IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	Cameron *et al.*
U.S. Patent No.:	5,915,210
Issue Date:	Jun. 22, 1999
Appl. Serial No.:	08/899,476
Filing Date:	Jul. 24, 1997
Title:	METHOD AND SYSTEM FOR PROVIDING MULTICARRIER SIMULCAST TRANSMISSION

DECLARATION OF DR. APOSTOLOS K. KAKAES

1. My name is Apostolos K. Kakaes of Vienna, Virginia. I understand that I am submitting a declaration offering technical opinions in connection with the above-referenced *Inter Partes* Review proceeding pending in the United States Patent and Trademark Office for U.S. Patent No. 5,915,210 (the "'210 patent"), and prior art references relating to its subject matter. My current *curriculum vitae* is attached and some highlights follow.

2. I have over thirty (30) years of experience in electrical engineering and computer science and in fixed and mobile communications networks. I attended the University of Colorado from 1974 to 1980, during which, I earned a Bachelor of Science (B.S.) and a Master of Science (M.S.) in applied mathematics with a minor in electrical engineering. I attended the Polytechnic Institute of New York between 1982 and 1988, during which, I earned a Doctor of Philosophy (Ph.D.) in electrical engineering, with a thesis titled "Topological Properties and Design of Multihop Packet Radio Networks." While pursuing the Ph.D. degree, I held a joint appointment as Special Research Fellow and Adjunct Instructor at the Polytechnic Institute of New York between 1985 and 1986.

3. Between 1982 and 1987, I worked at AT&T Bell Laboratories in Holmdel, New Jersey. While at AT&T Bell Laboratories, I worked on modeling, analysis, design, and performance evaluation of voice and data networks. I developed algorithms for DNHR (Dynamic, Non-Hierarchical Routing) used in the telephone network. I also worked on analysis

of advanced data services and formulation of long term plans for development of enhanced data services and network design tools to support such services.

4. I was an Assistant Professor of Electrical Engineering and Computer Science at The George Washington University (GWU), Washington, D.C., between 1987 and 1994. During my association with GWU, I taught graduate courses in the area of communication engineering, including communication theory, coding theory, voice and data networking, and mobile communications. I also received several research awards/grants, including the prestigious NSF Research Initiation Award.

5. In 1988, I founded Cosmos Communications Consulting Corporation ("Cosmos"), which is a private communications engineering consulting firm specializing in mobile communications, and I have been the President of the company since the founding. Since 1994, I have worked full-time at Cosmos. At Cosmos, among various activities, I have consulted on high level technology-related issues and trends to corporate entities, governmental agencies, and international organizations, such as the United Nations. I have provided technical consultancy to engineering firms, operators, and equipment vendors on issues related to existing or evolving technologies for mobile communications, and to the investment community on issues related to both fixed and wireless communications technologies. I have served as consultant on both civil and criminal legal cases, including several patent infringement cases both at the ITC and in district court. I also participated as a technical consultant in the analysis of large patent portfolios for the purposes of due diligence, sales, and merger and acquisition activities for some of the largest companies in the mobile communications space. These projects spanned a multidimensional spectrum of technologies in both fixed and mobile communications as they have evolved over the past thirty (30) years.

6. During my work at Cosmos, I have provided expert advice and conducted extensive training for practicing engineers in the field in diverse networking technology areas, including Wireless Local Area Networks (LAN), Metropolitan Area Networks (MAN), and Personal Area Networks (PAN) technologies, paging networks, ad hoc networks, including IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), HIPERLAN, Bluetooth, Near Field Communications, IrDA (Infrared Data Association). My experience includes detailed in depth analysis of cellular networks operating with any of the available access technologies as standardized in various standards, broadly known as AMPS, GSM, GPRS, EDGE (EGPRS); North American TDMA and IS-136, iDEN, IS-95, UMTS, HSPA, and LTE. I have experience in the design and implementation of voice and data networking (circuit switching as well as all the evolving all IP-based technologies), traffic engineering, RF design, Quality of Service (QoS) and resource allocation, MAC protocols, as well as in the design of core networks, both user plane and control plane.

7. Over the course of my career, I have authored and co-authored some thirty (30) publications on various aspects of fixed and mobile communications, as noted in my curriculum vita. I am a member of the Institute of Electrical and Electronics Engineers (IEEE) and actively involved in the Communications Society and the Information Theory Society of IEEE. Between 1991 and 1992, I served as the Secretary of IEEE Communications Society National Capital Area Chapter. Between 1992 and 1993, I was the Vice-Chair of IEEE Communications Society National Capital Area Chapter. I was the Vice-Chair of the Communication Theory Technical Committee of the Communications Society of the IEEE for the 1993-1996 term, and Treasurer of the Communication Theory Technical Committee of the Communications Society of the IEEE for the 1996-1999 term.

8. I have served as a reviewer for the IEEE, book editors, other technical publications, and various National Science Foundation (NSF) Panels. I have organized technical sessions in technical conferences, including the IEEE International Conference on Communications (ICC) and IEEE Global Communications Conference (Globecom). I served as the Technical Program Chair for the Communication Theory Mini-Conference in 1992.

9. I am familiar with the content of U.S. Patent No. 5,915,210 (the "'210 patent"). In addition, I have considered the various documents referenced in my declaration as well as additional background materials. For example, I have considered: (1) an English-language translation of German Patent Publication No. DE4102408 to Saalfrank ("Saalfrank"); (2) Yasuhisa Nakamura *et al.*, *256 QAM Modem for Multicarrier 400 Mbit/s Digital Radio*, 5 IEEE Journal on Selected Areas in Communications 329 (Apr. 1987) ("Nakamura"); and (3) Bernard Le Floch *et al.*, *Digital Sound Broadcasting to Mobile Receivers*, 35 IEEE Transactions on Consumer Electronics 493 (Aug. 1989) ("Le Floch"). I have also reviewed the prosecution history of the '210 patent and the claim construction orders from *Mobile Telecommunications Technologies, LLC v. T-Mobile USA, Inc., et al.*, Case No. 2:13-cv-00886-JRG-RSP (E.D. Tex.); *Mobile Telecommunications Technologies, LLC v. Sprint Nextel Corp., et al.*, Case No. 2:12-cv-00832-JRG-RSP (E.D. Tex.); *Mobile Telecommunications Technologies, LLC v. Leap Wireless International, Inc., et al.*, Case No. 2:13-cv-00885-JRG-RSP (E.D. Tex.); and *Mobile Telecommunications Technologies, LLC v. Clearwire Corp., et al.*, Case No. 2:12-cv-00308-JRG-RSP (E.D. Tex.). I have also reviewed the January 22, 2015 Decision on Institution of *Inter Partes* Review of the Patent Trial and Appeal Board in Case IPR2014-01036.

