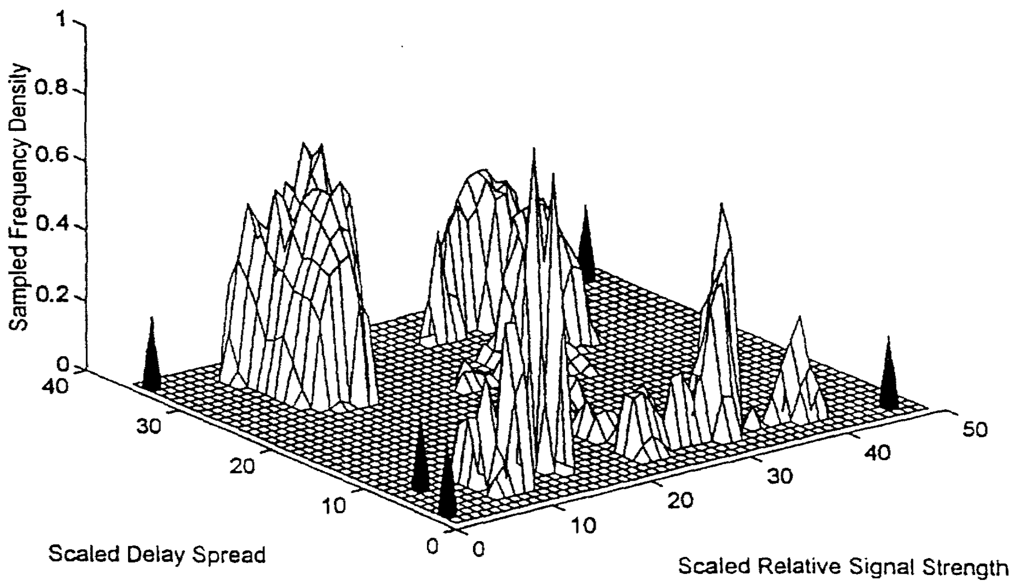


FIG. 32: CDMA Profile Image Before Filtering

Input Cropping: Clip below 50% of Freq. - 3D Mesh View fn=extrude0



33

Figure [redacted]: CDMA Profile Image After Input Cropping

Input Cropping & Median Filter: .4 Clip & 4x4 Neighbors-3D Mesh View fn=extrude5

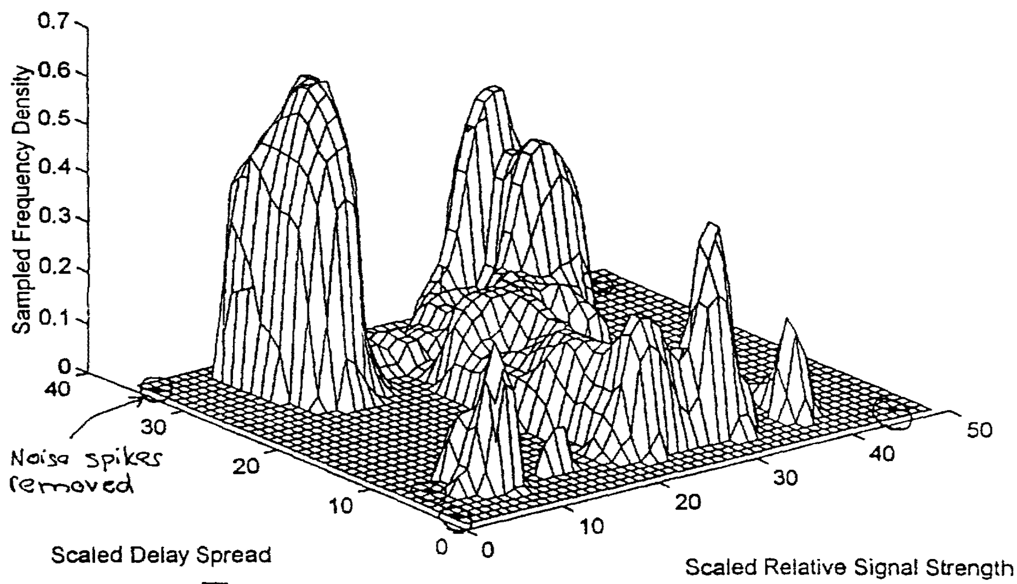
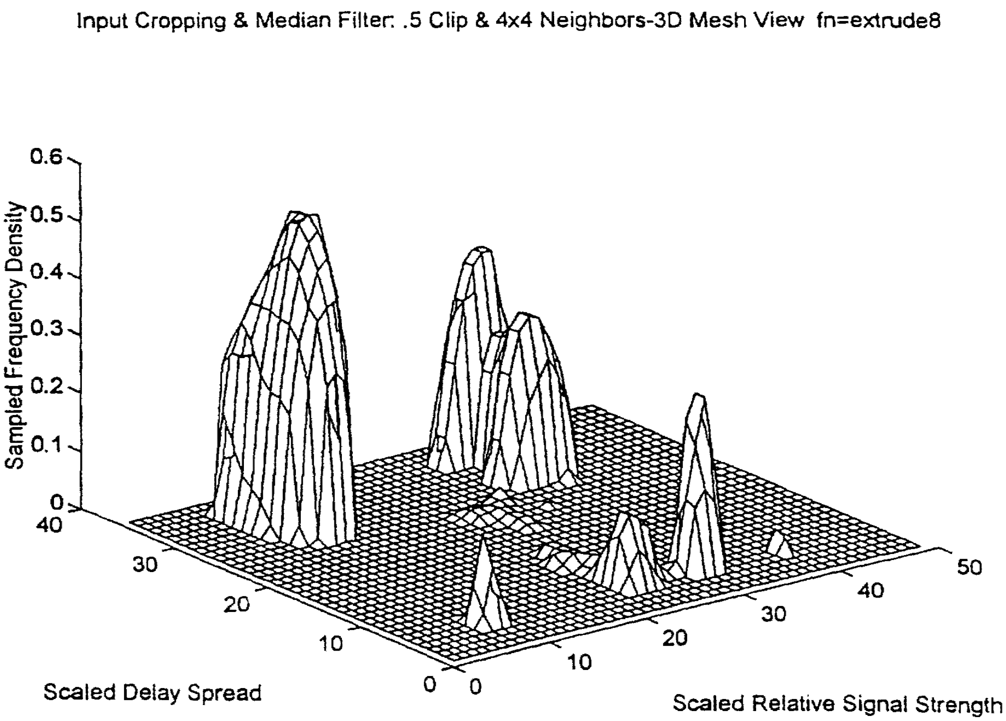


