

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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MICROSOFT CORPORATION and AFFIRMED NETWORKS, INC.,  
Petitioner,

v.

LEMKO CORPORATION,  
Patent Owner.

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Case IPR2023-00529  
U.S. Patent No. 7,653,414

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**DECLARATION OF TODOR COOKLEV, PH.D.**

## I. INTRODUCTION

1. My name is Todor V. Cooklev. I am an expert in mobile telecommunications and wireless technology. I have been retained as an expert witness to provide my independent opinion regarding certain matters at issue in *inter partes* review of U.S. Patent No. 7,653,414 (“the ’414 patent”) in IPR2023-00529. I have been retained by Lemko Corporation (“Lemko”), the Patent Owner in the above proceedings. Petitioners are Microsoft Corporation and Affirmed Networks, Inc. (collectively “Petitioners”).

2. For my work on this case, I am being compensated for my time at my typical consulting rate of \$500 per hour. I am also being reimbursed for reasonable expenses that I incur during the course of this work. My compensation does not depend on the substance of my opinions or the outcome of any issues in this case.

3. In preparation of this declaration, I have reviewed the Papers, including the Board’s Institution Decision (“DI”), Petitioner’s exhibits, and Patent Owner’s exhibits filed in this proceeding. This declaration represents only those opinions I have formed to date. I reserve the right to amend or supplement my opinions based on additional documents or evidence I am presented, including without limitation any arguments or expert declarations advanced by Petitioners in this case.

4. I am not a legal expert and offer no opinions on the law. However, I have been informed by counsel of the various legal standards that apply, and I have applied those standards in arriving at my conclusions.

## **II. QUALIFICATIONS**

5. I am currently Professor of Electrical and Computer Engineering at Purdue University in Fort Wayne, Indiana. At the same institution since 2008 I have served in several faculty and administrative positions, including as the Director of the Wireless Technology Center, ITT Associate Professor of Wireless Communication and Applied Research, and subsequently as Harris Professor of Wireless Communication and Applied Research.

6. I graduated from the Technical University of Sofia, Bulgaria in 1988 with a Diploma of Engineering in the field of Electrical Engineering. I graduated from Tokyo Institute of Technology in Tokyo, Japan in 1995 with a Doctor of Philosophy (Ph.D.) degree in Electrical Engineering.

7. I have contributed to the development of several major standards for communication systems and numerous amendments, including Wi-Fi, cellular, and tactical communication systems. I have participated in many meetings of standards committees and prepared, submitted, and presented documents relating to technical matters considered by these committees. I have also drafted liaison letters among

different standards committees. I have chaired some committee meetings and served in other leadership roles.

8. During 2000-2002 and 2005-2008 I was a Voting Member of the IEEE 802.11 Working Group. Around 2006-2008 I served as Chair of a Study Group within 802.11. For this work I received an award from IEEE Standards Association in 2012.

9. During 2011-2012 I attended 3GPP standards committee meetings. I contributed to and submitted several documents relating to LTE-Advanced.

10. My long record of service to the standards community includes being elected to the Board of Governors of the IEEE Standards Association in 2020 for one term beginning January 2021. The Board of Governors provides overall leadership of the IEEE Standards Association.

11. Also, I am the Series Editor for Wireless and Radio Communications for the IEEE Communications Standards Magazine (which is the premier journal in the field of communication standards) and have held that position since 2017. My responsibilities as an editor include coordinating the review of manuscripts submitted for publication and making publication decisions.

12. Since the 1990s I have reviewed many manuscripts submitted for journal and conference publication, including manuscripts in the field of wireless

networking. In addition, since about 2000 I have reviewed and voted on many IEEE 802.11, 802.15, and 802.16 standards.

13. My current research interests include most aspects of modern wireless systems, including hardware and software architectures. A significant part of my research is specifically focused on standards-related issues. I have received a number of research grants in these areas. My teaching responsibilities have included courses in communication systems and networks, signals and systems, software-defined radio, and digital signal processing.

14. For example, since about 2003 I have been doing research in the field of software-defined radio (SDR). I have participated in the work of the Software-Defined Radio Forum (later renamed Wireless Innovation Forum).

15. I am a named inventor on more than thirty U.S. patents, most of which relate to the hardware or software aspects of communication systems. In 2019, I was inducted into the Purdue Inventors Hall of Fame. I have also authored and co-authored more than one hundred peer-reviewed articles. A list of my publications, awards, courses I teach in electrical and computer engineering, research grants, and professional activities, etc. appears in my *curriculum vitae* attached as Appendix A.

### **III. LEGAL STANDARDS**

16. I am not a lawyer, and I do not intend to offer any opinions as to the interpretation of the law. When considering the '414 Patent and stating my opinions, I rely on the following legal standards as described to me by the attorneys for Lemko.

#### **A. Priority Date**

17. I understand that the analysis of alleged obviousness of the Patent should be performed from the perspective of a person of ordinary skill in the art as of the priority date of the Patent. The '414 Patent claims priority to February 24, 2006. My opinions in this matter are from the perspective of a person of ordinary skill in the art as of that date.

#### **B. Level of Ordinary Skill in the Art**

18. My opinions in this declaration are based on the understandings of a person of ordinary skill in the art ("POSITA" or "POSA"), as of the time of the invention. I understand that the person of ordinary skill in the art is a hypothetical person who is presumed to have known the relevant art at the time of the invention. By "relevant," I mean relevant to the challenged claims of the '414 patent.

19. I understand that various factors should be considered when determining the person of ordinary skill in the art in connection with a particular patent. I understand that these factors include, without limitation, the type of problems encountered in the art, the prior solutions to those problems found in the

prior art references, the rapidity with which innovations are made, the sophistication of the technology, the level of education of active workers in the field, and my own experience working with those of skill in the art at the time of the invention.

20. Mr. Proctor opines that: “[a]round 2006, a person of ordinary skill in the art (‘POSITA’) in the field of the ’414 Patent’s field would have had a bachelor’s degree in electrical engineering, computer engineering, or an equivalent, as well as two years of industry experience related to telecommunications networks. Such knowledge would encompass the design, architecture, and operations of mobile telecom networks, including gateways, servers, and user devices that were compliant with various standards, and how they interact with other components of a radio access network. Additional graduate education of a POSA could substitute for professional experience, or significant experience in the field could substitute for formal education.” Ex. 1003 (or “Proctor-Decl.”), ¶ 54. I understand that the Board adopted Mr. Proctor’s definition of a POSITA. DI at 11-12 (citing Pet. at 3). For the purpose of this declaration, I will apply the same definition of the level of skill of a POSA.

21. Based on my experience, education, and training, I met the definition of a POSA as of the priority date of the Patent. My qualifications at that time far exceeded that of a POSA, and I had worked with, as well as supervised, many

POSA's throughout my work in the field. My opinions concerning the '414 Patent claims and the prior art are from the perspective of a POSA, as set forth above.

22. As further discussed below, my opinions as stated in this declaration are valid even if the Board adopts a slightly different level of ordinary skill in the art.

### **C. Claim Construction**

23. I understand that claims in a patent-at-issue in an IPR are generally interpreted according to the district court-type claim construction. I further understand that claim terms are interpreted as they would have been interpreted by a person of ordinary skill in the art at the time of the invention, in light of the specification and the patent's prosecution history in the patent office.

### **D. Obviousness Legal Standard**

24. I understand that a patent claim is unpatentable if the claimed invention would have been obvious to a person of ordinary skill in the art at the time of the invention.

25. I understand that an obviousness analysis involves comparing a claim to the prior art to determine whether the claimed invention would have been obvious to a person of ordinary skill in the art at the time of the invention in view of the prior art and in light of the general knowledge in the art as a whole. I also understand that obviousness is ultimately a legal conclusion based on underlying facts of four

general types, all of which must be considered: (1) the scope and content of the prior art; (2) the level of ordinary skill in the art; (3) the differences between the claimed invention and the prior art; and (4) any objective indicia of non-obviousness, including any praise of the invention. Objective indicia of non-obviousness may include, for example, commercial success of an embodiment, a long-felt need, skepticism, failure by others to find the solution provided by the claimed invention, copying by others of the subject matter of the claim invention, unexpected results of the claimed invention, acceptance of others and industry praise, and licensing of the patents.

26. I also understand that obviousness may be established under certain circumstances by combining or modifying the teachings of the prior art. However, I have been informed that a claim is not proved obvious merely by demonstrating that each of the elements was independently known in the prior art. I have been informed that many, if not all, inventions rely on building blocks already previously known, and claimed discoveries almost of necessity will likely be combinations of what is already known. I have been informed that it is important to identify whether a reason existed at the time of the invention that would have motivated a person of ordinary skill in the art in the relevant field to combine the known elements in the way the claimed invention does. Specific teachings, suggestions, or motivations to combine any first prior art reference with a second prior art reference can be explicit

or implicit, but must have existed before the date of purported invention. I understand that prior art references themselves may be one source of a specific teaching or suggestion to combine features of the prior art, but that such suggestions or motivations to combine art may come from the knowledge that a person of ordinary skill in the art would have had.

27. I understand that a reference may be relied upon for all that it teaches, including uses beyond its primary purpose, but also including teachings that lead away from the invention. I understand that a reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, although the mere disclosure of alternative designs does not teach away.

28. I further understand that whether there is a reasonable expectation of success in combining references in a particular way is also relevant to the analysis.

29. I understand that it is improper to use hindsight to combine references or elements of references to reconstruct the invention using the claims as a guide. My analysis of the prior art is made from the perspective of a person of ordinary skill in the art at the time of the invention.

30. I am not offering any legal opinions in this declaration nor am I qualified to do so. I only consider such legal standards in framing my opinions and conclusions as well as placing assertions made by Petitioners in the Petition into the

proper context. Additionally, from a subject matter perspective, I understand that the petitioner always has the burden of persuasion regarding a challenge of patentability of an invention under an inter partes review.

#### **IV. THE '414 PATENT IS BASED ON LEMKO'S NEW DISTRIBUTED MOBILE ARCHITECTURE**

##### **A. Conventional Network Architectures Were Based on a Hierarchical, Specialized-Hardware Paradigm**

31. Cellular (also referred to as mobile) telephony was developed in response to the enormous market demand for “connectivity anytime anywhere.” A cellular network is a network distributed over areas of land, referred to as cells. Ex. 2029 at 14. At least one transceiver, commonly referred to as a “base transceiver station,” or “BTS,” provides network coverage for user equipment (“UE”) within each cell. *Id.* at 24.

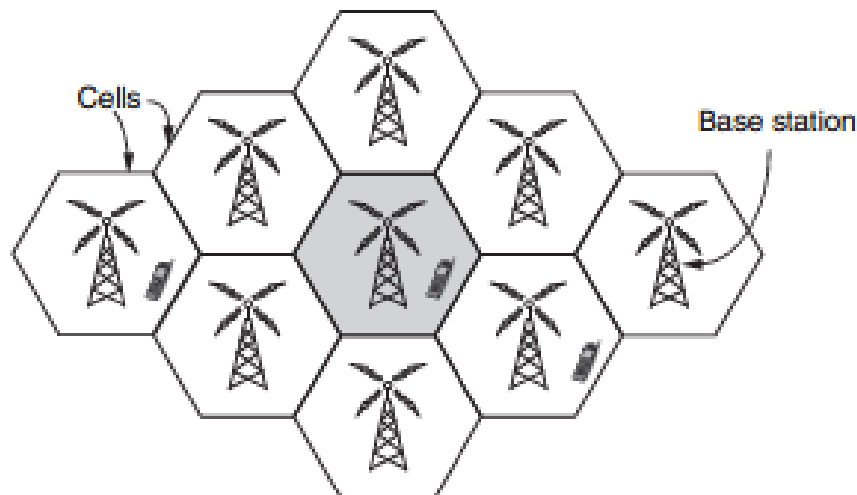


**Figure 1-30. Cellular design of mobile phone networks.**

Ex. 2030 (Tanenbaum 5<sup>th</sup> Ed. at 66). Multiple BTSs connect to a single Base Station Controller (“BSC”), and multiple BSCs connect to a single mobile switching center (“MSC”). *See* ’414 Patent at 1:34-47.

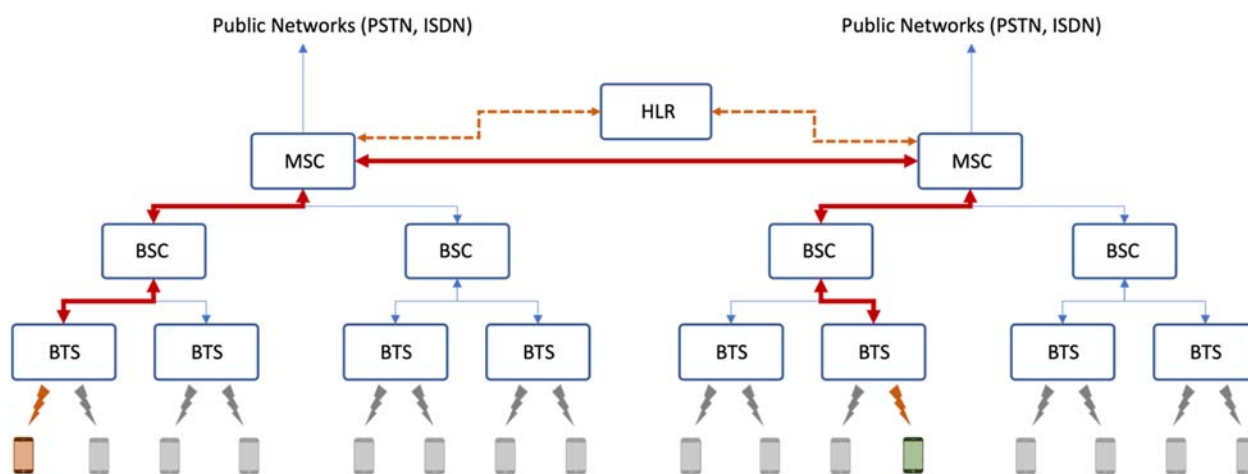
32. In order to build wireless wide area networks (WWANs) using this technology, carriers like Verizon® and AT&T® established multiple MSCs and built out the BSCs and BTSs necessary to cover a new geographic area. Ex. 2030 (Tanenbaum 5<sup>th</sup> Ed. at 168). The geographic area covered by these WWANs span entire nations or continents:

| Interprocessor distance | Processors located in same | Example                   |
|-------------------------|----------------------------|---------------------------|
| 1 m                     | Square meter               | Personal area network     |
| 10 m                    | Room                       |                           |
| 100 m                   | Building                   |                           |
| 1 km                    | Campus                     | Local area network        |
| 10 km                   | City                       |                           |
| 100 km                  | Country                    | Metropolitan area network |
| 1000 km                 | Continent                  |                           |
| 10,000 km               | Planet                     | Wide area network         |
|                         |                            | The Internet              |

**Figure 1-6.** Classification of interconnected processors by scale.

Ex. 2030 (Tanenbaum 5<sup>th</sup> Ed. at 18).

33. In these conventional cellular WWANs, each BTS is connected to one and only one BSC. BTSs do not have any ability to route calls, other than to connect to the single BSC. Each BSC is connected to one and only one MSC. BSCs do not have any ability to route calls beyond forwarding them to the single MSC. Expensive backhaul connections connect BSCs to MSCs. Backhaul connections use T1/E1 communication lines. See Ex. 2007 at 2 (“E1/T1 systems were widely used in telecommunications when 2G technologies including GSM were being rolled out and deployed”). A conventional WWAN based on Ex. 2022 is illustrated below:



Ex. 2022 at 4-5.

34. Centralized MSCs authenticate callers and route calls to other users (referred to as “UEs” by convention). Ex. 2031. When a user (UE shown in orange on the left in the illustration above) wishes to call another user (UE shown in green on the right), the call is routed from a BTS (left) to a BSC (left) to an MSC (left). *Id.* The MSC polls the carrier’s home location register (HLR) and visitor location

register (VLR) to determine whether the UE is registered with the MSC's network or whether the UE is visiting (roaming). *Id.* After authenticating the UE, the MSC routes the call to another MSC (if the party being called is another mobile user) or to a public telephony network, like the PSTN. *Id.*; Ex. 2029 at 20-22.

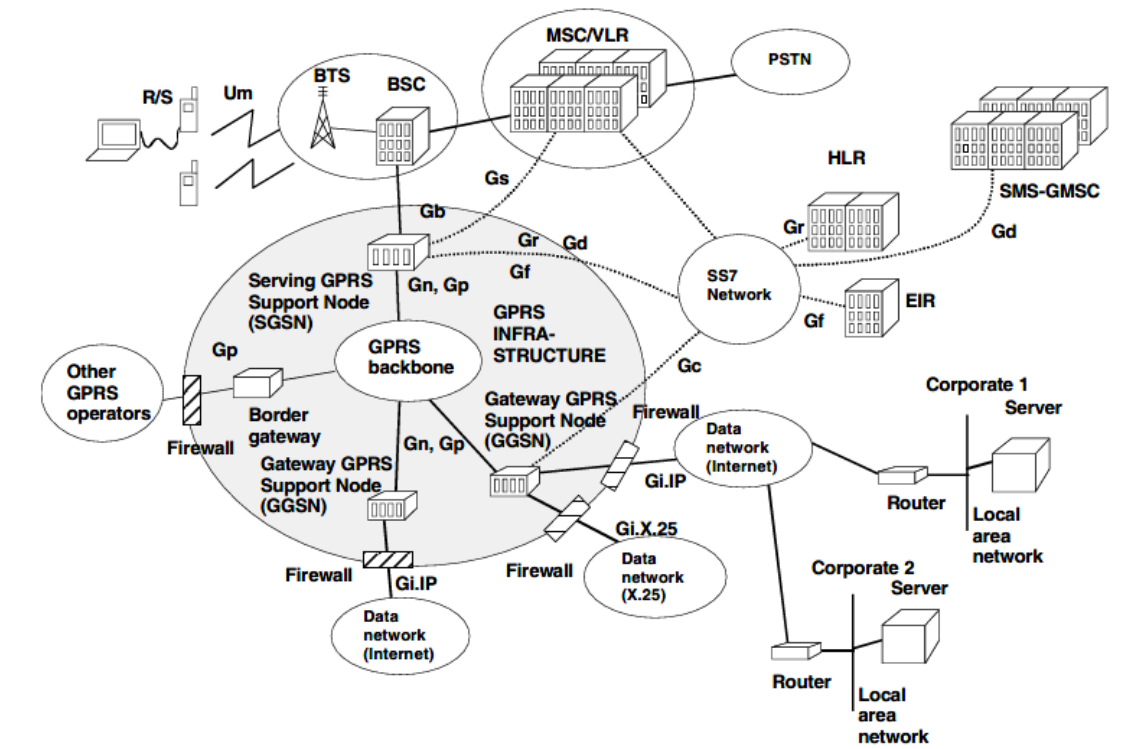
35. MSCs are large installations housed at server centers, and depend on network-card based hardware:



Ex. 2003; *see* Ex. 2002 at 1-3; Ex. 2032 at 3 (depicting an MSC).

36. The first generation (1G) of cellular network technologies, released between the late 1970s and early 1980s, carried only analog telephony signals. Ex. 2024 at 5, 9; Ex. 2030 (Tanenbaum 5<sup>th</sup> ed. at 166-170). These analog systems were soon replaced by second generation (2G) digital telecommunications networks, which introduced limited data services, like SMS text messaging via a packet-

switched “general purpose radio service” (“GPRS”) by SGSN (Serving GPRS Support Node) and GGSN (Gateway GPRS Support Node). Ex. 2024 at 5, 9, 13; Ex. 2030 (Tanenbaum 5<sup>th</sup> ed. at 170-174). While voice phone calls were routed between MSCs over circuit-switched networks to ensure lag-free voice calls, data signals were routed via the SGSN-GGSN to packet-switched networks, like the Internet. Ex. 2029 at 13; Ex. 2030 (Tanenbaum 5<sup>th</sup> Ed. at 67-68).



Ex. 2032 at 3 (showing routing of voice and data calls).

37. In the GPRS, a Serving GPRS Support Node (“SGSN”) performs the role of the MSC. Ex. 2025 at 6. Like the MSC, the SGSN receives data from BSCs and routes it, with the help of a Gateway GPRS Support Node (“GGSN”), to the appropriate recipient within the IP network. Ex. 2025 at 1-2, 5-6, 13. The SGSN is

also responsible for keeping track of which UEs are registered to which BSCs (or Node Bs). *Id.*

38. Expanding cellular network coverage using this hierarchal hub-and-spoke network architecture was very expensive, due in large part to the cost of installing an MSC and connecting new spokes (BTSs/Node Bs) and BSCs/RNCs to a hub (the MSC or GGSN) over backhaul connections.