10. Counsel has informed me that I should consider these materials through the lens of one of ordinary skill in the art related to the '210 patent at the time of the invention, and I have

done so during my review of these materials. I believe one of ordinary skill as of November 12, 1992 (the priority date of the '210 patent) would have at least a B.S. degree in electrical engineering, computer science, computer engineering, or equivalent education. This person would also need to have at least two years of experience in the design and configuration of wireless paging systems, or other two-way wireless communications systems and be familiar with the operation and functionality of multicarrier transmissions. I base this on my own personal experience, extensive training that I provided for those in the industry as well as my knowledge of colleagues and other professionals at the time. With this in mind, for purposes of this analysis, references that I make to the views of a person of ordinary skill are intended to relate the views of that person as of November 12, 1992 or earlier, whether stated with respect to the present or past tense.

11. Counsel has advised me that, during *Inter Partes* Review, claims of an expired patent are generally given their ordinary and customary meaning as understood by a person of ordinary skill in the art in question at the effective filing date of the patent. Counsel has also informed me that this may yield interpretations that are broader than, or different from, the interpretation applied during a District Court proceeding, such as the pending MTel litigation.

12. I have no financial interest in either party or in the outcome of this proceeding. I am being compensated for my work as an expert on an hourly basis. My compensation is not dependent on the outcome of these proceedings or the content of my opinions.

13. My findings, as explained below, are based on my study, experience, and background in the fields discussed above, informed by my education in applied mathematics and electrical engineering, and my experience in the design and analysis of fixed and mobile communications systems.

14. This declaration is organized as follows:

I. Brief Overview of the ’210 Patent

15. The ’210 patent is generally directed to a “method and system for providing multicarrier simulcast transmission.” Ex. SAM1001, Title. The ’210 patent includes 19 claims, of which claims 1, 10, and 19 are independent.

16. The ’210 patent acknowledges that simulcast technology existed in the prior art. *See generally* Ex. SAM1001, 1:19 to 4:40. The ’210 patent describes that “[s]imulcast technology in communication systems was originally developed to extend transmitter coverage beyond that which could be obtained from a single transmitter.” Ex. SAM1001, 1:47-49. The ’210 patent goes on to note that “simulcasting has evolved into a technique capable of providing continuous coverage to a large area.” Ex. SAM1001, 1:49-51. In simulcast systems, multiple transmitters operate on substantially the same frequencies and transmit the same information and are positioned to cover extended areas. *See* Ex. SAM1001, 1:52-55. In order to extend coverage areas, a person having ordinary skill in the art would have understood that these multiple simulcast transmitters, each of which defines a transmission zone, are necessarily and always geographically separated.

17. Independent claims 1, 10, and 19 add to the ’210 patent’s description of these prior art simulcast systems by reciting the use of multicarrier modulated signals. *See* Ex. SAM1001, 33:47-62, 34:45-64, 36:7-23.

18. In particular, claims 1, 10, and 19 recite a first plurality of carrier signals within the desired frequency band and a second plurality of carrier signals transmit in simulcast with the

first plurality of carrier signals. *See id.* According to claims 1, 10, and 19, each of the first plurality of carrier signals represents a portion of an information signal substantially not represented by others of the first plurality of carrier signals, and the second plurality of carrier signals correspond to and represent substantially the same information as a respective carrier signal of the first plurality of carrier signals.. *See id.*

19. As will be described in the following sections, however, simulcast transmission of multicarrier modulated signals was well known in the art well before November 12, 1992.

II. Saalfrank and Combinations Based on Saalfrank

A. Saalfrank

20. Saalfrank describes "a procedure for use in common-wave radio broadcasting." Ex. SAM1015, Abstract. Specifically, Saalfrank describes the "common-wave radio operation of transmitter stations participating within the scope of a nationwide radio program." Ex. SAM1015, col. 1, ¶ 4. In each region of such a network, "all transmitter stations simultaneously emit transmission signals with the same modulation content on the very same transmission frequency and/or the same carrier frequencies." *Id.* In other words, all of the transmitters in any given region operate in simulcast with each, transmitting the same information at the same time.

21. In the system described by Saalfrank, a "COFDM-method (Coded Orthogonal Frequency Division Multiplex) is provided as the transmission procedure, by which within a region, e.g., the transmission area of a statewide radio station, utilizing a carrier frequency – bandwidth of e.g., 1.5 MHz, <u>simultaneously approx. 5…6 stereo programs can be broadcasted.</u>" *Id.* (emphasis added). COFDM is one type of multi-carrier modulation. Specifically, "[w]ithin the channel bandwidth available here <u>a plurality of individual carriers</u> (e.g., 448 carrier frequencies equidistantly spaced over the frequency axis) is impinged with a 4-DPSK-modulation (DPSK – Differential Phase Shift Keying)." *Id.* (emphasis added).

