

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AT&T CORP., AT&T SERVICES, INC., AT&T MOBILITY LLC, AND AT&T
MOBILITY II LLC
Petitioners,

v.

DALI WIRELESS, LLC
Patent Owner.

U.S. Patent No. 8,682,338

Title: REMOTELY RECONFIGURABLE DISTRIBUTED ANTENNA SYSTEM
AND METHODS

Inter Partes Review No.: IPR2023-00646

DECLARATION OF HENRY HOUH, PH.D. IN SUPPORT OF PETITION
FOR INTER PARTES REVIEW OF
U.S. PATENT NO 8,682,338.

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I, Henry Houh, declare as follows:

I. INTRODUCTION

1. I am over the age of eighteen (18) and otherwise competent to make this Declaration.

2. I have been retained by AT&T Corp. et. al (Petitioners) as an independent, technical expert consultant in this proceeding before the United States Patent and Trademark Office (USPTO). I am being compensated at my rate of \$680 per hour for my services. No part of my compensation is dependent on my opinions or on the outcome of this proceeding. I have no financial interest in any of the parties to this proceeding.

3. This Declaration is in support of the Petition for *inter partes* review involving U.S. Patent 8,682,338 (the “’338 Patent” or “the Patent”) (EX-1001), entitled “Remotely Reconfigurable Distributed Antenna System and Methods” and listing Paul Lemson, Shawn Stapleton, Sasa Trajkovic, and Albert Lee as the inventors.

4. For the purposes of this *inter partes* review as I discuss later, I have been instructed to assume that the effective filing date of the Claims of the ’338 Patent challenged by the Petitioner in this *inter partes* review is no earlier than September 14, 2010.

5. I understand that, according to USPTO records, the '338 Patent is currently assigned to Dali Wireless, Inc. ("Dali Wireless" or "Patent Owner"). I assume for purposes of this proceeding that Dali Wireless is the patent owner.

6. The '338 Patent is generally directed to wireless communication systems employing Distributed Antenna Systems (DAS). I am familiar with the technology described in the '338 Patent as of the earliest possible priority date of September 14, 2010, the filing date of Provisional Application No. 61/382,836.

7. In preparing this Declaration, I have reviewed the '338 Patent (EX-1001) and its prosecution history (EX-1002), as well as the patents and documents cited herein, and I have considered these documents in light of the general knowledge in the art as of September 14, 2010. In formulating my opinions, I have relied upon my experience in the relevant art. I have also considered the viewpoint of a person of ordinary skill in the art ("POSA") in the relevant field, as of September 14, 2010, who I describe below (§ IV.D). For convenience, the materials I considered in arriving at my opinions are listed in Appendix A.

8. I have been asked to provide my technical expertise, analysis, insights and opinions regarding the '338 Patent and relevant references that

form the basis of the arguments set forth in the accompanying Petition for *inter partes* review of the '338 Patent. As described in detail below, I offer the following opinions in this Declaration:

- A POSA would have found Claim 1-3 of the '338 Patent to be obvious over *Leng* in view of *Cannon* and a POSA would have been motivated to combine the teachings of these references.
- A POSA would have found Claim 1-3 of the '338 Patent to be obvious over *Leng* in view of *Cannon* and further in view of *Gupta* and a POSA would have been motivated to combine the teachings of these references.

9. Unless otherwise indicated, the emphasis in quotations has been added.

II. QUALIFICATIONS

10. My qualifications for forming the opinions set forth in this declaration are summarized here and explained in more detail in my *curriculum vitae*, which is included as Appendix B. Appendix B also includes a list of my publications and patents.

11. I received a Ph.D. in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology ("MIT") in 1998. I also received a Master of Science degree in Electrical Engineering and

Computer Science in 1991, a Bachelor of Science degree in Electrical Engineering and Computer Science in 1989, and a Bachelor of Science Degree in Physics in 1990, all from MIT.

12. For the last 13 years I have been self-employed as an independent technical consultant which specializes in, among other things, in Web Site Development, Data Networking, Optical Networking, Telecommunications, and Media Streaming. My clients include almost every major law firm in the country.

13. My Career in the area of telecommunications began 1987 when I worked at AT&T Bell Laboratories as part of a five-year dual degree program at MIT. Later, as part of my doctoral research at MIT from 1991-1998, I was a research assistant in the Telemedia Network Systems (TNS) group at the Laboratory for Computer Science. The TNS group built a high-speed gigabit network and created applications that ran over the network. Example applications included ones for remote video capture, processing, and display of video on computer terminals. In addition to working on the design of core network components, designing and building the high speed links, and designing and writing the device drivers for the interface cards, I also set up the group's web server. Furthermore, because our group focused on real-time software processing of live

streamed data, some members of our group focused on research in software radios, which was thus commonly discussed in meetings and casual conversations. One of my labmates, Vanu Bose, went on to found Vanu, Inc., a software radio company focused on low cost base stations for rural cell carriers. Several members of our group joined Vanu's company and I continued to meet with Vanu and members of his company. Thus, I became aware of the architectures around software radios starting in the late 1990's.

14. I defended and submitted my Ph.D. thesis, titled "Designing Networks for Tomorrow's Traffic," in January 1998. As part of my thesis research, I analyzed local-area and wide-area flows to show a more efficient method for routing packets in a network, based on traffic patterns at the time.

15. From 1997 to 1999, I was a Senior Scientist and Engineer at NBX Corporation, a start-up that made business telephone systems for streaming packetized audio over data networks instead of using traditional telephone lines. NBX was later acquired by 3Com Corporation, and the phone system is still used today by numerous businesses. As part of my work at NBX, I designed the core audio reconstruction algorithms for the telephones, as well as the packet transmission algorithms. I also designed

and validated the core packet transport protocol used by the phone system. The protocol was used for all signaling in the phone system, including for the setup of conference calls. The NBX system also featured a computer interface for initiating phone calls, which could also initiate conference calls. The NBX system also supported TAPI, the Telephony Application Programming Interface, thus allowing other computer programs to integrate with our system telephony features. We obtained U.S. Patent No. 6,697,963, entitled “Telecommunication method for ensuring on-time delivery of packets containing time-sensitive data,” as a result of part of this work.

16. From 1999-2004, I was employed by Empirix or its predecessor company, Teradyne. Empirix was a leader in test tools for telecommunications protocols and systems, providing functional testing tools as well as load testing tools. From 2000-2001, I conceived and built a test platform for testing Voice- over-IP (VoIP). The first application on this new test platform was a cloud emulator for simulating the effects of transmitting VoIP over a busy network.

17. In 2006, as part of my role at BBN Technologies, I helped found PodZinger Inc., now known as RAMP Inc. PodZinger utilized BBN’s speech recognition algorithms to search through the spoken words

in audio and video segments. While I was Vice President of Operations and Technology, PodZinger followed its initial prototype with a full streaming audio and video search solution.

18. Furthermore, I have served as expert witness in over 140 patent-related cases where I wrote expert reports and testified in over 80 depositions on topics such as network communications and telecommunications, including Internet protocols, streaming media, and mobile wireless technologies. I have testified in Federal courts, the PTAB, and the ITC on behalf of leading companies such as Amazon, AT&T, Cisco Systems, Google, Microsoft, Comcast, Time Warner Cable, Samsung, and Apple.

19. I have been awarded several United States patents, including the following examples:

U.S. Pat. No.	Title
7,975,296	Automated security threat testing of web pages
7,877,736	Computer language interpretation and optimization for server testing
7,801,910	Method and apparatus for timed tagging of media content
7,590,542	Method of Generating Test Scripts Using a Voice-Capable Markup Language
7,860,999	Distributed computation in network devices
6,967,963	Telecommunication method for ensuring on-time delivery of packets containing time-sensitive data

7,359,993	Method and apparatus for interfacing external resources with a network element
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20. Based on my above-described over three decades of experience in network resource allocation and the acceptance of my publications and professional recognition by societies in my field, I believe that I am qualified to be an expert in the field of wireless technology.

21. Based on my experience described above, and as indicated in my *curriculum vitae*, I am qualified to provide the following opinions with respect the patents in this case. Additionally, I am at least a person having ordinary skill in the art as of the priority date of the '338 Patent.

III. RELEVANT LEGAL STANDARDS

22. I do not provide any legal opinions in this Declaration. I have been informed and understand that certain legal standards are to be applied by technical experts in forming opinions regarding the meaning and validity of patent claims. I have been asked to provide my opinions regarding whether the claims of the '338 Patent would have been obvious to a person having ordinary skill in the art at the time of the alleged invention, in light of the prior art.

23. Further, I have been informed and understand that a patent claim is not patentable as obvious (a requirement I understand to be

governed by a statute, 35 U.S.C. § 103) if the differences between the patent claim and the prior art are such that the claimed subject matter as a whole would have been obvious at the time the claimed invention was made to a person having ordinary skill in the relevant art. Obviousness, as I have been informed and understand, is based on the scope and content of the prior art, the differences between the prior art and the claim, the level of ordinary skill in the art, and, to the extent that they exist, certain objective indicia of non-obviousness.

24. I understand that objective indicia can be important evidence regarding whether a patent is obvious or nonobvious, if it has an appropriate nexus to the claimed invention, i.e., is a result of the merits of a claimed invention (rather than the result of design needs or market-pressure advertising or similar activities). Such indicia include: commercial success of products covered by the patent claims; a long-felt need for the invention; failed attempts by others to make the invention; copying of the invention by others in the field; unexpected results achieved by the invention as compared to the closest prior art; praise of the invention by the infringer or others in the field; the taking of licenses under the patent by others; expressions of surprise by experts and those skilled in the art at the making of the invention; the patentee proceeded contrary to

the accepted wisdom of the prior art, and, the contemporaneous development of the subject matter claimed by others.

25. I have been informed that whether there are any relevant differences between the prior art and the claimed invention is to be analyzed from the view of a person of ordinary skill in the relevant art at the time of the invention. As such, my opinions below as to a person of ordinary skill in the art are as of the time of the invention, even if not expressly stated as such; for example, even if stated in the present tense.

26. In analyzing the relevance of the differences between the claimed invention and the prior art, I have been informed that I must consider the impact, if any, of such differences on the obviousness or non-obviousness of the invention as a whole, not merely some portion of it. The person of ordinary skill faced with a problem is able to apply his or her experience and ability to solve the problem and also look to any available prior art to help solve the problem.

27. I have been informed that a precise teaching in the prior art directed to the subject matter of the claimed invention is not needed. I have been informed that one may take into account the inferences and creative steps that a person of ordinary skill in the art would have employed in reviewing the prior art at the time of the invention. For example, if the

claimed invention combined elements known in the prior art and the combination yielded results that were predictable to a person of ordinary skill in the art at the time of the invention, then this evidence would make it more likely that the claim was obvious. On the other hand, if the combination of known elements yielded unexpected or unpredictable results, or if the prior art teaches away from combining the known elements, then this evidence would make it more likely that the claim that successfully combined those elements was not obvious.

28. I have been informed and understand that there are recognized, exemplary, rationales for combining or modifying references to show obviousness of claimed subject matter. Some of the rationales include the following: combining prior art elements according to known methods to yield predictable results; simple substitution of one known element for another to yield predictable results; use of a known technique to improve a similar device (method or product) in the same way; applying a known technique to a known device (method or product) ready for improvement to yield predictable results; choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market

forces if the variations are predictable to one of ordinary skill in the art; and some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art teachings to arrive at the claimed invention.

IV. BACKGROUND

A. Summary of the '338 Patent

29. The '338 Patent is generally directed to wireless communication systems employing Distributed Antenna Systems (DAS) as part of a distributed wireless network in which a base station communicates to mobile devices through an interface, called a Digital Access Unit ("DAU") and remote radio units ("RRU"). EX-1001 1:15-17. The '338 Patent describes several problems associated with prior art DAS implementation. One problem is associated with the deployment of many low-power high-capacity base stations throughout a facility. The quantity of base stations is determined based on the coverage of each base station and the total space to be covered. Each of these base stations is provisioned with enough radio resources, i.e., capacity and broadband data throughput, to accommodate the maximum subscriber loading which occurs during the course of the workday and work week. Although this approach typically yields a high quality of service, the notable disadvantage of this approach

is that during a major part of the time many of the base stations' capacity is being wasted. Since a typical indoor wireless network deployment involves capital and operational costs which are assessed on a per-subscriber basis for each base station, the typically high total life cycle cost for a given enterprise facility is far from optimal. EX-1001 1:47-61.

30. Another problem identified with prior art DAS implementations is associated with a DAS having a centralized group of base stations dedicated to the DAS. If the DAS is a "fixed" system, the system configuration does not change based on time of day or other information about usage. The remote units associated with the DAS are set up during the design process so that a particular block of base station radio resources is thought to be enough to serve each small group of DAS remote units. A notable disadvantage of this approach is that most enterprises seem to undergo frequent re-arrangements and re-organizations of various groups within the enterprise over time. Therefore, it's highly likely that the initial setup will need to be changed from time to time, requiring deployment of additional staff and contract resources with appropriate levels of expertise regarding wireless networks. EX-1001 1:62-2:10.

31. The '338 Patent further explains that if the DAS is equipped with a type of network switch which allows the location and quantity of DAS remote units associated with any particular centralized base station to be changed manually, it frequently requires deployment of additional staff resources for real-time management of the network. Additionally, it is difficult or impractical for an enterprise IT manager to monitor the subscriber loading on each base station. And it is almost certain that the enterprise IT manager has no practical way to determine the loading at a given time of day for each DAS remote unit; they can only guess. EX-1001 2:11-2:26.

32. The '338 Patent describes that a solution to these problems include the capability to reconfigure the amount of radio resources (such as RF carriers, CDMA codes or TDMA time slots) assigned to a particular RRU or group of RRUs can be set via software control. Specifically, the '338 Patent describes the use of software-programmable frequency selective Digital Up-Converters (DUCs) and Digital Down-Converters (DDCs). EX-1001 4:2-11.

33. As illustrated in FIG. 1, a Digital Access Unit ("DAU") serves as an interface to the base station (BTS). The DAU is (at one end)

connected to the BTS, and on the other side connected to multiple Remote Radio Units (“RRU”):

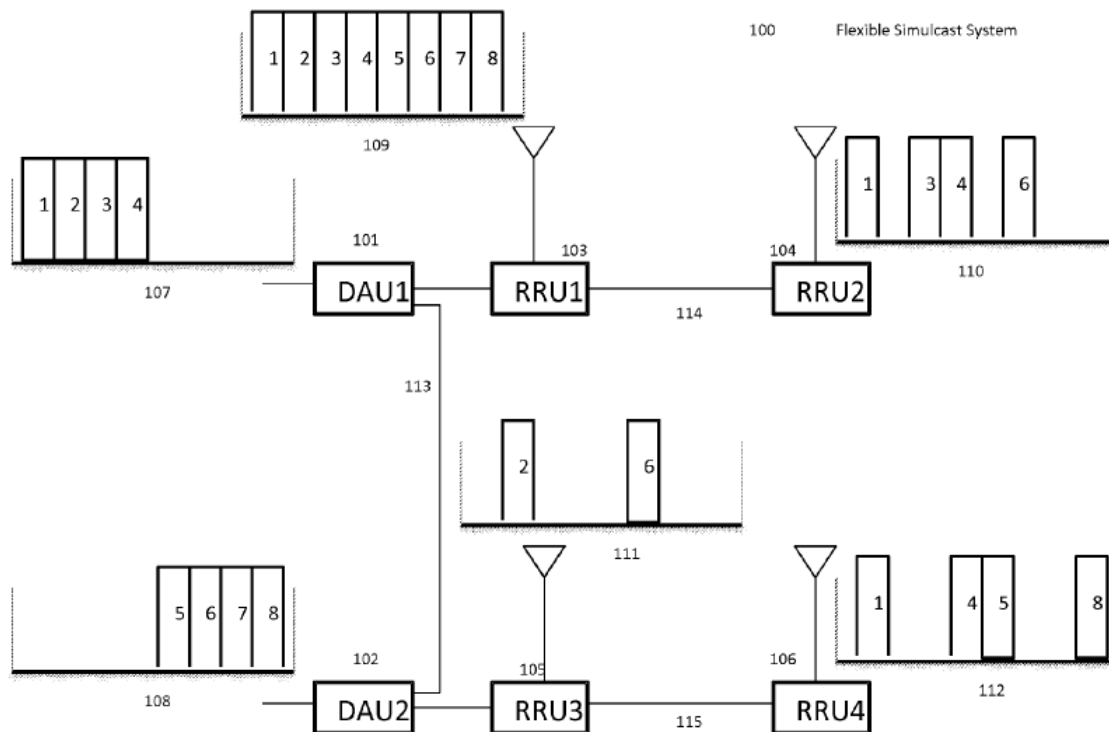


Figure 1: Flexible Simulcast Downlink Example

34. The DAU serves as an interface to the BTS and on the other side connected to multiple RRUs. For the downlink (DL) path, RF signals received from the BTS are separately down-converted, digitized, and converted to baseband (using a Digital Down-Converter). Data streams are then I/Q mapped and framed. Specific parallel data streams are then independently serialized and translated to optical signals and delivered to different RRUs over optical fiber cable. For the uplink (UL) path optical

signals received from RRUs are de-serialized, deframed, and up-converted digitally using a Digital Up-Converter. Data streams are then independently converted to the analog domain and up-converted to the appropriate RF frequency band. The RF signal is then delivered to the BTS. EX-1001 5:62-6:9.

35. In one embodiment shown in FIG. 1, a composite downlink input signal 107 (comprised of Carriers 1-4) from a base station belonging to one wireless operator enters DAU1 101 at the DAU1 RF input port. A second composite downlink input signal 108 (comprised of Carriers 5-8) from a second base station belonging to the same wireless operator enters DAU2 at the DAU2 RF input port. One optical output of DAU1 is fed to RRU1. A second optical output of DAU1 is fed to DAU2. This connection facilitates networking of DAU1 and DAU2, which means that all of Carriers 1-8 are available within DAU1 and DAU2 to transport to RRU1, RRU2, RRU3 and RRU4 depending on software settings within the networked DAU system comprised of DAU1 and DAU2. The software settings within RRU1 are configured either manually or automatically such that Carriers 1-8 are present in the downlink output signal 109 at the antenna port of RRU1. The presence of all 8 carriers means that RRU1 is potentially able to access the full capacity of both base stations feeding

DAU1 and DAU2. The '338 Patent explains that one possible application for RRU1 is in a wireless distribution system is e.g., a cafeteria in an enterprise building during the lunch hour where a large number of wireless subscribers are gathered. RRU2 is fed by a second optical port of RRU1 to RRU2. The software settings within RRU2 are configured either manually or automatically such that Carriers 1, 3, 4 and 6 are present in downlink output signal 110 at the antenna port of RRU2. The capacity of RRU2 is set to a much lower value than RRU1 by virtue of its specific Digital Up Converter settings. The individual Remote Radio Units have integrated frequency selective DUCs and DDCs with gain control for each carrier. The DAUs can remotely turn on and off the individual carriers via the gain control parameters. EX-1001 6:13-51.