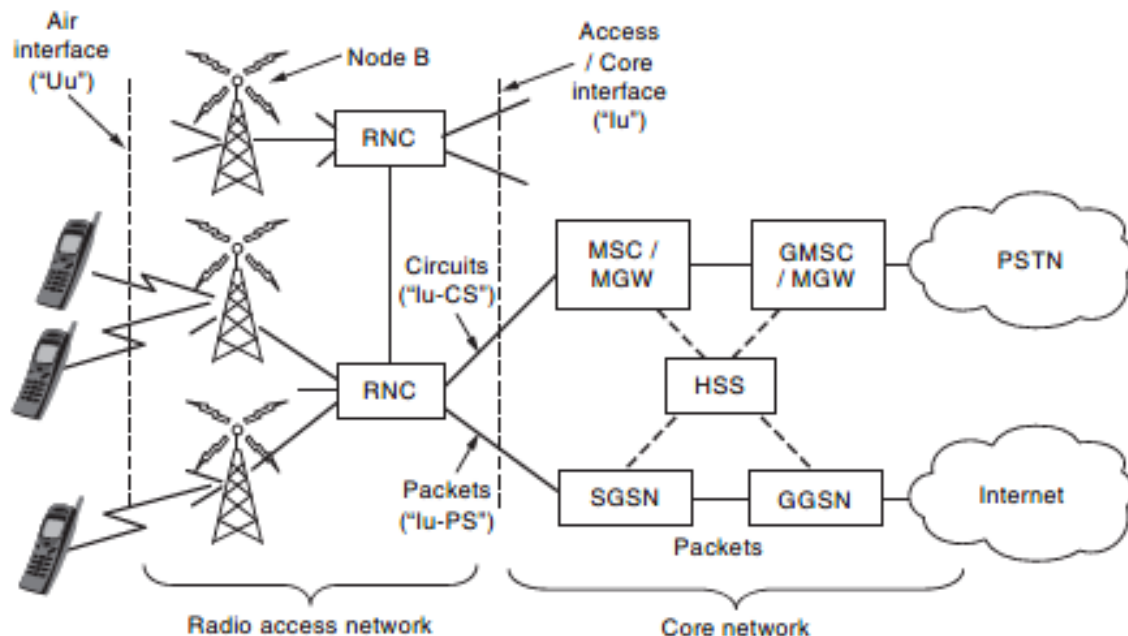


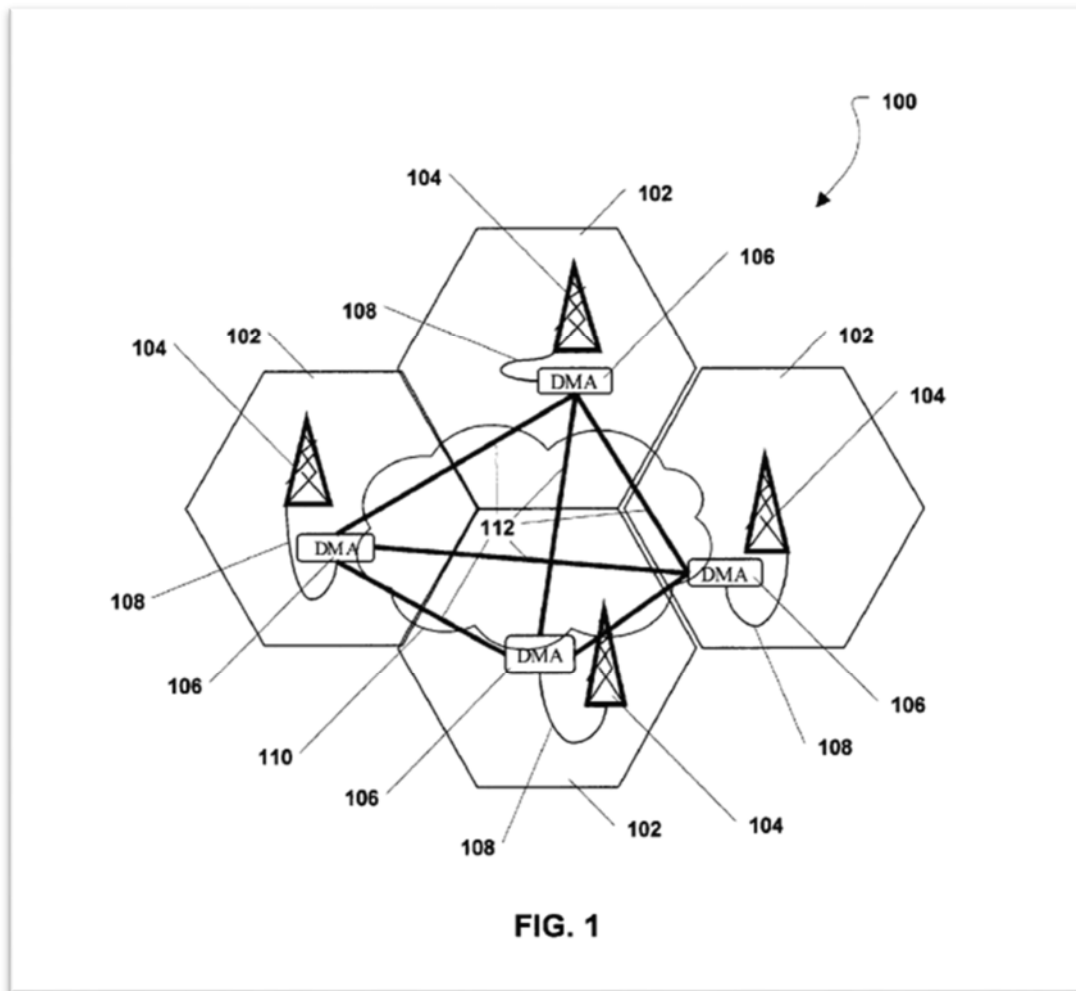
**Figure 1-31.** Architecture of the UMTS 3G mobile phone network.

Ex. 2030 (Tanenbaum 5<sup>th</sup> ed. at 67). Consequently, telecom companies were slow to expand cellular network service to rural areas, which could not muster the user base necessary to justify the expense of building new cell towers, installing BSCs, and connecting those BSCs to MSCs or SGSNs or GGSNs over expensive backhaul connections. See '414 Patent at 1:37-51.

**B. Lemko's Claimed Distributed Mobile Architecture (DMA)  
Introduced a New Distributed Cellular Network Architecture**

39. The '414 Patent discloses and claims a distributed mobile architecture ("DMA"). "Within the distributed and associative communications system 100, the "controlling logic can be distributed and de-centralized." '414 Patent at 4:45-47, 17:47-49. Rather than one centralized MSC controlling routing for a set of BTSs (via intermediary BSCs), the MSC and BSC controlling logic is distributed to each node of the DMA, which are called "DMA systems" or "DMA servers" and together form a "DMA network." *Id.* at 7:56-59.

40. Distributing the routing functionality to the DMA systems eliminates the need to carry every call over an expensive backhaul connection to a centralized MSC for switching and routing. Instead, when calls are made between UEs located within the same DMA network, calls are routed directly between DMA systems via peer-to-peer connections:



'414 Patent at Fig. 1. For example, the '414 Patent describes with reference to Figure 1 that "each DMA 106 is interconnected with the other DMAS 106 via an Internet protocol network 110" and therefore "there exists a peer-to-peer connection 112 between each DMA 106 in the system 100." *Id.* at 4:29-44.

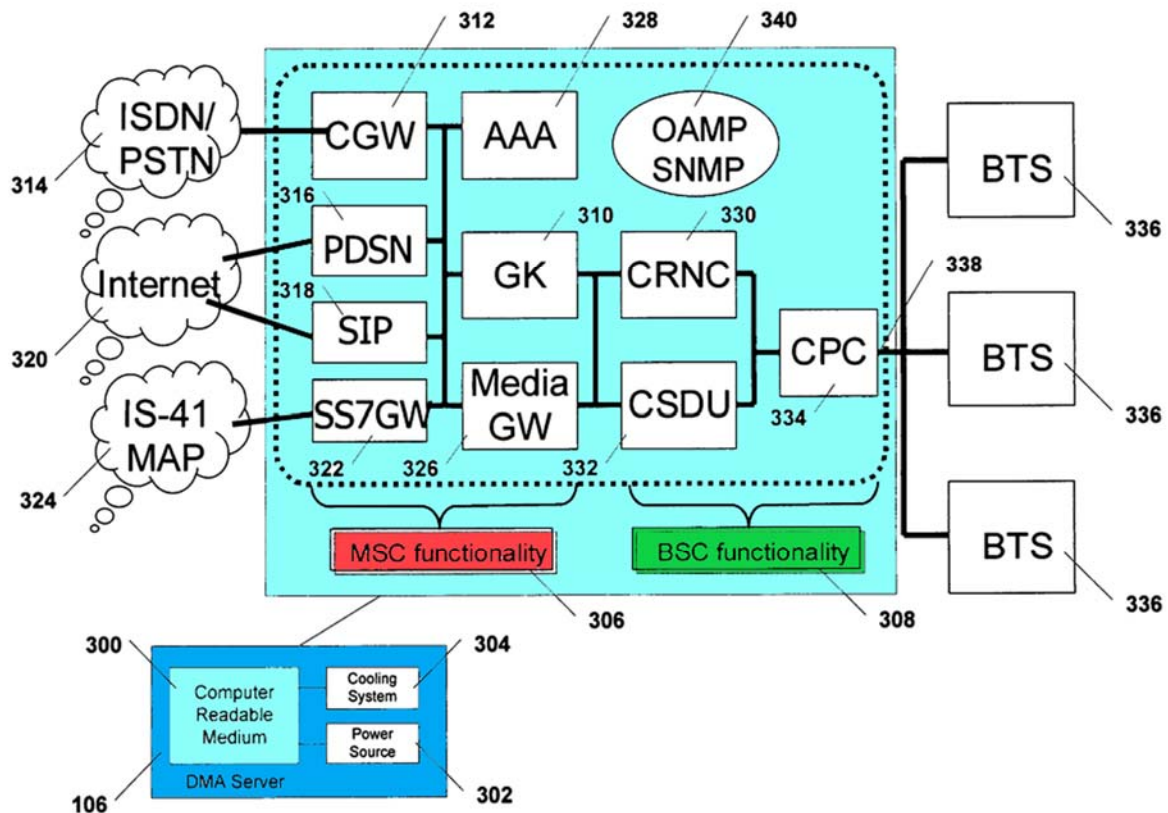
41. The use of these peer-to-peer IP network connections between DMA systems 106 in the same DMA network 100 eliminates or reduces the need to route traffic through a backhaul to a centralized device like an MSC or SGSN. Instead, in the claimed DMA network, and in contrast to the conventional network architectures

discussed in the previous section, a call from a first UE to a second UE is routed (1) from the BTS that provides wireless coverage to the first UE, (2) to a DMA system, (3) to a second DMA system (by a peer-to-peer IP connection), (4) to the BTS that provides wireless coverage to the second UE, (5) to the receiving UE. See '414 Patent at 5:41-54 (describing a mobile subscriber can be “connected locally” to another mobile subscriber via one or two DMA systems), 12:15-31.

42. Because the DMA systems route calls between each other, the distributed mobile architecture reduces the need for expensive centralized hubs and the expensive backhaul connections necessary to connect to those hubs. Ex. 2010 at 1 (“The heart of DMA is an all-IP software solution that contains infrastructure for cellular service” that eliminates a “center or hub”). The DMA systems route calls amongst themselves via peer-to-peer connections within a private IP network (a virtualized DMA network 110). '414 Patent at 4:38-40, 10:44-46, 16:55-57. Expanding the DMA network only requires connecting a new DMA system to the existing peer-to-peer IP network and connecting the new DMA system to a BTS. See *id.* at 4:15-44, 4:58-60.

43. To enable this decentralized architecture, the '414 Patent teaches implementing the functionality conventionally provided at the MSC and BSC in software located at the DMA systems. See '414 Patent at 6:20-23, 7:60-8:2; Ex. 2010 (“The heart of dMA is an all-IP software solution that contains mobile

infrastructure for cellular service. Specifically, it provides the functionality of the following elements: Mobile Switching Center (MSC), Radio Network Controller / Base Station Controller (RNC/BSC), Location Registers (HLR and VLR), Media and Data Gateways (MGW, GGSN, SGSN)”). The DMA servers include a computer-readable medium (light blue) storing an MSC module (red) and a BSC module (green):



*Id.* at Figs. 3 (annotated), 13, 15, and 18-20 (depicting the DMA server).

44. The DMA systems are connected to BTSs that provide cellular service to UEs in the area. *Id.* at 4:28-35, Fig. 1. Each DMA server has its own MSC and BSC functionality, including gateways and a cellular radio network controller

(CRNC), to allow for a fully functionally virtualized network. *See* Ex. 2009; Ex. 2010 at 1 (“The heart of dMA is an all-IP software solution that contains mobile infrastructure for cellular service”).

45. To enable seamless handoff of a UE between DMA systems in the same peer-to-peer DMA network, the ‘414 Patent teaches that the home location register (“HLR”) and visitor location register (“VLR”) are fully distributed among the DMA servers in the DMA network, in contrast to traditional HLRs (which serve many MSCs) and VLRs (stored locally at each MSC). ‘414 Patent at 4:53-56. The ‘414 Patent’s HLR stores information about the UEs registered with that DMA network, including the identity of the DMA servers serving the device. ‘414 Patent at 8:45-52, Fig 5; *see also id.* at 8:41-9:37. The VLR stores the same information about UEs that are roaming. *Id.*; Ex. 2028.

46. The ‘414 Patent leverages this flexible and unconventional architecture in multiple ways. For example, calls between two UEs that are subscribed to the same DMA Network are routed without any need to traverse expensive backhaul connections or conventional networks. ‘414 Patent at 5:37-54. Each DMA system’s HLR stores information about the mobile subscribers registered with that DMA system. *Id.* at 9:38-42; 10:21-23, 10:35-39. If the two UEs are registered to the same DMA system, (e.g., DMA System 202), as reflected in the DMA system’s HLR, calls are routed locally via the DMA system. *Id.*

47. If two UEs are registered to different DMA systems (e.g., DMA system 202 and 204) of the same DMA network, as reflected in the DMA systems' Community Location Registers ("CLRs"), calls are routed directly between the DMA systems. *Id.* at 5:41-54. The CLR at each DMA system stores information about mobile subscribers registered with another DMA system within the DMA network. *Id.* at 3:28-35. Each DMA system may include more than one CLR, each corresponding to the HLR of another DMA system in the DMA network. *Id.* at 8:3-29.

48. When a mobile subscriber is roaming and enters the coverage area of a new DMA system (*i.e.* a DMA system that it is not subscribed to), it temporarily registers with the DMA system. *Id.* at 5:55-59. Information about the roaming subscriber is stored in the DMA system's Visitor Location Register ("VLR"). *Id.* at 3:36-40. The DMA system then provides the roaming subscriber's information to the other DMA systems within the DMA network, which store the information in those DMA systems' CLRs. *Id.* at 5:59-61. This technique enables calls to be routed to the roaming subscriber over the DMA network. *Id.*

49. When a mobile subscriber subscribed to a DMA system of a DMA network calls a destination outside of the DMA network, the DMA system consults a Destination Preference Register ("DPR"). *Id.* at 8:30-36. Figure 2 of the '414 Patent illustrates a DMA network having DMA systems, which each have their own

separate interface to outside of the DMA network. '414 Patent at Fig. 2, 5:3-20 (describing one DMA system having an MSC interface, another DMA system having a VoIP interface, and another DMA system having an ISDN interface). When a call from a mobile subscriber is made to a destination outside of the DMA network, the peer-to-peer nature of the DMA network makes available (i.e., shares) all of these interfaces for routing the call outside. *Id.* at 5:62-6:4. Thus, the peer-to-peer aspect of the DMA network avoids the need for each DMA to have multiple interfaces to external networks (e.g., multiple MSC interfaces, multiple ISDN interfaces). The “destination preference register” (DPR) provides a preferred hierarchy of interfaces to make calls external to the DMA network. *Id.* at 5:65-67.

## **V. THE CHALLENGED CLAIMS**

50. I understand that Petitioners have challenged claims 1-8 as being obvious over Mauer (Ex. 1005) in view of Waylett (Ex. 1006). Independent claims 1 and 8 are method claims directed to providing communications using a distributed mobile architecture (DMA) system. Independent claim 8 is similar to claim 1, with the additional limitations for “a third DMA system” and a “CLR associated the third DMA system is stored at the first DMA system.” '414 Patent at 19:1-2, 19:20-28.

51. I also understand that Petitioners challenge claims 11-16 and 21 as being obvious over Waylett in view of Mauer. Independent claim 11 is a system claim that recites some similar limitations as claims 1 and 8, including “a community

location register (CLR)” and a “destination preference register (DPR),” but also differences, such as a computer readable storage medium having an authentication, authorization, and accounting (AAA) module embedded therein, and a call routing component. ’414 Patent at 19:59-20:16.

## **VI. CLAIM CONSTRUCTION**

52. As I mentioned above, I understand that claims in a patent-at-issue in an IPR are generally interpreted according to the district court-type claim construction. I further understand that claim terms are interpreted as they would have been interpreted by a person of ordinary skill in the art at the time of the invention, in light of the specification and the patent’s prosecution history in the patent office.

53. For the purpose of this proceeding, I have provided a construction for the term “distributed mobile architecture.” In my opinion, and consistent with the intrinsic record, the term “distributed mobile architecture (DMA)” should be construed as: a network architecture where DMA systems have distributed call-routing functionality and are connected with other DMA systems through peer-to-peer connections (i.e., without connecting through a hierarchical network hub architecture). This construction is dispositive, as Mauer and Waylett do not satisfy these requirements, as I discuss in detail below.

54. I understand that this claim construction is consistent with the proposed construction for the same term in unrelated but co-pending IPR2023-00531, which

concerns Lemko's U.S. Patent No. 7,855,988. The proposed construction in that case includes a further limitation that the DMA not be a legacy communications network, based on additional statements in that patent's specification and claims. That additional limitation is not relevant to the grounds asserted in this IPR.

**A. “Distributed Mobile Architecture (DMA)” is Distributed with Call-Routing Functionality Located on DMA Systems**

55. In my opinion, the term “distributed mobile architecture (DMA)” should be construed consistent with the plain meaning of its words, which require a mobile architecture with distributed functionality, instead of centralized functionality and hierarchal organization. Rather than routing calls from individual nodes (BTS/Node B) through centralized hubs (MSCs/SGSNs), the distributed mobile architecture distributes the task of routing calls among each node (DMA system) of the DMA network. I understand that the Board did not address this issue in its preliminary consideration of the meaning of the term distributed mobile architecture. DI at 14-15, 27-29.

56. Distributed systems differ from traditional computer networks in that “a collection of independent computers appears to its users as a single coherent system.” Ex. 2030 (Tanenbaum 5<sup>th</sup> at 2). Consistent with this understanding, the '414 Patent consistently uses the term “distributed mobile architecture” to refer to a mobile communications architecture where routing functionality, and the information necessary to route calls, are distributed among the multiple DMA

systems of a DMA network. See '414 Patent at 4:45:47 (“Within the distributed and associative telecommunications system 400 the controlling logic can be ***distributed and decentralized.***”) (emphasis added). Accordingly, in my opinion, a POSITA would understand that the DMA servers that form a DMA network appear as a “single coherent system” to any UE interacting with the network.

57. It is this distributed nature of the DMA network that allows DMA systems to seamlessly route messages among one another without having to traverse a centralized switching hub, like an MSC or SGSN:

As illustrated in FIG. 1, ***each DMA 106 is interconnected with the other DMAs 106 via an Internet protocol network 110.*** As such, there exists a peer-to-peer connection 112 between each DMA 106 in the system 100. The DMAs 106 can handle telephony traffic that is communicated at each antenna 104. For example, ***the DMAs 106 can switch and route calls received via each antenna 104.*** Additionally, ***the DMAs 106 can hand-off calls to each other as mobile communication devices move around and between the cellular coverage sites 102.*** The DMAs 106 can communicate with each other via the IP network 110 and can further transmit calls to each other via the IP network 110.

'414 Patent at 4:28-40 (emphasis added); see also *id.* at 17:47-49 (“control logic within the DMAs can be distributed and associated”), 10:44-46 (describing DMA systems “linked to each other via an IP network”), 16:55-57 (discussing a “peer-to-peer connection is established”), 4:58-60 (discussing how a new DMA system and its coverage can be “easily added to the system”), 6:20-23 (discussing implementing functionality including call routing in software located at the DMA systems), 7:60-

8:2 (same), 4:53-56 (describing the HLR and VLR are “distributed equally and fully among all the DMAs”), 5:37-54 (discussing routing a call between two UEs between different DMA systems in the same DMA network locally without the need to traverse expensive backhaul connections), 5:62-6:4 (discussing routing calls to a mobile subscriber outside of the DMA network by making available an interface from a peer DMA system).