Figure 34 [redacted]: Results of Combining Input Cropping (40%) with Median Filtering (4X4)



35

Figure [redacted]: Results of Combining Input Cropping (50% clip) with Median Filtering (4x4)

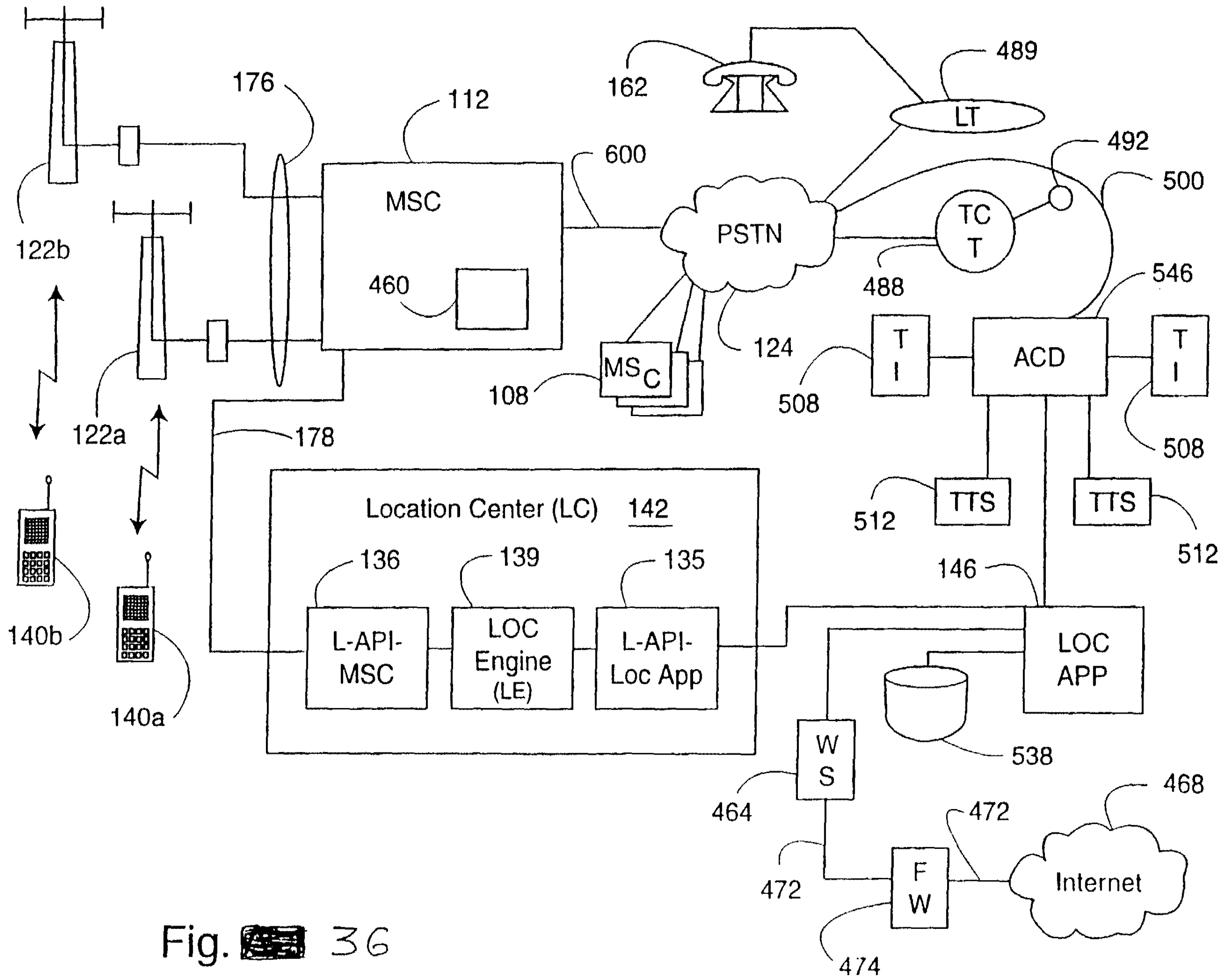


Fig. [redacted] 36

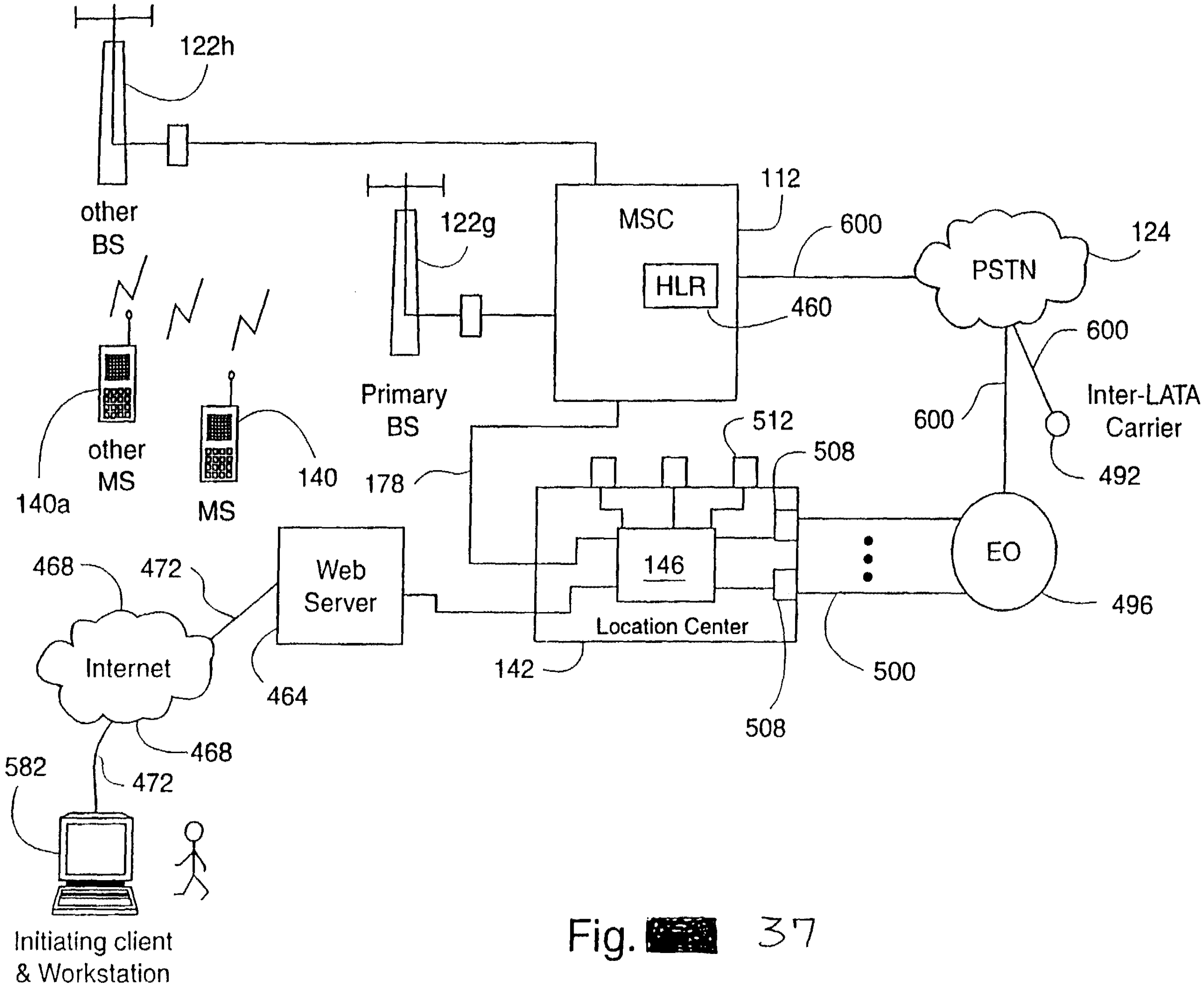