36. Likewise, the software settings within RRU3 are configured either manually or automatically such that Carriers 2 and 6 are present in downlink output signal 111 at the antenna port of RRU3. Compared to the downlink signal 110 at the antenna port of RRU2, the capacity of RRU3 which is configured via the software settings of RRU3 is much less than the capacity of RRU2. RRU4 is fed by a second optical port of RRU3 to RRU4. The software settings within RRU4 are configured either manually or automatically such that Carriers 1, 4, 5 and 8 are present in downlink

output signal 112 at the antenna port of RRU4. The capacity of RRU4 is set to a much lower value than RRU1. The relative capacity settings of RRU1, RRU2, RRU3 and RRU4 and can be adjusted dynamically as discussed in connection with FIG. 7 to meet the capacity needs within the coverage zones determined by the physical positions of antennas connected to RRU1, RRU2, RRU3 and RRU4 respectively. EX-1001 6:52-7:4.

37. Referring next to FIG. 7, the DAU embedded software control module and RRU embedded software control module determine and/or set the appropriate amount of radio resources (such as RF carriers, CDMA codes or TDMA time slots) assigned to a particular RRU or group of RRUs to meet desired capacity and throughput objectives. The DAU embedded software control module comprises a DAU Monitoring module that detects which carriers and corresponding time slots are active for each RRU. The DAU embedded software control module also comprises a DAU Management Control module which communicates with the RRU over a fiber optic link control channel via a control protocol with the RRU Management Control module. In turn, the RRU Management Control module sets the individual parameters of all the RRU Digital Up-Converters to enable or disable specific radio resources from being transmitted by a particular RRU or group of RRUs, and also sets the

individual parameters of all the RRU Digital Down-Converters to enable or disable specific uplink radio resources from being processed by a particular RRU or group of RRUs. EX-1001 11:18-11:39.

38. In an embodiment, the '338 Patent describes an algorithm operating within the DAU Monitoring module, that detects which carriers and corresponding time slots for each carrier are active for each RRU, provides information to the DAU Management Control module to help identify when, e.g., a particular downlink carrier is loaded by a percentage greater than a predetermined threshold whose value is communicated to the DAU Management Control module by the DAU's Remote Monitoring and Control function. If that occurs, the DAU Management Control module adaptively modifies the system configuration to slowly begin to deploy additional radio resources (such as RF carriers, CDMA codes or TDMA time slots) for use by a particular RRU which need those radio resources within its coverage area. At the same time, in at least some embodiments the DAU Management Control module adaptively modifies the system configuration to slowly begin to remove certain radio resources (such as RF carriers, CDMA codes or TDMA time slots) for use by a particular RRU which no longer needs those radio resources within its coverage area. EX-1001 11:40-58.

39. The original application issued with 12 claims with claims.

Independent claim 1 is directed to the embodiment of reconfiguring a remote radio unit based on the loading of the remote radio unit. Claim 1 recites:

1. A method for routing and switching RF signals comprising:
 - providing one or more remote radio units, each remote radio unit configured to transmit one or more downlink RF signals and to receive one or more uplink RF signals;
 - providing at least one digital access unit configured to communicate with the one or more remote radio units; translating the uplink and downlink signals between RF and base band as appropriate;
 - packetizing the uplink and downlink base band signals, wherein the packetized signals correspond to a plurality of carriers;
 - configuring each remote radio unit to receive or transmit a respective subset of the plurality of carriers, each respective subset of the plurality of carriers including a number of carriers;
 - reconfiguring each remote radio unit by:
 - determining a load percentage for each remote radio unit; and
 - increasing or decreasing the number of carriers in the respective subset of the plurality of carriers based on the load percentage; and
 - routing and switching the packetized signals among the one or more remote radio units via the at least one digital access unit according to a result of the reconfiguring.

B. Claim Construction

40. The claims should be given “their ordinary and customary meaning” as understood by a person of ordinary skill at the time of the claimed invention. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312, 1327 (Fed. Cir. 2005).

41. I understand that Petitioner proposes that each claim term in the Challenged Claims be given its plain and ordinary meaning in this proceeding, and that no specific construction of any claim term is required because the prior art relied on in this Petition meets each of the claim terms under any reasonable construction.

42. I understand, the Board in the 466 IPR proceeding construed the term “reconfiguring each remote radio unit” to be “changing the configuration of each remote unit,” which is consistent with the plain and ordinary meaning of the term.

C. Priority Date of the Challenged Claims

43. The ’338 Patent claims the benefit of U.S. Patent Application Ser. No. 61/382,836, filed on September 14, 2010. Solely for the purposes of this IPR, I have been instructed to assume the priority date is September 14, 2010.

D. Person of Ordinary Skill in the Art

44. With respect to the '338 Patent, a POSA in September 2010 would have been familiar with reconfiguring remote radio units in a DAS. A POSA would have gained knowledge of these concepts through a mixture of training and work experience, such as by having a Bachelor's degree in electrical engineering and four years of experience; or by obtaining a Master's degree in electrical engineering, but having only one to two years of experience; or by having no formal education but experience in cellular communications of at least eight years.

E. State of the Art

45. The following section describes the state of the art for power control for cellular systems as of September 2010. The prior art references, and the discussions of what was known to a POSA, provide the factual support for the general description of the state of the art at the time of the invention, provide additional motivation to modify or combine the references. Accordingly, these references should be considered by the Board.

1. Prior Art DAS

46. A Distributed Antenna System (DAS) is a network of spatially separated antenna nodes connected to a common node via a transport medium that provides wireless service within a geographic area or

structure. Common wireless communication system configurations employ a host unit as the common node, which is located at a centralized location (for example, at a facility that is controlled by a wireless service provider). The antenna nodes and related broadcasting and receiving equipment, located at a location that is remote from the host unit (for example, at a facility or site that is not controlled by the wireless service provider), are also referred to as "remote units." Radio frequency (RF) signals are communicated between the host unit and one or more remote units. In such a DAS, the host unit is typically communicatively coupled to one or more base stations (for example, via wired connection or via wireless connection) which allow bidirectional communications between wireless subscriber units within the DAS service area and communication networks such as, but not limited to, cellular phone networks, the public switch telephone network (PSTN) and the Internet. A DAS can provide, by its nature, an infrastructure within a community that can scatter remote units across a geographic area for providing wireless services across that area.

EX-1006 1:14-36.

2. Reconfiguring remote radio units based on loading

47. One such prior art DAS systems that reconfigures the carrier frequencies of the remote radio units based on loading is shown below in

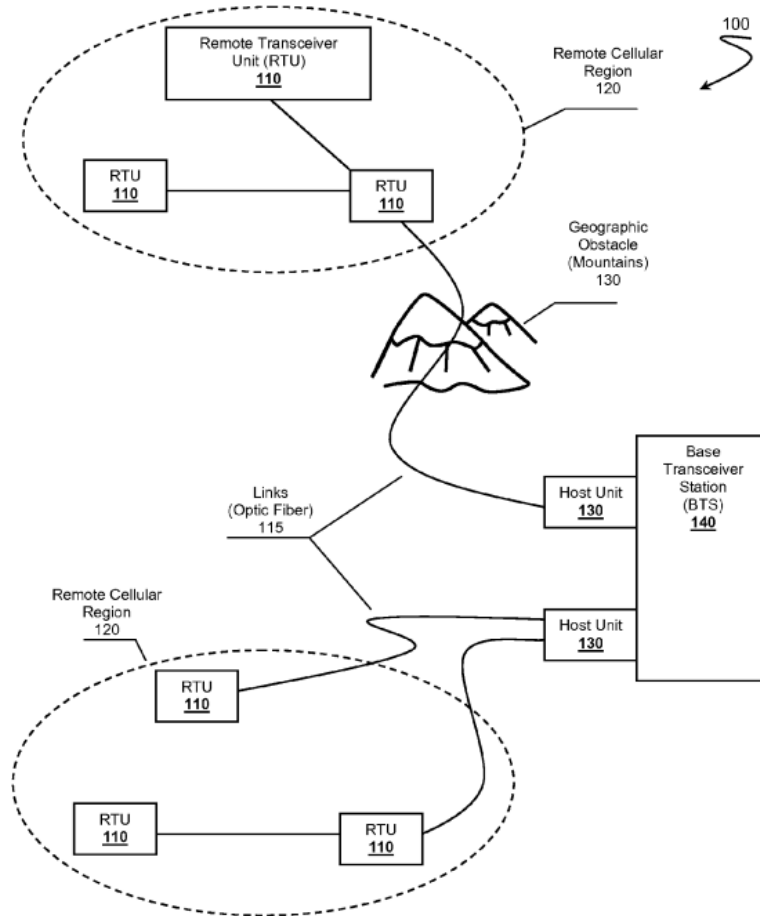


Figure 1

FIG. 1. is shown below:

48. Base transceiver stations (BTSs) communicate signals to remote transceiver units (RTUs) via one or more host units. EX-1009, Title, ¶0030. The system provides control over the communication by splitting carrier channels from their bands and routing only selected channels to RTUs according to a routing policy. EX-1009, ¶0009. The

carrier channels may be routed “individually, collectively as shown, or in arbitrary groups” to RTUs as desired using a matrix switch according to a routing policy, where the routing policy could be updated or reconfigured as desired. EX-1009, ¶¶0049, 0009, 0011, 0038-39, 0047. One example is that “more channels” could be allocated when needed to increase the bandwidth available in a particular region. EX-1009¶¶0046; ¶¶0039-45. Multiple hosts could serve a base station and transmissions between host units and RTUs were preferably occurring according to suitable standards such as the CPRI Standard. EX-1009, ¶¶ 31, 49.

3. Prior art DAS systems allowed for efficient use of infrastructure

49. One prior art system shown below allowed multiple service providers each to provide signals to a BTS which is in turn sent to a common DAS Head End (*DAU*).

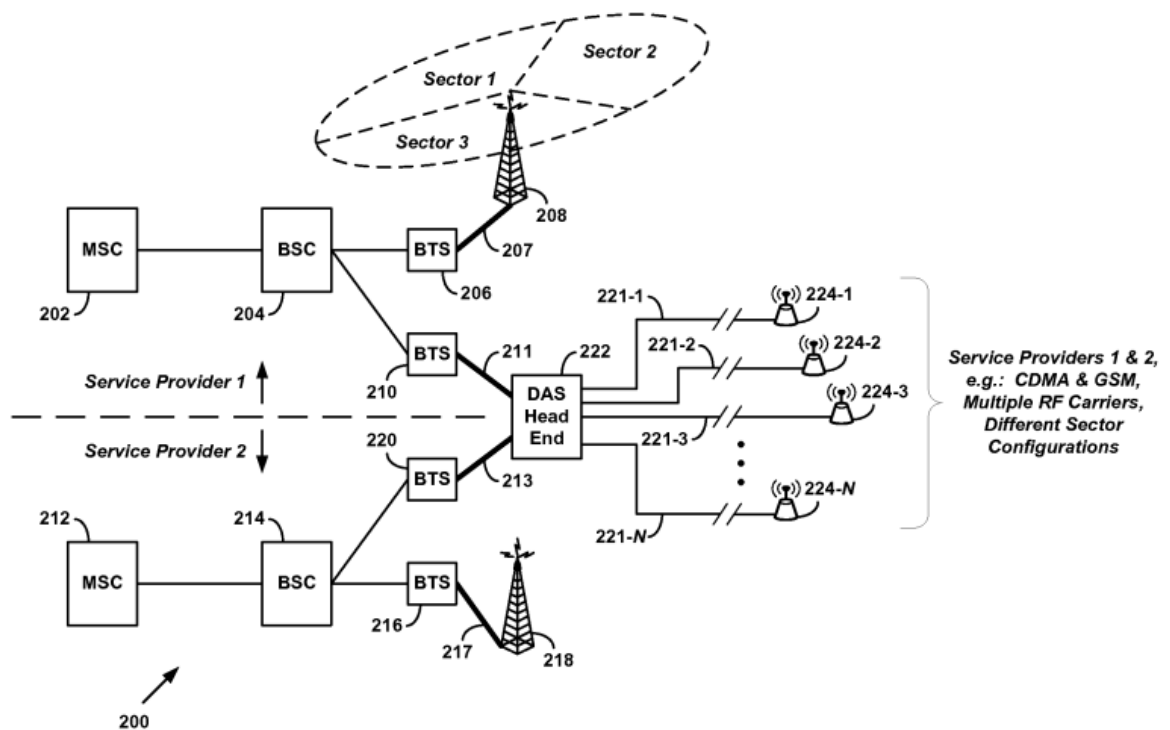


FIG. 2

EX-1010 Fig. 2.

The interface between the RF module and the DAS head end is same as that between the RF modulation Subsystem and the radio/antenna Subsystem of a traditional BTS. **As such, multiple BTSs from multiple service providers can be connected to single DAS head end, thus allowing them to share a common access infrastructure.**

EX-1010 2:24-29 (emphasis added).

50. As illustrated in FIG. 2, multiple service providers using different communications protocols (e.g., CDMA, GSM, etc.) could share

common infrastructure resources and thus avoid the cost and complexity of each provider proving its own infrastructure.

V. IDENTIFICATION OF CHALLENGES

A. Challenged Claims

51. Claims 1-12 of the '338 Patent are challenged in this Petition.

B. Statutory Grounds for Challenges

52. The Challenges are set forth in detail below and summarized as follows:

Ground	Claims	Basis	Reference
1	1-3	§ 103	Leng alone or in view of Cannon.
2	4-12	§ 103	Leng in view of Cannon and further in view of Gupta.

53. I have been informed that International Published Application WO 2009/090414 (“Leng”), U.S. Patent 8,270,387 (“Cannon”) and Patent Publication US 2008/0045254 A1 (“Gupta”) qualify as prior art under §102 for purposes of this IPR.

VI. IDENTIFICATION OF HOW THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. Challenge 1: Claims 1-3

1. The Leng Reference

54. The present invention relates to a distributed antenna system technology, and more particularly to a cell management apparatus, a distributed antenna system, and a reconfiguration method thereof, which are capable of reallocating a carrier in time to effectively adapt to a load change when a communication traffic of a region varies greatly. EX-1005 abstract.

55. Fig. 2 of Leng illustrates the basic structure of one embodiment of the digital distributed antenna system 20. The Remote Radio Head (RRH) 267 is placed around the building. A cell management device (CMU) 24, is connected to the base station 21, and is configured to distribute a downlink wireless signal to the radio remote unit 26, collect an uplink wireless signal, and transmit the uplink radio signal to the base station 21. CMU 24 also collects load information of the distributed antenna system 20 and reconfigures the distributed antenna system 20 based on the load information. The RRH corresponds to the RRU of the '338 Patent, and the CMU corresponds to the DAU of the '338 Patent. EX-1005 3:20-25.

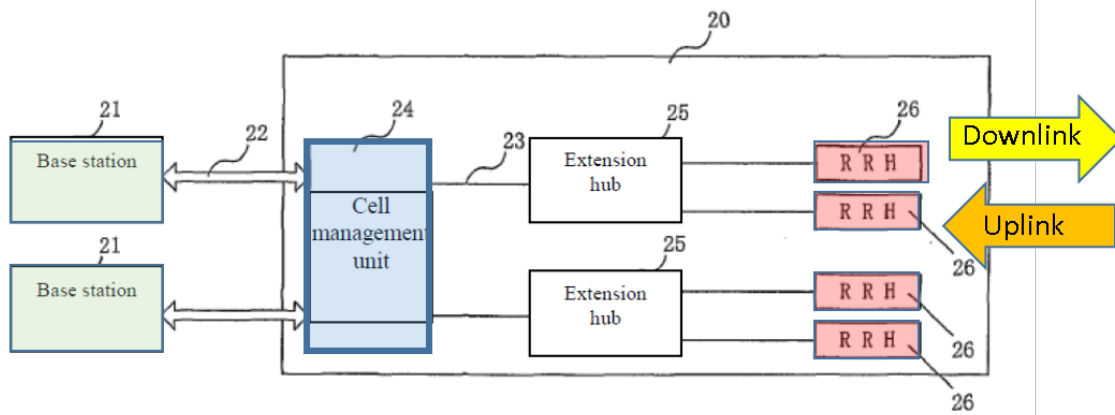


Fig. 2

EX-1005 FIG. 2 (annotated).

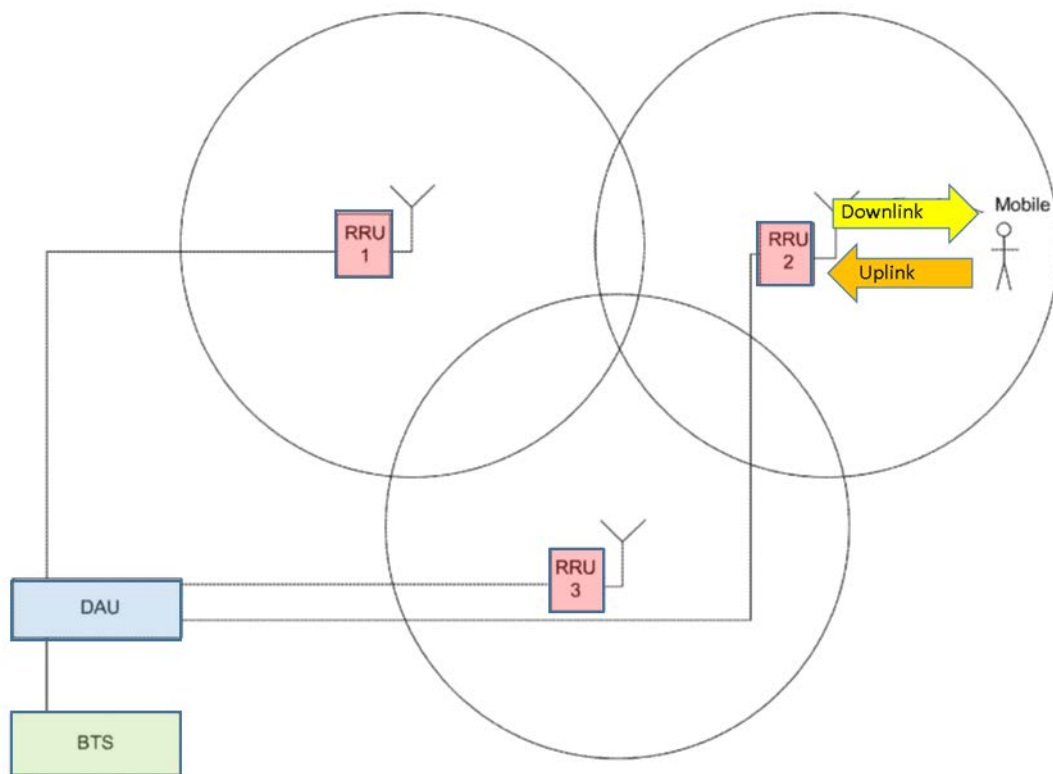


Figure 4 Indoor Localization System of GSM and LTE

56. Like the '338 Patent, Leng describes several problems with prior art DAS implementation. First, once the distributed antenna system has been installed, the allocation of the RF spectrum is fixed. This mode of operation is not suitable for areas where communication traffic varies greatly, such as auditoriums, conference halls, and the like. If too much spectrum is allocated to such areas, spectrum resources are wasted when these areas are idle. However, if only a small amount of spectrum resources are allocated to these areas, when these areas become crowded, spectrum resources may be insufficient. EX-1005 1:19-23.

57. Second, Leng explains the disadvantages of most existing distributed antenna systems are that the carrier cannot be reassigned in time to effectively adapt to load changes when the communication traffic of the area is large. Some of these distributed antenna systems have manual offline reconfiguration, which requires the administrator to manually reconfigure based on the expected load distribution and to stop the service during reconfiguration. This reconfiguration approach does not dynamically reconfigure in a timely and efficient manner based on real-time traffic distribution, and does not enable business continuity during reconfiguration. EX-1005 1:24-30..