58. Driving home the distinction between the claimed DMA and conventional, hierarchal network topologies is that the DMA network is self-healing and redundant, which depends on its distributed architecture that allows individual DMA systems to make routing decisions:

Moreover, the wireless coverage provided by the disclosed system 100 is self-healing and redundant. In other words, due to the interconnectivity via the IP network 110, if one or more of the DMAs 106 loses power, fails, or is otherwise inoperable, telephony traffic handled by the inoperable DMA 106 can re-routed to one of the remaining operable DMAs 106. Additionally, user data stored in a database, e.g., a home locator resource (HLR) or a visitor locator resource (VLR), can be distributed equally and fully among all of the DMAs 106. It can also be appreciated that new cellular coverage sites can be easily added to the system 100 as the demand for users increases. Specifically, a DMA can be deployed, connected to an antenna, connected to the IP network, and activated to provide cellular coverage in a new area.

’414 Patent at 4:47-60. The distributed nature of the DMA means that there are no centralized points of vulnerability as there are in conventional hierarchal networks.

’414 Patent at 17:53-55 (“distributed systems can be de-centralized to avoid single

points of failure.”); Ex. 2030 (Tenanbaum at pg. 55). The distributed mobile architecture, therefore, is distributed because it has no center or hub (like a centralized MSC or SGSN) and because each DMA system routes calls directly to other DMA systems in the DMA network. See ’414 Patent at 4:14-47 (describing a distributed and associated communications system), 6:20-37; Ex. 2010 (“Most important, the network infrastructure has no center or hub, meaning there is no single point of failure”); Ex. 2009.

59. I note that Petitioners’ expert, Mr. Proctor, agreed during deposition that the use of “distributed” requires that functionality be distributed among the DMA systems. Proctor Tr. at 74:15-22 (testifying that under a plain and ordinary meaning of “distributed mobile architecture” in light of the specification, “distributed” means that “there needs to be functionality distributed”), 71:22-72:4 (“Mobile architecture ... has got to be an architecture that addresses mobile devices” and “distributed means that something has got to be in multiple places”). This further confirms my opinion that “distributed mobile architecture” requires a network of DMA systems that distribute the call-routing functionality of the DMA network.

**B. Each “DMA System” is Connected to Other DMA Systems Through Peer-to-Peer Connections**

60. In my opinion, because the distributed mobile architecture (DMA) is a distributed and decentralized architecture with call-routing functionality distributed

to the DMA systems, each DMA system is able to connect to other DMA systems instead of transiting through a hierarchical network via a hub, such as an MSC or SGSN. These are peer-to-peer connections because the DMA systems connect directly, without traversing a hierarchical network. I understand that the Board declined at the institution stage to adopt a construction of “DMA network” that would require peer-to-peer connections. DI at 14-15.

**1. The Specification Provides For Peer-to-Peer Connections Between the DMA Systems**

61. As I discussed in Sections IV.B and VI.A above, a core concept of the ‘414 Patent is to provide and enable a distributed architecture to avoid costs associated with the backhaul needed to implement a centralized and hierarchical network that depends on routing all calls via a centralized hub. In order to do so, the nodes within the DMA network communicate with each other directly as peers.

62. I believe this requirement of the claimed invention to include a peer-to-peer connection between DMA systems is correct, especially in light of reading the specification as a whole. The primary system diagrams of the ‘414 Patent (Figures 1-2) and the accompanying disclosure in the specification make clear that the claimed invention’s “DMA network” includes peer-to-peer connections between its DMA systems. Figure 1 (reproduced below) depicts this peer-to-peer arrangement and its accompanying disclosure states that “each DMA 106 is *interconnected* with the other DMAs 106 via an Internet protocol network 110” and “[a]s such, *there*

*exists a peer-to-peer connection 112* between each DMA 106 in the system 100.”

’414 Patent at 4:28-32 (emphasis added). The use of such peer-to-peer connections is in contrast to the conventional networks where BTSs do not directly connect to each other as peers and, instead, rely on traversing a hierarchical backhaul to the BSC and MSC in order to connect to another BTS.

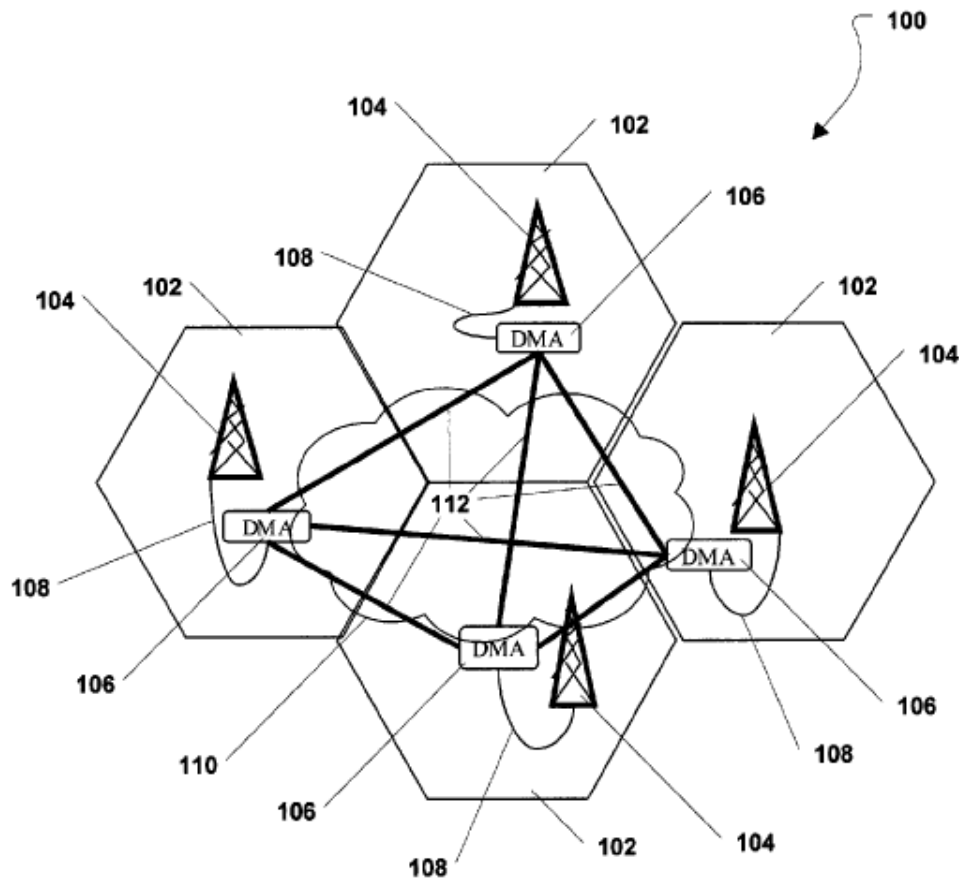
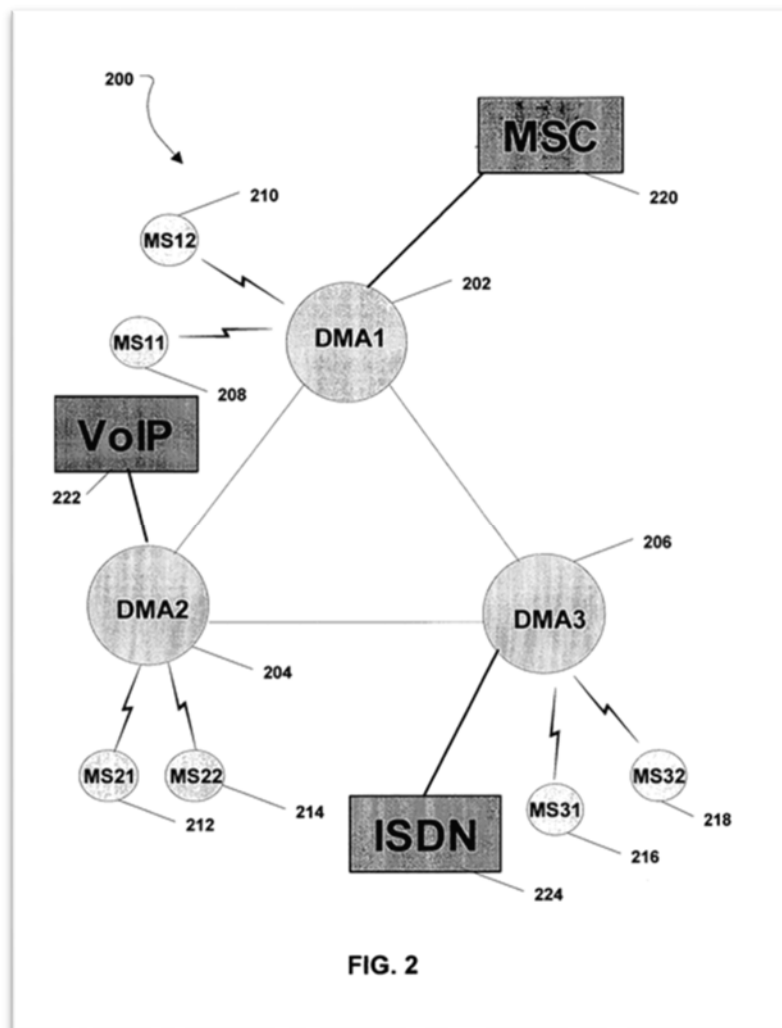


**FIG. 1**

’414 Patent at Fig. 1. I understand that based on the file history of the ’414 Patent, Lemko selected the peer-to-peer connections of Figure 1 as the cover page drawing figure for the ’414 Patent, highlighting the importance of this structure. ’414 Patent

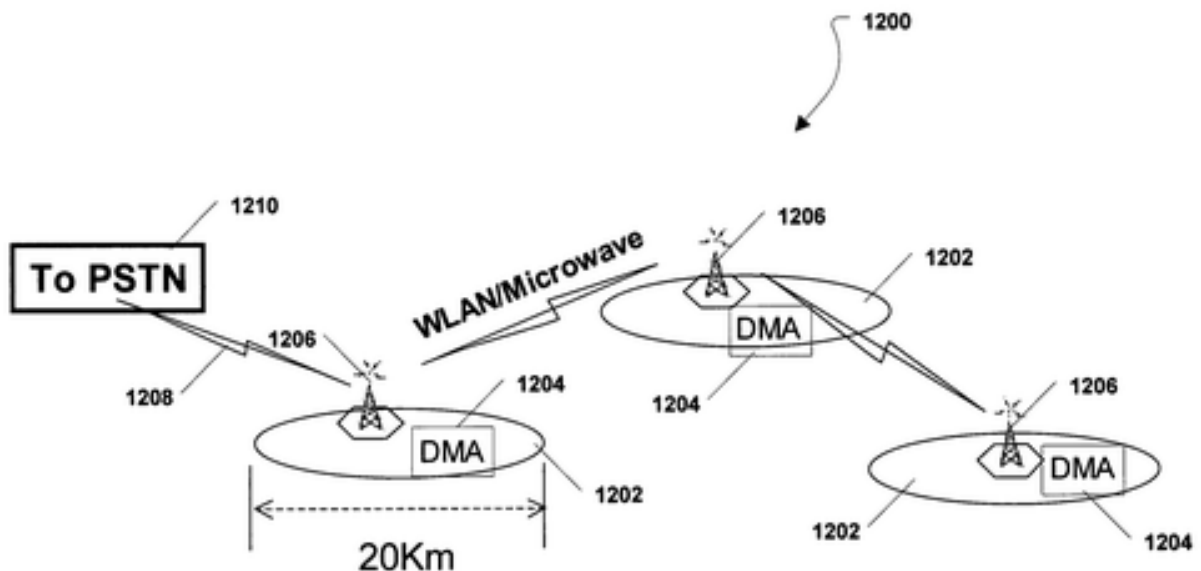
at 1; Ex. 1002 at 70 (Application Data Sheet specifying the Applicant-Suggested drawing figure as Figure “1”).

63. Similarly, Figure 2 depicts and the corresponding portions of the specification disclose a network system that “include[s] an Internet protocol (IP) peer-to-peer network” comprising a DMA 202 coupled to DMA 204 and to DMA 206, and the second DMA 204 is coupled to the third DMA 206. ’414 Patent at 4:61-5:2.



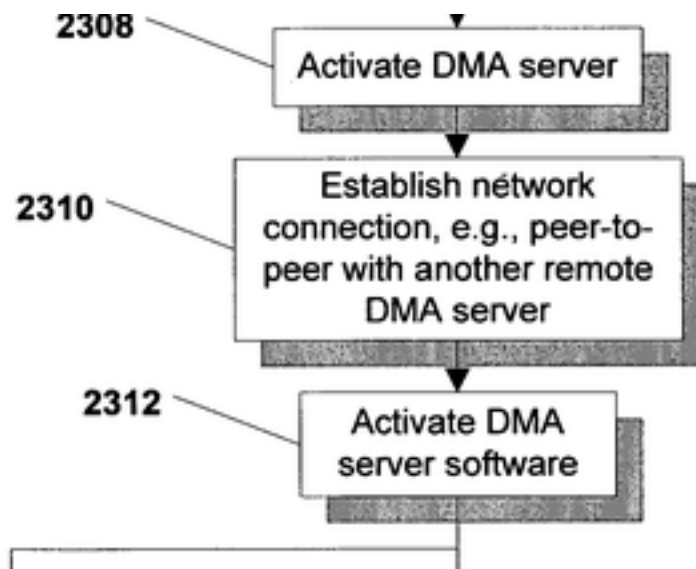
'414 Patent at Fig. 2. As discussed above, the purpose and benefit of this distributed architecture is that the DMA systems can communicate directly as peers without first traversing an intervening hierarchical network MSC, shown as element 220 in Figure 2 as outside of the DMA network of DMA systems.

64. Additionally, Figure 12 of the '414 Patent depicts, and the specification describes, a system of wireless local loops (WLLs) having DMA systems (element 1204). The specification discloses that the WLLs (each having a DMA system) “can be *interconnected* via a wireless local area network (WLAN),” and that “[s]ince *the DMAs 1204 are connected to each other* via the WLAN or microwave connections, the relatively expensive inter-site back-haul component is removed.” '414 Patent at 12:15-31. This further shows the use of peer-to-peer connections.



'414 Pat at Fig. 12.

65. As another example, Figure 23 shows a “method of deploying a distributed management architecture server,” and describes establishing “a network connection, e.g., *peer-to-peer* with another remote DMA server.” ’414 Pat at Figure 23 (shown below in excerpt); *id.* at 16:21-23 (“In a particular embodiment, the network connection is a *peer-to-peer connection* between the DMAs.”).



’414 Patent at Fig. 23 (excerpted). Consistent with the purpose of the ’414 Patent to provide a *distributed* mobile architecture, every embodiment depends on the DMA systems communicating with each other as peers.

66. In my opinion, the goal of the ’414 Patent is to distribute routing functionality so that, where possible, the nodes receiving calls (DMA systems) can communicate with each other as peers, instead of traversing a hierarchical and expensive backhaul infrastructure to a centralized MSC, and the only way the patent

discloses to achieve this is through peer-to-peer connections between the DMA systems. '414 Patent at *e.g.*, 1:34-51, 4:14-17, 4:61-62.

**2. The Claims Confirm the DMA Systems are Connected By Peer-to-Peer Connections**

67. In my opinion, the structure of the Challenged Claims confirms the peer-to-peer architecture of the claimed DMA network. Specifically, each of the independent claims requires that the community location registers associated with one DMA system are stored in a different DMA system. '414 Pat at 18:25-29 (“information stored at a community location register (CLR) associated with the second DMA system, wherein the CLR associated with the second DMA system is stored at the first DMA system”), 19:15-19, 19:24-28, 20:1-5 (claim 11 reciting “stores information associated with a second HLR of a second DMA system, wherein the second HLR stores information associated with one or more mobile subscriber devices that are registered with the second DMA system”).

68. The claims further recite that the DMA systems use the CLRs in order to route calls to subscribers located in and out of coverage areas of the DMA systems. '414 Pat at 18:22-29 (Claim 1: “determining whether the second mobile subscriber is located within a second wireless coverage area... based on information stored at a community location register”), 19:12-17 (same), 19:22-26 (similar but for “a third wireless coverage area”), 20:18-22 (similar). This arrangement has no purpose other than to permit the DMA systems to communicate directly without

traversing a hierarchical network through a centralized hub, i.e., as peers. ‘414 Patent at 5:37-54, 12:15-31.

69. I understand that, in its Institution Decision, the Board noted that dependent claims 3 and 10 specifically recite a “peer-to-peer connection.” DI at 14. I understand that the Board found this to be evidence that the independent claims should not be construed as requiring peer-to-peer connections in view of the doctrine of claim differentiation. *Id.*

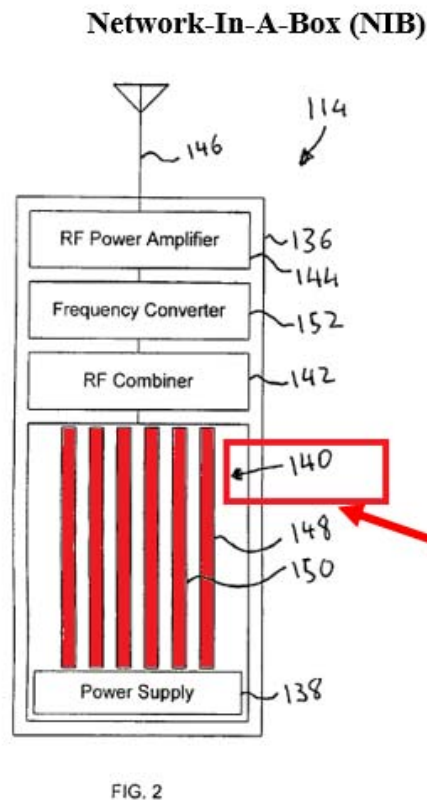
70. However, in my opinion, dependent claims 3 and 10 add a limitation that the calls are connected “via ***an Internet Protocol (IP)*** peer-to-peer connection.” ‘414 Patent at Claims 3, 10 (emphasis added). Because these claims require a specific type of peer-to-peer connection—an Internet Protocol connection—construing the independent claims as requiring peer-to-peer connections (but not necessarily Internet Protocol peer-to-peer connections) does not render dependent claims 3 and 10 as redundant. In addition, I note that dependent claims 3 and 10 appear narrower in scope as to when the Internet Protocol based peer-to-peer connection is used (when “the second mobile subscriber is located within the second wireless coverage”). ‘414 Patent at 18:43-46 (claim 3), 19:41-49 (claim 10). It is my understanding that the doctrine of claim differentiation does not apply where claims are not otherwise identical in scope. Based on this understanding, claim

differentiation does not apply here because in my opinion, there is no claim redundancy because of the additional limitations I discussed above.

## **VII. OVERVIEW OF THE ASSERTED REFERENCES**

### **A. Waylett's Network-in-a-Box is Based on the Conventional Network Appliance Approach**

71. Waylett (Ex. 1006) discloses a network-in-a-box (NIB), such as the WAVEXpress NIB platform (reproduced below), that located certain hardware-based components in a single enclosure. Ex. 1006 at 8:7-17, *id.* at 9:36-42 (explaining that embodiments are based on WAVEXpress's NIB platform). Waylett relies on hardware-based network cards 140 (highlighted in red below). These correspond to hardware-based network cards seen in the promotional photograph for a Network-in-a-box, in the below side-by-side comparison:



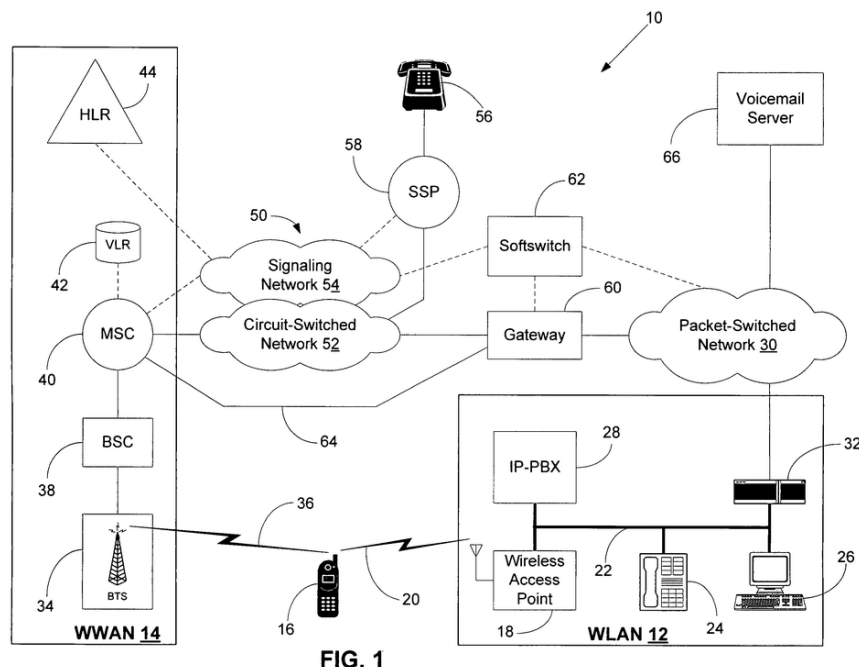
Compare Ex. 2012 at 1 (annotated) with Ex. 1006 at Fig 2 (annotated); see also *id.* at 8:7-36 (disclosing that the NIB includes a number of cards), *id.* at 9:32-46.