Fig. [redacted] 37

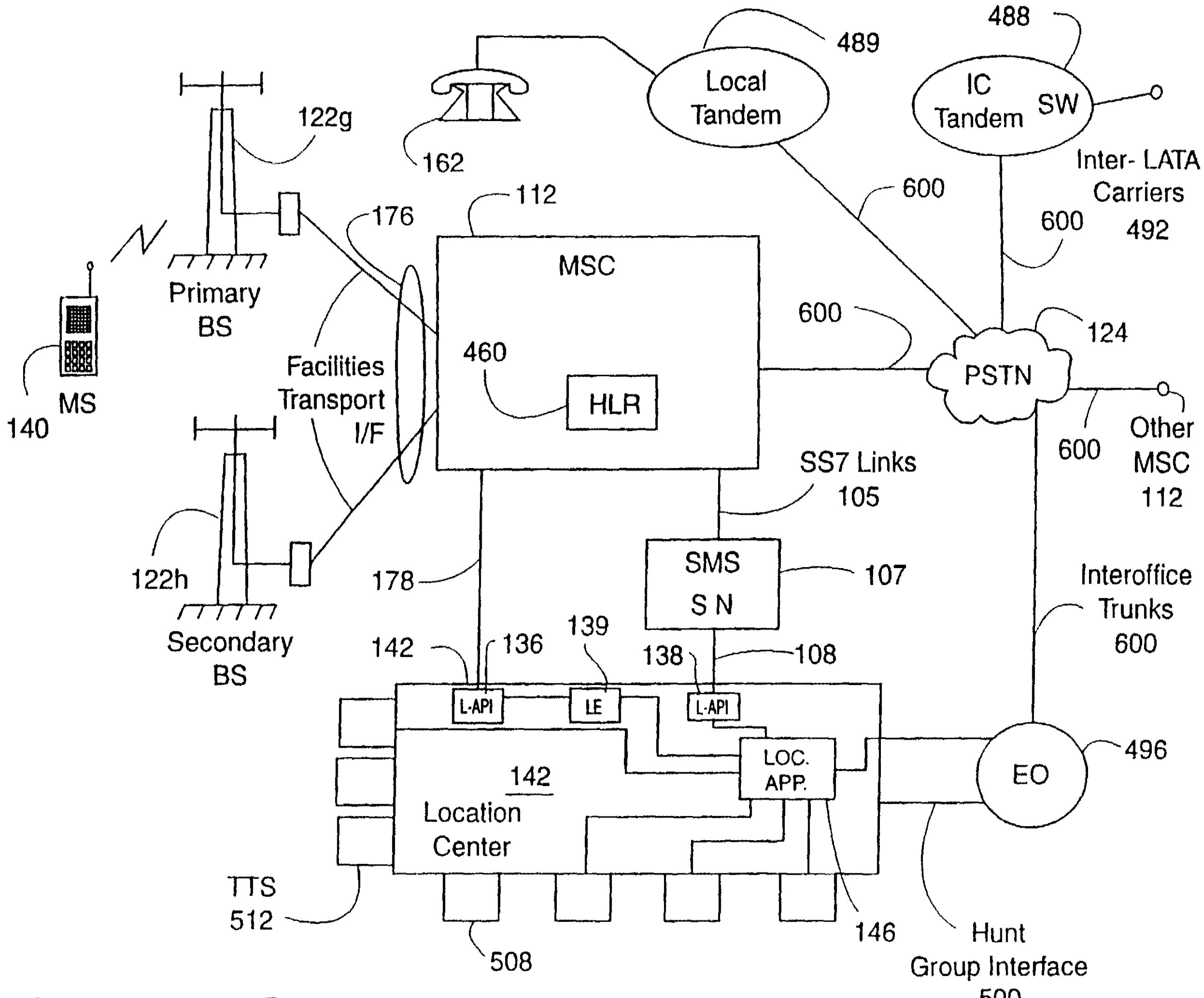


Fig. [redacted] 38

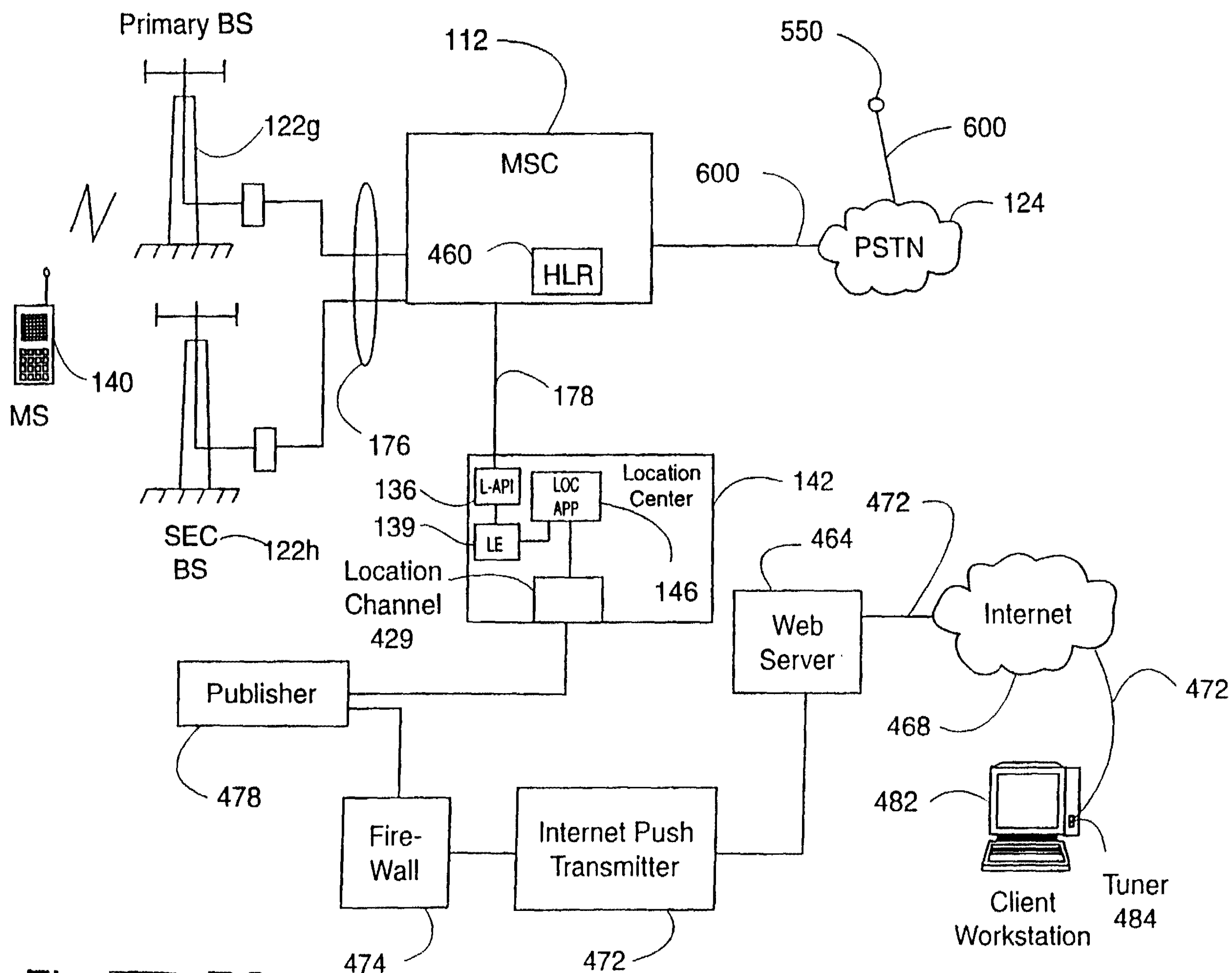


Fig. [redacted] 39

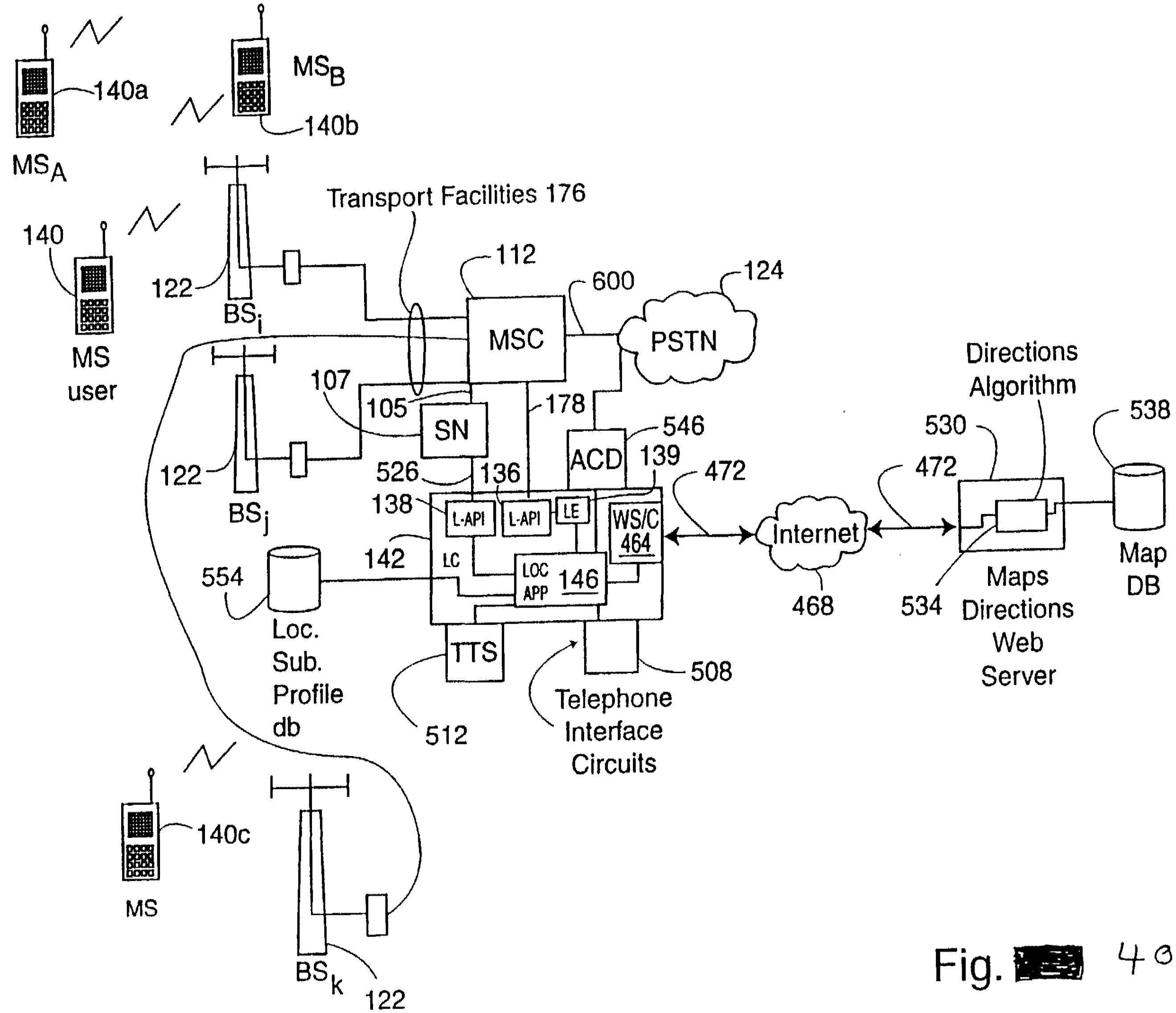


Fig. [redacted] 40

560 564 568

Turn #	**Directions**	**And Go**	**Total Miles**	
Start	Head SOUTH on BROADWAY, From **Start Marker (1999 Broadway, Denver)**	1.4 mi	1.4	
1	BEAR LEFT onto E. SPEER BLVD	0.9 mi	2.4	**Replace this column with detailed maps for all turns**
2	BEAR RIGHT onto S. DOWNING ST	0.4 mi	2.8	
3	TURN RIGHT onto E. CEDAR AV	0.1 mi	2.8	
4	TURN LEFT onto S. MARION PKY	And then	2.9	
END	**End Marker (255 marion Parkway, Denver, CO)**		2.9	

WARNING: use these directions at your own risk. Lucent Technologies is not responsible for their accuracy or for any losses resulting from their use. **Obey all traffic regulations.**

User Manual Sections: [Routes In General] [Turn-By-Turn Directions] [Caveats]