22. Differential Phase Shift Keying (DPSK) is a specific method by which a transmitter modulates (i.e., "impinges") a particular carrier frequency with the data of one of the stereo programs. *See, e.g.*, Ex. SAM1015, p. 3. I note the use of the word "impinge," by Saalfrank in the above quotation regarding 4-DPSK-modulation, where Saalfrank describes its carrier signals being "impinged with a 4-DPSK-modulation." Informed by an understanding of 4-DPSK modulation that is mentioned within this sentence, and accounting for the greater context of the Saalfrank paper and with an appreciation that the Saalfrank reference is a translation of a document originally written in German, this description of carrier signals being "impinged with a 4-DPSK-modulation" would have been readily understood by those of skill at the time of the '210 Patent filing to have referenced the process by which a carrier signal is modulated with data using the 4-DPSK-modulation technique. In fact, proof of this interpretation of the term "impinge" is found in the corresponding US patent application that claims priority to Saalfrank and matured into U.S. Patent No. 5,544,198. *See* Ex. SAM1015, p. 1, [30] (claiming priority to German Application 41 02 408). The text of the '198 patent that corresponds to the quote from Saalfrank that describes the carrier signals as being "impinged with a 4-DPSK-modulation" reads as follows: "Within the available channel bandwidth, a plurality of individual carriers (for example, 448 carrier frequencies equidistant on the frequency axis) are generated with a 4-DPSK (differential phase shift keying) **modulation**." Ex. SAM1015, 1:48-51 (emphasis added).

23. In general, Phase Shift Keying uses a finite number of phases of a carrier waveform to represent binary digits, also referred to as bits. *See, e.g.*, Ex. SAM1015, p. 3. In particular, each phase of the carrier represents a unique pattern of bits. *See id.* Examples include binary phase shift keying (BPSK) in which each of two phases is used to represent a bit having

the value of 1 or 0. Equally well known is quadrature phase shift keying (QPSK) in which each phase represents two bits, i.e., '00', '01', '10', and '11'). *See id.* A given implementation of phase shift keying modulation can be differential or not. *See id.* In standard, non-differential phase shift keying, the current phase of a carrier is determined based on the current value of the bit(s). *See id.* In this case, it is assumed that a reference phase is known to both a transmitter and a receiver, something that can cause a challenging problem. A well-known way to overcome this problem is to use what are known as differential schemes. *See id.* In such a scheme, rather than determining the absolute value of the phase of the carrier to be used, what is determined is the amount by which the current phase, whatever it might be, is increased depending on the values of the bits. *See id.* Thus, for example, in 4-DPSK, the bits sequence 00, 01, 11, and 10, could be represented by an increase in the phase, relative to the current phase, by 0 degrees, 90 degrees, 180 degrees, and 270 degrees respectively.

24. Accordingly, Saalfrank's description of "a plurality of individual carriers . . . [being] impinged with a 4-DPSK-modulation" reveal's disclosure by Saalfrank of each carrier signal within the channel bandwidth being modulated between four possible phases based on the data representing the portion of the stereo program currently being transmitted via that particular carrier signal. In other words, each of Saalfrank's transmitters utilizes a particular type of multicarrier modulation (i.e., using 4-DPSK-modulation) in order to generate and transmit signals representing the information contained in stereo radio programs. These radio programs are a form of audio messages.

25. Saalfrank summarizes the overall operation of its simulcast system with regard to FIG. 1a:

> within a statewide transmission region (e.g., 448) carrier frequencies are transmitted simultaneously with equidistant frequency distances Δf in a

> frequency range with the bandwidth B. The individual carriers are each modulated with one part of the digital data, with the modulation content of the individual carries [sic] being identical for all transmitter stations of the transmission region.

Ex. SAM1015, col. 2, ¶ 9 (emphasis added). An annotated version of FIG. 1a is reproduced below to aid understanding.

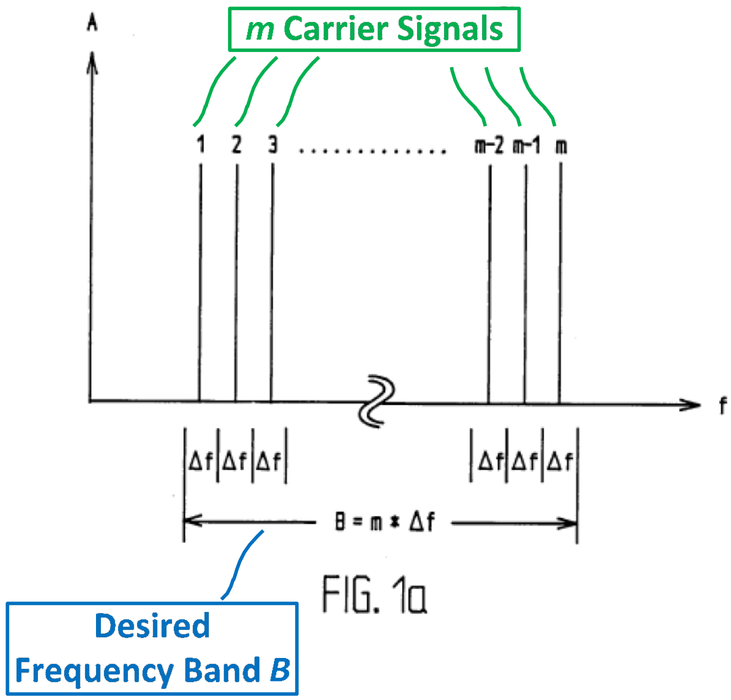


FIG. 1a

26. As evident from annotated Fig. 1a of Saalfrank, that reference describes a plurality of transmitters that each simultaneously transmit a plurality of carrier signals (e.g., the 448 equidistant carrier frequencies) within the desired frequency band (B). *See* Ex. SAM1015, col. 2,¶ 9. Moreover, Saalfrank describes that each of the transmitted plurality of carrier signals represents a portion of the information signal substantially not represented by others of the plurality of carrier signals (i.e., "individual carriers are each modulated with one part of the digital data"). *See* Ex. SAM1015, col. 2, ¶ 9. In other words, the digital data that represents the multiple stereo radio programs is split into multiple "parts" and each different "part" is used to

modulate one of the multiple carrier signals. *See id.* The following annotated version of FIG. 1a illustrates the signals transmitted by each of Saalfrank's individual transmitter.