58. Leng describes that its solution to these problems is a distributed antenna system and a reconfiguration method thereof, which are capable of reallocating carriers in a timely and efficient manner when the communication traffic of a region varies greatly to adapt to load changes by collecting load information of the distributed antenna system and reconfiguring the distributed antenna system based on the load information. EX-1005 1:33-36. As part of the reconfiguration, Leng describes the RRH switch their carriers upon notification from the carrier reconfiguration module. EX-1005 9:1-10.

59. FIGS 4 and 5 of Leng demonstrate the principle of reconfiguration of the distributed antenna system in the embodiment. Figure 4 shows the initial configuration of the distributed antenna system 20. RRH A and RRH B use carrier 1 (annotated in red), RRH C and RRH D use carrier 2 (annotated in blue), RRH E and RHH F use carrier 3 (annotated in green). EX-1005 4:18-22.

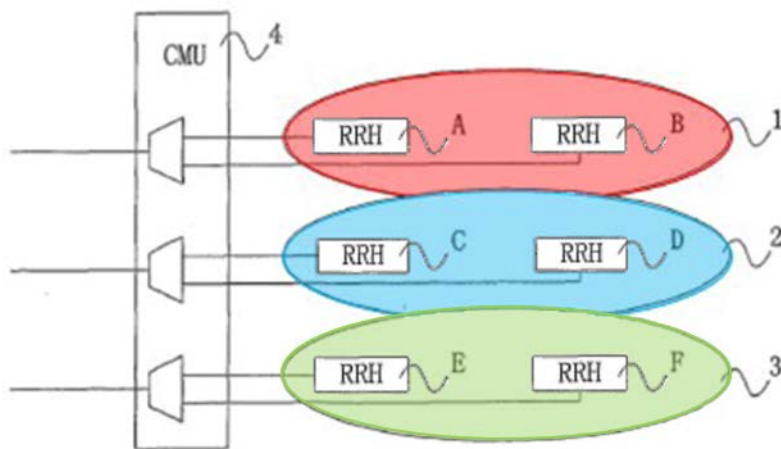


图 4

EX-1005 FIG. 4 (annotated).

60. When CMU 24 detects that RRH A and RRH B become temporary hot spot areas of high load, the distributed antenna system 20 is reconfigured as shown in FIG. 5. After reconfiguration, RRH B is reconfigured to use carrier 2 (annotated in blue), and RRH C and D are reconfigured to use carrier 3, along with RRH E and F (annotated in green). As a result, RRH A uses carrier 1 and RRH B uses carrier 2 and thus the heavy load which previously was only on carrier 1 is split between carriers 1 and 2 load. Carrier 3 which was being used before configuration only by RH E and RRH F, now is also shared with RRH C and RRH D since it is sufficient to carry the load of all four remote radio units. EX-1005 4:18-27.

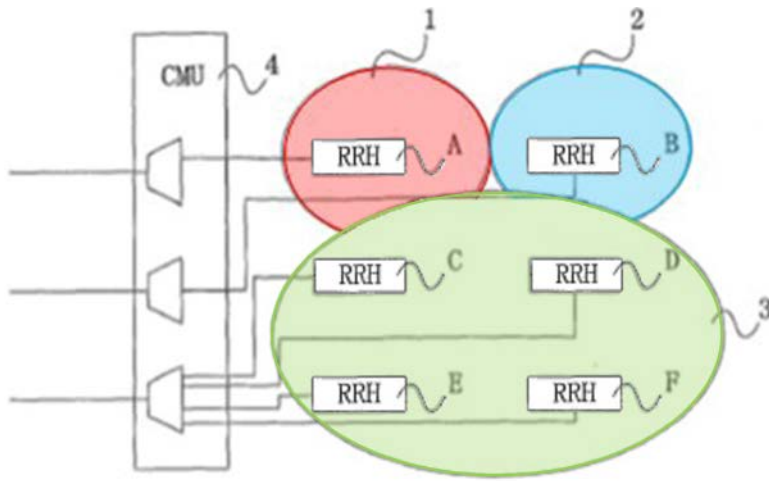


图 5

EX-1005 FIG. 5 (annotated).

61. Although the examples in FIGs 4 and 5 showing each RRH using one carrier, Leng discloses that “the RRHs can also support multiple carriers.” EX-1005 3:31-32. Just like the example described in the ‘338 Patent, by using the distributed antenna system provided by this embodiment, for areas with large changes in communication traffic, such as auditoriums, conference halls, etc., it is possible to dynamically allocate radio frequency resources according to the current traffic state, and greatly balance the traffic load and improve system efficiency. EX-1005 2:14-17.

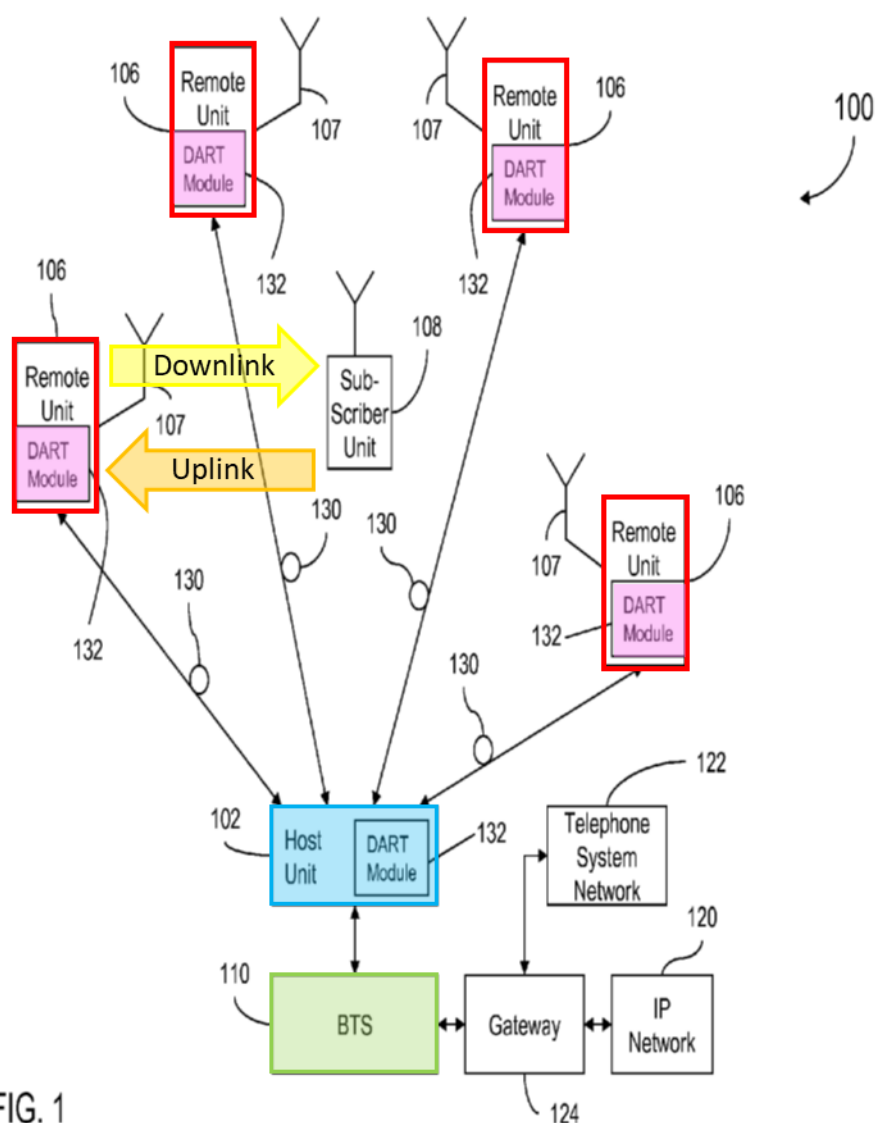
62. Leng discloses several different embodiments of a CMU 24, all of which include a load information collecting module 32 and a reconfiguration module 33. FIGS. 6, 8 and 15. Load information collecting module 32 is configured to collect load information of the

64. The reconfiguring of the routing of the wireless signal is performed by route reconfiguration module 45 and the reallocation of the carrier in the corresponding remote radio unit is performed by carrier reconfiguration module 46 (blue). Leng discloses that the switching module 54 (red) in carrier reconfiguration module 46 (blue) is configured to notify the high-load radio remote unit 26 to switch the carrier to the carrier of the corresponding low-load radio remote unit according to the new topology determined by the topology reconfiguration module 44. EX-1005 10:21-27, 11:17-21.

65. Leng further discloses that each RHH may support multiple carriers. EX-1005 1:15-18, 3:39-43.

2. The Cannon Reference

Cannon is directed to a distributed antenna system (DAS) for receiving and distributing radio frequency signals within a coverage area. FIG. 1 of Cannon illustrates one embodiment:



EX-1006 FIG. 1 (annotated).

66. DAS 100 includes a host unit 102 (blue) and a plurality of remote units 106 (red). Remote units 106 each house electronic devices and systems used for wirelessly transmitting (yellow) and receiving (orange) modulated radio frequency (RF) communications via antenna 107

with one or more mobile subscriber units 108. Host unit 102 is coupled to at least one base station BTS 110 (green). BTS 110 communicates voice and other data signals between the respective host unit 102 and a larger communication network via a gateway 124 coupled to a telephone system network 122 (for example, the public switched telephone network and/or wireless service provider networks) and an internet protocol (IP) network 120, such as the Internet. EX-1006 2:59-3:23.

67. In the embodiment shown in FIG. 1, each remote unit 106 and host unit 102 comprises a digital to analog radio frequency transceiver (DART) module 132 (pink) configured to conserve the available bandwidth of the communication links 130 by separating and individually processing spectral regions of interest from a larger RF spectrum. Ex-1006 4:6-11.

68. Cannon describes that the DART modules are realized using field programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), digital signal processing (DSP) boards, or similar devices. EX-1006 4:20-23.

69. FIG. 5 is a block diagram illustrating a DART Module 500 of one embodiment.

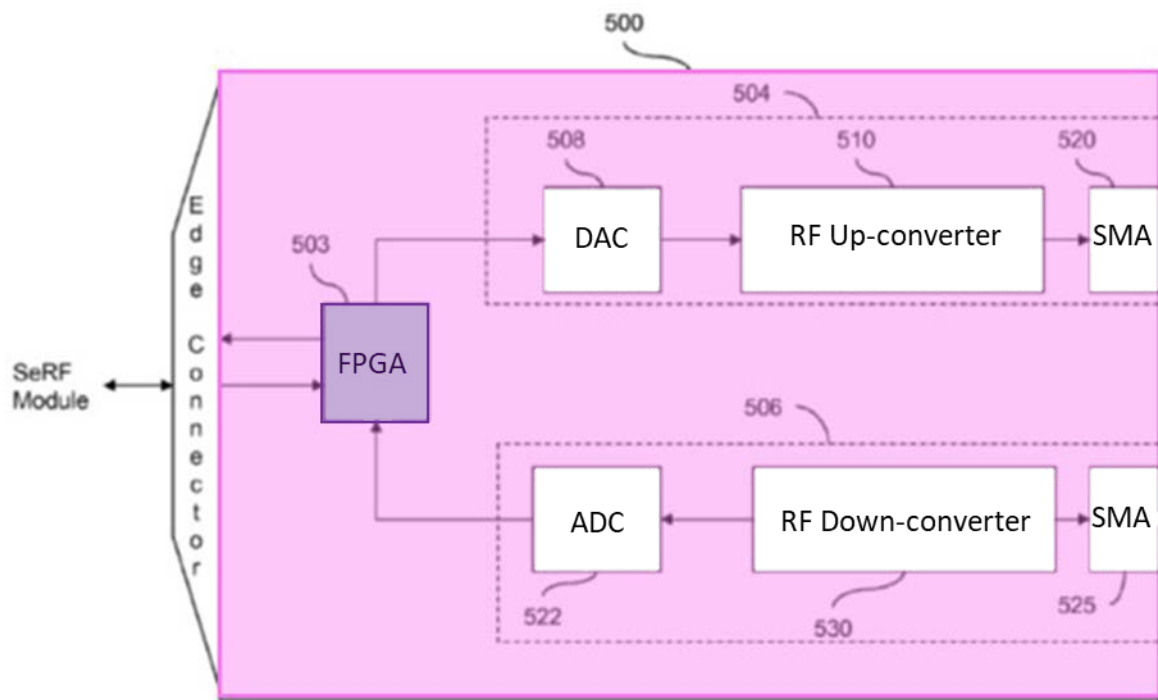


Fig. 5

EX-1006 Fig. 5 (annotated).

70. DART module 500 (pink) has two main signal paths; a transmission path 504 and a reception path 506. For signals received from a SeRF module, DART module 500 forms parallel digital RF data from the incoming data stream. In this embodiment, FPGA 503(purple) is a logic device that is programmed to convert serial digital data into RF sampled data and programmed to convert RF sampled data into serial digital data. DART module 500 then converts the digital RF data to an analog signal with digital to analog converter (DAC) 508. Transmission path 504 continues with RF transmission interface 510 which filters, amplifies, and

up-converts the analog signal for RF transmission. Cannon describes that RF transmission interface 510 will typically include an assortment of filters, amplifiers, oscillators and attenuators known to a POSA. In one embodiment, the transmission path exits DART module 500 at a subminiature version A RF coaxial connector (SMA) connector 520. EX-1006 7:10-33.

71. FIG. 6 is a block diagram providing further details for FPGA 503 (purple) for one embodiment.

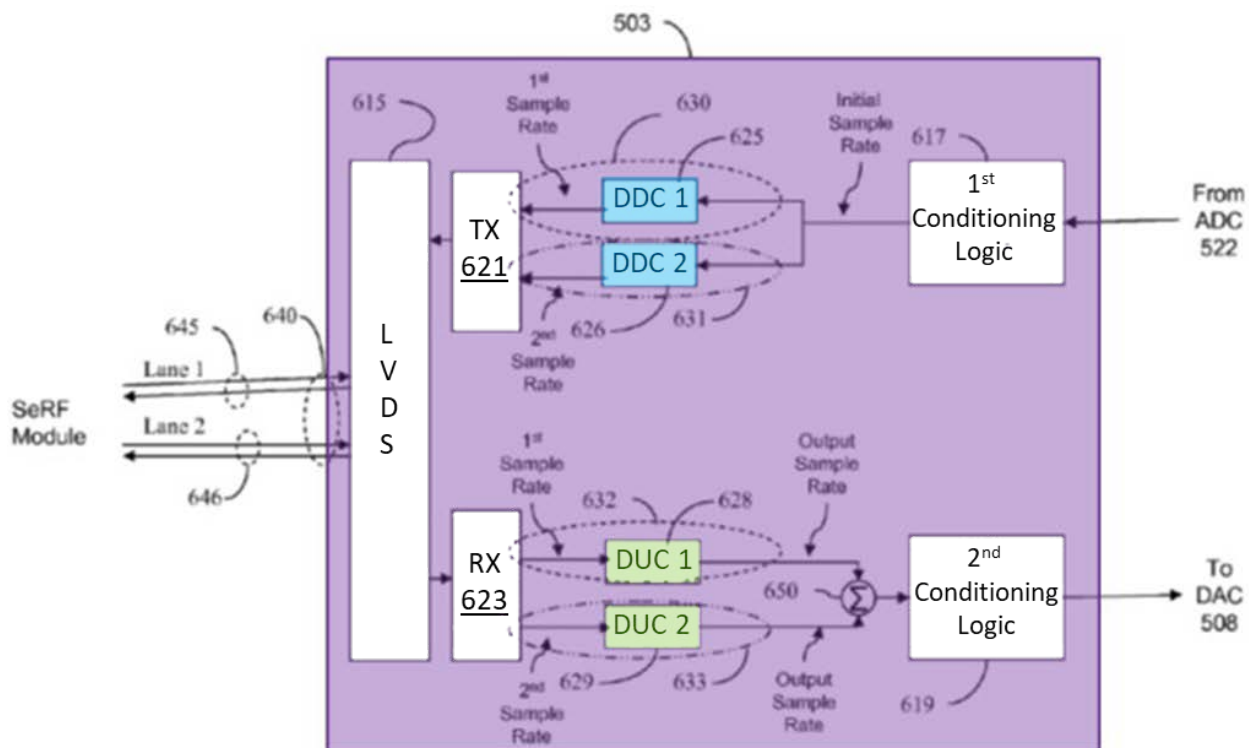


Fig. 6

EX-1006 Fig. 6 (annotated).

72. FPGA 503, for both the upstream and downstream directions, provides separate signal processing paths for each discrete spectral region of a digitized RF spectrum (such as 400 or 460 from FIG. 4) that is to be mapped onto timeslots of the transport frame 460. Although the FPGA 503 described in FIG. 6 illustrates an FPGA configured to process two discrete spectral regions in each direction (illustrated by first and second paths 630,631 in the receive direction and first and second paths 632,633 in the transmit direction), Cannon makes clear that the number of carriers is not limited to only two, the DART can be programmed to handle three or more carriers, limited only by the limits of the implementing hardware (for example, the number of available gates provided by the FPGA hardware selected by the DART equipment designer). EX-1006 6:47:55; 7:47-64. Thus, a POSA understood that Cannon teaches that each FPGA could be programmed with a set of carrier frequencies.

73. Cannon describes that using a FPGA includes Digital Up-Converters (DUCs) (green) and Digital Down-Converters (DDCs) (blue) that can be programmed with a center frequency and bandwidth to reconfigure the carrier of the remote radio unit. EX-1006 FIG. 6; 8:45-9:10. Cannon describes that the use of a FPGA in a remote radio unit is beneficial because the remote radio unit can be adjusted to meet the

changing needs of the end user very simply using programming. EX-1006 9:45-47.

3. Motivation to Combine Leng and Cannon

74. The '338 Patent, Leng and Cannon are all directed to dynamically allocating frequency spectrum in a DAS. All three provide examples of mobile subscribers communicating with a remote radio unit of a DAS. EX-1001 FIG. 1, EX-1005 FIG. 2; EX-1006 FIG. 1. The '338 Patent describes reconfiguring each remote radio unit based on load percentage of each remote radio unit. EX-1001 13:2-24. The '338 Patent describes that the remote radio units are reconfigured by the use of software-programmable frequency selective Digital Up-Converters (DUCs) and Digital Down-Converters (DDCs). EX-1001 4:1-15. Leng likewise describes reconfiguring each remote radio unit based on load percentage of each remote radio unit. EX-1005 FIGs 4, 5. Leng describes that the carrier of a remote radio unit is switch at the RRH in response to a notification by a carrier reconfiguration module based on the load of the radio, but does not provide the details of how the frequency of the remote radio unit is changed. Specifically, as described above, in one embodiment, Leng discloses that the switching module 54 in carrier reconfiguration module 46 is configured to notify the high-load radio

remote unit to switch the carrier to the carrier of the corresponding low-load radio remote unit according to the new topology determined by the topology reconfiguration module. Cannon describes that the remote radio unit can use a DART in the form of a field programmable gate array (FPGA). Cannon describes that using a FPGA includes Digital Up-Converters (DUCs) and Digital Down-Converters (DDCs) that can be programmed with a center frequency and bandwidth to reconfigure the carrier of the remote radio unit. EX-1006 FIG. 6; 8:45-9:10. Cannon describes that the use of a FPGA in a remote radio unit is beneficial because the remote radio unit can be adjusted to meet the changing needs of the end user very simply using programming. EX-1006 9:45-47.