Fig. [redacted] 41

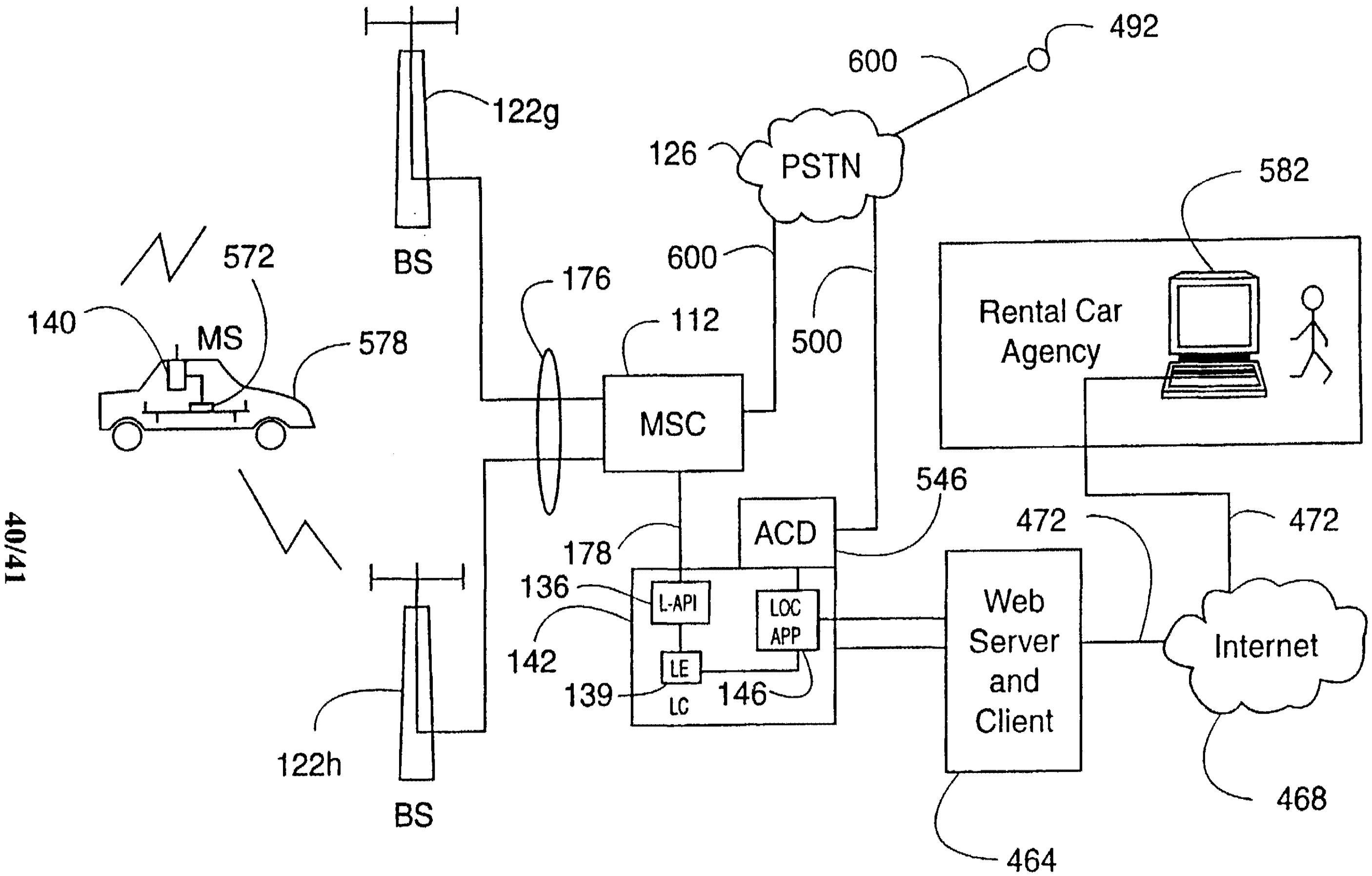


Fig. [redacted] 42

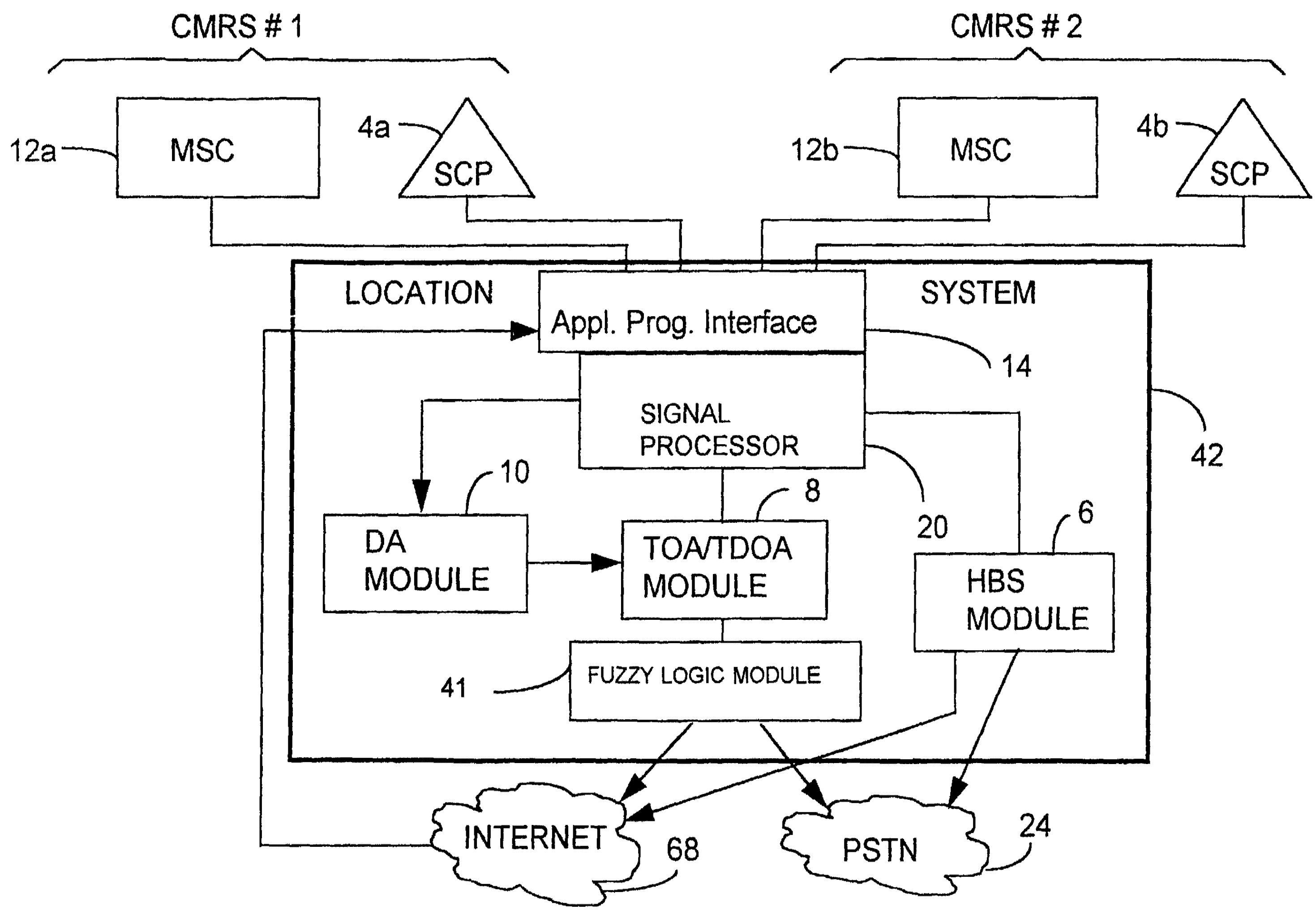


FIG. 43: WIRELESS LOCATION USING FUZZY LOGIC

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/15933

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :Please See Extra Sheet.
US CL :Please See Extra Sheet.
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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,390,339 A (BRUCKERT ET AL.) 14 February 1995, col. 2, lines 38-48, col. 4, lines 51-60, col. 7, lines 32-47, col. 10, line 54 through col. 11, line 28, abstract lines 3-15 and Fig.2A.	1-12, 48-63, 77-81, 91-94
X	US 5,485,163 A (SINGER ET AL.) 16 January 1996, col. 1, lines 49-55, col. 2, lines 44-67, col. 3, lines 9-16 and 65-67, col. 4, lines 4-25, col. 5, lines 1-8 and 14-36.	13-22, 31-47, 52-63, 77-81, 88-90
X,P	US 5,619,552 A (KARPPANEN ET AL.) 08 April 1997, col. 2, lines 4-10, col 3. lines 5-10, col. 4, lines 52-55.	13-22
X	US 5,293,645 A (SOOD) 08 March 1994, Fig. 1 and col. 2, lines 50-58.	23-30, 87

[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 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
07 DECEMBER 1997	03 FEB 1998
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 Lester Kincaid Telephone No. (703) 305-3900

Form PCT/ISA/210 (second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/15933

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,218,716 A (COMROE ET AL.) 08 June 1993, Fig. 2, blocks 201-206.	31-47
X	US 5,519,760 A (BORKOWSKI ET AL.) 21 May 1996, col. 8, lines 22-39.	41-47
X,P	US 5,564,079 A (OLSSON) 08 October 1996, col. 2, lines 58-67, col. 3, lines 10-52.	64-76, 87