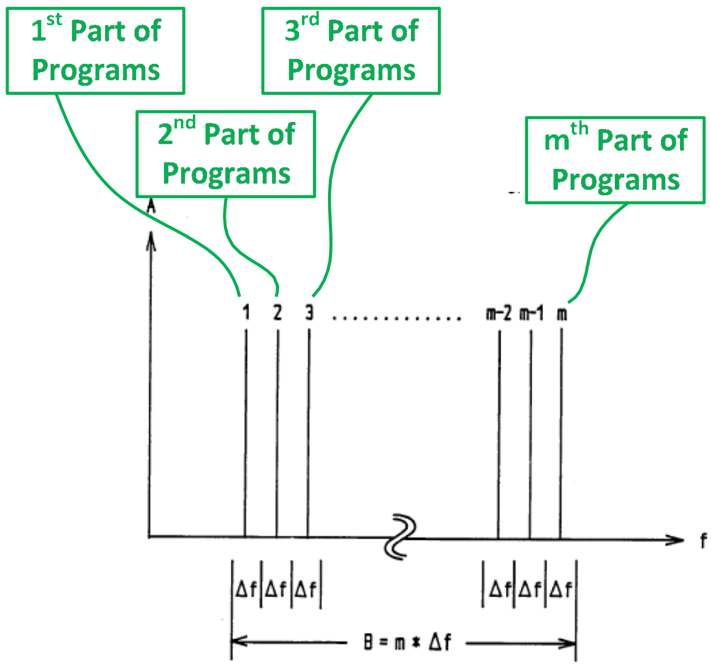
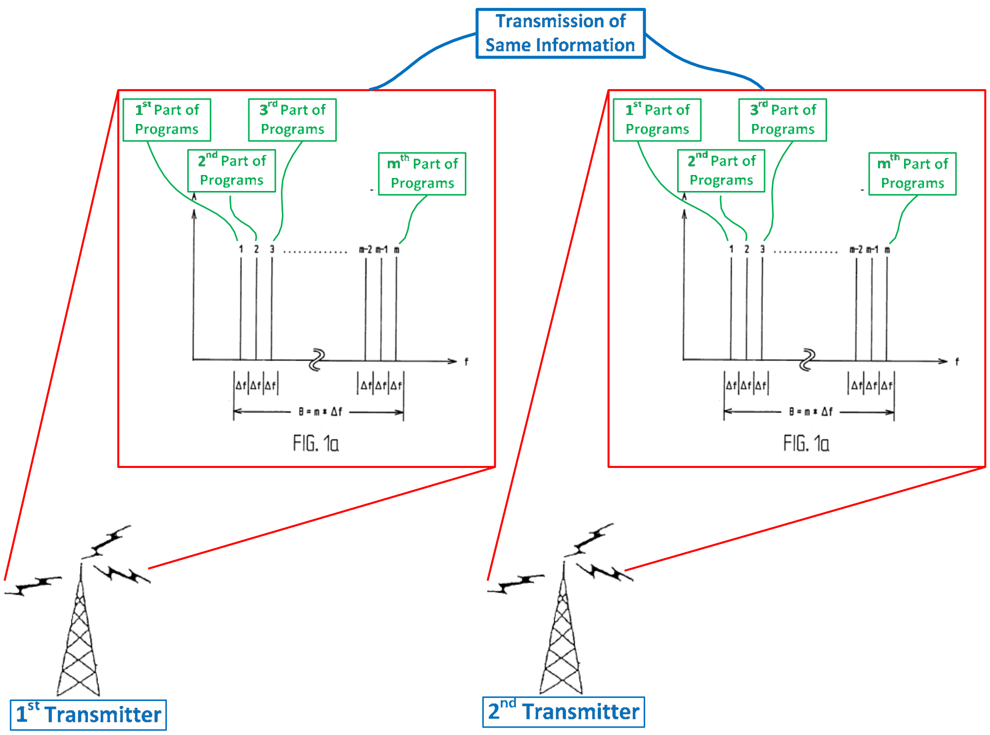


FIG. 1a

27. Moreover, Saalfrank describes that "the modulation content of the individual carries [sic] [is] identical for all transmitter stations of the transmission region." Ex. SAM1015, col. 2,¶ 9. In other words, each of the plurality of transmitters (i.e., at least a first and a second transmitter) in a region of Saalfrank's system transmits the same set of carrier signals illustrated in the previous annotation of FIG. 1a. Thus, at least a first and a second transmitter in a region of Saalfrank's system transmits carrier signals corresponding to and representing substantially the same information as the carrier signals transmitted by the other transmitters in the same region. Indeed, Saalfrank teaches that, "[i]n order to ensure a flawless common-wave operation within a transmission region it is mandatory that all carrier frequencies used for transmitting programs or

data are impinged with respectively identical modulation content." Ex. SAM1015, col. 3, ¶ 3. Moreover, Saalfrank describes that a "network" of transmitters installed within each region. *See* Ex. SAM1015, col. 2, ¶ 1. Such a "network" of transmitters is necessarily spatially separated throughout the region to the provide proper coverage contemplated by Saalfrank. *See, e.g.*, Ex. SAM1015, FIG. 2, 7:40-53. The following diagram based on FIG. 1a illustrates these points.



28. Though Saalfrank does not include a system diagram illustrating the transmitters used in its broadcasting system, one of ordinary skill in the art would have readily identified relevant structures (transmitters) from Saalfrank's description. The structure described by Saalfrank is the same as the structure used to depict transmitters in FIG. 13 of the '210 patent. In particular, one of ordinary skill in the art would have understood Saalfrank to describe a data input, control logic, a plurality of modulators, a combiner, a power amplifier, and an antenna, as detailed below.

29. With regard to data input, Saalfrank contemplates "approx. 5…6 stereo programs [that] can be broadcasted (in addition to data related to or independent from said programs)." Ex. SAM1015, col. 1, ¶ 4. The stereo programs and additional data are data input to Saalfrank's transmitters.