75. A POSA would be motivated to modify the teachings of Leng to include a FPGA in the remote radio unit as taught by Cannon because Cannon expressly teaches that the use of a FPGA allows each remote radio unit to be adjusted to meet the changing needs of the end user, and Leng teaches that the needs of the end user can be determined by the load of the remote radios. Specifically, a POSA understood that Leng teaches to reconfigure a remote radio unit in a DAS by changing the carriers of the remote radio unit based on the relative load of the remote radio unit, and that there are only a few finite ways to reconfigure a radio by changing its

carrier frequency. Cannon discloses one such suitable way to reconfigure the carrier frequency of the remote radio is the use of a FPGA and requires only a programming change.

76. In view of this section (and discussed further below in the claims analysis) it has demonstrated at least:

i. Leng and Cannon themselves provided teaching, suggestion, or motivation that would have led a POSA to modify Leng's teaching of reconfiguring a remote radio unit in a DAS based on the relative loading of the remote radio unit, with the use of an FPGA in the remote radio unit as taught by Cannon because an FPGA is adjustable to meet the changing needs of the end user.

ii. The general knowledge in the art was that Cannon's use of FPGA was an accepted, known and predictable mechanism to adjust the carrier frequencies of DUCs and DDCs in remote radio units in a DAS by using programming, and the use of software-programmable frequency selective DUCs and DDCs was identified as a known benefit in the '338 Patent.

iii. The beneficial aspects of Leng's technique for dynamic reassignment of the DAS based on a real-time load distributing condition, improving the efficiency of the system, and achieving reassignment on line without interrupting the service, would be accomplished by using an FPGA with predictable results.

iv. A POSA would also be confident the modification would have a high likelihood of success given the predictable nature of FPGA and radio transceivers.

4. Detailed Application of Leng and Cannon to Challenged Claims 1-3

a. Claim 1

i. A method for routing and switching RF signals comprising:

77. To the extent the preamble is limiting, Leng discloses a method for routing and switching RF signals. As shown below, Leng discloses distributing (*routing and switching*) the downlink radio signals (*RF signals*) to the remote radio units and reconfiguring a digital antenna system in accordance with the load information.

[T]he cell management unit 24 is connected to the base station 21 and connected to the remote radio heads 26 via the extension hub 25 **for distributing downlink radio signals to the remote radio heads 26, collecting uplink radio signals and transmitting them to the base station 21, and collecting the load information of the distributed antenna system 20 and reconfiguring the distributed antenna system 20 according to the load information.**

EX-1005 3:22-25 (emphasis added).

ii. providing one or more remote radio units, each remote radio unit configured to transmit one or more downlink RF signals and to receive one or more uplink RF signals.

78. Leng discloses providing one or more RRH (remote radio unit).

Each of the RRHs is configured to distribute (transmit) downlink radio signals (downlink RF signals) and collect (receive) uplink radio signals (uplink RF signals).

Fig. 2, an embodiment of the present disclosure provides a **distributed antenna system 20 comprising at least one remote radio head (RRH) 26.**

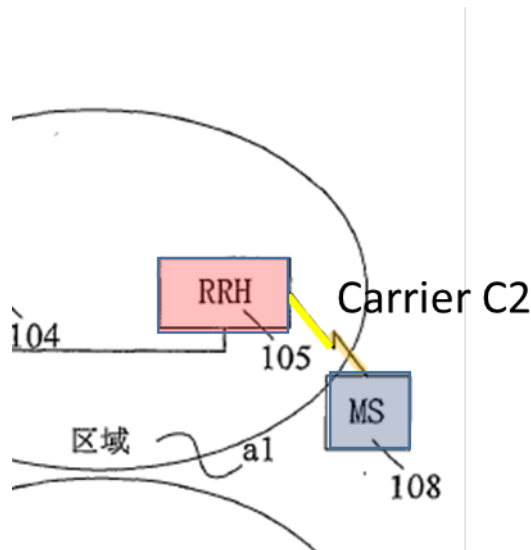
EX-1005 3:20-21 (emphasis added).

The cell management unit 24 is connected to the base station 21, and is configured to **distribute downlink radio signals to the remote radio head 26, collect uplink radio signals and transmit them to the base station 21.**

EX-1005 3:22-24 (emphasis added).

The base station 101 transmits carriers C1 and C2, and assigns them to RRH 104 and RRH 105. The base station 102 transmits carriers C3 and C4, and assigns them to RRH 106 and RRH 107. **The mobile station (MS) 108 is in the area a1 and uses carrier C2.**

EX-1005 9:11-14 (emphasis added).



EX-1005 FIG. 10 (annotated).

79. A POSA understood from the disclosure of Leng and an understanding of the function of radio heads that the RRHs make up the last leg of the downlink to the mobile stations and the first leg of the uplink from the mobile stations, in which the downlink and uplink radio signals are transmitted to the mobile station and received from the mobile station respectively via the carriers.

iii. providing at least one digital access unit configured to communicate with the one or more remote radio units.

80. Leng discloses a cell management unit (CMU) (blue) (*digital access unit*) which is configured to communicate with one or more RRHs (red) (*remote radio units*).

According to an embodiment of the present disclosure, the cell management unit (CMU) 24 is the control center of the distributed antenna system 20, and **the cell management unit 24 is connected to the base station 21 and connected to the remote radio heads 26 via the extension hub 25.**

EX-1005 3:26-28 (emphasis added).

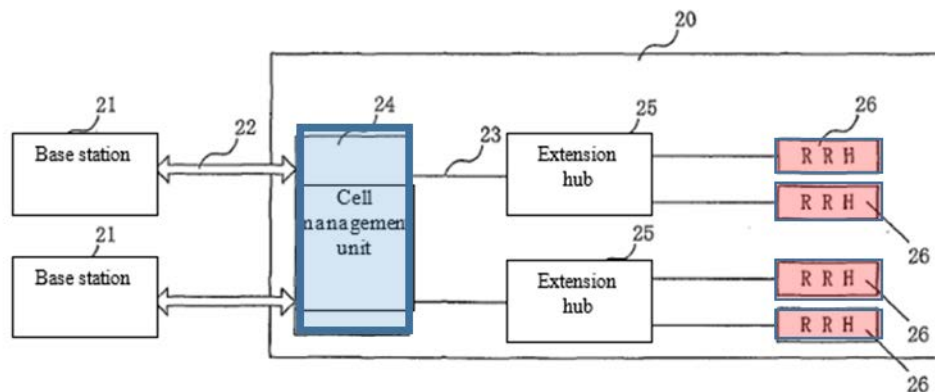


Fig. 2

EX-1005 FIG. 2 (annotated).

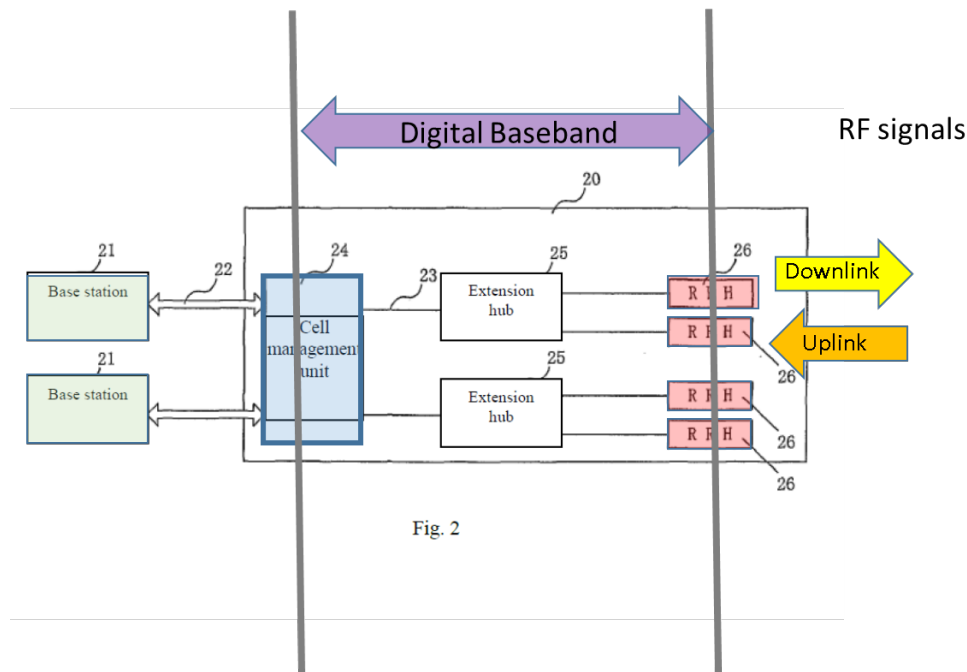
iv. translating the uplink and downlink signals between RF and base band as appropriate.

81. Leng discloses the RRH converts the downlink digital base band signals from the transmission medium to an RF signal and the uplink from an RF signal to a digital base band signal on the transmission medium.

The remote radio heads (RRHs) 26 are used for **digital filtering, analog/digital-to-analog conversion**, and analog front-end functions. The transmission medium 23 of the distributed antenna system 20

may be an optical fiber or a UTP/STP cable, etc., the transmission network may be Gigabit Ethernet, and the **transmitted radio signals are digital baseband signals.**

EX-1005 3:34-38 (emphasis added).



EX-1005 FIG. 2 (annotated).

82. On the other end, Leng discloses the CMU via an interface supplies signal from the base station 21 to the appropriate RRH as digital base band signals over medium 23. The uplink signal received by the CMU as a digital base band signal 23 is also transmitted to the base station via interface 22.

The number of carriers supported depends on the wireless technology used and its operating bandwidth. For example, for 5 MHz WiMAX technology, **the digital baseband signal traffic is 137 Mbps.** Considering an overhead of 25%, the traffic would be 171.25 Mbps, so a Gigabit Ethernet link can support five carriers.

EX-1005 3:40-43 (emphasis added).

The current trend in distributed antenna systems is to use fiber optic or unshielded twisted pair/shielded twisted pair (UTP/STP) cables to **transmit digital radio signals, which are primarily digital baseband signals.**

EX-1005 1:12-14 (emphasis added).

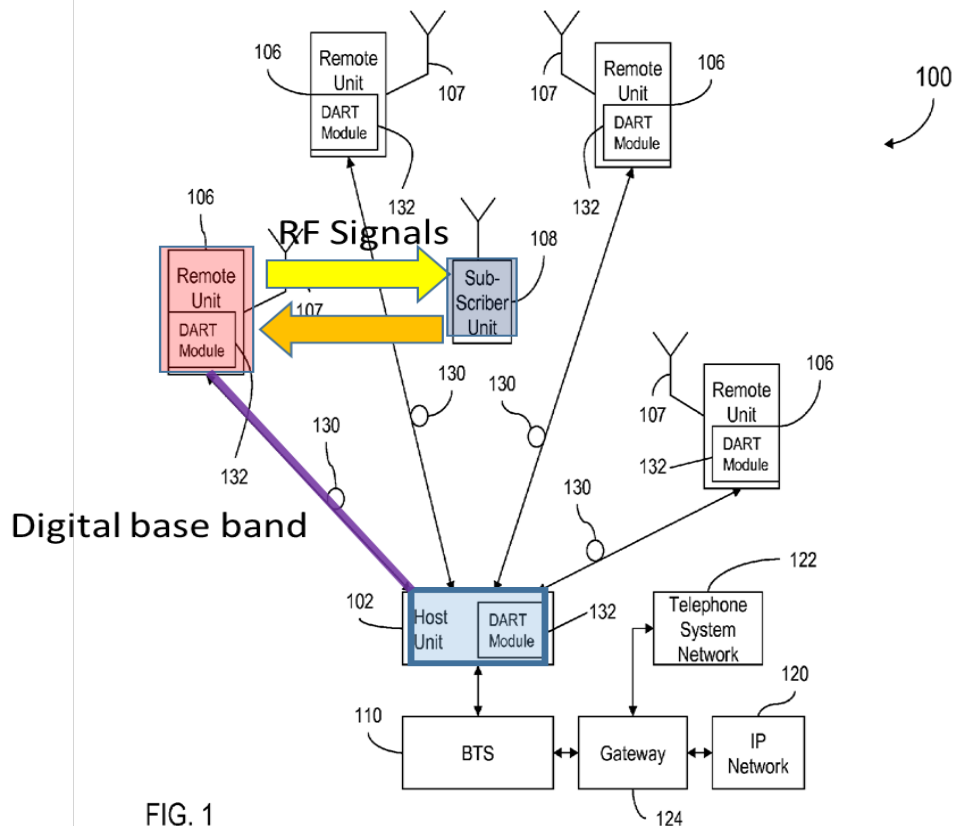
83. A POSA understood that before transmission of an RF signal, the baseband signal would be upconverted to RF for transmission and after receipt, the RF signal would be downconverted to a baseband signal.

84. To the extent the Patent Owner argues that Leng does not expressly disclose translating between an RF band and a base band as appropriate, Cannon does. Cannon discloses translating between the RF signal and the digital baseband. Cannon describes that the RF signals received by the remote unit are sent to the DART module 500 and downconverted to provide a data stream of digitally sampled RF. EX-1006 7:37-46, 8:3-6. Cannon describes that a digitally sampled RF signal is a baseband version of the received signal:

DAS 100 comprises a digital DAS transport meaning that the **downlink and uplink transport signals transmitted between host unit 102 and remote units 106 over communication links 130 are generated by digitizing the downlink and uplink RF signals**, respectively. In other words, the downlink and uplink transport signals are not analog RF signals but instead are digital data signals representing digital RF samples of a modulated RF signal. **These digital data signals, which may be alternately referred to herein as "digital RF", "digitally sampled RF" and "digital baseband", may comprise digital representations of an RF, IF or baseband version of the original RF signal.**

EX-1006 3:45-56 (emphasis added).

85. For processing the downlink signal, the FPGA includes a digital up converter to convert the digital baseband signal to an RF signal for transmission. EX-1006 8:6-16.



EX-1006 FIG. 1 (annotated).

86. As described above, (section VI.A.3), it would have been obvious to combine the teachings of Cannon to the method and system of Leng. Specifically, a POSA would have been motivated to transport the signals between the RRH and the CMU in a baseband format as taught by Cannon to conform with conventional practice that favors transport of digital baseband signals in order to minimize the sampling rate needed to

digitize the full band signal compared to the original upconverted RF signal.

- v. **packetizing the uplink and downlink base band signals, wherein the packetized signals correspond to a plurality of carriers.**

87. As mentioned above, (section VI.A.4.a.iv), the method and system of Leng discloses utilizing uplink and downlink signals are packetized for transport between the CMU and the RRHs. Leng discloses these uplink and downlink signals support multiple carriers (*corresponding to a plurality of carriers*).

According to an embodiment of the present disclosure, the distributed antenna system 20 can support multiple carriers and multiple base stations, of which the RRHs can also support multiple carriers.

EX-1005 3:39-43 (emphasis added).

88. Each of these digital base band signals corresponds to one of the multiple carrier (*plurality of carriers*) signals and are transported between the CMU and the RRH in packets via a packet address (*packetized uplink and downlink signals*).

the cell management unit 24 updates the radio signal route by reconfiguring the I/Q packet addresses and updating the routing

table stored in the cell management unit 24 and the extension hub 25 according to the new topology determined.

EX-1005[6:19-21] (emphasis added).

89. An example of the transport of the radio signals provided by Leng is that of a 5 MHz WiMax.

The number of carriers supported depends on the wireless technology used and its operating bandwidth. For example, for 5 MHz WiMAX technology, the digital baseband signal traffic is 137 Mbps.

Considering an overhead of 25%, the traffic would be 171.25 Mbps, so a Gigabit Ethernet link can support five carriers.

EX-1005 3:40-43.

90. A POSA understood that a WiMax network, utilizes packetized data, and that an Ethernet link also utilizes packetized data.

vi. configuring each remote radio unit to receive or transmit a respective subset of the plurality of carriers, each respective subset of the plurality of carriers including a number of carriers.

91. Leng discloses each RRH is configured to receive or transmit using one or more carriers of the available carriers (*subset of a plurality of carriers*). For example, Fig. 4 shows, a configuration where each RRH (A,B,C,D,E,F) has a single carrier (e.g. 1), which is a subset of a plurality of carriers (e.g., 1, 2, and 3).

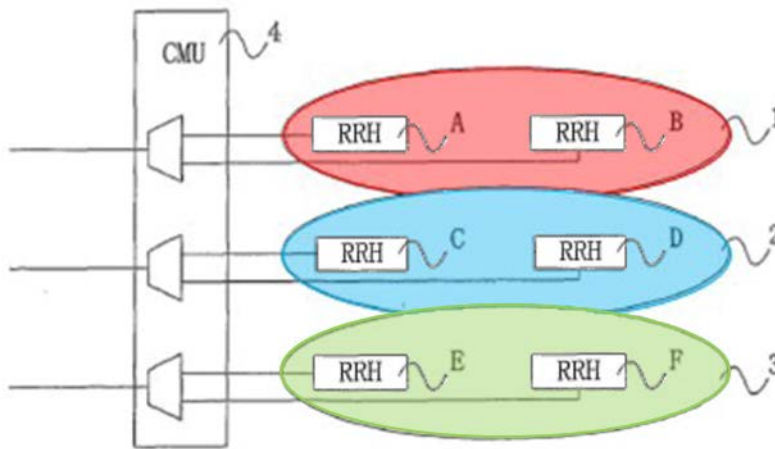


图 4

EX-1005 Fig. 4 (annotated).

Fig. 4 shows the initial configuration of the distributed antenna system 20, with **RRH A and RRH B using carrier 1, RRH C and RRH D using carrier 2, and RRH E and RRH F using carrier 3.**

EX-1005 3:19-20 (emphasis added).

92. Although the example in FIG 4 showing each RHH using one carrier, Leng discloses that “the RHHs can also support multiple carriers.”

EX-1005 3:39-40. Thus, a POSA understood that each RRH can be configured with a subset of the plurality of carriers 1-3, where the subset includes a number of carriers, e.g., carriers 1-2.

93. To the extent that Patent Owner argues that Leng does not expressly disclose this limitation, Cannon expressly discloses that each FPGA in a DART module could be programmed to handle multiple

carriers which would include the limitation of a subset of the plurality of carriers. EX-1006 6:47:55; 7:47-64. A POSA would be motivated to combine the teachings of Leng with the teachings of Cannon as discussed above.

vii. reconfiguring each remote radio unit by:

94. Leng discloses reconfiguring the DAS, the network topology of the RRHs and their respective carriers (*reconfiguring each remote radio unit*).

As shown in FIG. 3, ... **a reconfiguration module 33, configured to determine a new topology, reassign carriers among the corresponding remote radio heads, and reconfigure the routing of radio signals according to the load information collected by the load information collection module 32.**

EX-1005 4:11-17 (emphasis added).

95. Leng discloses the RRH are notified to switch carrier frequencies and the RRH switch their carriers quicker than the base station reassigns the mobile stations to the switched carriers.

The carriers of the corresponding low-load remote radio heads may be a neighboring available carrier. If there is no neighboring available carrier, the base station switches the mobile station to a specific target carrier after a predetermined delay time, with the target carrier being a low-load target carrier to which the RRH corresponding to the mobile

station should be switched according to the determined new topology. Obviously, the delay time should be greater than the time for the RRH to switch carriers in order to switch the mobile station to the target carrier after the RRH has switched to the target carrier.

EX-1005 9:6-10.