72. In my opinion, Waylett does not teach or suggest connecting NIBs through peer-to-peer connections. Instead, Waylett's NIBs transfer call data to an MSC via a BSC using the standard backhaul circuit-switch T1/E1 communication lines. See Ex. 2013 at 1 (disclosing that the NIB communicates "over E1 or T1 timeslot or Ethernet Port."), Ex. 2014 at 1 (disclosing the NIB has up to 256 E1 ports); Ex. 1006 at 7:9-11, 8:33-36 (disclosing the E1 or T1 trunks contained in cards). In other words, Waylett's NIBs are installed as adjuncts to existing

conventional networks and connect to those networks using the same standard interfaces. Proctor Tr. at 48:1-5 (“So the 3G GPRS network would interface to a NIB through that standardized interface, which is how all NIBs would interface, right. So you could have multiple NIBs all having each of the respective line into the GPRS network.”), 14-17 (“Well, it is not a standard NIB interface. It is a standard GSM/GPRS interface”), 45:21-46:20.

**B. Mauer’s WWAN and WLAN Use Conventional Cellular and Wireless Networks**

73. Mauer (Ex. 1005) discloses a cellphone that can communicate over two different types of existing wireless networks. Ex. 1005 at 1:32-58. This so-called “multi-mode” cellphone “may have one interface for communication with a WWAN, using a wireless access technology such as CDMA, and another interface for communication with a WLAN, using a wireless access technology such as IEEE 802.11.” *Id.* at 1:36-40. Figure 1 of Mauer (reproduced below) illustrates the typical network environment of its multi-mode cellphone, having one type of wireless network (e.g., a cellular network, or “WWAN 14”) and a different type of wireless network (e.g., a Wi-Fi network, or “WLAN 12”). *Id.* at 4:35-53; *see also* Ex. 1003 at ¶¶ 69-71.



Ex. 1005 at Fig. 1.

74. The wireless networks in Mauer are conventional, hierarchical networks. Mauer's WWAN 14 is a conventional cellular network having BTSs, MSCs, BSCs, an HLR, and VLR hardware appliances, where all calls are routed from a BTS to a BSC to an MSC. Ex. 1005 at 5:65-6:44. Mauer's WLAN 12 is a conventional wireless local area network providing wireless coverage over a limited area, like a single building, where connectivity is provided by one wireless access point 18. *Id.* at 5:11-15. These WWAN and WLAN networks lack peer-to-peer connections between each other and/or other networks, such as the PSTN. Instead, Mauer discloses interconnecting these disparate circuit-switched (52) and packet-switched networks (30) with a gateway (60). *Id.* at 7:9-12. For these reasons, it is my opinion that Mauer does not disclose or suggest establishing peer-to-peer IP

connections between anything resembling DMA systems within a mobile network, as recited in the Challenged Claims of the '414 Patent.

**VIII. IN MY OPINION THE CHALLENGED CLAIMS ARE PATENTABLE OVER WAYLETT AND MAUER**

75. In my opinion, and for the reasons described below, Mauer and Waylett do not teach or suggest at least the following limitations of the Challenged Claims:

- (1) “distributed mobile architecture;” (including distributed mobile architecture systems and distributed mobile architecture network);
- (2) a “destination preference register” (DPR); and
- (3) a “community location register” (CLR).

**A. The Proposed Combinations of Mauer and Waylett Do Not Teach a DMA Network or DMA System**

76. I note that all of the Challenged Claims require a distributed mobile architecture (DMA) network and at least one DMA system. As discussed in the Claim Construction section (Section VI) above, it is my opinion that “distributed mobile architecture” should be construed as “a network architecture where DMA systems have distributed call-routing functionality and are connected with other DMA systems through peer-to-peer connections.” Mauer and Waylett do not satisfy this construction.

77. In my opinion, neither Mauer nor Waylett teaches a distributed network, let alone one with peer-to-peer connections between the DMA systems.

Petitioners do not show how and why, absent hindsight and use of the '414 Patent as a roadmap, a POSITA would have been motivated to modify Waylett with Mauer's alleged teaching of peer-to-peer IP connections to obtain the inventions of the Challenged Claims.

**1. Petitioners' Proposed Combinations of Mauer and Waylett  
Do Not Result in a DMA Network of DMA Systems**

78. I understand that Petitioners and its expert, Mr. Proctor, alleges that Mauer's WLAN (12) and WWAN (14) are a DMA network having "two separate and distinct DMA systems." Ex. 1003 at ¶¶ 88-91. Alternatively, Mr. Proctor contends that the WWAN could be substituted for another WLAN to satisfy a second DMA system. *Id.* I disagree. Neither scenario involves peer-to-peer connections between Mauer's WLAN(s) and WWAN(s).

79. In my opinion, Mauer describes how it uses conventional hierarchical or hub-style networks to connect voice calls to a UE served by either a WLAN or a WWAN. Ex. 1005 at 10:65-13:67. For example, a call from a WWAN to a "multi-mode mobile station 16" is routed via a centralized MSC and out of the WWAN to a softswitch element. *Id.* at 11:8-21. The softswitch "attempts to establish the call ... via WLAN 12" by sending a SIP Invite message, which the softswitch obtains from an external database or centralized SIP registrar. *Id.* at 11:22-36. If the call attempt is unsuccessful (i.e., the mobile station is inaccessible via the WLAN), the softswitch will "try to locate multi-mode mobile station 16 in WWAN 14 by

querying HLR 44,” *i.e.*, using the conventional backhaul. *Id.* at 13:4-32. As such, a POSITA would understand that Mauer’s process is entirely limited to the use of conventional hierarchical networks, without using peer-to-peer connections between the alleged DMA systems (WLAN and WWAN).

80. I note that Petitioner’s expert only addresses peer-to-peer connections with respect to dependent Claim 3. Ex. 1003 at ¶¶ 132-134. Claim 3 requires use of an Internet Protocol (IP) peer-to-peer connection between the first and second DMA systems. Petitioners rely on Mauer, alleging that the use of a Session Initiation Protocol (SIP) satisfies the requirement of an IP peer-to-peer connection between two DMA systems. Ex. 1003 at ¶ 134 (citing Ex. 1005 at 5:34-38, 3:59-61, 5:56-58, 4:66-5:2, Ex. 1015 at Abstract, 1:17-20)). But the SIP protocol is a client-server protocol, and would not have been known to a POSITA at the time the invention to be a peer-to-peer connection. Ex. 2033 at 3 (“In the common SIP-using architectures that we refer to as ‘Conventional SIP’ or ‘Client/Server SIP’, there is a relatively fixed hierarchy of SIP routing proxies and SIP user agents”). Petitioners also rely on an O’Brien reference (Ex. 1015) for characterizing SIP as a “peer-to-peer signaling network,” but I understand that the earliest priority date of O’Brien is December 21, 2006 based on a foreign filing date. Ex. 1015 at 1:17-20; *id.* at field (3). O’Brien therefore post-dates the effective filing date of the ‘414 Patent, and cannot be used to support a POSITA’s understanding of SIP or Mauer at the time

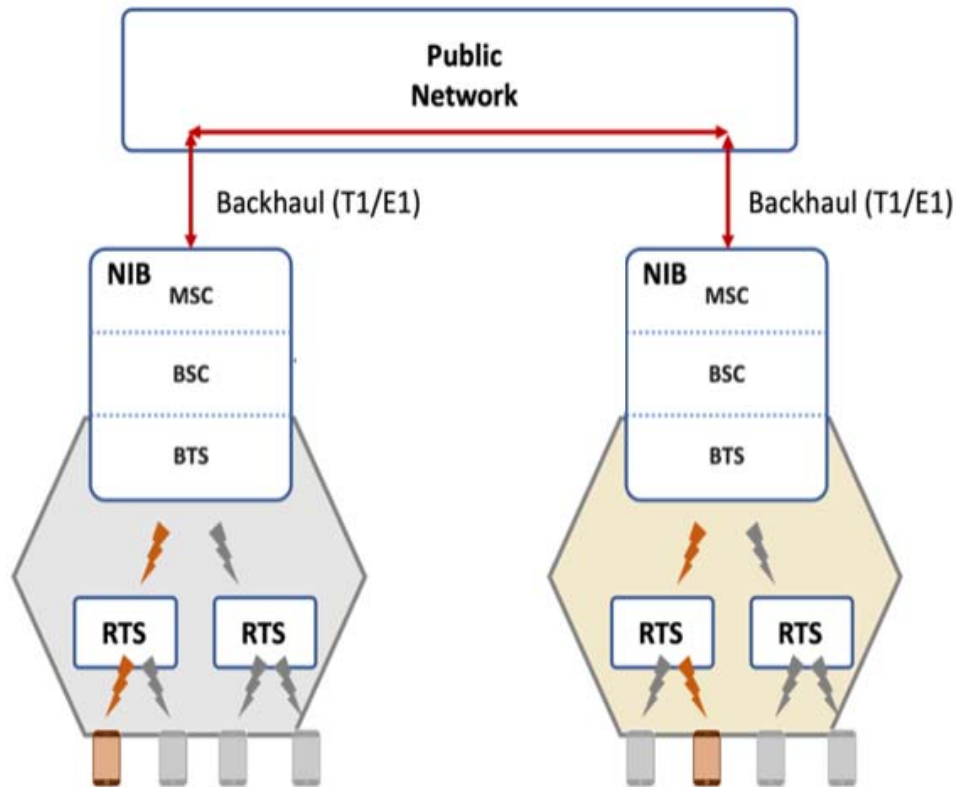
the invention was made. I also understand that a standardized extension to support peer-to-peer connections was added to the SIP protocol in 2016, over a decade after the priority date of the '414 Patent. For example, RFC 7890 describes the addition of a P2P extension to the SIP protocol being released in 2016. Ex. 2033.

81. In my opinion, even if SIP connections could be considered peer-to-peer connections, they are not peer-to-peer connections between **DMA systems**. Instead, the alleged “peers” in these connections are the mobile devices that communicate over the WLAN. Ex. 1005 at 7:30-36 (“softswitch 62 may use SIP ... to establish communication sessions through packet-switched network 30 between gateway 60 and **various endpoints, e.g., multi-mode mobile station 16** when it is accessible via WLAN 12”) (emphasis added). For example, a POSITA would know that establishing a SIP media session results in a media stream between two mobile devices (*i.e.*, SIP user agents). Thus, Petitioners’ alleged “peer-to-peer” connections are not peer-to-peer connections **between DMA systems**, as the Challenged Claims require.

82. In fact, I understand that Petitioners’ expert repeatedly confirmed that the mobile phones **are excluded from and not part of a DMA system**. Proctor Tr. at 67:14-21 (“That is pretty obvious that a phone is not part of the DMA network”), 69:12-16 (“the telephones would not be part of that [DMA] network”). As such,

Mauer's use of SIP to connect mobile devices fails to disclose peer-to-peer connections between ***DMA systems***.

83. In my opinion, Waylett does not cure Mauer's deficiencies. Waylett describes a network in a box (NIB) that connects to existing WWAN networks using then-conventional T1/E1 communication links for backhaul to provide voice and data communication and a private wide area network (PWAN) for "distributing HLR registration and authentication loads." Ex. 1006 at 17:10-12; *see also* Ex. 2013 (disclosing the T1/E1 ports for communication); Ex. 1006 at 7:9-11, 9:65-10:6, 17:7-17, Fig. 11. This setup is illustrated below, which is a diagram based on Ex. 1006 at Fig. 11, *see also* Ex. 2013 at 1 (disclosing that the NIB has "all E1 or all T1" ports for voice and data communication):



Ex. 1006 at Fig. 11.

84. As shown above, the call path from one UE to another UE goes from the NIB, over T1/E1 backhaul, to a public network, over T1/E1 backhaul to a second NIB, to the recipient UE. Thus, a POSITA would understand that there were no peer-to-peer connections between NIBs (which Petitioners contend are DMA systems in Ground 2) and, in particular, no Internet-Protocol-based peer-to-peer connections, as Claim 3 requires.

85. For at least the reasons above, it is my opinion that Mauer and Waylett, alone or in combination, do not disclose DMA networks formed by DMAs interconnected with peer-to-peer connections.

**2. Petitioners Do Not Explain How Mauer and Waylett Disclose DMA Systems and a DMA Network**

86. Even if the Board does not adopt Lemko’s proposed claim construction for distributed mobile architecture, it should reject Petitioners’ grounds because in my opinion, Petitioners and their expert have failed to articulate a coherent theory of how Mauer’s WWAN and WLAN are “DMA systems.” Pet. at 18; Ex. 1003 at ¶¶ 82-87. Petitioners contend that Mauer’s WWAN is a “Wireless Wide Area Network” (like a 2G/3G cellular network) and Mauer’s WLAN is a “Wireless Local Area Network” (like an IEEE 802.11 Wi-Fi network). Ex. 1005 at 1:12-31. Petitioners have not attempted to explain how these networks are *distributed* networks, such that they could comprise DMA systems of a DMA network.

87. In my opinion, Petitioners and their expert have failed to give any weight to the terms “DMA” or “distributed mobile architecture,” essentially treating them as nonce words. Pet. at 18-23, 49-51; Ex. 1003 at ¶¶ 82-87, 148-151. As I explained above, “DMA” and “distributed mobile architecture” are central concepts in the ‘414 Patent, appearing over 550 times in the specification and claims. For Ground 1, I understand that Petitioners assert that the presence of “separate” or “distinct” systems, WLAN and WWAN, are sufficient to satisfy the distributed

mobile architecture systems limitations. Pet. at 17-22, Ex. 1003 at ¶¶ 82-91. But, in my opinion, Petitioners simply contend that these are networks, without demonstrating that they are ***distributed mobile architecture*** networks.

88. It is my understanding that, for Ground 2, Petitioners contend that Waylett's NIBs are DMA systems because its "description mirrors how the '414 patent describes a DMA system." Pet. at 59, Ex. 1003 at ¶ 168 (citing Fig. 3, 6:5-25). Petitioners again do not explain how the NIBs are nodes in a distributed mobile architecture network. Thus, Petitioners have failed to make a *prima facie* showing that Mauer and Waylett alone or in combination disclose DMA systems and a DMA network.

### **3. Petitioners' Proposed Combination of Mauer and Waylett Lacks Any Rational Motivation to Combine**

89. I understand that Mr. Proctor asserts that it would have been obvious to a POSITA "to implement Waylett's NIB solution into Mauer's system architecture" and "[t]he combination would involve using Waylett's Network-in-a-Box 224 in each of Mauer's WWAN 14 and WLAN 12, resulting in at least two DMA systems." Pet. at 13, 68; Ex. 1003 at ¶¶ 74-75, 195. Mr. Proctor further asserts a POSITA would have been motivated to combine Mauer and Waylett for three reasons: (1) the references each provide reasoning to make such a combination, (2) the "resulting combination would improve Mauer's distributed wireless network system by consolidating it into a single box, making it compact in design allowing for faster

deployment,” and (3) “Waylett’s NIB would help mitigate the shared concern of Mauer—that is, reaching a mobile station as it roams or moves outside of the service or coverage area.” Ex. 1003 at ¶ 78; Pet at 15-16. I disagree. All of these arguments reflect a superficial understanding of Mauer’s network architecture and Waylett’s NIB and they ignore how a POSITA would have understood the respective teachings.

90. In my opinion, Petitioners’ proposed combination—“using Waylett’s Network-in-a-Box 224 in each of Mauer’s WWAN 14 and WLAN 12, resulting in at least two DMA systems”—ignores that Waylett expressly discloses its NIB already provides a WLAN and the type of cellular network technology provided by Mauer’s WWAN. Ex. 1003 at ¶ 75, Pet. at 13; Ex. 1006 at 8:7-10 (describing a base transceiver station, CBTS 114 is a Network-In-a-Box), *id.* at Fig. 5, 2:38-48 (describing the CBTS as having both a GSM/GPRS transceiver, i.e., WWAN, and “a WLAN transceiver”); *see also id.* at 9:13-46 (describing the system coupled to a WLAN and a public GSM/3G network). Accordingly, a POSITA would understand that a single NIB would be used to provide the two communication modes, cellular (via network 222) and WLAN (via network 228) disclosed in Mauer:

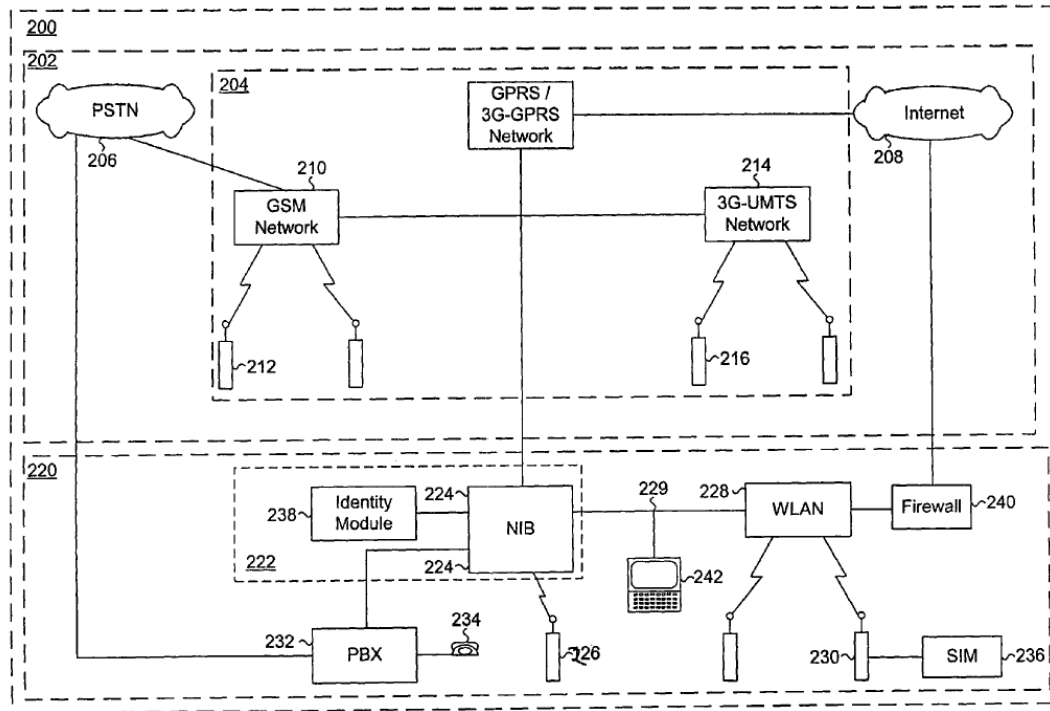


FIG. 5

Ex. 1006 at Fig. 5.

91. In my opinion, a POSITA would not be motivated to use a NIB “in each of” Mauer’s WWAN 14 and WLAN 12 because a single instance of Waylett’s NIB already provides access to both types of networks (cellular and WLAN). Adding an extraneous NIB would run contrary to Waylett’s express teachings of reducing costs and expenses. Ex. 1006 at 2:3-13; Pet. at 15; Ex. 1003 at ¶ 78. Without NIBs on either side of Mauer’s architecture, Petitioners’ obviousness combination does not facially read on the claims because there are no longer two DMA Systems that form a DMA network; there is just a single NIB that provides both cellular and WLAN access.