30. Each of Saalfrank's transmitter stations includes control logic. In particular, Saalfrank transmitters utilize "DPSK-modulation (DPSK – Differential Phase Shift Keying)." Ex. SAM1015, col. 1, ¶ 4. This modulation technique includes "scrambling the digital program data within the sequence and the allocation to individual carrier frequencies." Ex. SAM1015, col. 1, ¶ 4. One of ordinary skill in the art at the time of the '210 patent filing would readily have appreciated that such phase shifting and data scrambling rely upon control logic.

31. As described by Saalfrank, each of the transmitter stations includes more than one modulator to simultaneously modulate the plurality of carriers. In particular, Saalfrank describes that "[t]he individual carriers <u>are each modulated</u> with one part of the digital data, with the modulation content of the individual carries [sic] being identical for all transmitter stations of the transmission region." Ex. SAM1015, col. 2, ¶ 9. Moreover, Saalfrank describes that certain disadvantages of adding carrier frequencies "can be avoided when one or more of these additional carriers are modulated with a particular identification signal." Ex. SAM1015, col. 3, ¶ 5. Through these descriptions, Saalfrank reveals that its transmitters individually modulate the carrier signals, which requires multiple modulators.

32. One of ordinary skill in the art would have understood that in order to transmit multiple modulated carriers (e.g., 448 carrier signals contemplated by Saalfrank), each of the several modulated carrier frequencies would have been combined by Saalfrank into a single output signal. *See* Ex. SAM1015, col. 1, ¶ 4; *see also* Ex. SAM1020, FIG. 5A.

33. In order to have employed Saalfrank for its stated purpose of creating a transmission network, one of ordinary skill would have readily appreciated the need for a power amplifier in Saalfrank's transmitter to amplify the combined signal before it is emitted by the antenna. To this point, one goal of Saalfrank's stated goals for the radio network is to cover "several states." *See* Ex. SAM1015, col. 1, ¶ 6. In order to transmit to such a large geographic area, a power amplifier is necessary at each transmitter station. *See, e.g.*, Ex. SAM1020, FIG. 5A.

34. Finally, one of ordinary skill in the art would have understood that an antenna transmits signals wirelessly. *See, e.g.*, Ex. SAM1020, FIG. 5A. Thus, when Saalfrank describes "wireless transmission" (*see* Ex. SAM1015, col. 4, claim 1), one of ordinary skill in the art would understand the transmitter performing the transmission to include an antenna. In fact, Saalfrank notes the use of antennas in the mobile receivers of digital radio transmission systems. *See* Ex. SAM1015, col. 1, ¶ 2. The transmitter stations in such a digital radio transmission system would necessarily use corresponding antennas. *See, e.g.*, Ex. SAM1020, FIG. 5A.

B. Combination of Saalfrank and Nakamura

35. As described above, Saalfrank does not feature a system diagram illustrating the transmitters used in its broadcasting system. Nonetheless, the transmitters described by Saalfrank are the same as the transmitters shown in FIG. 13 of the '210 patent. Moreover, even if Saalfrank did not describe a transmitter like the one shown in either of FIGS. 13 or 14 of the '210 patent, which it does, common-wave transmitters like those illustrated in FIGS. 13 and 14 of the '210 patent were well known in the art at the time of filing. For example, Nakamura describes one example of a common-wave transmitter that is the same as the transmitters illustrated in FIG. 14 of the '210 patent. It would have been obvious to implement the broadcast system and method

described by Saalfrank using any multicarrier transmitter capable of the described transmissions. One such multicarrier transmitter is described by Nakamura.

36. In particular, Saalfrank does not require a particular type of transmitter to implement its described common-wave transmission system. Notably, Saalfrank focuses its description of the transmitters used in its common-wave system on the function of those transmitters (e.g., "individual carriers . . . [being] impinged with a 4-DPSK-modulation") and not on their structure. *See generally* Ex. SAM1015, col. 1, ¶¶ 4-6. From this, one of ordinary skill in the art would have understood that any transmitter capable of performing the functions described by Saalfrank would be compatible with Saalfrank's common-wave transmission network.

37. The transmitter described by Nakamura is capable of transmitting, with a plurality of carrier signals, an amount of data that is comparable to the amount transmitted by Saalfrank's transmitters. As such, Nakamura's transmitter is an example of a particular type of transmitter that one of ordinary skill in the art would have employed in Saalfrank's common-wave transmission network.

38. In particular, Saalfrank describes transmitting its 5 to 6 stereo radio programs by modulating 448 carrier signals using 4-DPSK-modulation. *See* Ex. SAM1015, col. 1, ¶ 4. However, Saalfrank does not describe a specific duration for transmitting each modulated data symbol (i.e., symbol rate). Therefore, determining the throughput required of a transmitter to broadcast "5…6 nationwide programs additionally 6 to 18 local programs," as proposed by Saalfrank, is not a straightforward calculation based only on the disclosure of Saalfrank. *See* Ex. SAM1015, col. 2, ¶ 1.

39. However, Le Floch, a paper from which Saalfrank largely draws its description for the operation of its transmitters and capability of its common-wave system (*see* Ex.

SAM1015, col. 1, ¶ 5), describes transmitters in a very similar configuration (i.e., COFDM using 4-DPSK- modulation to transmit radio programs). *See* Ex. SAM1018, p. 10, §8.1. Le Floch describes a system capable of transmitting "16 stereophonic programmes, each with a rate of 336 kbit/s." Ex. SAM1018, p. 10, § 8.1. In other words, 16 stereophonic programs require a total throughput of 5.376 Mbit/s. Accordingly, a transmitter in Saalfrank's system would ideally be capable of transmitting at least 5.376 Mbit/s.