96. Leng discloses reconfiguring each RRH using carrier reconfiguration module 46 to change the carrier frequency of the RH. Specifically, Leng discloses that the switching module 54 in carrier reconfiguration module 46 (blue) is configured to notify the high-load radio remote unit 26 (pink) to switch the carrier to the carrier of the corresponding low-load radio remote unit according to the new topology

determined by the topology reconfiguration module 44: EX-1005 10:21-

27

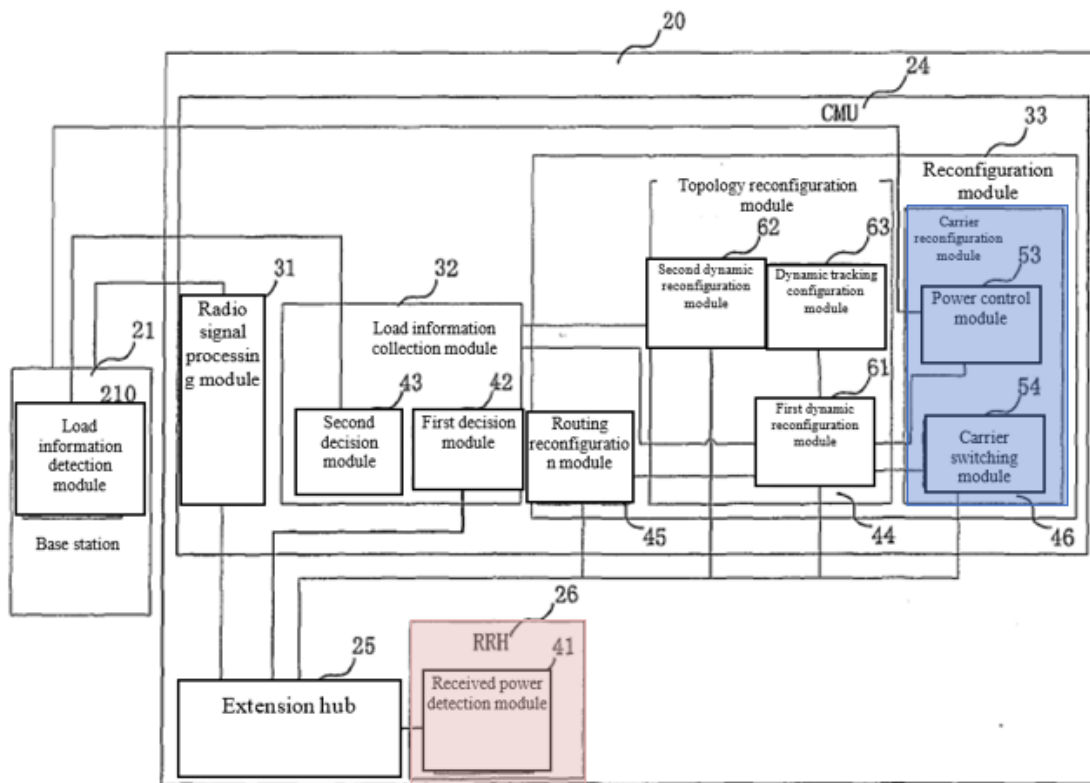


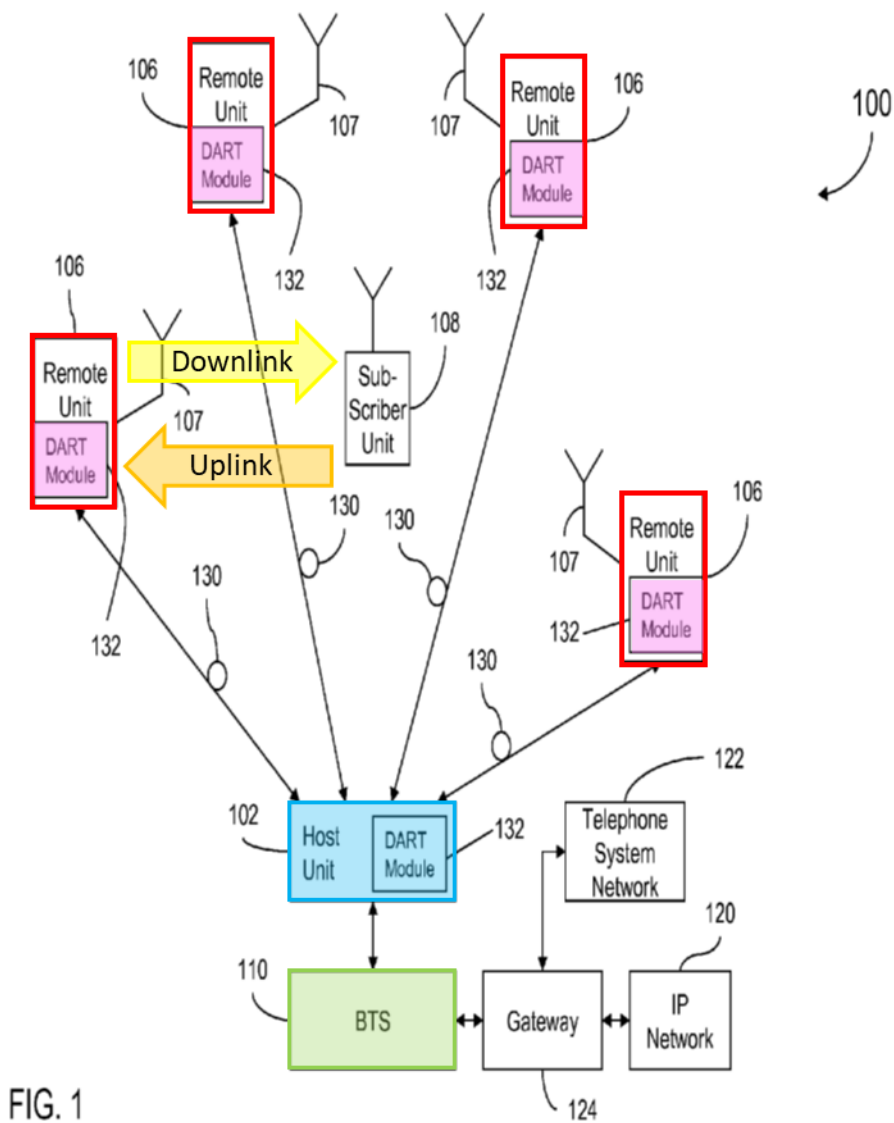
Fig. 15

EX-1005 Fig. 15 (annotated).

97. Thus, Leng discloses reconfiguration of the carrier signal at a RRH which meets the claim limitation *reconfiguring each remote radio unit*.

98. To the extent the Patent Owner argues that Leng does not expressly disclose how the carrier frequency is reconfigured at a RRH,

Cannon discloses reconfiguring the carrier frequency of a remote radio unit using the same method described in the '338 Patent.



EX-1006 Fig. 1 (annotated).

99. Cannon discloses a digital to analog radio frequency transceiver (DART) module that separates spectral regions of interest of the overall spectrum.

In the embodiment shown in FIG. 1, **each remote unit 106 and host unit 102 comprises a digital to analog radio frequency transceiver (DART) module 132 configured to conserve the available bandwidth of the communication links 130 by separating and individually processing spectral regions of interest from a larger RF spectrum.**

EX-1006 4:4-11 (emphasis added).

100. Further, Canon discloses that using a FPGA 503 includes Digital Up-Converters (DUCs) 632 and Digital Down-Converters (DDCs) 630 that can be programmed with a center frequency and bandwidth to reconfigure the carrier of the remote radio unit. EX-1006 FIG. 6; 8:45-9:10.

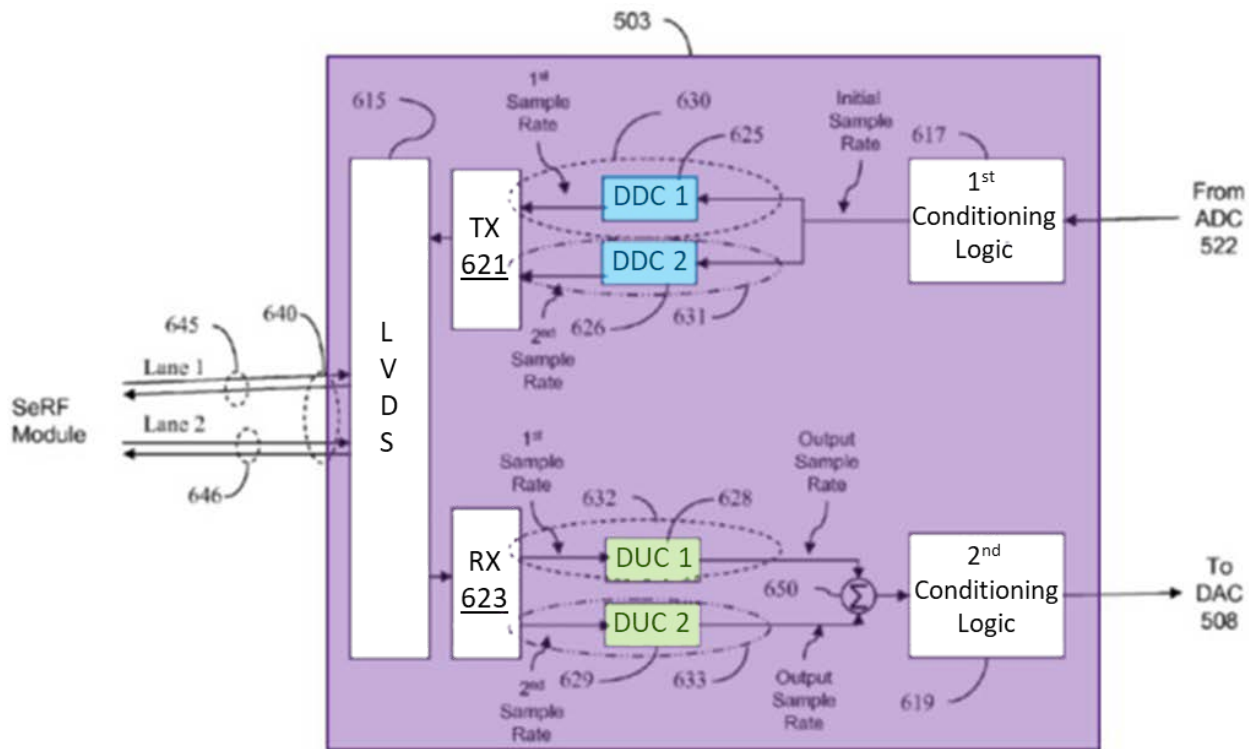


Fig. 6

EX 1006 Fig. 6 (annotated).

101. As illustrated in FIG. 4A, each FPGA is programmable to adjust (*reconfigure*) the remote unit (*remote radio unit*) itself to alter both the bandwidths and the frequencies (*carrier*) of the digital upconverters

and downconverters of the remote unit (*remote radio unit*).

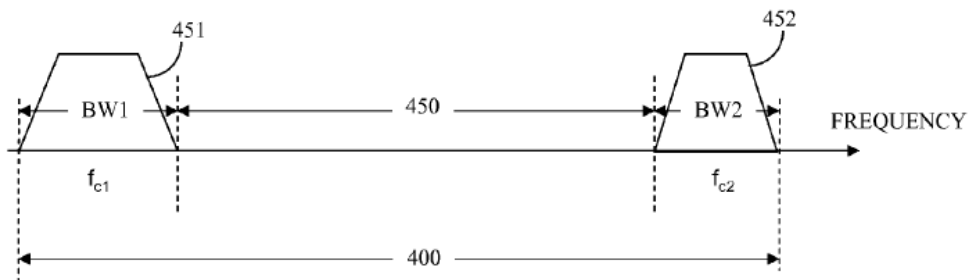


Fig. 4A

EX-1006 FIG. 4A.

Because **FPGA 503** is a field programmable device, it can be adjusted to meet changing needs of the end user. For example, the center frequencies f_{c1} and f_{c2} can be reprogrammed into **FPGA 503** in order to shift the locations of spectral regions 451 and 452 within spectrum 400. Similarly, $BW1$ and $BW2$ may be adjusted to accommodate larger or narrower bandwidths. The number and/or position of timeslots within frame 460 provisioned for each discrete spectral region can also be reconfigured. As mentioned previously, **the number of individual signal paths for handling additional spectral regions may be increased by configuring the FPGA with additional digital up converters and digital down converters**. In one embodiment, a plurality of predefined configuration builds are stored in a memory, for example within a SeRF Module. In such an embodiment, a DART Module's FPGA can be reconfigured by pushing a new build image onto the FPGA.

EX-1006 9:45-67 (emphasis added).

102. Cannon's description of changing the carrier frequencies of the upconverters and downconverters is consistent with the disclosure in the '338 patent that the RRU Management Control module sets the individual parameters of all the RRU Digital Up-Converters to enable or disable specific radio resources from being transmitted by a particular RRU or group of RRUs, and also sets the individual parameters of all the RRU Digital Down-Converters to enable or disable specific uplink radio resources from being processed by a particular RRU or group of RRUs.

EX-1001 11:18-11:39.

103. As described above, (section VI.A.3), it would have been obvious to combine the teachings of Cannon to the method and system of Leng.

a) determining a load percentage for each remote radio unit; and

104. Leng discloses determining the load distribution (*load percentage*) for each RRH (*remote radio unit*).

the distributed antenna system 20 is reconfigured the CMU 24 based on the collected load information, instead of via manual configuration during service interruption by the administrator based on the expected situation as based on the prior art. This thus allows the distributed

antenna system 20 to be **dynamically reconfigured in a timely and efficient manner based on the real-time load distribution, balancing the load and improving the system efficiency in a timely manner**, while greatly improving the convenience, real-time nature and accuracy of the configuration, and without service interruption, ensuring the continuity of services.

EX-1005 4:5-10 (emphasis added).

Clearly, by using the distributed antenna system provided by this embodiment, for areas where communication traffic varies greatly, such as auditoriums, conference halls, etc., **it is possible to dynamically allocate radio frequency resources according to the current traffic condition, and greatly balance the traffic load** and improve system efficiency.

EX-1005 4:24-27 (emphasis added).

The remote radio heads 26 comprise a received **power detection module 41 configured to detect the total broadband power received by the remote radio heads 26** and transmit the detected power value to the load information collection module 32.

EX-1005 5:13-15 (emphasis added).

According to the above configuration, **the cell management unit 24 receives the power information detected and transmitted by the RRH 26, compares it with a predetermined threshold, and then decides whether to reconfigure the intelligent distributed antenna system**. This embodiment does not require any changes to the base

station and allows fine-grained load information (**specific to each RRH**) to be obtained.

EX-1005 5:27-30 (emphasis added).

The load information detection module 210 is provided in each base station 21, and it is configured to collect various load information (for example, throughput, **number of connections, number of registered users**, etc.) and transmit the collected load information to the CMU through the OBSAI/CPRI interface or a local management interface.

EX-1005 6:1-4 (emphasis added).

It should be understood by those skilled in the art that the **structure and method of the foregoing two methods for obtaining load information may be flexibly selected according to the needs of the actual application scenario**, or a combination thereof may be applied.

EX-1005 6:23-25 (emphasis added).

The topology reconfiguration module 44 comprises: a storage module 51, configured to store a predefined topology, wherein the predefined topology **corresponds to load information or a combination of load information**.

EX-1005 7:26-27 (emphasis added).

the distributed antenna system can be dynamically reconfigured in a **timely and effective manner according to the real-time load distribution**.

EX-1005 14:13-14 (emphasis added).

105. A POSA understood Leng to disclose load balancing, the use of a load percentage (i.e. the amount of load used by RRH compared to the total load on the network) to determine a new network topology to most efficiently distribute network resources using the combination of load information of the RRHs.

106. A POSA understood to use a load percentage (i.e. the amount of load used by RRH compared to the total load on the network) to determine a new network topology to most efficiently distribute network resources for load balancing using the combination of load information of the RRHs as is one of the disclosed purpose of Leng.

b) increasing or decreasing the number of carriers in the respective subset of the plurality of carriers based on the load percentage; and

107. Leng discloses reconfiguring the number of carriers each RRH (*increase or decreasing the number of carriers*) is currently using (*the subset of the plurality of carrier*) based on load information (*load percentage*).

As shown in FIG. 3, ... **a reconfiguration module 33, configured to determine a new topology, reassign carriers among the corresponding remote radio heads, and reconfigure the routing of radio signals according to the load information collected by the load information collection module 32.**

EX-1005 4:11-17 (emphasis added).

108. Leng gives an example of increasing and decreasing the number of carriers each RRH is using based on the load information.

Fig. 4 and Fig. 5 are schematic diagrams showing the principle of reconfiguration of the distributed antenna system in the embodiment. Fig. 4 shows the initial configuration of the distributed antenna system 20, **with RRH A and RRH B using carrier 1**, RRH C and RRH D using carrier 2, and RRH E and RRH F using carrier 3. **When the load of carrier 2 and carrier 3 is transferred to the area of carrier 1, that is, when the CMU 4 detects that RRH A and RRH B have become temporary hot spots of high load.**

EX-1005 3:18-22 (emphasis added).

109. Although the examples in FIGs. 4 and 5 showing each RHH using one carrier, Leng discloses that “the RHHs can also support multiple carriers.” EX-1005 3:31-32. Thus, a POSA understood that each RRH can be configured more than one carrier and thus the number of carriers in the subset assigned to each RRH can be decreased or increased as appropriate based upon load.

110. Likewise, Cannon expressly discloses that each FPGA in a DART module could be programmed to handle multiple carriers which would include a subset of the plurality of carriers that can either be

increased or decreased. EX-1006 6:47:55; 7:47-64. A POSA would be motivated to combine the teachings of Leng with the teachings of Cannon as discussed above.

viii. routing and switching the packetized signals among the one or more remote radio units via the at least one digital access unit according to a result of the reconfiguring.

111. Leng discloses the reconfiguration module 33 of the CMU (*digital access unit*) reconfigures the network topology based on the load information and then re-allocates the carriers to their appropriate RRH (*remote radio units*) based on the new topology (*routing and switching the packetized signals according to a result of the reconfiguring*).

As shown in Fig. 3, according to another embodiment of the present disclosure, in the above distributed antenna system 20, the cell management unit 24 may comprise: ... a reconfiguration module 33, configured to determine a new topology, reassign carriers among the corresponding remote radio heads, and reconfigure the routing of radio signals according to the load information collected by the load information collection module 32.

EX-1005 4:11-17.

112. The reconfiguration module of the CMU (*DAU*) 33, discussed above, updates the signal pack address to route the packetized

digital base carrier signal to the appropriate RRH (*routing and switching the packetized signals*).

The reconfiguration module 33 comprises: a topology reconfiguration module 44, configured to determine a corresponding new topology according to the load information collected by the load information collection module 32; a routing reconfiguration module 45, **configured to update the radio signal route by reconfiguring the I/Q packet addresses and updating the routing table stored in the cell management unit 24.**

EX-1005 5:20-23 (emphasis added).

b. Claim 2

i. The method of claim 1

ii. wherein each carrier corresponds to a respective RF band.

113. Leng discloses that each carrier corresponds to an RF band:

According to an embodiment of the present disclosure, the distributed antenna system 20 can support multiple carriers and multiple base stations, of which **the RRHs can also support multiple carriers. The number of carriers supported depends on the wireless technology used and its operating bandwidth.** For example, for 5 MHz WiMAX technology, the digital baseband signal traffic is 137

Mbps. Considering an overhead of 25%, the traffic would be 171.25 Mbps, so a Gigabit Ethernet link can support five carriers.

EX-1005 3:39-43 (emphasis added).