X,P	US 5,570,412 A (LEBLANC) 29 October 1996, col. 10, lines 52-61, col. 16, lines 47-59, col. 17, lines 12-47, col. 25, lines 6-40.	82-86, 88-90
A	US 5,490,204 A (GULLEDGE) 06 February 1996, col. 2, lines 8-10 and Abstract lines 14-27.	1, 31, 41
A	US 5,513,246 A (JONSSON ET AL.) 30 April 1996, col. 10, lines 43-55.	1-6, 12
A,P	US 5,561,840 A (ALVESALO ET AL.) 01 October 1996, col. 2, lines 62-66, col. 3, lines 5-26, col. 4,lines 55-66	13-22
A	US 5,548,835 A (SASAKI) 20 August 1996, Fig.3.	23-30
A,P	US 5,621,414 A (NAKAGAWA) 15 April 1997, Fig. 1.	23-30
A	US 5,329,576 A (HANDFORTH) 12 July 1994, Fig.1.	23-30
A	US 5,355,511 A (HATANO et al.) 11 October 1994, Abstract.	31
A	US 5,357,561 A (GRUBE) 18 October 1994, Abstract.	31
A	US 5,481,588 A (RICKLI et al.) 02 January 1996, Fig.1 and Abstract.	64-76
A	US 5,465,390 A (COHEN) 07 November 1995, Fig. 2.	64-76
A	US 5,293,642 A (LO) 08 March 1994, Abstract.	41-47, 82-86
A	US 5,390,124 A (KYRTSOS) 14 February 1995, Abstract.	82-86
A	US 5,539,810 A (KENNEDY, III ET AL.) 23 July 1996, Fig. 1.	31
A	US 5,432,841 A (RIMER) 11 July 1995, Fig. 2 and Abstract, lines 1-5.	31

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/15933

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet(1))(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/15933

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

H04B 7/26, 17/00; H04Q 7/20, 7/22, 7/24, 7/26; G01S 3/02; H04M 11/00

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

455/426, 432, 433, 435, 466, 14, 15, 521, 524; 342/451, 457; 364/449.1, 449.8

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