40. Nakamura describes a transmitter that modulates 4 carrier signals using 256 Quadrature Amplitude Modulation (QAM). *See* Ex. SAM1019, p. 1, § 2(A). QAM is a modulation technique that relies upon varying both amplitude and phase. *See, e.g.*, Ex. SAM1021, 1:17 to 2:40. Nakamura describes a 256 QAM transmitter that is capable of transmitting at up to 400 Mbit/s. *See* Ex. SAM1019, Abstract. This throughput is much greater than the 5.376 Mbit/s to transmit 16 stereophonic programs, leaving plenty of bandwidth for addition programs and control signals. Therefore, though the transmitter described by Nakamura relies upon a more complex form a modulation (i.e., 256-QAM vs. 4-DPSK), Nakamura's transmitter would be capable of transmitting at least the amount of data to that described as being transmitted by Saalfrank's transmitters.

41. Notably, the transmitter described by Nakamura is the same as the transmitter illustrated in FIG. 14 of the '210 patent. Below is an annotated version of Nakamura's transmitter presented and annotated to enable a visual comparison with the transmitter illustrated in FIG. 14 to emphasize the similarity.

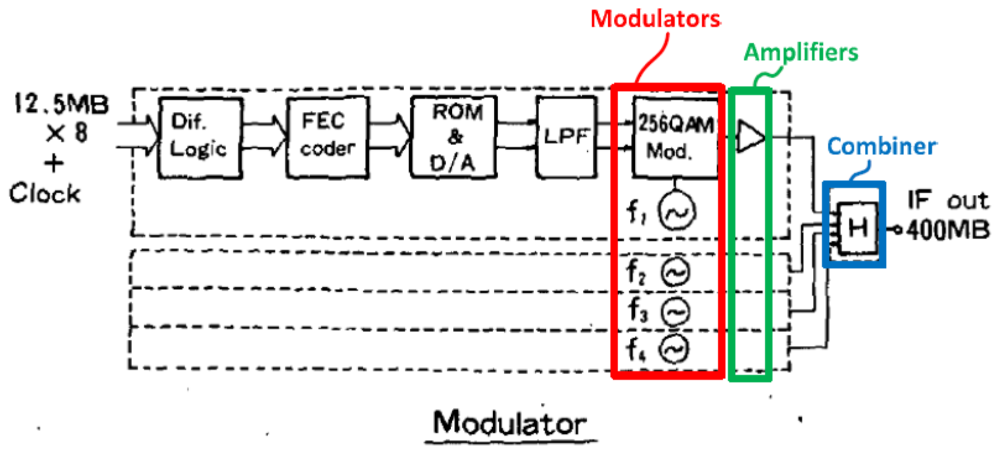
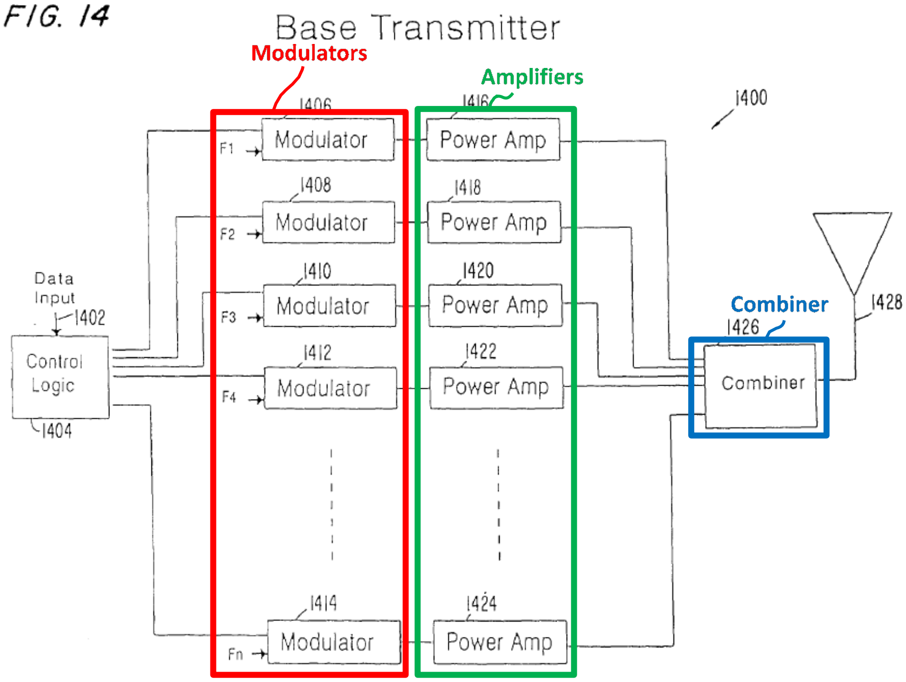


FIG. 14



42. Though FIG. 1 of Nakamura doesn't overtly reflect control logic or an antenna, one of ordinary skill in the art would have readily appreciated the existence of each contextually and from reading Nakamura's written description. For example, Nakarmua describes the use of various control signals, which would necessarily be issued by some form of control logic. *See,*

e.g., Ex. SAM1019, p. 331, § III(B)(1) (describing a "VCO control signal" and a "VCXO control signal"). Nakamura also discloses that the modulator outputs an "IF out" signal at 400 Mbps. *See* Ex. SAM1019, FIG. 1. IF stands for "Intermediate Frequency" (a common acronym for those of ordinary skill). A person of ordinary skill in the art would understand that since Nakamura also describes that its modem is for use in a "digital microwave radio system" (*see* Ex. SAM1019, Abstract), the IF out signal would be up-converted to a Radio Frequency (RF) signal which necessarily relies upon an antenna for transmission. *See, e.g.*, Ex. SAM1020, FIG. 5A (showing a QAM transmitter connected to an antenna), 1:43-45. Therefore, Nakamura necessarily relies on having an antenna in order to transmit the radio signals. *See id.* Therefore, the multicarrier modem described by Nakamura includes all of the elements arranged in the manner shown in FIG. 14 of the '210 patent. Moreover, to the extent that Nakamura were not found to disclose control logic or an antenna, it would have been obvious to one of ordinary skill in the art to include these elements in Nakamura's transmitter, as they were commonly found in similar transmitters. *See id.*