92. Petitioners' argument that a POSITA would implement Mauer's WWAN and WLAN with a NIB is also nonsensical because a single NIB is not a replacement for an existing WWAN. Pet. at 13-15; Ex. 1003 at ¶¶ 75-78; Proctor Tr. at 37:7-42-21 (arguing that one would implement Mauer's WWAN using Waylett's NIB). A POSITA understand that a WAN is a network that covers a large geographical footprint, like a country or continent. Ex. 2030 (Tanenbaum) at 18; Ex. 1005 at 4:54-57 ("WWAN 14 may provide wireless coverage in a relatively large geographic area, such as an entire city"). However, it is my opinion (and apparently Mr. Proctor agrees) that a single NIB provides coverage over, at most, a single building and could not serve as a replacement for a WAN. This opinion is based on my review of the specification sheet for the WAVEXpress Network-In-A-Box (Ex. 2013), and its output power, frequency bands, and other radio specifications, that is mentioned in Waylett (Ex. 1006 at 8:7-10). This is also based on the promotional materials for that WAVEXpress NIB that describes "[i]ts usage has ranged from remote small coverage areas often with satellite backhaul to enterprise private GSM networks integrating with private PBXs." Ex. 2012 at 1. .

93. I understand that during cross-examination, Mr. Proctor expanded his argument, suggesting that a POSITA would have built an entire WWAN using Waylett's NIBs, purportedly because it would have been less expensive. Proctor Tr. at 54:22-56:3. However, Waylett's cost savings are realized by using Waylett's NIB

as disclosed in Waylett—as an adjunct to existing infrastructure. Ex. 1006 at 9:57-63; Proctor Tr. at 59:13-60:13 (Mr. Proctor confirming the same) . Accordingly, rather than disclosing arranging NIBs into a WWAN, Waylett discloses that its NIB can be used to provide a “private IP network” that operates as an adjunct to existing networks, like Mauer’s WWAN.

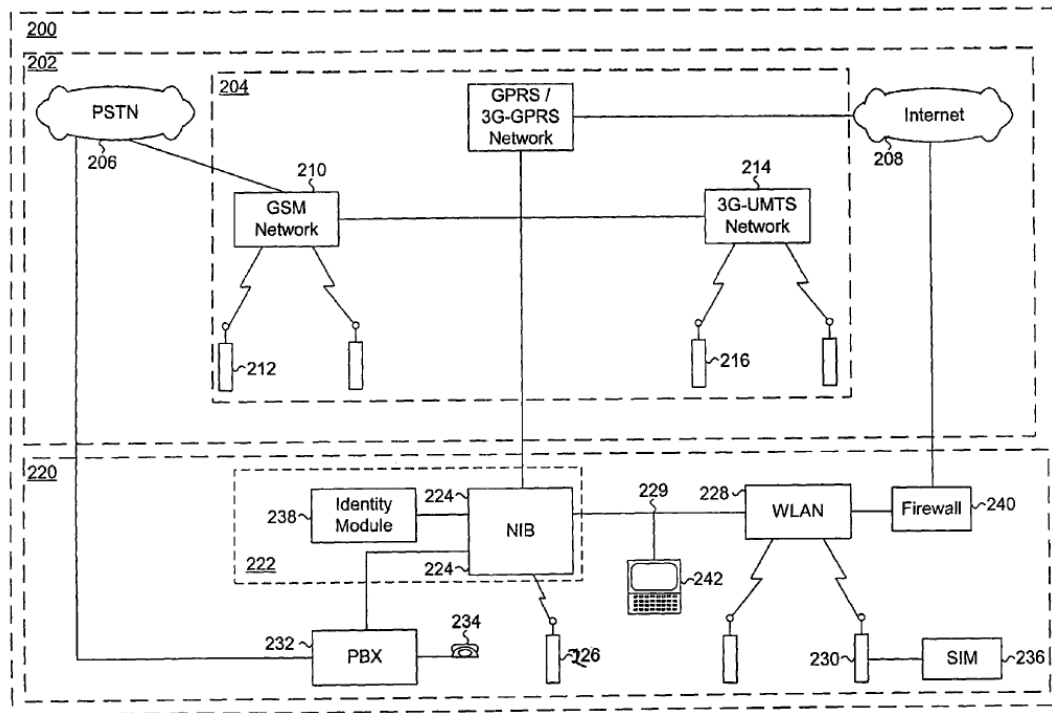


FIG. 5

Ex. 1006 at Fig. 5 (illustrating a NIB connected to public 2G and 3G networks 204).

94. Accordingly, a POSITA considering the teachings of Waylett would have, at most, used the NIB as an adjunct to Mauer’s existing WWAN, not as a replacement. Mr. Proctor acknowledged during cross-examination that it would not

be cost-effective to replace an existing WWAN with a new WAN implemented with Waylett's NIBs, and that he had not calculated whether it would have been more cost-effective to build an entire WWAN out of NIBs from scratch. Proctor Tr. at 66:6-9 ("Well, if it is already deployed, it is not more cost effective to replace it, if it already exists, right, unless you're upgrading to a new standard in which case it very well may be"), 66:2-67:8.

95. Hence, in my opinion, there is no motivation to combine Mauer and Waylett in any manner that would yield the Challenged Claims.

**B. Mauer and Waylett Do Not Render Obvious a Destination Preference Register**

96. In my opinion, Mauer and Waylett do not disclose the destination preference register limitation and, therefore, cannot render obvious any of the Challenged Claims. I note that Claims 1 and 8 require "determining a preferred call path to route the call outside of the DMA network based on information stored at a destination preference register (DPR), wherein the DPR is stored at the first DMA system." '414 Patent at 18:32-36, 19:32-34. Claim 11 recites a similar limitation. *Id.* at 20:6-17 ("a destination preference register . . . route[s] the call via a particular preferred call path of the one or more preferred call paths stored at the DPR when the AAA module determines that the call is directed to a destination device that is outside of the DMA network").

97. As discussed above, the '414 Patent describes how a peer-to-peer DMA network of DMA systems enables each DMA system to have its own separate interface to networks outside of the DMA network. '414 Patent at Fig. 2, 5:3-20 (describing one DMA system having an MSC interface, another DMA system having a VoIP interface, and another DMA system having an ISDN interface). Normally, when a call is made between mobile subscribers within the same DMA network, that call can be handled entirely and directly between the DMA systems without the need to traverse a backhaul. '414 Patent at 5:37-54. But, when a call from a mobile subscriber is made to a destination outside of the DMA network, the peer-to-peer nature of the DMA network makes available all of these interfaces for routing the call outside of the DMA network. *Id.* at 5:62-6:4. Thus, the peer-to-peer aspect of the DMA network enables each DMA system to share its interfaces and reduce the need to separately have its own (duplicative) interface (e.g., multiple MSC interfaces, multiple ISDN interfaces). *Id.* at 9:59-10:4 (describing the use of a third DMA's ISDN interface to route a call outside the DMA network).

98. In my opinion, a POSITA would understand that the DPR provides interface preferences to make calls external to the DMA network. *Id.* at 5:65-67. The '414 Patent explains how these preferences are a flexible feature that enables mobile subscribers to customize their use of the DMA network and utilize the full potential and capabilities of the DMA network. For example, "if a user wishes to

save money, the user can choose to make calls outside of the DMA network via a VoIP interface” and “if a user wishes to have a higher call quality, the user can choose to make calls outside of the DMA network via an ISDN interface.” *Id.* at 9:32-37.

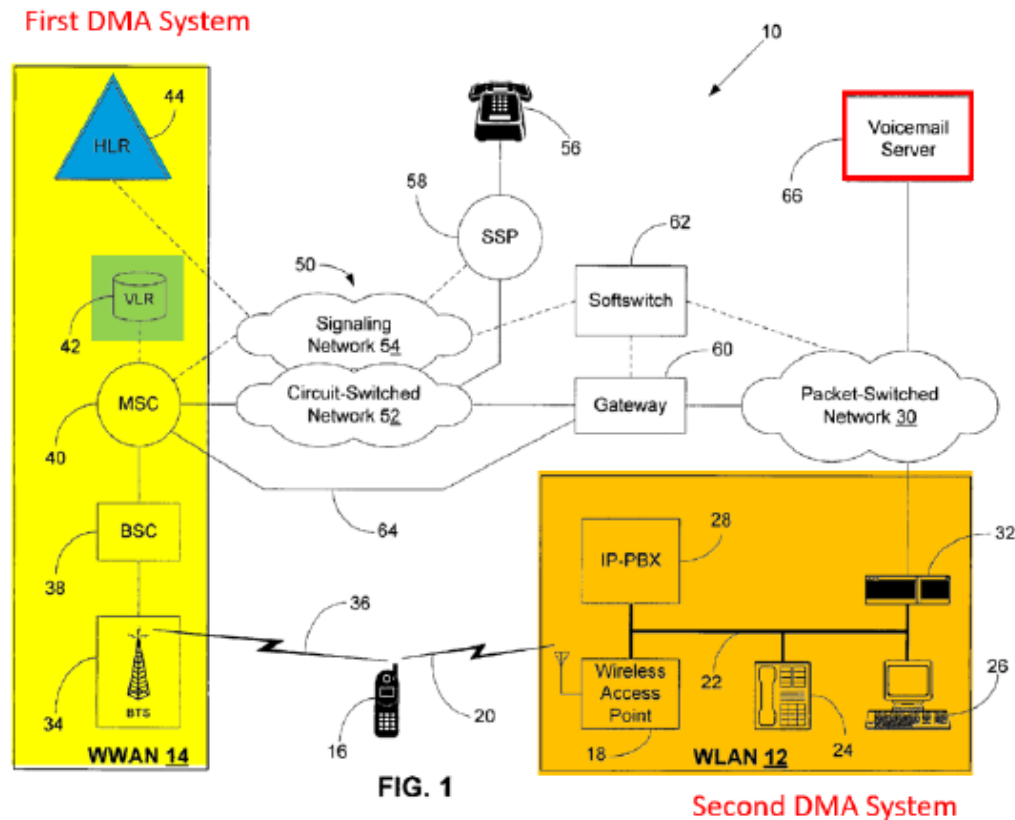
99. For the foregoing reasons, the DPR must be able to route calls through a preferred call path outside of the DMA networks to second user equipment. I note that the Petition cites Mauer’s voicemail server as a “preferred call path to route the call,” but in my opinion it fails to satisfy the claims for multiple reasons. Pet. at 38-42; Ex. 1003 at ¶¶ 118-121.

**1. Mauer’s Voicemail Server is Located Within the Alleged DMA Network**

100. In my opinion, a POSITA would understand that Mauer’s voicemail server is ***within*** the alleged DMA network and is not, therefore, an external path. Petitioners allege that telecommunications system 10 is the claimed “DMA network.” Ex. 1003 at ¶ 90 (“Both WWAN 14 and WLAN 12 belong to the same system 10 (‘DMA network’)”). However, Mauer expressly discloses that the voicemail server is ***within*** the communications network that includes the WLAN and WWAN. Ex. 1005 at 8:25-34 (“Wireless telecommunications network 10 may also ***include*** a voicemail server 66...” (emphasis added)). Thus, in my opinion, the optional voicemail server is within the alleged network, not external to it.

101. Mauer also discusses that voicemail server 66 is positioned or coupled to other network elements (e.g., “to PSTN 50,” “to MSC 40”) and may “be otherwise **located in** network 10.” *Id.* (emphasis added). There is nothing in Mauer that would suggest to a POSITA that the voicemail server is outside of the wireless telecommunications network 10 that includes WWAN 14 or WLAN 12, as required by the Challenged Claims. *Id.*

102. Petitioners’ argument that the voicemail server is not part of the network appears to rely exclusively on the schematic diagram in Fig. 2 of Mauer, which does not depict the voicemail server 66 in the box that Petitioners annotated orange and contend is the second DMA system (see excerpt below). But, the schematic layout of elements in Mauer’s Figure 1 is not evidence that the voicemail server is “outside of the DMA network.”



Pet. at 39 (reproducing Ex. 1005, Fig. 1 (annotated in the Petition)).

103. I understand that in its Institution Decision, the Board gave Petitioners the benefit of the doubt and interpreted their argument as **not** suggesting that every component of Mauer's telecommunications system 10 corresponds to Claim 1's DMA network. DI at 36-37. Perhaps taking this cue, Petitioners' expert clarified his opinion during cross-examination on what elements in Mauer's network 10 were considered "inside" and "outside" of the network. Proctor Tr. at 67:9-70:18 (arguing mobile phones are outside of the network, but declining to confirm whether "signaling network 54, circuit switch 20 network 52, soft switch 62, gateway 60 packet, switch network 30" were part of a DMA network). In my opinion, this

exercise in arbitrary line drawing is pure hindsight reasoning that would only be done in hindsight of the Challenged Claims.

104. A POSITA would not consider voicemail server 66 to be outside of what Petitioners' contend to be the DMA network. A POSITA would understand that voice-mail servers ("VMS") are typically provided by cellular service providers, are considered part of a mobile architecture, and are even often co-hosted in the same data centers as the MSC. This understanding is reflected in this Nokia diagram illustrating a classic "GMS network architecture," where the "Voice Mail System" is depicted as being part of the "Exchange System" tier and connected to the MSC.

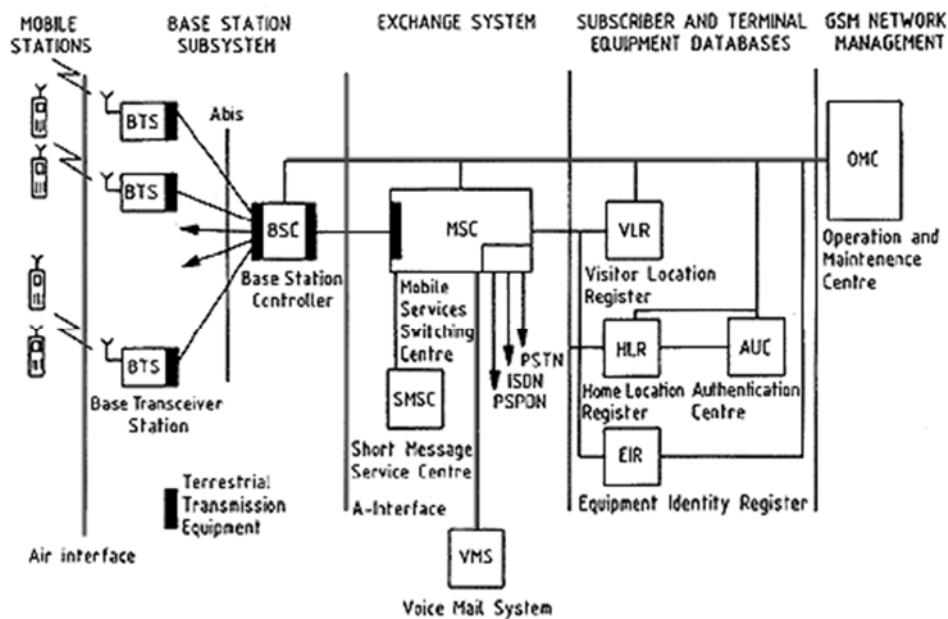
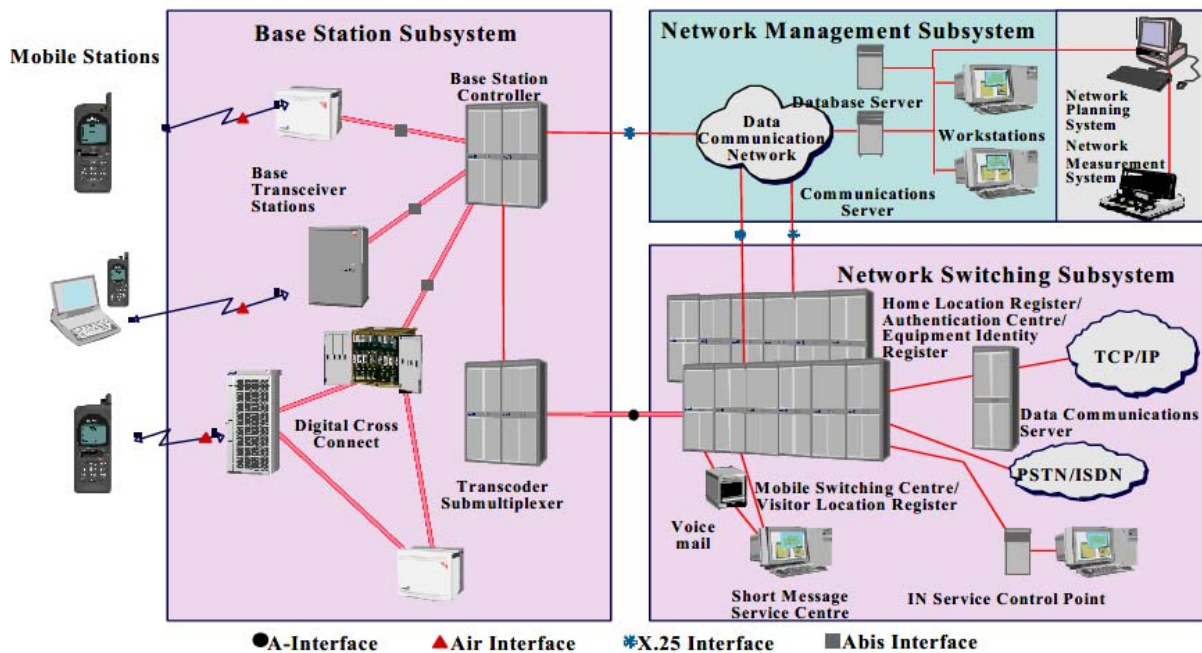


Fig. 1. GSM network architecture

Ex. 2034 (showing "VMS" or "Voice Mail System" as part of the "Exchange System" layer)



See also, Ex. 2035 at 20 (showing “Voice mail” as part of the “network switching subsystem”)

105. Petitioners’ own evidence (Pet. at 40-41) further demonstrates that the voice-mail system is part of Mauer’s network architecture. Ex. 1016 at 4:56-57 (“MSC 22 may be coupled by a voice trunk with a voice-mail server (VMS) 38”); *id.* at 5:39-42 (“The enterprise voice mail server 60 may be integrated as a function of the IP PBX server 50 or, as shown, may exist as a separate component”); *id.* at 7:64-67 (“**Sitting as nodes on network 90**, in addition to the MGW 78, MGC 80, and IP PBX server 50, are CSCF 76, HSS 82, policy servers 84, **and voice mail server(s) 86**”) (emphasis added).

106. For the foregoing reasons, it is my opinion that Mauer does not disclose determining a preferred call path to route a call outside of the DMA network based on information stored at a destination preferred register.

**2. Mauer’s Voicemail Server is Not the Second Mobile Subscriber**

107. In my opinion, Petitioners’ argument also fails because a POSITA understands that Mauer’s voicemail server is not a second mobile subscriber. Each of the independent claims requires receiving “a call from a first mobile subscriber to a second mobile subscriber” and a DPR for “determining a preferred call path to route **the call** outside of the DMA network.” ’414 Patent at Claims 1, 8, and 11 (emphasis added). A POSITA would understand that, based on antecedent basis, “the call” outside of the DMA network must be a call from the first mobile subscriber to the second mobile subscriber, and Mauer’s voicemail server is not the second mobile subscriber. In fact, Mauer discloses it **cancels** routing the call to connect to the intended second mobile subscriber when sending the call to voicemail. Ex. 1005 at 13:58-62 (“cancel the SS7 signaling for routing the call to MSC 40”).

108. I understand that, in its Institution Decision, the Board found that Mauer does not teach cancelling call routing completely, and that it “establish[es] the call to voicemail” by “rout[ing] the call to voicemail server 66.” DI at 38 (citing Ex. 1005 at 13:59-64). But, the claims require “rout[ing] **the** call,” whose antecedent basis refers to “a call from a first mobile subscriber to a second mobile subscriber.”

'414 Pat at 18:8-10, 18:66-67. I understand that during his deposition, Mr. Proctor admits he disregarded the “to a second mobile subscriber” limitation. Proctor Tr. at 115:16-22 (“Q: Is a voicemail server a mobile subscriber? ... A: No, it is not a mobile subscriber. It is an account associated with a subscription service. ***Of course that is not what the claim requires either.***”); *id.* at 116:10-117:20.

109. I believe that, under this plain reading, establishing a call to a voicemail system no longer constitutes the same “call” from one mobile subscriber’s UE to a second mobile subscriber’s UE. A POSITA would understand this because the underlying switching technology of Mauer cancels the SS7 signalling for routing the original call to the MSC signalling, as discussed above. In fact, I understand that Mr. Proctor admitted that establishing a connection to the voicemail server requires addressing a message to the voicemail server’s IP address instead of the second mobile subscriber. Proctor Tr. at 115:12-22, 116:10-117:1 (acknowledging that Mauer’s call gets routed to the voicemail system’s address). This stands in contrast to the claimed invention whose plain purpose is to connect the first mobile subscriber to the second mobile subscriber when the second mobile subscriber is accessible via a network outside of the DMA network. ’414 Patent at 9:59-63 (“the DMA establishes the call to the MDN outside of the DMA network via a DMA server that routes the call over the preferred call path”).