455/426, 432, 433, 435, 466, 14, 15, 521, 524, 404, 411, 414, 421, 422, 434, 457, 437, 16, 17, 517, 560; 342/357, 451, 457; 364/449.1, 449.8, 449.7, 449.3

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claim(s) 1-12, 48-51 and 91-94, drawn to locating a mobile station by measuring forward and reverse signals.

Group II, claim(s) 13-22, drawn to locating a mobile station by accessing a predetermined storage location representative of a status change.

Group III, claim(s) 23-30 and 87, drawn to locating a mobile station by measuring a plurality of signal time delay measurements with a system of antennas connected in series and having a predetermined delay between each antenna.

Group IV, claim(s) 31-40, drawn to locating a mobile station by instructing the mobile to search for a signal from a different network.

Group V, claim(s) 41-47, drawn to activating the location estimator a second time if the first estimate does not exist.

Group VI, claim(s) 52-63 and 77-81, drawn to locating a mobile station by measuring pairs of signal strength values and corresponding time delay values.

Group VII, claim(s) 64-76, drawn to obtaining data related to wireless signal characteristics by driving a test mobile over a predetermined route.

Group VIII, claim(s) 82-86, drawn to locating a mobile by categorizing and filtering measured data.

Group IX, claim(s) 88-90, drawn to tracking permission to receive location data.

The inventions listed as Groups I-IX 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: the special technical feature unique to each group, as identified above, enable nine separate independent inventions capable of use without the inventions of the other groups.