114. A POSA understood that each carrier used by an RHH utilized its own RF band to prevent interference between the carriers.

c. Claim 3

i. The method of claim 1

ii. wherein determining the load percentage comprises detecting which carriers are active for each remote radio unit.

115. Leng discloses receiving the total power of each RRH (*remote radio unit*).

The remote radio heads 26 comprise a received power detection module 41 configured to **detect the total broadband power received by the remote radio heads 26 and transmit the detected power value to the load information collection module 32.**

EX-1005 5:13-15 (emphasis added).

116. Leng also discloses collecting various other types of information and data and using it to dynamically determine if the carriers need to be reallocated to other RRHs to balance load and to increase the

availability of resources where there are “hot spots.” EX-1005 11:22-26
(emphasis added).

The load information detection module 210 is provided in each base station 21 for collecting **various load information** (e.g., throughput, **number of connections**, number of registered users, **etc.**).

EX-1005 6:1-4 (emphasis added).

With the present disclosure, a distributed antenna system can be **dynamically reconfigured in a timely and effective manner according to the real-time load distribution**, balancing the load and improving the system efficiency in a timely manner.

EX-1005 2:14-16 (emphasis added).

the cell management unit 24 receives the **load information transmitted by the base station 21, and when the load information meets the reconfiguration conditions**, the need to reconfigure the distributed antenna system 20 according to the load information (step 71) is determined.

EX-1005 6:12-15 (emphasis added).

Fig. 4 and Fig. 5 are schematic diagrams showing the principle of reconfiguration of the distributed antenna system in the embodiment. Fig. 4 shows the initial configuration of the distributed antenna system 20, with RRH A and RRH B using carrier 1, RRH C and RRH D using carrier 2, and RRH E and RRH F using carrier 3. When the load of carrier 2 and carrier 3 is transferred to the area of carrier 1, that is, when the CMU 4 detects that RRH A and RRH B have become temporary hot

spots of high load, the distributed antenna system 20 is reconfigured. **Fig. 5 shows the reconfigured state of the distributed antenna system 20, with RRH A using carrier 1, RRH B using carrier 2, and RRH C, RRH D, RRH E, and RRH F using carrier 3. Clearly, by using the distributed antenna system provided by this embodiment, for areas where communication traffic varies greatly, such as auditoriums, conference halls, etc., it is possible to dynamically allocate radio frequency resources according to the current traffic condition, and greatly balance the traffic load and improve system efficiency.**

EX-1005 4:18-27 (emphasis added).

117. A POSA understood to properly redistribute resources to balance loading you would need to know which of the multiple carriers on each of the RRHs are being used. If this was not done, a carrier which was in use would be transferred to augment a “hot spot” overloading the carrier causing an unexpected disconnection of the user(s) using the carrier that was transferred.

118. To the extent the Patent Owner argues that Leng does not disclose determining a load percentage for each remote radio unit, a POSA understood that Leng’s disclosure of the relative loading of each remote radio unit can be converted to a load percentage using well-known simple mathematical conversions.

119. It would have been obvious and routine to perform the conversion into a load percentage as known to a POSA in the method and system of Leng.

B. Challenge 2, Claims 4-12

1. The Gupta Reference

120. Gupta is directed to providing a device and connection methodology for connecting resources of a system of BTSs to maximize the use of capacity resources in a communication network.

121. Gupta discloses that radio resources are provided in a distributed fashion by connecting a set of base stations (blue) to one or more common Public Radio Interfaces (green) that communicates with a plurality of radio heads (red). EX-1008 [0017-0018].

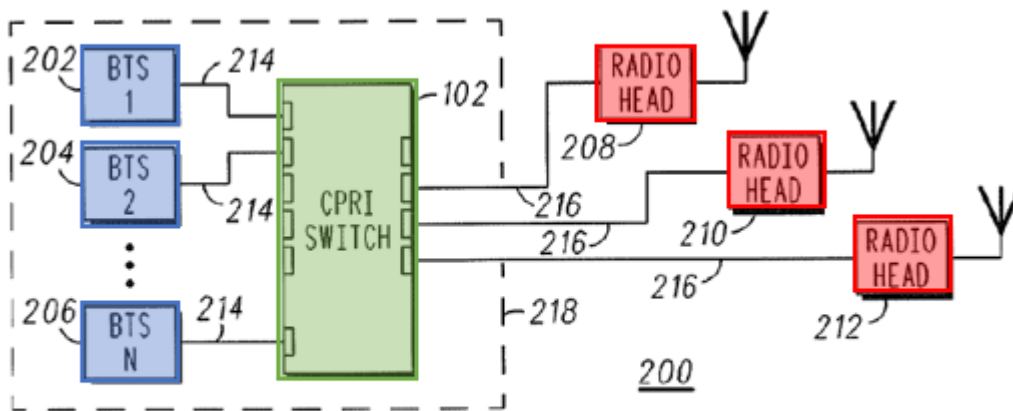


FIG. 2

EX-1008 Fig. 2 (annotated).

122. Gupta discloses that the CPRI switch can be used for allocating resources of one or more base stations to allow high-traffic sites to become capable of utilizing the resources of under-utilized sites. The CPRI switch uses the CPRI protocol to provide aggregation, switching and distribution of baseband signals between one or more radio resources. EX-1008 [0019].

123. Gupta describes that its architecture reduces the infrastructure costs and needs, while increasing the overall capacity of a set of base stations by increasing the effective utilization of the resources. EX-1008 [0031]. In addition, Gupta describes that the architecture allows for integration of different types of base stations using the CPRI switches. EX-1008 [0031].

2. Detailed Application of Leng, Cannon and Gupta to Claims 4-12

a. Claim 4

- i. The method of claim 1**
- ii. wherein the at least one digital access unit comprises a first digital access unit and a second digital access unit configured to communicate with each other via a first optical cable.**

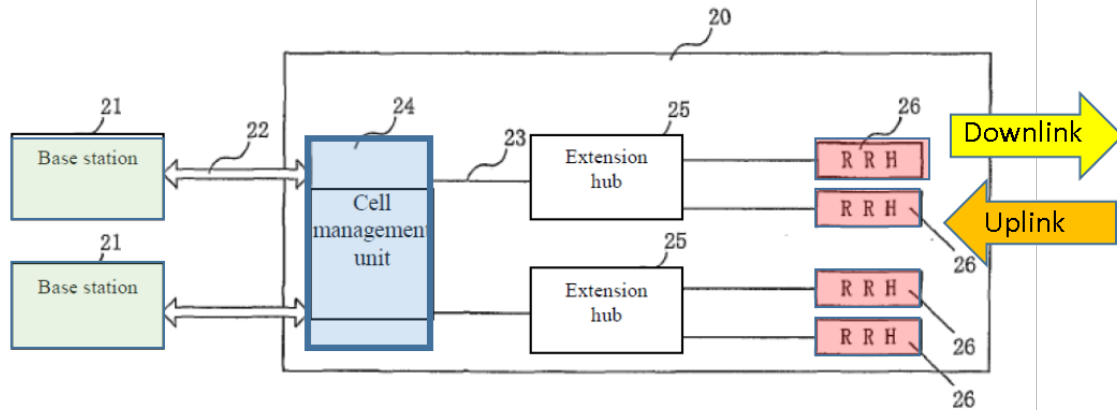


Fig. 2

EX-1005 Fig. 2 (annotated).

124. Leng discloses having two expansion slots, each with two RRHs attached. The expansion slots 25 are connect through an optical fiber, 23 and the CMU.

An extension hub 25 is used to aggregate and distribute I/Q data to an extended coverage area. The remote radio heads (RRHs) 26 are used for digital filtering, analog/digital-to-analog conversion, and analog front-end functions. **The transmission medium 23 of the distributed antenna system 20 may be an optical fiber or a UTP/STP cable, etc.**

EX-1005 3:34-37 (emphasis added).

As shown in Fig. 2, an embodiment of the present disclosure provides a distributed antenna system 20 comprising **at least one remote radio head (RRH) 26 and a cell management unit (CMU) 24 connected to**

the remote radio heads 26 via at least one extension hub 25. The cell management unit 24 is connected to the base station 21, and is configured to distribute downlink radio signals to the remote radio head 26, collect uplink radio signals and transmit them to the base station 21, and collect the load information of the distributed antenna system 20 and reconfigure the distributed antenna system 20 based on the load information.

EX-1005 3:20-25 (emphasis added).

125. A POSA understood that, akin to the multiple extension hubs, 25, the method and system of Leng could just as easily use a second CMU (*DAU*) connected via an optical fiber similar to transmission line 23 to attach additional RRHs (*remote radio units*) and extend the coverage.

126. For example, FIG. 6 of Gupta describes an architecture that provides for two CPRI switches communication with each other and a plurality of radio heads via optical cables. The CPRI switches are the functional equivalent of the CMU taught by Leng. Thus Gupta discloses a *digital access unit* that includes a first CPRI 102 (*a first digital access unit*) and CPRI 602 (*a second digital access unit*) configured to communicate with each other via *a first optical cable* 610.

127. A POSA would be motivated to combine the teachings of Gupta to add a second CMU (*a second digital access unit*) and additional

radio heads to the first CMU (*a first digital access unit*) of Leng in order to extend the geographical footprint of the network to achieve the benefits describes by Gupta, e.g., reduce the infrastructure costs and needs, while increasing the overall capacity of a set of base stations by increasing the effective utilization of the resources. Thus, a POSA implementing the teachings of Gupta for their intended purpose and would expect the combination to be successful.

b. Claim 5

- i. The method of claim 4**
- ii. wherein the one or more remote radio units comprise a first remote radio unit and a second remote radio unit, the first remote radio unit configured to communicate with the first digital access unit via a second optical cable, and the second remote radio unit configured to communicate with the second digital access unit via a third optical cable.**

128. As discussed with respect to Claim 4, Gupta discloses a second CPRI switch (*digital access unit*) 602 that is in communication with the first CPRI 102 switch that allows for an increase in the number of radio heads (*remote radio units*) by adding radio heads 604 and 606.

The CPRI switch 102 can also be connected through an electrical or fiber optic cable 610 to a remote CPRI switch 602. Further, the remote CPRI switch 602 can be connected through the plurality of electrical or fiber optic cables 608 to a fourth RH 604 and a fifth RH 606. The first base station 202, the second base station 204, and the third base station 206 can then distribute the communication network data to the forth [sic] RH 604 and a fifth RH 606. The fourth RH 604 and the fifth RH 606 can then radiate and receive the communication network data and can behave like another base station

EX-1008 [0029] (emphasis added).

129. A POSA would have understood that CPRI switch 102 would also have been connected to its RHs using optical fiber cables just as the CPRI switch 602 is connected via optical fiber cables to RH 604 and RH 606.

130. For the reasons described above with respect to Claim 4, it would have been obvious to modify the combination of Leng and Cannon with the teachings of Gupta.

c. Claim 6

- i. The method of claim 5**
- ii. wherein the first digital access unit is configured to communicate with a first base station, and the second digital access unit is**

configured to communicate with a second base station.

131. As discussed with respect to Claim 4, Gupta discloses each CPRI switch (*digital access unit*) is configured to communicate via optical line, 214, to its base stations.

FIG. 2 illustrates an exemplary way of connecting a set of base stations and a set of RHs to a CPRI switch 102 in a communication network 200, in accordance with various embodiments of the present invention. The communication network 200 includes a first base station 202, a second base station 204, and a third base station 206. **The first base station 202, the second base station 204, and the third base station 206 can be connected to the CPRI switch 102 through a plurality of electrical or fiber optic cables 214.**

EX-1008 [0029] (emphasis added).

132. For the reasons described above with respect to Claim 4, it would have been obvious to modify the combination of Leng and Cannon with the teachings of Gupta.

d. Claim 7

- i. The method of claim 6**
- ii. wherein the first base station transmits or receives RF signals corresponding to a first number of carriers, and the second base station**

transmits or receives RF signals corresponding to a second number of carriers.

133. Leng discloses multiple base stations and multiple carriers.

Fig. 1 shows the basic structure of an existing digital distributed antenna system 10. Remote radio heads (RRHs) 17 are placed around the building. The primary hub 14 and the extension hubs 16 distribute downlink radio signals to the remote radio heads 17 and collect uplink radio signals for the base station 11. **Since the transmitted signals are digital radio signals, it is easy to support multiple carriers and multiple base stations at the same time.**

EX-10051:15-18 (emphasis added).

134. Leng also discloses that the CMU receives radio signals (*RF signals*) from the base stations.

In order to avoid service interruption to mobile stations (MS) caused by the carrier switching of the RRH and ensure service continuity, the embodiment of the present disclosure provides a manner of implementation for carrier reconfiguration and the corresponding structure. By gradually reducing the transmit power of the carriers to be switched, a situation in which mobile stations leave the cell is simulated, and this makes the mobile stations actively **send a request to the base station to switch carriers, thus enabling the base station to be informed of the specific mobile stations that need a switch of**

carriers and switch these mobile stations to the target carriers through the base station.

EX-1005 8:29-35 (emphasis added).

135. A POSA understood that if a first base station were transmitting a carrier that would mean that the first base station was transmitting a first number of carriers and the second base station was transmitting a carrier that would mean that it was transmitting a second number of carriers.

e. Claim 8

- i. The method of claim 7**
- ii. wherein the first number of carriers and the second number of carriers correspond to different RF bands.**

136. Leng discloses that each carrier has an operating bandwidth within the overall bandwidth and therefore only a fixed number of carriers can be supported.

According to an embodiment of the present disclosure, the distributed antenna system 20 can support multiple carriers and multiple base stations, of which **the RRHs can also support multiple carriers. The number of carriers supported depends on the wireless technology used and its operating bandwidth.** For example, for 5 MHz WiMAX technology, the digital baseband signal traffic is 137 Mbps.

Considering an overhead of 25%, the traffic would be 171.25 Mbps, so a Gigabit Ethernet link can support five carriers.

EX-1005 3:39-43 (emphasis added).

Fig. 1 shows the basic structure of an existing digital distributed antenna system 10. Remote radio heads (RRHs) 17 are placed around the building. The primary hub 14 and the extension hubs 16 distribute downlink radio signals to the remote radio heads 17 and collect uplink radio signals for the base station 11. **Since the transmitted signals are digital radio signals, it is easy to support multiple carriers and multiple base stations at the same time.**

EX-1005 1:15-18 (emphasis added).

137. A POSA understood that carriers are generally defined by distinct RF Bands, thus different carriers have different RF Bands. A POSA also understood that in a system with multiple bases stations and multiple carriers with overlapping coverage areas, each base station, each with its own number of carriers, would utilize different RF bands for their carriers than that of adjacent base stations, especially in the overlapping areas, in order to minimize interference.

f. Claim 9

- i. The method of claim 7**
- ii. wherein the first remote radio unit is configured to receive or transmit RF signals**

corresponding to one of the second number of carriers.

138. Leng discloses that the system of Leng can be reconfigure such that each RRH (*remote radio unit*) may utilized any carrier as to dynamically allocate resources as needed bases on load distribution.

Fig. 4 and Fig. 5 are schematic diagrams showing the principle of reconfiguration of the distributed antenna system in the embodiment. Fig. 4 shows the initial configuration of the distributed antenna system 20, with RRH A and RRH B using carrier 1, RRH C and RRH D using carrier 2, and RRH E and RRH F using carrier 3. **When the load of carrier 2 and carrier 3 is transferred to the area of carrier 1, that is, when the CMU 4 detects that RRHA and RRH B have become temporary hot spots of high load, the distributed antenna system 20 is reconfigured.** Fig. 5 shows the reconfigured state of the distributed antenna system 20, with RRH A using carrier 1, RRH B using carrier 2, and RRH C, RRH D, RRH E, and RRH F using carrier 3. Clearly, **by using the distributed antenna system provided by this embodiment, for areas where communication traffic varies greatly, such as auditoriums, conference halls, etc., it is possible to dynamically allocate radio frequency resources according to the current traffic condition,** and greatly balance the traffic load and improve system efficiency.

EX-1005 4:18-27 (emphasis added).

139. A POSA understood that in a system with multiple bases stations and multiple carriers, wherein each carrier is dynamically allocated (*configured to receive*) as necessary to a RRH (*remote radio unit*) that each carrier (*one of the second number of carriers*) from each base station would be one of the RF bands corresponding to the carriers used by that base station.

g. Claim 10

- i. The method of claim 7**
- ii. wherein the second remote radio unit is configured to receive or transmit RF signals corresponding to one of the first number of carriers.**

140. Leng discloses that the system of Leng can be reconfigure such that each RRH (*remote radio unit*) may utilize any carrier as to dynamically allocate resources as needed bases on load distribution.

Fig. 4 and Fig. 5 are schematic diagrams showing the principle of reconfiguration of the distributed antenna system in the embodiment. Fig. 4 shows the initial configuration of the distributed antenna system 20, with RRH A and RRH B using carrier 1, RRH C and RRH D using carrier 2, and RRH E and RRH F using carrier 3. **When the load of carrier 2 and carrier 3 is transferred to the area of carrier 1, that is, when the CMU 4 detects that RRHA and RRH B have become**

temporary hot spots of high load, the distributed antenna system 20 is reconfigured. Fig. 5 shows the reconfigured state of the distributed antenna system 20, with RRH A using carrier 1, RRH B using carrier 2, and RRH C, RRH D, RRH E, and RRH F using carrier 3. Clearly, **by using the distributed antenna system provided by this embodiment, for areas where communication traffic varies greatly, such as auditoriums, conference halls, etc., it is possible to dynamically allocate radio frequency resources according to the current traffic condition,** and greatly balance the traffic load and improve system efficiency.

EX-1005 4:18-27 (emphasis added).

141. A POSA understood that in a system with multiple bases stations and multiple carriers, wherein each carrier is dynamically allocated (*configured to receive*) as necessary to a RRH (*remote radio unit*) that each carrier (*one of the first number of carriers*) from each base station would be one of the RF bands corresponding to the carrier used by that base station.

h. Claim 11

- i. The method of claim 6**
- ii. wherein the first base station and the second base station are associated with different wireless operators.**

142. Leng discloses using multiple carriers and multiple base stations.

Fig. 1 shows the basic structure of an existing digital distributed antenna system 10. Remote radio heads (RRHs) 17 are placed around the building. The primary hub 14 and the extension hubs 16 distribute downlink radio signals to the remote radio heads 17 and collect uplink radio signals for the base station 11. **Since the transmitted signals are digital radio signals, it is easy to support multiple carriers and multiple base stations at the same time.**

EX-1005 1:15-18 (emphasis added).

143. A POSA understood different carriers are associated with different base stations and different carriers are typically associated with different wireless operators, therefore it is not uncommon that base stations are associated with different operators.

144. Further, a POSA understood that it was common to utilize common DAS infrastructures among different carriers. *See* section IV.E.3. As discussed in the state of the art section above, a POSA understood that the multiple service providers using different communications protocols (e.g., CDMA, GSM, etc.) could share common infrastructure resources and thus avoid the cost and complexity of each provider proving its own infrastructure. EX-1010 2:24-29. In addition, Gupta expressly discloses that its teachings allow for integration of

different types of base stations within the same network. Thus, a POSA would be motivated to modify the teachings of Leng to include base stations associated with different wireless operators to achieve the benefits of reduced infrastructure costs, with an expectation that such modification would be successful.

i. **Claim 12**

- i. **The method of claim 6**
- ii. **wherein the first base station and the second base station are associated with a common wireless operator.**

145. Leng discloses using multiple carriers and multiple bases stations.

Fig. 1 shows the basic structure of an existing digital distributed antenna system 10. Remote radio heads (RRHs) 17 are placed around the building. The primary hub 14 and the extension hubs 16 distribute downlink radio signals to the remote radio heads 17 and collect uplink radio signals for the base station 11. **Since the transmitted signals are digital radio signals, it is easy to support multiple carriers and multiple base stations at the same time.**

EX-1005 1:15-18 (emphasis added).