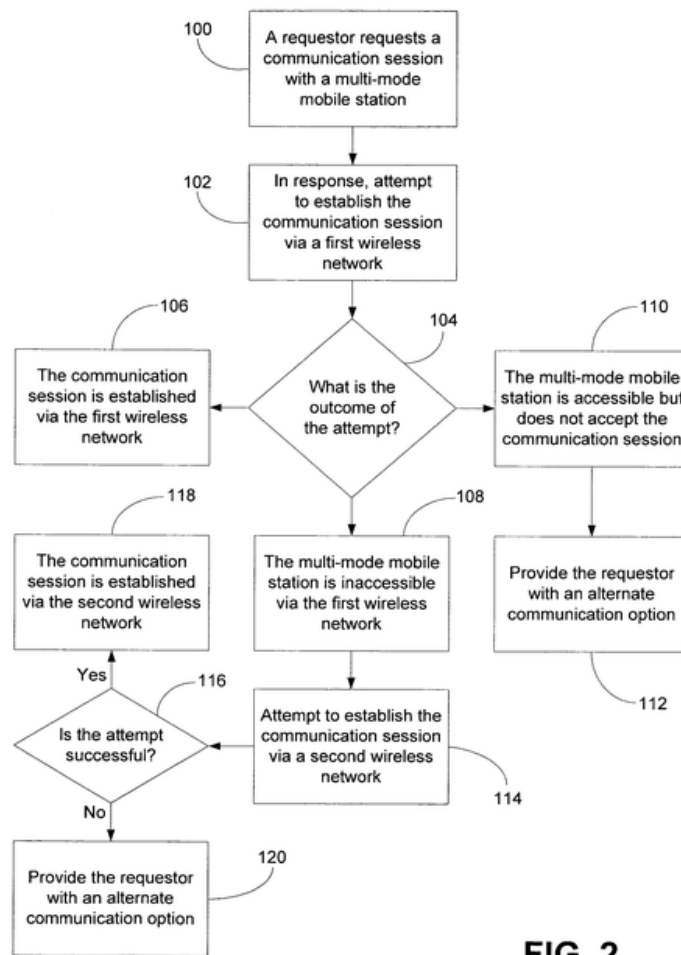
110. I understand that Petitioners' expert argued, for the first time on cross-examination, that "one of ordinary skill in the art would understand" that "the call" is a "request to set up a call to the ... second mobile subscriber" or "a request to initiate the call." *Id.* at 119:3-8, 119:11-13; *see also id.* at 117:14-121:15. But in my opinion, even this interpretation requires a request to set up a call to still be "to the second mobile subscriber" when it is routed outside the DMA network, and not to a voicemail server. Thus, I believe that a POSITA would understand that routing a call to voicemail is not routing a call to the second mobile subscriber's UE, as the Challenged Claims require.

**3. Mauer's "Alternative Communication Option" is Not Triggered When "The Call Is Directed to a Destination Device That is Outside of the DMA Network"**

111. In my opinion, Mauer does not teach or suggest how the destination preference register is used in the claims, namely, when the call is being routed to a destination mobile subscriber ***outside of the DMA network***. Specifically, Claim 11 requires that the preferred call paths stored at the DPR are used to route calls when it is "determine[d] that the call is directed to a destination device that is outside of the DMA network." '414 Pat at 20:15-17. Challenged claims 1 and 8 recite a similar limitation where the preferred call path based on "information stored at a destination preference register" is determined "when the second mobile subscriber is not located

within the first wireless coverage area and is not located within the second wireless coverage area.” ’414 Pat at 18:30-32, 19:20-22, 19:28-31 (similar).

112. I understand that Petitioners argue that Mauer discloses “an alternate communication option” that is activated when the call receiver is “inaccessible.” Pet. at 70-72; ¶¶ 203-207; Ex. 1005 at Fig. 2, 9:39-10:5. This occurs at the end of multiple attempts after the system exhausts its options, at which point (step 120 below) the multi-mode mobile station is assigned “inaccessible” status. Ex. 1005 at 9:39-10:5.



Ex. 1005 at Fig. 2.

113. But, a POSITA would understand that “inaccessible” is a broad term, and does not imply a specific determination that the UE is outside of the coverage area of the DMA network. *Id.* at 9:42-43 (“The multi-mode mobile station may be inaccessible via the first wireless network for various reasons”); *id.* at 10:54-59 (“because the multi-mode mobile station is inaccessible via the second wireless network or *is accessible but does not accept the communication session*”)

(emphasis added). Thus, I believe that the assignment of “inaccessible” status fails to satisfy the Challenged Claims’ requirement that the DPR is used “when” it is “determine[d] that the call is directed to a destination device that is outside of the DMA network” (Claim 11) or “**when** the second mobile subscriber is not located within the first wireless coverage area and is not located within the second wireless coverage area” (Claims 1 and 8). In my opinion, Mauer does not teach such a determination.

#### 4. Mauer Does Not Disclose Information Stored at a DPR at a DMA System

114. I understand that Petitioners concede that Mauer does not disclose “information stored at a destination preference register (DPR), wherein the DPR is **stored at the first DMA system.**” Pet. at 40-42 (emphasis added); Ex. 1003 at ¶¶ 122-123. Relying on conclusory expert testimony and hindsight reasoning, Petitioners fail to fill this and establish why “[a] POSITA would have been motivated to store information pertaining to Mauer’s voicemail server 66 in a ‘destination preference register (DPR)’ in the ‘first DMA server.’” Pet. at 40-42 (emphasis omitted); Ex. 1003 at ¶¶ 122-123.

115. **First**, in my opinion, Petitioners provide no evidence supporting their assertion that “information about the voicemail server” would be the type of information needed to be shared across multiple DMA systems in case any DMA failed. Pet. at 41. Mr. Proctor provides no evidence and simply repeats what the

Petition says. Ex. 1003 at ¶ 125. In my opinion, if POSITA found it necessary to store the information for sending a call to voicemail, as Petitioners assert, the POSITA would have understood that information to have been stored in the softswitch element 62. This is because Mauer teaches that it is the softswitch that handles the calls to voicemail server 66. Ex. 1005 at 8:32-34 (“softswitch 62 may establish a call to voicemail server 66 when the multi-mode mobile station intended to receive the call does not answer it”). Mauer’s softswitch is not part of either WLAN 12 or WWAN 14 (i.e., the alleged first and second DMA systems), and Petitioners do not explain why a POSITA would modify softswitch 62 to yield the claimed DPR limitation by moving the DPR to multiple DMA systems. Pet. at 18 (citing annotated Mauer’s Fig. 1).

116. **Second**, I disagree with Petitioners’ characterization of their evidence relating to GSM standard. Pet. at 41; Ex. 1003 at ¶ 126. The textbook cited by Petitioners states that the “IMSI detach” procedure occurs “because of powerdown or because the SIM is removed.” Ex. 1013 at 3. There is no indication in the GSM standard that IMSI detach occurs “when the second mobile subscriber is not located within the first” or “second wireless coverage area,” as the claims require.

117. **Finally**, in my opinion, it would not have been obvious to store the DPR at the claimed DMA system. Petitioners’ modifying is not applying a “known technique” or rearranging a “known element” because Petitioners concede that the

DPR was not, in fact, a known element or technique. Pet. at 40 (conceding Mauer does not disclose a DPR); Ex. 1003 at ¶ 127.

118. With regards to Independent Claim 11, I understand that Petitioners also concede that Waylett “does not expressly disclose the AAA module includes ‘a destination preference register,’” as that claim requires. Pet. at 68; Ex. 1003 at ¶ 195. For at least the reasons provided above with respect to Claims 1 and 8, Petitioners fail to establish that the missing limitation of Claim 11 would have been obvious.

119. In addition, in my opinion, Petitioners fail to show that it would have been obvious to a POSITA to use Waylett’s configuration table to achieve the DPR. Pet. at 68 (referring to Pet. 30-36). Petitioners cross-reference their argument about Waylett’s configuration tables, but that argument was limited to the CLR, and does not address the DPR. *Id.* Petitioners do not explain how it would have been obvious to have an AAA module that included a DPR as part of the claimed DMA system, as required by Claim 11. *Id.*

120. For the foregoing reasons, I believe that Mauer and Waylett do not render obvious the use of information stored at a DPR where the DPR is stored at the first DMA system (claims 1 and 8) or where the DMA system includes an AAA module that includes the DPR (claim 11) for routing the call.

**C. Mauer and Waylett Do Not Render Obvious the Community Location Register Limitation**

121. In my opinion, Mauer and Waylett do not render obvious any of the Challenged Claims because they fail to disclose the Community Location Register (CLR) limitations.

122. I note that Independent claims 1 and 8 require that the CLR is used to determine whether “the second mobile subscriber is located within a second wireless coverage area of the DMA network that is associated with the second DMA system.” ’414 Patent at 18:22-25, 19:13-15. Claim 12, depending from Claim 11, recites a similar limitation. ’414 Patent at 20:18-22 (“the AAA module determines that the destination device is outside of the DMA network based on the information stored at the HLR, the information stored at the VLR, and the information stored at the CLR”). I believe that These limitations enable the DMA networks to route calls among the various DMA systems that make up the DMA network without having to access external, conventional networks via expensive backhaul connections. See Section VI.B.1, *supra*.

123. In my opinion, these “community location register” limitations are non-obvious in view of the asserted references Mauer and Waylett. I understand that Petitioners admit that Mauer does not teach a CLR. Pet. at 30 (“Mauer, however, does not expressly disclose using ‘information stored at a community location register...’”) (emphasis omitted); *id.* at 33 (same); Ex. 1003 at ¶¶ 108-109.

Petitioners exclusively rely on Waylett, but it fails to disclose or render obvious the CLR limitations, as set forth below.

124. I understand that, in its Institution Decision, the Board summarized Petitioners’ and Patent Owner’s arguments related to this limitation. DI at 32. I understand that the Board viewed Petitioners’ evidence and arguments as supporting the view that a POSITA “may have understood from this that Waylett uses the configuration register to determine whether the subscriber is in a particular coverage area.” DI at 32. But, a POSITA would have understood that Waylett uses other means for coverage-area determinations, like mobility management procedures such as those used in a GSM architecture.

125. Petitioners assert that Waylett’s configuration table satisfies this requirement. Pet. at 34-35; Ex. 1003 at ¶ 110-111. I disagree. Waylett’s configuration table is not used to determine if a mobile subscriber is in a wireless coverage area (e.g., a coverage area associated with a second DMA system). Waylett discloses routing a query for this information to the appropriate HLR/VLR. Ex. 1006 at 14:61-66, 21:10-28. Thus, the requisite determination of where the second subscriber is located is not made “based on” the cited configuration table (the alleged CLR) and is instead based on the part of the HLR/VLR responsible for that mobile phone that is stored elsewhere (as described above). Petitioners are, therefore, incorrect to assert that Waylett’s configuration tables “store these subscriber

identities along with their appropriate HLR.” Pet. at 67. Instead, Waylett’s configuration table uses “IMSI ranges,” rather than specific IMSI or subscriber identities, which help identify the appropriate HLR. Ex. 1006 at 15:6-8, 21:25-28. IMSI ranges do not identify subscriber identities because the IMSI ranges represent a multitude of subscribers that fall between a starting address to an end address.

126. Waylett describes using a RADIUS server, which is “a networking protocol that provides centralized authentication, authorization, and accounting (AAA) management for users who connect and use a network service.” Ex. 2036 at 1, Ex. 2041; Ex. 1006 at 14:3-11. A POSITA would understand that a RADIUS server performs authentication procedures to perform “accounting” features such as “billing” using “call records,” or to confirm a user can access the services at the WWAN/WWLAN. Ex. 1006 at 14:16-22. Waylett provides a list of RADIUS functions, and none of the functions describe anything about locating a mobile subscriber or checking a coverage area. Ex. 1006 at 21:1-22:4. As such, a POSITA would understand that Waylett’s configuration table does not describe the use of the RADIUS server to determine coverage areas. Waylett’s configuration table does not teach or suggest a modification to Mauer that would yield “determining whether the second mobile subscriber is located within a second wireless coverage area of the DMA network that is associated with the second DMA system ***based on information stored at a community location register (CLR) associated with the second DMA***

**system,”** as required by Challenged Claims 1 and 8. See also Claim 12 (“the AAA module determines that ***the destination device is outside of the DMA network based on the information stored*** at the HLR, the information stored at the VLR, ***and the information stored at the CLR***”) (emphasis added).

127. In contrast to Waylett’s configuration table, the CLR includes the location information necessary to route calls among the DMA systems so that each DMA system can determine how to route calls itself, without the need for the conventional backhaul infrastructure. ’414 Patent at 5:37-40 (“the first mobile subscriber 210 of the first DMA 202 can be connected locally to the second mobile subscriber 210 of the first DMA 202 after locating the second mobile subscriber 210 within [] a home location register (HLR) within the first DMA 202”), 5:21-61, 10:35-11:41.

128. For the foregoing reasons, it is my opinion that Waylett fails to render obvious “a community location register (CLR) that stores information associated with a second HLR of a second DMA system, wherein the second HLR ***stores information associated with one or more mobile subscriber devices that are registered with the second DMA system,***” as required by Challenged Claim 11.

**D. Waylett and Mauer Fail to Teach the Claimed Computer Readable Storage Medium Within the Housing (Ground 2, Claim 21)**

**1. Claim 21 Requires Software-Based MSC, BSC, and CDR Functionality**

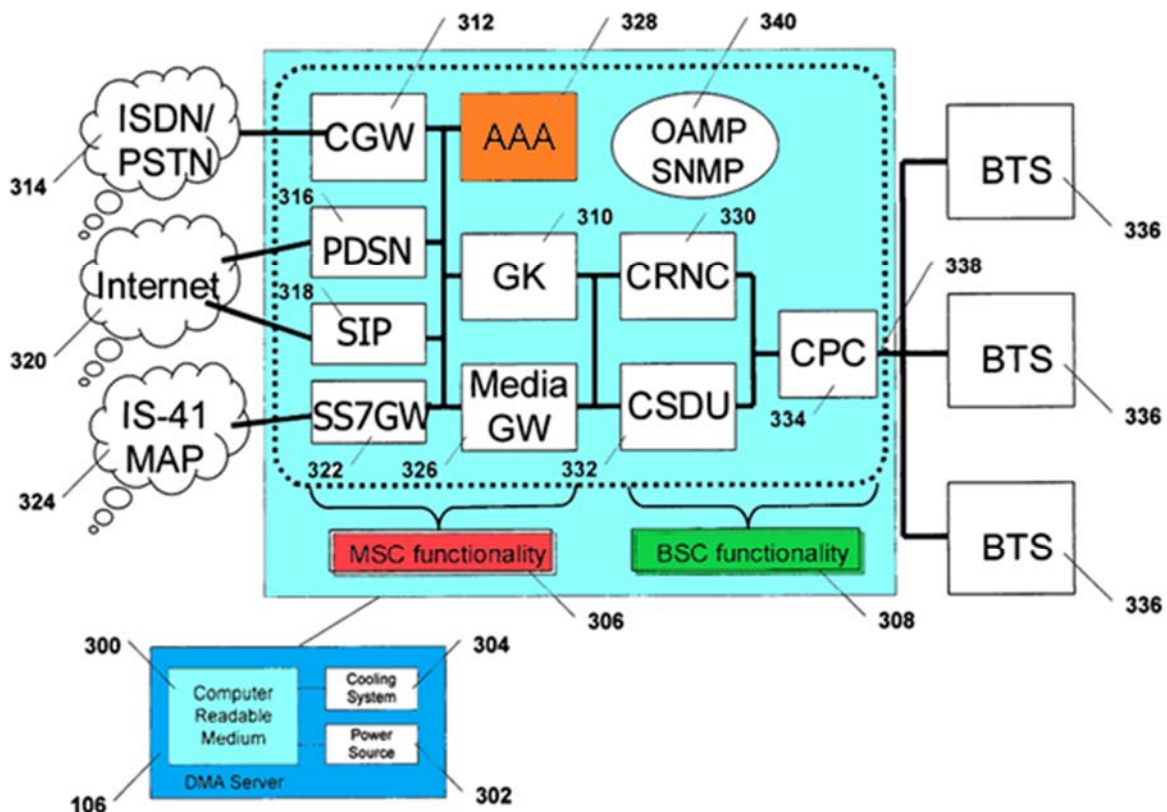
129. I understand that dependent Claim 21, which depends from independent Claim 11, requires that the DMA system includes computer readable storage medium having MSC, BSC, and call detail record (“CDR”) generation functionality embedded in the computer readable storage medium. In my opinion, Waylett does not disclose such computer readable storage media. Instead, Waylett is based on the conventional, hardware-implemented paradigm.

130. As an aside, I understand that in another proceeding between these same parties before this same panel, this Board denied institution of inter partes review challenging U.S. Patent No. 7,548,763 (“the ’763 Patent”) in view of Waylett and another reference. Ex. 2053 at 2, 7. I understand that this Board considered a computer readable medium limitation in the ’763 Patent, similar to that recited in the ’414 Patent’s Claim 21, and rejected Petitioners’ contention that Waylett “necessarily” teaches a computer readable storage medium as “not sufficiently supported by the evidence.” Ex. 2053 at 14-15; *see also generally* Ex. 2053 at 14-24.

131. A POSITA would understand that the “computer readable storage medium” limitation requires a storage device that contains software-based

functionality, unlike hardware-based implementations. I understand that the Federal Circuit instructs that computer readable medium claims refer to “a disk, hard drive, or other data storage device” that “contain[s] program instructions for a computer to perform a particular process.” For at least these reasons, the Challenged Claims require that the DMA system’s computer readable storage medium store software modules that implement its MSC, BSC, and CDR generation functionalities.

132. The specification confirms the claimed computer readable storage medium stores software modules because the MSC (red) and BSC (green) are embedded within the computer readable medium (light blue) of DMA server (dark blue):



'414 Patent at Figs. 3 (annotated with color), 13, 15, and 18-20; *see also id.* at 4:14-17.

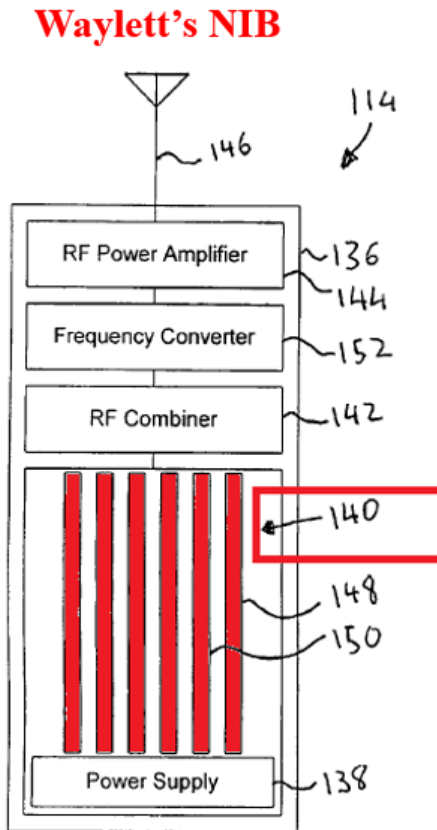
133. In my opinion, Lemko explicitly distinguished its software-based implementation from conventional hardware-based MSC, BSC, and CDR components, such as network cards located in centralized MSCs. *See* '414 Patent at Cover, 1:35-48 (noting the high cost of providing a centralized, mobile switching center). Thus, the Challenged Claim requires MSC, BSC, and CDR functionality implemented as software, not through hardware, such as network cards.

**2. Waylett's Hardware-Based NIB Does Not Include the Claimed Computer Readable Storage Medium and Embedded Functionality**

134. In my opinion, Waylett's NIB does not include a computer readable storage medium with embedded MSC, BSC, and CDR functionality. *See* '414 Patent at Claims 21. Petitioners contend that a POSITA would have understood that Waylett's NIBs 224 "includes these modules on its computer readable storage medium," but provides no evidence supporting this position, and Petitioners' expert testimony is not helpful because it simply parrots what the Petition says. Pet. at 78; Ex. 1003 at ¶ 223.

135. In my opinion, the record evidence demonstrates that Waylett's NIB operates based on the classic, hardware-based network-appliance approach, with the various network functions being implemented using network cards 140 (shown in

red below), not software. See Ex. 1006 at 8:7-32, 9:32-46, Fig. 2; see also Ex. 2013 at 1.



Ex. 1006 at Fig 2 (annotated) (disclosing that the NIB depends on network cards).

Waylett's NIB platform with network cards is depicted below:



Ex. 2012. I believe that Waylett does not disclose embedding MSC, BSC, or CDR functionalities into a computer readable medium, as required by Claim 21, because, like traditional networks systems, those functions are implemented in network-card hardware.