43. One of ordinary skill in the art would have understood that the transmitter described by Narakmura could be used in the system and method described by Saalfrank without substantial alteration of either Saalfrank's overall common-wave transmission system or Nakamura's transmitter. In particular, a person of ordinary skill in the art would have distributed a plurality of Nakamura's transmitters in the regional configuration described by Saalfrank and input the "5…6 nationwide programs" and "6 to 18 local programs" to these transmitters for transmission to the vehicles described by Saalfrank. *See* Ex. SAM1015, col. 2, ¶¶ 1-2. The consistent input of these programs to Nakamura's transmitters, as provided for by Saalfrank's system (*see* Ex. SAM1015, col. 2, ¶ 2), would facilitate the simultaneous emission of the radio

programs necessary for common-wave broadcast. In order to demodulate these transmitted signals, one of ordinary skill in the art would have installed corresponding 256-QAM demodulators, which are described by Nakamura (*see* Ex. SAM1019, FIG. 1 "Demodulator"), in the receivers of Saalfrank's vehicles.

44. Employed in the common-wave transmission system described by Saalfrank, a person of ordinary skill in the art would have configured a plurality of Nakamura's transmitters to perform the functions described by Saalfrank. A person of ordinary skill would have been motivated to use the transmitter described by Nakamura, because Nakamura's transmitter provides, among other things, "good phase jitter performance and no false lock phenomenon," and provides more than enough throughput to handle the radio programs described by Saalfrank. Ex. SAM1019, Abstract.

III. Conclusion

45. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: August 7, 2015 Signature: ____________________

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AREAS OF EXPERTISE

All aspects of fixed and mobile communications. Over the years, my emphasis has been both in breadth and in depth, originally in fixed communications networks and then in mobile communications. Specific areas of in-depth expertise include:

- LTE/LTE-Advanced and evolution issues of 3G to 4G and beyond
- UMTS, including FDD, TDD, HSDPA/HSUPA, HSPA+, both air interface (UTRA) and core networking issues
- cdma2000 family from IS-95, through its evolution to 1x, 3x, 1xEV-DO (HDR), 1xED-DV (all aspects of the evolution to "3G" and beyond)
- Wireless Local Area Networks (LAN), Metropolitan Area Networks (MAN), and Personal Area Networks (PAN) technologies, Paging networks, Ad hoc networks, including IEEE 802.11 (WiFi), IEEE 802.16 (WiMAX), HIPERLAN, Bluetooth, Near Field Communications, IrDA (Infrared Data Association) operating with any of the available access technologies
- GSM, GPRS, EDGE (EGPRS) and related evolutionary issues
- North American TDMA and IS-136
- TETRA
- iDEN™
- Core Network technologies, IS-41, SS7, ATM, MAP, etc.
- Voice over IP (VoIP)
- Design and implementation of voice and data networking (circuit switching as well as all the evolving all IP-based technologies)
- Traffic engineering and network design; both air interface aspects (including resource allocation, QoS, MAC protocol, etc.) and design of core network, both user plane and control plane

EMPLOYMENT HISTORY

9/88 – Present
Cosmos Communications Consulting Corporation. Founder and president of private communications engineering consulting firm specializing in mobile communications. Initially part time; full time since 1994.

- Developed and presented courses, seminars, and lectures on fixed and mobile communications to both corporate and government entities, such as the FCC and the US Marshal's Office.
- Consulted on high level technology-related issues and trends, pros and cons of each, etc. to corporate entities, governmental agencies, and international organizations, such as the UN.

- Consulted at the detailed technical level to engineering firms, operators, and equipment vendors on technical issues related to existing or evolving technologies for mobile communications.
- Served as technology consultant to the investment community both fixed and wireless communications technologies.
- Served as consultant and expert witness on both civil and criminal legal cases, including a class action lawsuit brought in California, a murder case in Illinois, and several patent infringement cases both at the ITC and in district court.
- Participated as a technical consultant in the analysis of large patent portfolios for the purposes of due diligence, sales, and/or M/A activities for some of the largest companies in the mobile communications space.

These projects spanned a multidimensional spectrum of
- Technologies: both fixed and mobile communications as they have evolved over the past 30+ years;
- Audiences: non-technical support personnel, highly specialized engineers, Wall Street analysts, hedge fund managers, litigation teams, as well as decision making executives at the CEO/CFO/CTO level;
- Geographic and cultural backgrounds that span all continents and over 40 countries.

9/87 - 5/94
The George Washington University, Washington, D.C. Department of Electrical Engineering and Computer Science.
- Taught mostly graduate courses in the area of communication engineering, including communication theory, coding theory, voice and data networking, and mobile communications.
- Proposed, developed and taught new graduate courses in the area of mobile communications.
- Received several research awards/grants, including the prestigious NSF Research Initiation Award.
- Participated in several committees, including the departmental Graduate Curriculum Committee as well as various University-wide committees.

7/85 - 12/86
Polytechnic Institute of New York, Brooklyn, New York. Joint appointment as Special Research Fellow and Adjunct Instructor (while pursuing the Ph.D. degree)

1/82 - 7/87
AT&T Bell Laboratories, Holmdel, New Jersey. Worked on modeling, analysis, design, and performance evaluation of voice and data networks. Developed algorithms for DNHR (Dynamic, Non-Hierarchical Routing) used in the telephone network. Analysis of advanced data services and formulation of long term plans for development of enhanced data services and network design tools to support such services.

7/76 - 12/81
University of Colorado, Boulder, Colorado and Michigan State University, East Lansing, Michigan. Undergraduate and then graduate teaching assistant.

EDUCATION

09/82 - 01/88
Polytechnic Institute of New York. Ph.D. in Electrical Engineering.
Thesis Title: Topological Properties and Design of Multihop Packet Radio Networks.
Thesis Advisor: Professor Robert R. Boorstyn.