146. A POSA understood that it would obvious that single wireless operator would have multiple base stations to provide coverage to a large area. A POSA would also understand that the coverage areas would

have varying amount of load demand it would therefore be advantageous to reallocate resources between a first a second base station have a common carrier.

CONCLUSION AND DECLARATION

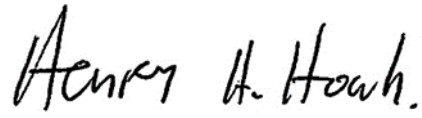
My findings and opinions set forth in this Declaration are based on my work and examination to date. I may continue my examinations in view of additional documents or other factual evidence over the course of this proceeding that may necessitate supplementing and/or refining my opinions. I reserve the right to add to, alter, or delete my opinions and my Declaration upon discovery of additional information. I reserve the right to make such changes as necessary.

In signing this Declaration, I understand that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross-examination in this case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and 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.

[SIGNATURE ON FOLLOWING PAGE]

By:

A handwritten signature in black ink that reads "Henry H. Houh." The signature is written in a cursive style with a period at the end.

Henry H. Houh

Date: March 1, 2023

APPENDIX A – MATERIALS RELIED UPON

<i>Exhibit #</i>	<i>Description</i>
1001	U.S. Patent No. 8,682,338 (“the ’338 Patent”)
1002	Select portions of prosecution history of the ’338 Patent (“File History”)
1004	International Application Publication WO 2009/021359 A1 published on February 19, 2009 (“Leng”)
1005	Certified English Translation of EX-1004 (Leng)
1006	U.S. Patent No. 8,270,387 (“Cannon”)
1007	Institution Decision of IPR2020-01466
1008	U.S. Patent Application Publication US2008/0045254A1 (“Gupta”)
1009	U.S. Patent Application Publication US2010/0128676 (“Wu”)
1010	U.S. Pat. No. 8,588,614 (“Larsen”)

APPENDIX B – RÉSUMÉ

Henry H. Houh

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Lexington, MA 02420
henry.houh@gmail.com
cell: 781-325-8273

Education

Massachusetts Institute of Technology, Cambridge, MA

- PhD in Electrical Engineering and Computer Science, February 1998. “Designing Networks for Tomorrow's Traffic,” thesis supervised by Professor David Tennenhouse and Professor John Guttag. GPA 4.7/5.0
- Master of Science in Electrical Engineering and Computer Science, February 1991. “Demonstration of a laser repetition rate multiplier,” thesis. GPA 4.5/5.0
- Bachelor of Science in Electrical Engineering and Computer Science, June 1989. “Boundary element analysis of arbitrarily shaped dielectric structures,” thesis. GPA 4.7/5.0
- Bachelor of Science in Physics, February 1990. GPA 4.7/5.0

MITx, Cambridge, MA

- September 2020 – present: Enrolled in Statistics and Data Science MicroMasters program, a sequence of five MIT-offered graduate-level courses in statistics and machine learning, culminating in a MicroMasters certificate, expected 2022. Have completed four of five required courses.

Experience

BlocksCAD Inc. (H3XL spin-out)

- 2014 - present: Founder and member of Board of Directors. BlocksCAD is a visual Computer-Aided Design (CAD) program, designed to teach children mathematics and geometric visualization. BlocksCAD is being used in U.S. schools and worldwide in maker spaces, with 350,000+ users. BlocksCAD was selected to be part of the LearnLaunch 2017 Boost Accelerator, the MIT Play Labs 2018 Summer Accelerator, and the MassChallenge 2018 Boston Cohort. Recipient of DARPA DSO grant in 2014, and SBIR grant from the USDA in 2019.

H3XL Inc. d/b/a Einstein's Workshop (formerly Lexington Robotics)

- 2009 - present: Founder and President. Started local league providing science and engineering education programs based on LEGO Mindstorms, LEGO WeDo, and FIRST LEGO League. In 2012, grew program into a full science, technology, engineering and math enrichment program and creative/maker space, in 7,000 square feet of space. Serve 2,000+ kids and families annually. As of end of 2021, have delivered an estimated 220,000 student-instruction-hours of

STEM courses. Principle Investigator for 2-year DARPA grant to improve 3D Computer Aided Design tool developed in-house for the purposes of teaching 8 year olds and up 3D CAD.

Houh Consulting Inc. / Independent Consultant

- 2009 - present: Technical consultant specializing in Social Networking, Web 2.0, Web Site Development, Data Networking, Optical Networking, Telecommunications, Media Streaming and Voice Over IP. Clients include: Akin Gump Strauss Hauer & Feld LLP, Arnold & Porter Kaye Scholer LLP, BBN, Baker Botts LLP, Barnes & Thornburg LLP, BBN Technologies, Beus Gilbert McGroder PLLC, Bracewell LLP, Christensen O'Connor Johnson Kindness PLLC, Cooley LLP, Covington & Burling LLP, Cozen O'Connor P.C., DLA Piper, Davis Polk & Wardwell LLP, Desmarais LLP, Duane Morris LLP, Erise IP, P.A., Faegre Baker Daniels LLP, Finnegan, Henderson, Farabow, Garrett & Dunner, LLP, Fish & Richardson P.C., Goldman Ismail Tomaselli Brennan & Baum LLP, Haynes and Boone, LLP, Kaye Scholer, Kellogg Huber Hanson Todd Evans & Figel PLLC, Kirkland & Ellis LLP, Klarquist Sparkman, LLP, McCarthy Tetrault LLP, McGuireWoods LLP, Morgan, Lewis & Bockius LLP, Munger Tolles & Olson LLP, Orrick, Herrington & Sutcliffe LLP, O'Melveny & Myers LLP, Orrick, Herrington & Sutcliffe LLP, Paul Hastings LLP, Paul, Weiss, Rifkind, Wharton & Garrison LLP, Perkins Coie LLP, Quinn Emanuel Urquhart & Sullivan, LLP, Sidley Austin LLP, Smith Baluch LLP, Sterne, Kessler, Goldstein & Fox PLLC, Troutman Sanders LLP, Venable LLP, Weil, Gotshal & Manges LLP, Wiley Rein LLP, Wilmer Cutler Pickering Hale and Dorr LLP, and Winston & Strawn LLP.

Eons

- 2008 - 2009: Chief Technology Officer. Created product that Eons acquired from BBN Technologies. Integrated BBN product with Eons social networking platform and significantly increased the Eons group creation rate. Helped evaluate advertisement platform offerings and rolled out the "Boom Network" advertising network. Eons raised \$32 million from General Catalyst Partners, Charles River Ventures, Sequoia Capital, and Intel Capital.

BBN Technologies

- 2007 - 2008: Delta Division, Vice President of Technology. Grew "Boomerang" counter-sniper project engineering team and significantly de-risked \$10 million worth of product deliveries. Boomerang was a significant asset leading to the acquisition of BBN by Raytheon in 2009. Created new business plan and grew team; launched new fully-featured social networking web site in 5 months. Served as lead expert witness in patent infringement lawsuit, resulting in \$58 million jury award to client; verdict for patents I testified on were upheld on appeal which resulted in a \$120 million settlement.
- 2004 - 2007: Delta Division, Director of Technology, responsible for commercializing IP and creating new businesses. Hired and grew division's initial engineering team. Wrote three business plans, two of which are funded and active. For call center business plan, acted as general manager, hiring and managing engineering team, inside sales team, and identifying and recruiting a new general manager. Identified and recruited other key employees to Delta Division, including senior members of team leading to successful internal sales growth and spin-outs of projects. Contracted by BBN to BBN spin-out PodZinger as VP of Operations and

Technology. Identified sales team for counter-sniper system, leading to \$10 million dollars of new sales within 6 months and \$100+ million in additional orders in the following two years.

PodZinger Inc. (BBN spin-out, also known as EveryZing and now RAMP)

- 2006: Vice President of Operations and Technology. Significantly upgraded capability of consumer-facing search site and redeployed web site from company to co-location facility. Identified key portions of infrastructure for upgrading and cost reduction. Helped write business plan, evaluating advertisement models of revenue. Hired in operations replacement and phased back to BBN.

Commonwealth Capital

- 2004: Entrepreneur-in-residence (informally), performed technical due diligence on business plans, brainstormed ideas for new businesses with venture partner. With venture partner, left for portfolio company BBN to form core of commercialization team.

Empirix, Inc./Teradyne, Inc.

- 2001 - 2004: Chief Technologist, Engineering Manager, Web Application Test Group. Researched potential new product areas; developed product plan and prototype. Responsible for three new and existing products. Managed off-shore development team. Chief architect for all web testing products. Re-architected core testing product, helped write javascript interpreter. Provided technical vision for core product.
- 2000 - 2001: Chief Technologist, Communication Infrastructure Test Group. Responsible for incorporating new technology internally, tracking new technologies, technical evaluation of partnerships and potential acquisitions. Helped develop division strategy. Developed plans which formed core capabilities for successful new products introduced in 2004-5.
- 2000 - 2001: Engineering Manager, Communications Infrastructure Test Group. Execution of new product plan developed in prior role. Grew team from four existing engineers to team of over 30 on immediate team and over 40 on project. Delivered new platform in one year. Platform and derivatives accounted for large portion of booked products for the division within 2 years and is currently (2008) a key portion of new product offerings.
- 2000: Empirix was formed as a spin-out of Teradyne in January 2000. Reported to CEO in carve-out of Empirix from Teradyne.
- 1999: (Teradyne) Director of Business Development, Software Test Units. Reported directly to Chairman of the Board/Founder and then to general manager of software test unit (6 divisions of Teradyne). Evaluated and researched acquisition and partnership candidates. Internally assessed technology position in market and gaps in product lines. Worked with senior division staff to develop new product strategies. Attended internal Teradyne divisional board meetings. Chairman served as my mentor.

3Com Corporation/NBX Corporation

- 1999: Software Engineer 5. Continued work after 3Com acquisition of NBX. Built cross-division relationships for new products and research directions. NBX was acquired by 3Com in March 1999.

- 1997 - 1999: (NBX) Senior Scientist and Engineer. Work in IP Telephony. Architected next-generation product. Protocol design and validation for core protocol now used tens of millions of times daily. Led team in integration of IP protocols into current product. Designed audio reconstruction algorithms. Developed applications for bug analysis and diagnosis of system problems. Implementation of network simulator. Work on collaborative projects with external partners. Worked to identify gaps in product. Representative at numerous trade shows. Innovated novel methods of using product.

MIT Department of Electrical Engineering and Computer Science, Cambridge, MA

- 1991 - 1998: Research assistant, Telemedia Network Systems Group. Design, development, and implementation of Gigabit ATM network for distributed multimedia system. Studied host interface design issues. ATM network simulation.
- Spring 1989, Fall 1990, Spring 1995: Teaching assistant, Computation Structures digital systems course. (Spring 1995 Head TA)
- 1988 - 1989: Head laboratory teaching assistant for Computation Structures. Responsibilities included writing and revising lab assignments, and maintaining the lab.
- 1987: Laboratory teaching assistant for Computation Structures.
- 1987: Design, construction, and programming of 16-bit computer.

Agora Technology Group, Incorporated

- 1994 - 1996: Founder and CEO. Conceived and oversaw development of targeted advertising-supported Web sites. Responsible for company's vision and direction. Attended the first two WWW Conferences, presenting a workshop and paper at the first, and appearing on the "Commercialization and Economics of the Web" panel and chairing the "Where Commercial Services and the Web Are Headed" panel at the second. Sold company intact; is currently an operating stand-alone company.

AT&T Bell Laboratories, Holmdel, NJ

- 1989 - 1990: Implementation of cascable all-optical fiber logic gate. Modelocking of all-fiber erbium laser. Construction of modelocked laser repetition rate booster. Strong optics laboratory and fiber optic experience.
- Summer 1988, 1987: Research in integrated optics. Analysis of rectangular waveguides using microwave modeling. Fabrication of integrated optical components.

Honors

- MIT Alumni Association Great Dome Award, 2010, Baker 60th Anniversary Reunion Co-Chair (highest group award given by MIT Alumni Association)
- MIT Alumni Association Presidential Citation Award (now known as Great Dome), 2008, Member of MIT Chairman's Salon committee
- MIT Alumni Association Bronze Beaver Award, 2007 (highest individual award given by MIT Alumni Association)
- MIT Alumni Association Volunteer Honor Roll, February 2004
- MIT Alumni Association Lobdell Award, 1999

- Boston Museum of Science Gold Pin for 1000 hours of Volunteer Service, April 1999
- MIT Alumni Association Presidential Citation Award (now known as Great Dome), 1997, Member of Alumni Online Communications Committee

Patents and Patent Publications

- U.S. Patent #9,697,231, H. Houh, J. Stern, R. Spina, M. Meter, “Methods and apparatus for providing virtual media channels based on media search,” July 4, 2017.
- U.S. Patent #9,697,230, H. Houh, J. Stern, “Methods and apparatus for dynamic presentation of advertising, factual, and informational content using enhanced metadata in search-driven media applications,” July 4, 2017. See also WO2007056485.
- U.S. Patent #7,975,296, L. Apfelbaum, H. Houh, T. Mayberry and G. Friedman, “Automated security threat testing of web pages,” July 5, 2011. See also US20030159063, WO2003067405.
- U.S. Patent #7,877,736, H. Houh and J. N. Stern, “Computer language interpretation and optimization for server testing,” January 25, 2011. See also US20050138104, WO2005043300.
- U.S. Patent #7,801,910, H. Houh and J. N. Stern, “Method and apparatus for timed tagging of media content,” September 21, 2010. See also US20070112837, US20090222442, WO2007056535.
- U.S. Patent #7,590,542, D. C. Williams, W. C. Hand, H. Houh, A. R. Seeley, “Method of Generating Test Scripts Using a Voice-Capable Markup Language,” September 15, 2009. See also EP1530869, US20030212561, WO2003096663.
- U.S. Patent #6,967,963, H. H. Houh, P. Anderson, C. Gadda, “Telecommunication method for ensuring on-time delivery of packets containing time-sensitive data,” November 22, 2005. See also EP1060400, WO2000033092, CA2318774.
- U.S. Patent #5,144,375, M. C. Gabriel, H. H. Houh, N. A. Whitaker, “Sagnac Optical Logic Gate,” September 1, 1992. Also issued as European Patent # EP0456422, July 23, 1997, German Patent #DE69126913, August 28, 1997
- U.S. Patent Application Publication No. 20020015387, “Voice Traffic Packet Capture and Analysis Tool for a Data Network” (Abandoned in 2007)
- U.S. Patent Application Publication No. 20020016708, “Method and Apparatus for Utilizing a Network Processor as Part of a Test System” (Abandoned in 2007)
- U.S. Patent Application Publication No. 20020016937, “Method and Apparatus for Utilizing a Network Processor as Part of a Test System.” (Abandoned in 2007) See also WO2002011413.
- U.S. Patent Application Publication No. 20070106646, “User-directed navigation of multimedia search results” (Abandoned in 2009)
- U.S. Patent Application Publication No. 20070106660, “Method and apparatus for using confidence scores of enhanced metadata in search-driven media applications” (Abandoned in 2009)
- U.S. Patent Application Publication No. 20070106685, “Method and apparatus for updating speech recognition databases and reindexing audio and video content using the same” (Abandoned in 2015)
- U.S. Patent Application Publication No. 20070118873, “Methods and apparatus for merging media content” (Abandoned in 2015)
- U.S. Patent Application Publication No. 20090222442, “User-directed navigation of multimedia search results” (Abandoned in 2016)

- U.S. Patent Application 11/395,732, “Search snippet creation for audio and video data” (Abandoned in 2009)
- U.S. Patent Application 11/774,931, “Methods and apparatus for managing a social networking web site”
- U.S. Patent Application 11/774,947, “Methods and apparatus for organizing media files”
- U.S. Patent Application 11/774,956, “Methods and apparatus for managing an online event”
- U.S. Provisional Patent Application 61/086,909, “Measuring and ranking relationship activity”
- U.S. Provisional Patent Application 61/086,914, “Detecting media object commonality”
- U.S. Provisional Patent Application 61/086,904, “Message categorization based on message characteristics”
- U.S. Provisional Patent Application 61/086,905, “Photo tagging to request action”

Trials, Testimony and Depositions

- Case No. 1:06CV682 (CMH/BRP), Verizon vs. Vonage, U.S. District Court for the Eastern District of Virginia, filed expert report, was deposed and testified at trial.
- Case No. 1:08CV157 (CMH/TRJ), Verizon vs. Cox, U.S. District Court for the Eastern District of Virginia, was deposed and testified at trial.
- Case No. 5:09-cv-476, Two-Way Media vs. AT&T, U.S. District Court for the Western District of Texas, filed expert report, testified at trial.
- Case No. 2:10-cv-248 (RAJ/FBS), ActiveVideo Networks vs. Verizon, U.S. District Court for the Eastern District of Virginia, filed expert report and was deposed as an expert witness.
- Case No. 1:11-cv-00880-TSE-JFA, Bear Creek Technologies, Inc. vs. Verizon Services Corp., et al, U.S. District Court for the Eastern District of Virginia, was deposed as an expert witness.
- Case No. 3:10-CV-298-BBC, AlmondNet, Inc. vs. Microsoft Corp., U.S. District Court for the Western District of Wisconsin, filed expert report.
- Case No. 6:10-cv-00597, Guardian Media Technologies, Ltd. Vs. AT&T Operations, Inc. et al., U.S. District Court for the Eastern District of Texas, Tyler Division, filed expert report.
- Case No. ESCV2010-02282C, The Octopus Solution LLC v. Gary Brown et al., Essex, MA Superior Court, testified at trial.
- Investigation No. 337-TA-882, In the matter of Certain digital media devices, including televisions, Blu-ray disc players, home theater systems, tablets and mobile phones, components thereof and associated software, U.S. International Trade Commission, filed expert reports, was deposed and testified at hearing.
- Investigation No. 337-TA-995, In the matter of Certain communications or computing devices, and components thereof, U.S. International Trade Commission, filed expert reports, and was deposed.
- Case No. 8:12-cv-122-LES-TDT, Prism Technologies LLC v. AT&T Mobility LLC, U.S. District Court for the District of Nebraska, filed expert report, was deposed and testified at trial.
- Case No. 11-2684 (JWL), Sprint Communications Co., L.P., v. Comcast Cable Communications, LLC, et al., U.S. District Court for the District of Kansas, filed expert report and was deposed.
- Case No. 11-2686 (JWL), Sprint Communications Co., L.P., v. Time Warner Cable, Inc., et. al., LLC, et al., U.S. District Court for the District of Kansas, filed expert report, was deposed, and testified at trial.
- Case No. 12-487 (SLR), Cox Communications, Inc., et al., v. Sprint Communications Company L.P., et al., U.S. District Court for the District of Delaware, filed expert report and was deposed.