136. In my opinion, Waylett also does not inherently disclose the claimed computer readable storage medium. Petitioners contends that Waylett's NIB includes multiple processors and a POSITA would have understood that "processors necessarily include 'computer readable storage medium' to store the instructions operable on the processors." Pet. at 61 (citing Ex. 1006 at 8:10-27); Ex. 1003 at ¶

177. I understand that the idea of “inherency” and how it, may not be established by probabilities or possibilities. Here, Petitioners fail to show that software for implementing MSC, BSC, and CDR functionality is necessarily embedded in computer-readable medium in the NIB. To the contrary, consistent with the then-conventional hardware-based paradigm, Waylett’s MSC and BSC are implemented in hardware network cards, not in software. *See* Ex. 1006 at 8:7-36, Fig. 2; Ex. 2013. Therefore, I believe that Waylett does not inherently disclose software-based MSC, BSC, or CDR functionality embedded in a computer readable medium.

**IX. SECONDARY CONSIDERATIONS DEMONSTRATE THE CLAIMS ARE NOT OBVIOUS**

137. I have been informed by counsel that objective indicia of non-obviousness include the invention’s commercial success, commercial acquiescence (licensing), a long felt but unresolved need, the failure of others, praise by others, recognition of a problem, and copying of the invention by others, among others. I have further been informed that objective indicia of non-obviousness are relevant to the determination of whether a product or process was obvious at the time of invention to one of ordinary skill in the art.

138. I understand that the weight accorded to objective indicia of non-obviousness evidence depends on there being a nexus between the merits of the claimed invention and the evidence of objective indicia of non-obviousness, and that the evidence must be reasonably commensurate with the scope of the claims.

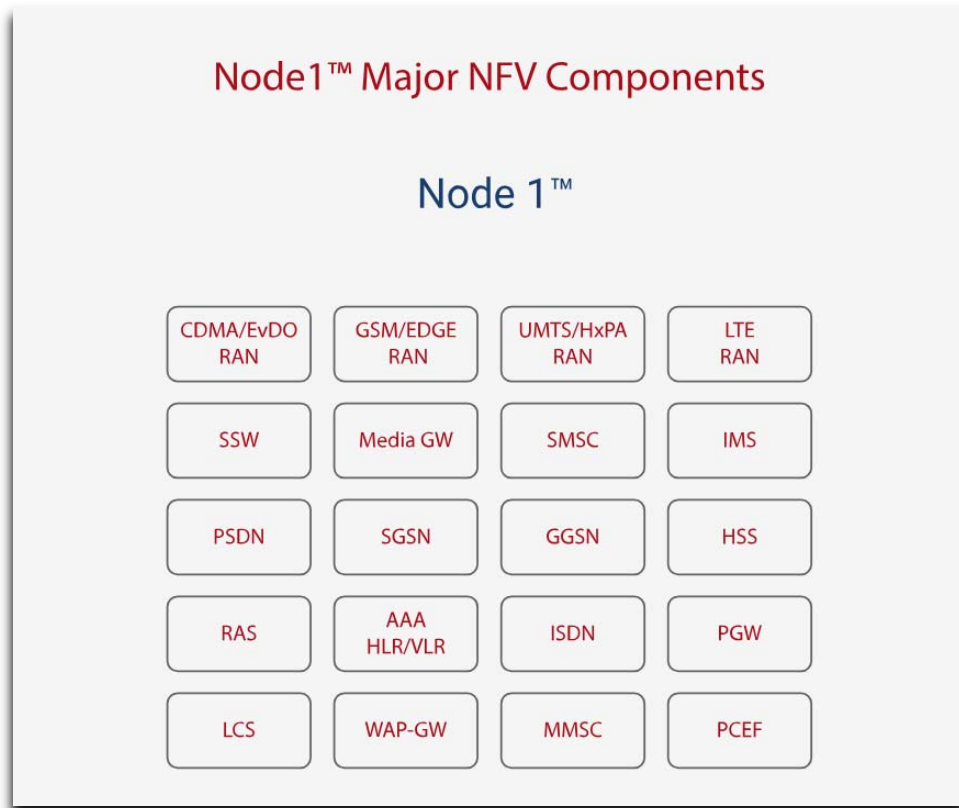
139. I have reviewed evidence relating to objective indicia of non-obviousness for the '414 Patent. In my opinion, these objective indicia show that the Challenged Claims of the '414 Patent would not have been obvious at the time of their invention, including based on any of the provided obviousness combinations or as combined with the knowledge of a person of ordinary skill in the art. My analysis is performed in the context of the claims asserted in this case and the claim constructions afforded these claims. My analysis related to objective indicia of non-obviousness is applicable to the above obviousness arguments as well as other potential combinations of prior art.

**A. Lemko's Commercial Node1 Product Practices the Challenged Claims, Establishing Nexus**

140. As discussed in Section IV.B, above, the Challenged Claims are based on distributed mobile architecture systems that allow for communications to be routed locally as opposed to a centralized hub. '414 Patent at 4:28-60, Claim 1, 7:56-59 (each DMA system includes a DMA server). Particularly, each DMA system includes its own MSC, BSC, HLR, VLR, and CLR controlling logic to route calls in a distributed fashion amongst one another. *See* § IV.B, *supra*; see also '414 Patent at Fig. 3 (depicting the controlling logic functionality implemented on computer readable medium of the DMA system).

141. Lemko's commercial Node1 product, which is the subject of the secondary considerations discussed below, embodies the claimed DMA system of

the '414 Patent, and includes MSC, BSC, HLR, VLR, CLR controlling logic that enable the distributed mobile architecture (referred to as network function virtualization or “NFV”):



Compare Ex. 2011 (listing modules within the Node1 product) at 2 with '414 Patent at Fig. 3 (listing the same functional components running on the DMA system).

142. Through the NFV functionality, Lemko’s commercial Node1 “delivers a cost efficient mobile solution for rural and remote low population areas,” which “replaces the switch (MSC) and base station controller / radio network controller (BSC/RNC) with an IP-interconnected software control system.”:

Lemko delivers a cost efficient mobile solution for rural and remote low population areas by utilizing DMA. The system replaces the switch (MSC) and base station controller/radio network controller (BSC/RNC) with an IP-interconnected software controlled system. The DMA can be used in a variety of applications. These include standard cellular coverage in areas where no coverage exists, wireless local loop in rural locations, and campus wide communication.

Ex. 2037 at § 1.2, § 3.7-3.9 (describing Node1's CLR and VLR functionality), 2038 (depicting Node1's DPR functionality); Pan Decl., ¶ 19. In this way, Node1 provides a complete cellular network at every cell cite," by "performing all switching, control, authentication and even billing record creation at each cell cite." Ex. 2039 at 1; Pan Decl., ¶ 25.

143. In so doing, Lemko's NFV functionality creates distributed networks with HLR, VLR, CLR databases that "enables a customer to create a virtualized network with multiple deployments with its Nodes." Ex. 2009 at 1; Ex. 2. "A big part of [Lemko's] secret sauce is the way [it] handles the database," particularly by connecting the Nodes as a mesh to distribute the database information. *Id.* This corresponds to the distribution of the routing functionality and the CLR and DPR in order to enable routing calls locally and outside the DMA network, as required by the Challenged Claims. Pan Decl., ¶ 20; '414 Patent at 4:53-56 (describing the HLR and VLR are "distributed equally and fully among all the DMAs), 6:20-23 (discussing implementing functionality including call routing in software located at

the DMA systems), 7:60-8:2 (same), 5:37-54 (discussing routing a call between two UEs between different DMA systems in the same DMA network locally without the need to traverse expensive backhaul connections), Claim 1. In particular, the Node1s within a DMA network communicate with each other using IP-based peer-to-peer connections. Ex. 2037 at §5.7.2 (showing list of peers for connection over IP network). Thus, the Node1 embodies and has a nexus to the inventions of the Challenged Claims.

**B. Lemko's Claimed DMA Solution Resolved a Long-Felt Need For Low Cost Distributed Architecture**

144. Lemko's claimed DMA solution, as embodied in the Node1, solved the long-felt problem of providing a low-cost distributed architecture, capable of providing mobile networks in environments where the cost of conventional network architectures and backhaul was prohibitive.

145. By at least 2000, there was a recognized need for a low-cost distributed network architecture that reduces the deployment cost associated with centralized, hierarchical architectures. This was especially a problem for rural and low population density environments as the hardware implementation of centralized MSCs, BSCs, and HLR/VLR cost over \$2.0 million. '414 Patent at 1:35-39; Ex. 2040 at 2 (noting that in the late 1990s, there was a need for telecommunication services in rural areas); Ex. 2042 at 25 (noting that in 2000, there was a need for extending network coverage to rural areas), 25 (a main technology need is for "low

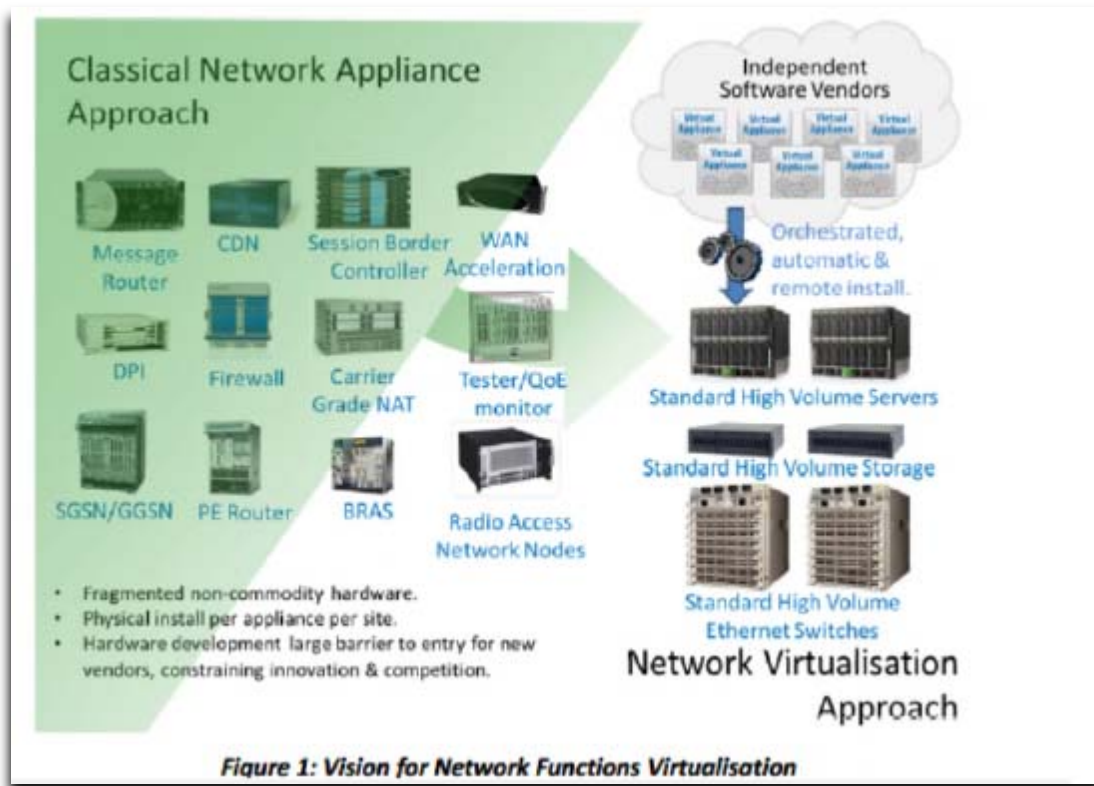
cost devices”), 29 (“There is a strong motivator for work in developing lost-cost intermittent networking devices”), 32 (“[T]he need for network infrastructure” for developing countries and rural areas); Pan Decl., ¶ 21.

146. In the centralized, hierarchical architecture, routing required expensive backhaul T1/E1 connections to centralized MSCs, even when the callers on both sides of the call were being serviced by the same tower (BTS) or by nearby BTSs. While Waylett recognized this industry need, it offered a hardware-based approach that did not resolve the problem. See Ex. 1006 at 1:34-2:13. Specifically, as discussed in Section VII.A, Waylett is directed to a network-in-a-box (NIB), such as the WAVEXpress NIB platform (reproduced below), that located certain hardware-based components in a single enclosure. Ex. 1006 at 8:7-10, *id.* at 9:36-42 (explaining that embodiments are based upon WAVEXpress’s NIB platform). Waylett depended on a network-card hardware-based solution. Section VII.A; see *also* Ex. 2012 at 1 (annotated)); Ex. 1006 at Fig. 2, 8:7-36 (disclosing that the NIB uses network cards), *id.* at 9:32-46. Waylett’s NIBs transfer call data using the standard, expensive backhaul circuit-switch T1/E1 communication lines. See Ex. 2013 at 1 (disclosing that the NIB communicates “over E1 or T1 timeslot or Ethernet Port.”), Ex. 2014 at 1 (disclosing the NIB has up to 256 E1 ports); Ex. 1006 at 7:9-11, 8:33-36 (disclosing the E1 or T1 trunks contained in cards).

147. Waylett's hardware-based approach did not provide a solution to the industry's need. In 2012, the industry published a whitepaper entitled "Network Functions Virtualisation" (the "NFV Paper"), reemphasizing the need to transform from a classical hardware-based approach (exemplified by Waylett) to a network functions virtualization (NFV) approach given the drawbacks associated with the classical approach. Ex. 2008 at 3, 5 (listing cost, network service deployment, and integration and operation difficulty). The NFV Paper was co-authored by representatives from major telecommunications organizations, including AT&T, BT, CenturyLink, China Mobile, Deutsche Teleko, NTT, Verizon, and others. Ex. 2008 at 1. Specifically, the NFV approach called for a consolidation of hardware network components onto software:

It involves the implementation of network functions in software that can run on a range of industry standard server hardware, and that can be moved to, or instantiated in, various locations in the network as required, without the need for installation of new equipment.

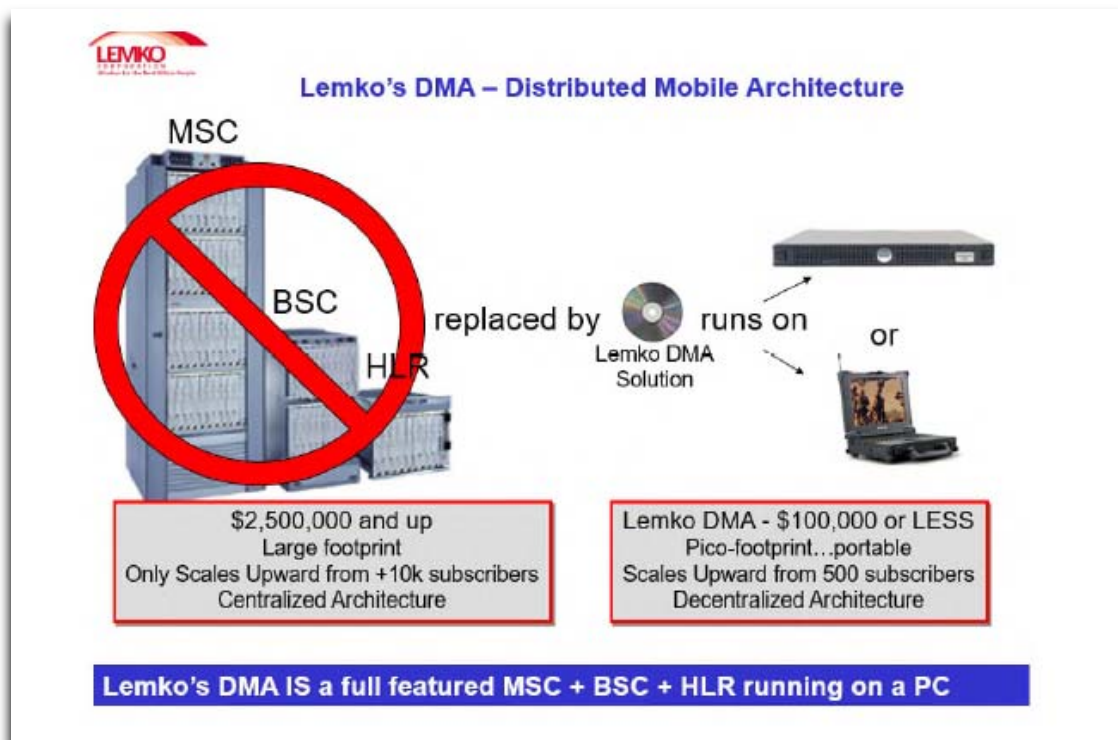
Ex. 2008 at 5. This implementation is demonstrated in the figure below:



Ex. 2008 at 5.

148. As discussed above, Lemko’s claimed DMA system, as embodied by Lemko’s commercial Node1, presents such an NFV approach. In fact, Lemko “developed Network Functions Virtualization (NFV) before that term was coined,” as its DMA systems/Node1 products include “software [that] enables all of [the] core network functions, databases and gateways.” Ex. 2009 at 1. Lemko’s Node1 thus provided a far more cost-effective approach that scaled economically for deploying in rural areas. Pan Decl., ¶¶ 25-26; Ex. 2039 at 1 (2009 press release: “Lemko Corporation is pleased to announce the first commercially available 4G Core Network Solution, Node1™. Node1 delivers the all IP, packet-switched solution

defined by the industry for next generation mobile networks. The software definable network solution eliminates backhaul, meaning that Node1 provides a complete cellular network at every cell site. Lemko's Node1 eliminates backhaul by performing all switching, control, authentication and even billing record creation at each cell site.").



Ex. 2001 at ¶¶ 54-55 (showing that Lemko's Node1 solution provided a decentralized architecture that cost \$100,000 or less and economically scaled with as few as 500 customers). The ability of Lemko's Node1 to solve this long-felt need was directly tied to its distributed mobile architecture and ability to route calls locally within the DMA network by distributing CLR, HLR, and DPR data at the Node1, directly corresponding to the Challenged Claims.

149. Accordingly, in my opinion, Lemko's claimed DMA systems/commercial Node1 products resolved the industry need for a low-cost distributed architecture.

**C. The Industry Praised Lemko's Commercial Node1 Products, Which Achieved Commercial Success**

150. The industry and Lemko's customers praised Lemko's claimed DMA solution and commercial Node1 products. I understand that such appreciation from competitors as well as contemporaries skilled in the field of the invention provides significant evidence of nonobviousness.

151. I understand that AT&T, one of the leading telecommunications providers, praised Lemko's Node1 product and its claimed DMA solution. In 2013, AT&T and Lemko had a series of meetings during which AT&T investigated Lemko's technology (with other 70 participants from AT&T), including AT&T's Assistant Vice President and co-author of the 2012 NFV Paper, Margaret Chiosi. Pan Decl., ¶¶ 28-30. After observing a demonstration of Lemko's Node1 product, Ms. Chiosi stated that Lemko had solved the problems addressed in her 2012 NFV Paper and sent a copy of the paper to Lemko. In an email to Lemko, Ms. Chiosi described Lemko's Node1/DMA solution as "a radical design" that AT&T "should look at." Ex. 2008 at 1; Ex. 2043 at 1. Lemko's email correspondence with AT&T shows that AT&T was focused on the "unique differentiators of Lemko's distributed mobile wireless network solution," which included that it was based on "peer-to-

peer communications,” “independent nodes that all act like one network,” software based. Ex. 2044 at 1-2; Pan Decl., ¶ 30.

152. I also understand that Lemko’s customers praised Lemko’s Node1 products as providing the only and best solution for their needs, further confirming the non-obviousness of Lemko’s Challenged Claims. For instance, TelAlaska sought a solution for providing cellular services to its customers in remote regions of Alaska, where it was too costly to do so using conventional network technologies. Pan Decl., ¶¶ 31-35. Lemko’s Node1 solution met this need as it can be deployed in remote areas given its IP software solution that “distributes the core functions of a cellular system,” and did not require extensive use of backhaul to connect calls within the same area. Ex. 2045 at 2; Ex. 2049 at 1. TelAlaska successfully deployed Lemko’s technology in 2009, where it has continued to operate for nearly 15 years, and praised Lemko as having “***the only solution that met our business needs and challenges***” and continued their “***tradition of innovation and excellence in communication.***” Pan Decl., ¶ 33; Ex. 2045 at 2 (David Goggins, President of TelAlaska: “Lemko’s Solution has helped us to provide a dependable and affordable cellular service to our customers in the state of Alaska including many remote towns. The reliability of the Lemko solution is critical as many of our sites are in remote areas where travel is expensive and weather dependent”).