09/74 - 06/80
University of Colorado.
M.S. in Applied Mathematics with a minor in Electrical Engineering.
B.S. in Applied Mathematics with a minor in Electrical Engineering.

PROFESSIONAL ASSOCIATIONS AND ACTIVITIES

- Member of the IEEE (Active in the Communications Society and the Information Theory Society).
- Secretary, IEEE Communications Society National Capital Area Chapter, 91/92.
- Vice-Chair, IEEE Communications Society National Capital Area Chapter, 92/93.
- Vice-Chair of the Communication Theory Technical Committee of the Communications Society of the IEEE; Elected for the 1993-1996 term.
- Treasurer of the Communication Theory Technical Committee of the Communications Society of the IEEE, Elected for the 1996-1999 term.
- Reviewer for the IEEE, book editors, and other technical publications.
- Reviewer for various NSF Panels.
- Active Participant and Organizer of Technical Sessions in Technical Conferences, including the IEEE International Conference on Communications (ICC) and IEEE Global Communications Conference (Globecom).
- Technical Program Chair for the Communication Theory Mini-Conference, Dec. 1992.

PUBLICATIONS AND PRESENTATIONS

1. "Topological Properties and Design of Multi-Hop Packet Radio Networks"; Presented at the IEEE Information Theory Society Meeting; Arlington, Virginia; February 1988.
2. "Topology and Capacity of Multi-Hop Packet Radio Networks" (Joint with R.R. Boorstyn); 1988 International Symposium on Information Theory; Kobe, Japan; June 1988.
3. "Placing Repeaters in Multi-Hop Packet Radio Networks" (Joint with R.R. Boorstyn); *Proceeding of Globecom* '89, Dallas, Texas; November 1989.
4. "Topological Properties and Design of Packet Radio Networks"; Invited Presentation at the National Technical University of Athens; Athens, Greece; January 10, 1990.
5. "Channel Allocation Strategies in Dual Mode Digital Cellular Networks"; *Proceedings of Globecom* '90, San Diego, California; December 1990.
6. "Bandwidth Allocation Techniques in Dual Mode Cellular Systems"; Invited Presentation at the Rutgers University Wireless Information Networks Laboratory (WINLAB); January 25, 1991.

7. “Some Topological Properties of Different Classes of Random Applications to Communication Networks”, *Proceedings of the IEEE Information Theory Symposium*, Budapest, Hungary; June 1991.
8. “The Effects of Residual Bandwidth in TDMA Cellular Networks”, IEEE Communication Theory Workshop, Rhodes, Greece, July 1991.
9. “Concentrators and Concentrator Design”, *Encyclopedia of Telecommunications*, Fritz E. Froehlich, Editor-in-chief; Marcel Dekker, Inc, 1992.
10. “Comparison of TDMA and CDMA for Cellular Networks,” Ecole Nationale Superieure des Telecommunications, Paris, France, March 5, 1992.
11. “Dual Mode Digital Cellular Networks: The Effects of Bandwidth Segmentation on Digital and Analog Users,” Presented at the IEEE Communications Society Meeting, April 16, 1992.
12. “Dynamic Channel Allocation and Reallocation for Dual-System Cellular Networks, *Workshop Record*, (with Sirin Tekinay and Bijan Jabbari), Third Winlab Workshop on Third Generation Wireless Information Networks, Piscataway, NJ, April 28-29, 1992.
13. “Spread Spectrum Technology Applications in Telecommunications,” Tutorial presented at the 1992 IEEE Mohawk Valley Section Conference, June 1992.
14. “Spread Spectrum Fundamentals: Techniques and Applications”, Tutorial (in cooperation with Giovanni Vannucci) presented at ICC’92, June 1992.
15. “Global System for Mobile Communications (GSM)”, Presented at ICC’93, Geneva, Switzerland, May 25, 1993.
16. “Data Communications Basics”, *Encyclopedia of Software Engineering*”, John Wiley & Sons, Inc., 1993.
17. “Modelling of Cellular Communication Networks with Heterogeneous Traffic Sources” (with Sirin Tekinay and Bijan Jabbari), *Proceedings of the International Conference on Universal Personal Communications*, 1993, October 1993.
18. “Global System for Mobile Communications (GSM)”, Presented at the Francusko-Polska Wysza Szkowa, Poznan, Poland, March 1994.
19. “Traffic Engineering for Cellular Network Design”, Presented at the Francusko-Polska Wysza Szkowa, Poznan, Poland, March 1994.
20. “Principles of Traffic Engineering and Network Design”, Presented at the Regional Seminar on Mobile Cellular Radio Telephone Systems, by invitation of the ITU, April 19, 1994.
21. “Principles of Spread Spectrum Systems for Mobile Communications”, Presented at the Regional Seminar on Mobile Cellular Radio Telephone Systems, by invitation of the ITU, April 20, 1994.
22. “Global System for Mobile Communications (GSM)”, Presented at the Regional Seminar on Mobile Cellular Radio Telephone Systems, by invitation of the ITU, April 21, 1994.
23. “Global System for Mobile Communications (GSM)”, Presented at ICC’94, New Orleans, LA.; May 1, 1994.
24. “GSM and DCS1900: Evolution to PCS”, ICC/Supercom 1996, Dallas, Texas; June 23-27, 1996.
25. “Traffic Engineering Models for Mobile Communications”, ICUPC96, Cambridge, Massachusetts; Sept. 29 - October 2, 1996.

26. “GSM-Recent Advances and Future Developments”, Globecom ‘96, London, UK; November 1996.
27. “Advances in GSM and DCS1800/1900”, ICC ‘97, Montreal, Canada; June 1997.
28. “The Global System for Mobile Communications (GSM) and i (DCS1800, PCS1900)”, ICC/Supercom ‘98, Atlanta, GA; June 1998.
29. “Teletraffic Engineering”, Globecom ‘98, Sydney, Australia; November 1998.
30. “Traffic Engineering” in Encyclopedia of Telecommunications, Edited by John Proakis, John Wiley, 2002.