- Case IPR 2014-00039, Microsoft Corporation v. B.E. Technology LLC, U.S. Patent No. 6,628,314. Submitted declaration and cross-examined in deposition.
- Case IPR 2014-00086, Apple, Inc. v. Evolutionary Intelligence, LLC, U.S. Patent No. 7,010,536. Submitted declaration and cross-examined in deposition.
- Case No. 6:11-CV-421, Stragent, LLC v. Intel Corporation, U.S. District Court for the Eastern District of Texas, Tyler Division, deposed and testified at trial as a fact witness.
- IPR2014-01366, IPR2014-01367, IPR2014-01368, Samsung et al. v. Straight Path, submitted IPR declarations and was deposed.
- IPR2015-1006, IPR2015-1007, Cisco v. Straight Path, submitted IPR declarations.
- IPR2014-01457, IPR2014-01459, Microsoft v. Biscotti, submitted IPR declaration and was deposed.
- IPR2016-00302, Apple v. Nonend, submitted IPR declaration.
- IPR2014-00812, Yelp and Twitter v. Evolutionary Intelligence, submitted IPR declaration.
- IPR2015-00307, Cisco v. AIP, submitted IPR declaration.
- Microsoft v. Acacia, submitted IPR declaration.
- IPR2015-00342, AT&T Mobility LLC and Cellco Partnership d/b/a Verizon Wireless v. Solocron, submitted IPR declaration.
- Mediatube v. Bell Canada, Canadian Federal Court, submitted expert report and testified at trial.
- CBM2016-00036, Google v. At Home Bondholder's Liquidating Trust, submitted CBM declaration.
- IPR2016-01198, IPR2016-01201, Apple, Inc. v. VoIP-Pal.com, Inc., submitted IPR declaration and was deposed.
- Case No. 3:14-cv-2824-VC, Trend Micro Incorporated v. Rpost Holdings, Inc., et al, submitted expert report and was deposed
- Akamai v. Limelight Networks, IPR2016-01631, IPR2016-01711, IPR2017-00249, IPR2017-00349, submitted IPR declarations and was deposed
- Hyperlync Technologies v. Verizon Sourcing, No. 650151/2015 New York Supreme Court, submitted declaration and was deposed
- Cascades Streaming Technologies v. Big Ten Networks, submitted expert reports and was deposed
- Klaustech, Inc. v. Google LLC., Case No. 4:10-CV-05899-JSW (N.D. Cal.), submitted expert report and was deposed
- Cisco v. Uniloc, IPR2017-00198, IPR2017-00058, submitted IPR declarations and was deposed.
- Cisco v. Uniloc, IPR2017-00597, submitted IPR declaration and was deposed
- Twitter v. Youtoo Technologies, LLC, IPR2017-01133, IPR2017-01131, submitted IPR declarations and was deposed
- Taser International Inc. (now Axon Enterprise, Inc.) v. Digital Ally Inc., IPR2017-00375, submitted IPR declaration and was deposed
- Taser International Inc. (now Axon Enterprise, Inc.) v. Digital Ally Inc., IPR2017-00376, IPR2017-00515, IPR2017-00775, submitted IPR declarations
- HTC Corporation v. IPA Technologies, IPR2018-00306, IPR2018-00307, submitted IPR declaration
- Hulu v. Soundview, IPR2018-00864, IPR2018-01023, submitted IPR declarations and was deposed
- XpertUniverse v. Cisco, 3:17-cv-3848, U.S. District Court for Northern District of California, submitted declaration in support of claim construction and was deposed
- Improved Search v. Microsoft, C.A. No. 16-cv-650-JFB-SRF (Del.), submitted declaration in support of claim construction

- Apple v. Uniloc, IPR2018-00361, IPR2018-00394, IPR2018-00395, IPR2019-00700, IPR2019-00701, IPR2019-01667, submitted IPR declarations
- LG Electronics v. Uniloc, submitted IPR declaration
- SRC Labs and Saint Regis Mohawk Tribe v. Microsoft, 2:18-cv-00321-JLR, U.S. District Court for Western District of Washington at Seattle, submitted declaration in support of claim construction and was deposed
- Verizon Wireless v. Barkan Wireless IP Holdings LP, submitted IPR declarations
- Verizon Wireless and Samsung Electronics America Inc. v. Barkan Wireless IP Holdings LP, IPR2019-199, IPR2019-200, IPR2019-234, IPR2019-631, IPR2019-632, submitted IPR declarations
- Samsung Electronics America Inc. v. Barkan Wireless IP Holdings LP, IPR2019-100, submitted IPR declaration
- Cisco Systems Inc. v. Meetrix IP LLC, IPR2019-539, IPR2019-540, IPR2019-541, IPR2019-542, IPR2019-543, IPR2019-544, submitted IPR declarations
- GMG Products LLC v. Traeger Pellet Grills LLC, PGR2019-24, PGR2019-34, PGR2019-35, PGR2019-36, submitted PGR declaration and was deposed
- Uniloc 2017 LLC v. Google LLC, 2:18-cv-00502-JRG-RSP, U.S. District Court for the Eastern District of Texas, Marshall Division, submitted declaration in support of claim construction
- Microsoft Corporation v. Uniloc 2017 LLC, IPR2020-00102, IPR2020-00103, submitted IPR declarations
- Microsoft Corporation and HP Inc. v. Synkloud Technologies, LLC, IPR2020-00316, IPR2020-01031, IPR2020-01032, IPR2020-01269, IPR2020-01270, IPR2020-01271, submitted IPR declarations
- Seven Networks, LLC v. Apple Inc, 2:19-cv-115-JRG, U.S. District Court for the Eastern District of Texas, Marshall Division, submitted declaration in support of claim construction
- Unified Patents Inc. v. Ortiz & Associates Consulting, LLC, IPR2019-00743, submitted IPR declaration
- Uniloc 2017 LLC v. Apple Inc., 3:19-cv-01905-JD, U.S. District Court for the Northern District of California, San Francisco Division, submitted declaration in support of claim construction and was deposed
- ClearPlay Inc. v. Dish Network LLC et al.; 2:14-cv-00191, U.S. District Court for the District of Utah, Central Division, submitted expert report and re-examination declarations
- AMC Networks, Inc. et al v. Sound View Innovations, LLC, IPR2020-00482, submitted IPR declaration
- Case No. 1:17-cv-01734-RGA, Sprint Communications Co., L.P., v. Charter Communications, Inc., et al., U.S. District Court for the District of Delaware, filed expert report and was deposed.
- CommScope Technologies LLC et al. v. Barkan Wireless IP Holdings LP et al., IPR2020-00827, IPR2020-00829, IPR2020-00831, IPR2020-00833, IPR2020-00835, IPR2020-00838, submitted IPR declarations
- Cisco Systems Inc. v. Monarch Networking Solutions LLC, IPR2020-01226, submitted IPR declaration
- CoolTV Network.com v. Blackboard, Inc., Facebook, Inc., International Business Machines Corporation, Kaltura, Inc., Limelight Networks, Inc., Microsoft Corporation, Ooyala, Inc., Snap, Inc., and Trapelo Corp., submitted declaration in support of claim construction and was deposed
- Facebook, Inc. v. Onstream Media Corporation, IPR2020-01507, IPR2020-01508, IPR2020-01525, IPR2020-01527, IPR2020-01528, submitted IPR declarations
- Hisense Co LTD. v. Maxell, LTD, IPR2020-01598, IPR2020-01600, submitted IPR declarations
- Microsoft Corp. v. O'Brien, IPR2021-00015, submitted IPR declaration and was deposed

- Sable Networks Inc. v. Cisco Systems, Inc., WA:20-CV-00288-ADA, U.S. District Court for the Western District of Texas, Waco Division, submitted declaration in support of claim construction
- Peloton Interactive, Inc. v. Icon Health and Fitness Inc et al., IPR2021-00342, submitted IPR declaration
- Hulu, LLC v. SITO Mobile R&D IP, LLC et al., CBM2020-00028, IPR2020-00158, IPR2020-00206 , IPR2020-00219 , IPR2020-00265 , IPR2020-00298 , IPR2020-00304 , IPR2020-00308 , submitted CMB and IPR declarations and was deposed
- Twitter, Inc. and Google LLC v. B.E. Technology, LLC, IPR2021-00482, IPR2021-00483, IPR2021-00484, IPR2021-00485, submitted IPR declarations
- MG Freesites LTP v. ScorpCast, LLC, IPR2021-00511, submitted IPR declaration
- Avionte, LLC v. Sandeep Acharya, Samar Basnet, and Aqore LLC, Arbitration, Hon. Jeffrey Keyes (Ret.)
- Microsoft Corporation v. WSOU Investments, LLC d/b/a Brazos Licensing and Development, IPR2021-00751, submitted IPR declaration
- SAP America, Inc. v. Express Mobile, Inc., IPR2021-01144, IPR2021-01145, IPR2021-01146, submitted IPR declarations
- StratosAudio Inc. v. Hyundai Motor America, 6:20-cv-01125-ADA, U.S. District Court for the Western District of Texas, Waco Division, submitted claim construction declaration and was deposed
- Peloton Interactive, Inc. v. Ifit Health and Fitness Inc, IPR2022-00029, IPR2022-00030, submitted IPR declarations and was deposed
- Investigation No. 337-TA-1263, In the matter of Certain televisions, remote controls, and components thereof, U.S. International Trade Commission, filed expert reports, was deposed, and testified at hearing
- Alexander Stross v. Netease, Inc., et al., U.S. District Court (Central District of California), Case 2:20-cv-00861-AB(JC), filed expert reports, and was deposed
- Ralph Ledergerber v. Netease, Inc., et al., U.S. District Court (Central District of California), Case 2:20-cv-00862-AB(JC), filed expert reports and was deposed
- John Walmsley v. Netease, Inc., et al., U.S. District Court (Central District of California), Case 2:20-cv-00863-AB(JC), filed expert reports and was deposed
- Bernhard Kuhmstedt v. Netease, Inc., et al., U.S. District Court (Central District of California), Case 2:20-cv-02044-AB(JC), filed expert reports and was deposed
- F45 Training Pty Ltd. v. Body Fit Training USA Inc., C.A. No. 20-1194 (LPS) (D. Del.), filed expert report

Publications

- “IP switching: server driven flow classification,” H. H. Houh, *Proceedings of the Washington University Workshop on Integration of IP and ATM*, November 1996.
- “Aurora at MIT,” D. D. Clark, H. H. Houh, and D. L. Tennenhouse, Editors, *MIT Laboratory for Computer Science Technical Report 673*, December 1995.
- “ViewStation Applications: Implications for Network Traffic,” C. J. Lindblad, D. Wetherall, W. Stasior, J. F. Adam, H. H. Houh, M. Ismert, D. Bacher, B. Phillips, and D. L. Tennenhouse, *IEEE Journal of Selected Areas in Communications*, 1995.
- “The VuNet Desk Area Network: Architecture, Implementation, and Experience,” H. H. Houh, J. F. Adam, M. Ismert, C. J. Lindblad, and D. L. Tennenhouse, *IEEE Journal of Selected Areas in Communications*, 13 (4), May, 1995.

- “Reducing the Complexity of ATM Host Interfaces,” H. H. Houh and D. L. Tennenhouse, Hot Interconnects II Symposium Proceedings, Stanford, August 11-12, 1994.
- “Media-intensive data communications in a ‘desk-area’ network,” J. F. Adam, H. H. Houh, M. Ismert, and D. L. Tennenhouse, IEEE Communications, August 1994.
- “ViewStation Applications: Intelligent Video Processing Over A Broadband Local Area Network,” C. J. Lindblad, D. J. Wetherall, W. Stasior, B. Phillips, D. Bacher, J. Adam, H. Houh, M. Ismert, and D. L. Tennenhouse, Proceedings of the 1994 USENIX Symposium on High-Speed Networking, Oakland, CA, August 1994.
- “The Media Gateway: Live Video on the World Wide Web,” H. H. Houh, C. J. Lindblad, J. Soo, D. L. Tennenhouse, and D. J. Wetherall, Workshop at the 1994 World Wide Web Conference, Geneva, Switzerland, May 1994.
- “Active Pages: Intelligent Nodes on the World Wide Web,” H. H. Houh, C. J. Lindblad, and D. J. Wetherall, Proceedings of the 1994 World Wide Web Conference, Geneva, Switzerland, May 1994.
- “Wavelength Division vs. Code Division Access Methods for Optical Networks,” H. H. Houh, Area Exam Paper, May 1993.
- “Experience with the VuNet: A Network Architecture for a Distributed Multimedia System,” J. F. Adam, H. H. Houh, D. L. Tennenhouse, Proceedings of the 18th Conference on Local Computer Networks, pp. 70-76, September 1993
- “The VudBoard: A Simple DMA Interface,” H. H. Houh, Proceedings of the 4th Gigabit Minijam, January 1994.
- “A Software-Oriented Approach to the Design of Media Processing Environments,” D. L. Tennenhouse, J. Adam, D. Carver, H. Houh, M. Ismert, C. Lindblad, W. Stasior, D. Weatherall, D. Bacher, and T. Chang., submitted to the International Conference on Multimedia Computing and Systems, May 1994.
- “A Network Architecture for Distributed Multimedia Systems,” J. F. Adam, H. H. Houh, M. Ismert, and D. L. Tennenhouse, submitted to the International Conference on Multimedia Computing and Systems, May 1994.
- “The Viewstation Collected Papers,” D. L. Tennenhouse, J. Adam, C. Compton, A. Duda, D. Gifford, H. Houh, M. Ismert, C. Lindblad, W. Stasior, R. Weiss, D. Wetherall, D. Bacher, D. Carver, and T. Chang, MIT Laboratory for Computer Science Technical Report, MIT/LCS/TR-590, November 1993.
- “A System’s Perspective of the Sagnac Fiber Logic Gates and Their Possible Applications,” A. Huang, N. Whitaker, C. Gabriel, H. Avramopoulos, P. M. W. French, H. H. Houh, and I. Chuang, Applied Optics, September 10, 1994
- “Complete Switching in a Three-Terminal Sagnac Switch,” H. Avramopoulos, P. M. W. French, M. C. Gabriel, H. H. Houh, N. A. Whitaker, T. Morse, IEEE Phot. Tech. Lett. **3** (3), 235
- “Complete Switching in a Three-Terminal Sagnac Switch,” H. Avramopoulos, P. M. W. French, M. C. Gabriel, H. H. Houh, N. A. Whitaker, IEEE/LEOS Annual Meeting, Paper PDP-13, November 1990
- “All-optical phase-locked oscillator,” N. A. Whitaker, Jr., H. H. Houh, H. Avramopoulos, T. F. Morse, IEEE/LEOS Annual Meeting, Paper ELT2.4/MOO3, November 1990
- “Passive modelocking of an all-fiber erbium laser,” H. Avramopoulos, H. H. Houh, N. A. Whitaker, M. C. Gabriel, T. F. Morse, IEEE/LEOS Conference on Optical Amplifiers and their Applications, Paper PDP-8, August 1990
- “Transverse modes, waveguide dispersion, and 30ps recovery in submicron GaAs/AlAs microresonators,” J. L. Jewell, S. L. McCall, A. Scherer, H. H. Houh, N. A. Whitaker, A. C. Gossard, and J. H. English, Appl. Phys. Lett. **55** (1), July 3, 1989

Leadership, Activities and Interests

- Leadership
 - Discovery Museums (Acton, MA)
 - Science and Technology Advisory Council, 2012 - present
 - MIT Alumni Association Board of Directors
 - National Selection Committee, 3 year term, 2020 – 2023
 - K-12 STEM Initiatives Co-chair, 2013 – 2017
 - Awards Committee Chair, 2012 – 2014
 - Awards Committee, 3 year term, 2011 – 2014
 - Vice President, 2 year term, 2004 – 2006
 - Alumni Ad-Hoc Committee, Chair, 2005-2006
 - Board Member, 2 year term, 1997 – 1999
 - MIT Club of Boston
 - Board of Directors, 2006 - 2011
 - K-12 Initiatives Chair, 2009 - 2012
 - VP of Communications, MIT Club of Boston, 2003 - 2006
 - Past-President, MIT Club of Boston, 2002 - 2003
 - President, MIT Club of Boston, 2001 - 2002
 - President-Elect, MIT Club of Boston, 2000 - 2001
 - VP of Programs, MIT Club of Boston, 1999 - 2000
 - Activities Super-Chair, MIT Club of Boston, 1998 - 1999
 - MIT Enterprise Forum of Cambridge, Inc.
 - Past Chair, 2009 – 2011
 - In-NOW-vation Co-chair, 2010
 - Chair, 2007 - 2009
 - Vice Chair, 2005 - 2007
 - Executive Board Member, 2002 - 2011
 - Winter Workshop Co-Chair, February 2007 - conceived idea for conference, which sold-out and produced largest attendance numbers in recent memory
 - Spring Workshop Co-Chair, Spring 2004
 - Membership Committee Chair, Fall 2003 - 2006
 - 25th Anniversary Dinner Chair, Fall 2003
 - As Membership Chair and Board Member, started Special Interest Groups in 2004; a SIG won the MIT Presidential Citation award, the MIT Alumni Association's highest award for organizations, in 2006
 - Estabrook Elementary School PTA
 - Advisory committee to the superintendent on PCB issue, 2010-2011
 - 4th Grade after-school science program co-organizer, 2010-2012
 - 4th and 5th Grade before-school Math Olympiad co-organizer, 2009-2013
 - 5th Grade BBQ and Yearbook Committee, 2011, 2013
 - Family Math Night volunteer, 2008-2012
 - Tau Beta Pi National Engineering Honor Society
 - Advisor, MA B Chapter at MIT, 2003 - present
 - District Director (National Officer), Tau Beta Pi, New England Area, 1991 - 2003
 - President, MA B Chapter at MIT, Fall 1988 - Spring 1989
 - Laureate award, 1989

- MIT Class of 1989
 - Secretary, five consecutive 5 year terms, 1989 - 2014
 - 30-year Reunion Committee, 2019
 - 25-year Reunion Committee, 2014
 - 20-year Reunion Committee and Gift Committee, 2009
 - 15-year Reunion Committee and Gift Committee, 2004
 - 10-year Reunion Committee and Gift Committee, 1999
 - 5-year Reunion Committee, 1994
 - Interim Treasurer, 1993 - 1994
 - Instituted annual senior class career fair, now raising over \$100,000 annually for senior class activities, Fall 1988
- Strong, consistent record of leadership dating to high school
- Acting
 - ‘21’ (Sony Pictures), credited as “Chinatown Dealer,” 2007, Kevin Spacey's movie about the MIT Blackjack Team inspired by “Bringing Down the House” by Ben Mezrich, opened nationwide on March 28, 2008. 21 was the number one movie in US for two weeks and number one globally for one week. 21 also topped the DVD sales, Blu-ray sales and DVD rental charts.
 - Spring Lake Theater Company, first New York-area off-broadway production of “A Chorus Line,” played role of Mark, Summer 1990
- Former member of the MIT Blackjack team
- Producer for 10,000 Maniacs’ 2013 album “Music from the Motion Picture”
- Executive Producer for 10,000 Maniacs’ 2015 album “Twice Told Tales”
- Violist, violist, harpist, guitarist, singer, actor: played in many amateur/semi-professional groups including Reading Symphony Orchestra, MIT Summer Philharmonic Orchestra, Freisinger Chamber Orchestra, Merrimack Valley Philharmonic, Longwood Symphony, MIT Symphony, and Somerville Community Chorus
- Violist, “Coming Home” album by Karen Phillips, 2014
- Google Scholar citations: 1914, h-index: 21, i10-index: 26 (since 2016: 649/13/13)
- Erdos-Bacon number of 7
- Erdos-Bacon-Sabbath number of 11