153. Lemko’s customer Kuhkenah Network (K-Net) provided similar praise. Like TelAlaska, K-Net needed to provide cellular services to remote areas in Ontario, Canada. Pan Decl., ¶¶ 36-37. K-Net has successfully utilized Lemko’s Node1 solution for over 14 years, praising it as “bringing our community the **best wireless network technology choice in 2009.**” Ex. 2050 at 1 (emphasis added). K-Net specifically praised Lemko’s distributed architecture. Ex. 2046 at 2 (“Lemko’s distributed architecture enabled us to upgrade the network from 2G to 3G with zero disruption to the service to the customers”). Other Lemko customers, including Bristol Bay Cellular, the island of Niue, ADAK Eagle (operating in a remote island in Alaska), Globe Internet (in Malawi), Glocall Telecoms (in Mogadishu), Dryden Municipal Telephone System (Ontario), and the Republic of Kiribati have successfully deployed and praised Lemko’s technology. Exs. 2045-2052; Pan Decl., ¶ 38. This commercial success and praise from industry and customers further demonstrates the value and non-obviousness of the Challenged Claims.

## **X. CONCLUSION**

154. For the foregoing reasons, based on my expertise and experience and the record of this case that I have reviewed, it is my opinion that the challenged claims are not shown to be disclosed or obvious.

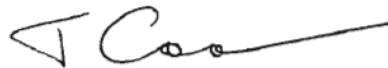
155. I understand that my opinions discussed above support a legal conclusion that the challenged claims are nonobvious.

156. In signing this declaration, I recognize 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 also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required, I will appear for cross-examination within the United States during the time allotted.

157. I hereby declare that all statements made herein of my own knowledge are true and all statements made herein on information and belief were and are believed by me to be true, and that all statements herein were and are made with the knowledge that wilfully false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code and that any such wilfully false statements may jeopardize the validity of the application or any patents issued thereon.

December 21, 2023

Respectfully Submitted,

A handwritten signature in black ink, appearing to read 'T. Cooklev', with a stylized flourish at the end.

Todor V. Cooklev, Ph.D.

# **APPENDIX A**

# Todor Cooklev, PhD.

## Curriculum Vitae

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### Personal

1336 Sycamore Hills Parkway, Fort Wayne, IN 46814

Contact e-mail: [tcooklev@gmail.com](mailto:tcooklev@gmail.com)

Cell: 925-984-5283

Citizenship: United States (by naturalization)

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### Professional experience

2016 –

#### **Professor of Electrical and Computer Engineering**

*2101 E Coliseum Blvd., ETCS 349*

*Purdue University Fort Wayne, Indiana 46805*

- Research on most aspects of wireless systems, including hardware, signal processing, and software techniques, in particular for software-defined radios.
- Courses:
  - ECE 428 Communication Systems
  - ECE 549 Software-Defined Radio
  - ECE 543 Wireless Communications and Networks

2013 – 2017

#### **Co-founder and CEO, Adaptive RF, Fort Wayne, IN**

- Developed innovative RF technology and served as co-founder of a company that received funding from the Department of Defense

2018 – 2019

#### **Chief Technology Officer, Stryke Industries LLC**

- CTO of a company receiving a grant from the Air Force Research Laboratory, Rome, NY

2010 – 2016

#### **ITT Associate Professor of Wireless Communication and Applied Research, Purdue University Fort Wayne**

2008 – 2022

#### **Director, Wireless Technology Center *Purdue University Fort Wayne***

2005 – 2008

#### **Consultant, Hitachi America Ltd., San Jose, California**

- Voting Member, IEEE 802.11 WG; participated in the work on several 802.11 amendments
- Chair, IEEE 802.11 VTS Study Group; responsible for the proposal and approval to create a Task Group that lead to the IEEE 802.11aa standard

- 2011 – 2012 Consultant, Hitachi America Ltd., San Jose, California**
- Attended meetings of the 3GPP RAN1 standardization committee in Dresden, Germany, Jeju Island, Korea, Prague, Czech Republic, and Qindao, China, 2012.
  - Contributed to several documents submitted to 3GPP
- 2006 – 2008 Consultant, Datamars, Lugano, Switzerland**
- Evaluated and produced reports on certain wireless technologies and standards
  - Participated in the IEEE 802.15.4f committee
- 2004 – 2006 Consultant, Leica Geosystems, Switzerland**
- IEEE 802.16 (WiMAX) and related technologies
- 2005 – 2007 Technical Advisory Board Member, Doceotech, San Ramon, CA**
- 2002 – 2008 Assistant Professor with tenure (2008), San Francisco State University.**
- 2000 – 2002 Member of the Technical Staff, Aware, Inc., Bedford, MA and Lafayette, CA**
- Worked on DSL standards. Participated in the International Telecommunications Union, Study Group 15, Question 4. Chaired the session on coding for DSL at the session in Antwerp, Belgium, June 2000. Participated in the Telecommunications Industry Association T1E1 Committee on DSL
  - Developed advanced coding and decoding methods for DSL
  - Worked on the design of an IEEE 802.11a chipset.
  - Voting member, IEEE 802.15; Co-Founder and First Vice-Chair of IEEE 802.15.3 (High-data rate wireless personal area networking)
- 1998-1999 Consultant, Quantronix, Framingham, Utah**
- Image processing; developed software for edge detection and wrote a report
- 1996-1997 Consultant, Communications Research Center, Government of Canada.**
- Designed digital filter banks for communication systems and wrote two technical reports
- 1997-1999 Senior Engineer, 3Com Corporation**
- Worked on V.90 voice-band modems
  - Implemented data compression and other signal processing algorithms V.42 and V.42bis
  - Worked on the Bluetooth Standard, one of the first contributors to the Host Controller Interface of Bluetooth.
  - Participated in the Bluetooth/IEEE group, which drafted the license agreement between Bluetooth and the IEEE 802, which in turn led to the establishment of the IEEE 802.15 Working Group.

## Grants Awarded

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1. Office of Naval Research Summer Fellow 2020, Naval Surface Warfare Center Crane
2. National Science Foundation S<sup>2</sup>ERC I/UCRC, “FPGA implementation of shared-memory middleware”, 2017-2019, PI
3. National Science Foundation S<sup>2</sup>ERC I/UCRC, “Shared-memory middleware”, 2016-2017, PI
4. City of Fort Wayne, Economic Development Fund, 2013-15, co-PI.
5. Allen County Capital Improvement Board (CIB), 2013-15, co-PI
6. U.S. Defense Advanced Research Projects Agency (DARPA) Small Business Technology Transfer (STTR) Phase I “A flexible and extensible solution to incorporating new RF devices and capabilities into EW/ISR networks, co-PI, August 2013 – February 2014.
7. National Science Foundation S<sup>2</sup>ERC I/UCRC, “The performance of middleware solutions for SDR”, 2013-2014, PI
8. National Science Foundation S<sup>2</sup>ERC I/UCRC, “Cognitive decision applications for embedded use,” 2011-2012, PI
9. Visiting Fellowship, National Institute of Communication Technology (Japan), 2011
10. National Science Foundation S<sup>2</sup>ERC I/UCRC, “Signal processing techniques for multicarrier modulation,” 2009-2011, PI
11. NMDG, Belgium, laboratory grant 2010, PI
12. National Science Foundation, Professional Science Master’s Program, MS in engineering, with concentration in wireless and systems engineering, 2010-2013, Co-PI.
13. Emona Instruments, Sydney, Australia, Laboratory exercises in communications, Principal Investigator, 2008.
14. Lilly Endowment, wireless laboratory grant, 2010, PI.
15. ITT (now Harris) Communications Systems, 2007-2011, PI.
16. State of Indiana, workforce development, 2008-2010, PI
17. National Science Foundation DUE-0442313, “Standards in Education for Product, Process, and Service Design and Development: A Proof-of-Concept Project,” 2005-2008, PI.

18. France Telecom, Paris, France, “New methods for multicarrier modulation for high data-rate wireless systems,” Principal Investigator, 2006.
19. Agilent Technologies/Sun Microsystems, Palo Alto, CA, “Distributed wireless sensor network for environmental monitoring,” Co-principal Investigator, 2005.
20. CSU summer research grant, 2004.
21. U.S. Air-Force Research Laboratory, Wright-Patterson AFB, “Data over voice communications,” Principal Investigator, 2004.

## **Honors and Awards**

- |           |                                                                                                                                                              |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2012      | IEEE Standards Association, “for outstanding contributions to the development of IEEE 802.11aa”                                                              |
| 2006      | Wireless Educator of the Year Award with the citation “In recognition of the pivotal role of educators in preparing tomorrow’s wireless technology leaders”. |
| 2005      | Duke’s Choice Award, Sun Microsystems, (group award)                                                                                                         |
| 2003      | IEEE Communications Society Oakland/East Bay Chapter Achievement Award, (group award)                                                                        |
| 1999      | 3Com Inventor Award                                                                                                                                          |
| 1995-1997 | NATO Science Fellowship                                                                                                                                      |
| 1994      | IEEE Asia - Pacific Conference on Circuits and Systems Best Paper Award for the paper “Theory of filter banks over finite fields”                            |

## **Education**

- |               |                                                                                                       |
|---------------|-------------------------------------------------------------------------------------------------------|
| 1995          | <i>Tokyo Institute of Technology, Tokyo, Japan,</i><br>Doctor of Philosophy in Electrical Engineering |
| Dissertation: | Regular Perfect-Reconstruction Filter Banks and Wavelet Bases                                         |
| 1988          | <i>Technical University of Sofia, Bulgaria,</i> Dipl. Eng. in Electrical Engineering                  |

## **Professional Activities**

### **Board Membership:**

Board of Governors, IEEE Standards Association, 2021-2022

### **Committee/Editorial Board Membership:**

IEEE Communications Standards Magazine, Series Editor, Wireless and Radio Communications, 2017-

### **Committee Membership:**

- IEEE 802.11 Working Group Voting Member, 2001-2003, 2006-present

- IEEE 802.15 Working Group Voting Member 1999-2001
- Chairman, IEEE Standards in Education Committee, 2006 – present
- Member of the Editorial Board, Journal of Networks.
- 2004-2005 Chairman and 2003-2004 Secretary of the Oakland/East Bay Chapter of the IEEE Communication Society.

#### **Program Committee Membership:**

- General Chair, Tactical Communications and Interoperability Conference, 2011
- General Chair, Fort Wayne Wireless Summer School 2009 and 2010
- Program Committee Member, Int. Conf. on Wireless Applications and Computing, 2007.
- Program Committee Member, Int. Conference on WLAN, WPAN, and WMAN, Hawaii, Aug. 2007.
- Program Committee Member, Int. Joint Conf. e-Business and Telecommunications, Barcelona, Spain, 2007.
- Program Committee Member, Int. Conf. Wireless Information Networks and Systems, Lisbon, Portugal, 2006.
- Technical Program Committee Member, Int. Conf. Networking and Services, ICNS 2006, Santa Clara, CA.
- Technical Program Committee Member, Advanced Int. Conference on Telecommunications, AICT, Guadeloupe, French Caribbean 2006.
- Program Committee Member, Int. Joint Conf. e-Business and Telecommunications, Reading, UK, 2005.
- Technical Program Committee Member, Int. Conf. Convergent Services and Next-Generation Networks, June 2005, Chicago, IL.
- Technical Program Committee Member, Int. Conference on Service Assurance with Partial and Intermittent Resources, Lisbon, Portugal, July 2005.
- Technical Program Committee Member, Int. Conf. Telecommunications, 2004, Brazil.
- 3rd Int. Workshop on Signal and Image Processing, Manchester, UK, Special session on wavelets in communication systems, signal and image processing, special session co-organizer, Nov. 1996.

#### **Tutorials at International Conferences**

- 1) T. Cooklev, “The analog RF-digital interface: the VITA 49 standard and evolution roadmap,” First IEEE Next G Summit, Johns Hopkins University, June 14, 2022.
- 2) T. Cooklev, “Open RF-digital interfaces and wireless ontologies,” IEEE BlackSeaCom, 4<sup>th</sup> International Black Sea Conference on Communications and Networking, Varna, Bulgaria, June 2016.
- 3) M. Cummings, T. Cooklev, “Software Defined Radio Technology”, Tutorial at the 2008 Symposium System on Chip, Tampere, Finland, Nov. 2008.
- 4) M. Cummings, T. Cooklev, “Software Defined Radio Technology”, Tutorial at the IASTED Int. Conference Computer Communications, Palma de Mallorca, Spain, Sept. 2008.
- 5) M. Cummings, T. Cooklev, “Software Defined Radio Technology”, Tutorial at the 2007 International Conference on Computer Design, Squaw Creek, CA 2007.
- 6) T. Cooklev, “Wireless communication standards: 802.11, 802.15, and 802.16,” Int. Conference Telecommunications, Fortaleza, Brazil, Aug. 2004, tutorial.
- 7) T. Cooklev, “Wireless data communication standards, IEEE Globecom 2003, Dec. 2003, San Francisco, CA, tutorial.

### Short Courses and Invited Talks excluding conferences:

- 1) T. Cooklev, "Open RAN", Technical University of Sofia, Bulgaria, November 2019.
- 2) T. Cooklev, "Software-defined radio technology," Oulu University, Finland, Oct. 2017.
- 3) T. Cooklev, "Software-defined radio technology," Aarhus University, Denmark, Oct. 2017.
- 4) T. Cooklev, "Modern wireless systems," Technical University of Sofia, Bulgaria, 2014.
- 5) T. Cooklev, "Modern Wireless Systems," Featured faculty presentation, Feb. 2012, IPFW.
- 6) T. Cooklev, "Software-defined radio technology," Tokyo Institute of Technology, Dec. 2011.
- 7) T. Cooklev, "Software-defined radio technology," University of Akron, OH, 2010.
- 8) T. Cooklev, "Modern wireless systems," Catholic University of Leuven, Leuven, Belgium, 2010
- 9) T. Cooklev, "Modern wireless systems," University of Qatar, Doha, Qatar, 2009.
- 10) T. Cooklev, "Modern wireless systems," Technical University of Sofia, Bulgaria, 2009.
- 11) T. Cooklev, "Modern wireless systems: from Marconi's radio to cognitive radio," Sigma Xi presentation, February 2009, IPFW.
- 12) T. Cooklev "Software-Defined Radio Technology," Talk at IPFW, Oct. 2008.
- 13) M. Cummings, T. Cooklev, "Software Defined Radio Technology", IEEE Communication Society, Oakland/East Bay Chapter, presentation, Oct. 2007, San Ramon, CA.
- 14) T. Cooklev, "Engineering Standards in Engineering Education," presentation and a panel participant, Standards Engineering Society Annual Conference, San Francisco, CA, August. 2007. (panelist and presenter)
- 15) T. Cooklev, "Vector transform for multicarrier modulation", France Telecom, June 2007, Rennes, France.
- 16) T. Cooklev, "Wireless Communication Standards," Distinguished Lecture, IEEE Communication Society, Oct. 2006, University of Maine.
- 17) T. Cooklev, "The IEEE 802.11, 802.15, and 802.16 Families of Standards," Short Course, April 2006, Lietuvos Telekomas, Vilnius, Lithuania,
- 18) T. Cooklev, "The IEEE 802.11, 802.15, and 802.16 Families of Standards," Short Course, Feb. 2006, Austin, TX.
- 19) T. Cooklev, "The IEEE 802.11, 802.15, and 802.16 Families of Standards," Invited Talk, Dec. 2005, Cisco Systems, San Jose, CA.
- 20) Wireless local area networks, Hitachi Ltd., Brisbane, CA, June 2005.
- 21) T. Cooklev, "The IEEE 802.11, 802.15, and 802.16 Families of Standards," Invited Talk, May 2005, Texas Instruments, Dallas, TX.
- 22) T. Cooklev, "Standards for the Wireless Internet", IEEE Communication Society, Oakland/East Bay Chapter, presentation, January 2005. Freemont, CA.
- 23) T. Cooklev, "Wireless data communication standards, IEEE Wescon, Aug. 2003, San Francisco, CA, tutorial.
- 24) Short Course on 802.11, 802.15, 802.16, West Long Branch, NJ, August 2003
- 25) Wireless data communication standards, Lockheed Palo Alto Research Center, June 5, 2003.
- 26) Short Course on IEEE 802.11, 802.15, and 802.16, San Francisco, CA, Dec. 2002.
- 27) Standards for wireless data communications, University of Utah, Salt Lake City, UT, 1999
- 28) OFDM for wireless communications, 3Com Technology Forum, Boston, MA, Nov. 1998.
- 29) Filter banks and wavelets: a modern applied mathematics tool, Invited Lecture at the Analysis Day, Department of Mathematics and Statistics, Carleton University, Ottawa, Canada, 1997
- 30) Filter banks and wavelets for video signal processing, Genesis Microchip Inc, Markham, Ontario, Canada, July 1996.

- 31) Advanced topics in filter banks, wavelets, and their applications in modern communications systems, CRC, Ottawa, March and August 1996.
- 32) Digital filter banks and wavelets, Dept. Elect. Eng., University of Ottawa, March 1996.
- 33) Digital filter banks and wavelets, Dept. Elect. Eng., Queen's University, Kingston, March 1996.
- 34) Perfect-reconstruction filter banks and wavelet bases and their applications in digital communications, Fujitsu Laboratories, Kawasaki, Japan, July 1994.
- 35) Fast algorithms for signal processing, Istanbul University, Istanbul, Turkey, Jan. 1994.

## **Publications**

### **Books and Monographs**

- 1) T. Cooklev and A. Yagle, *Modern Communication Systems: A first course*, Michigan Publishing, 2023 (in preparation).
- 2) T. Cooklev, *Wireless communications standards: A Study of IEEE 802.11, 802.15, 802.16*, IEEE Press, New York, NY. 2004.

### **Chapters in Books**

- 1) A. Vlahov, D. Elkova, V. Poulkov, T. Cooklev, Virtualized, open, and intelligent: the evolution of the Radio Access Network,” River Publishers, 2021.
- 2) Subbu Ponnuswamy, Todor Cooklev, Yang Xiao, and Krishna Sumanth Velidi, “Security in fixed and mobile IEEE 802.16 networks,” Chapter 4, *WiMAX/MobileFi: Advanced Research and Technology*, edited by Yang Xiao, Taylor and Francis, January 2008.
- 3) T. Cooklev and A. Hristozov, “The Software Communications Architecture,” in *Resource Management in Future Internet*, edited by Ramjee Prasad, River Publishers, Denmark, 2015.

### **Journal Papers**

- 1) V. Kolev, T. Cooklev, F. Keinert, *Design of a Simple Orthogonal Multiwavelet Filter by Matrix Spectral Factorization*, Circuits, Systems, and Signal Processing, 2019.
- 2) Y. Acar and T. Cooklev, “High performance OFDM with index modulation”, *Physical Communication*, vol. 32, pp. 192-199, 2019.
- 3) M. Sherman and T. Cooklev, “Abstract descriptions of spectrum: VITA 49 and IEEE 1900.5.2”, *IEEE Communications Standards Magazine*, vol. 2, no. 4, pp. 43-48, December 2018.
- 4) T. Cooklev, V. Poulkov, D. Bennett, K. Tonchev, “Enabling RF data analytics services and applications via cloudification,” *IEEE Aerospace Electronic Systems Magazine*, vol. 33, no. 5-6, pp. 44-55, May-June 2018.
- 5) V. Kolev, T. Cooklev, F. Keinert, “Matrix spectral factorization for the SA4 multiwavelet,” *Journal of Multidimensional Systems and Signal Processing*, vol.29, Issue 4, pp 1613–1641, 2018.

- 6) H. Dogan, T. Cooklev, and J. Darabi, "Improved low-complexity zero-padded OFDM receivers", *Digital Signal Processing*, vol. 51, pp. 92–100, April 2016.
- 7) P. Baltiiski, I. Iliev, B. Kehaiov, V. Poulkov, and T. Cooklev, "Long-Term Spectrum Monitoring with Big Data Analysis and Machine Learning for Cloud-Based Radio Access Networks," *Wireless Personal Communications*, vol. 87, issue 3, pp. 815-835, April 2016.
- 8) T. Cooklev, J. Darabi, C. McIntosh, and M. Mosaheb, "Cloud-based approach for spectrum monitoring," *IEEE Instrumentation and Measurement Magazine*, vol. 18, no. 2, pp. 33-37, April 2015.
- 9) Sven Bilen, A. Wyglinski, C. Anderson, T. Cooklev, C. Dietrich, B. Farhang-Boroujeny, "On Software-Defined Radio as an integrative educational resource," *IEEE Communications Magazine*, vol. 52, no. 5, pp. 184-193, May 2014.
- 10) Hakan Yıldız, Yusuf Acar, Todor Cooklev, Hakan Dogan, "Generalized Prefix for Space-Time Block Coded OFDM Wireless Systems over Correlated MIMO Channels," *IET Communications*, vol. 8, no. 9, pp. 1589-1598, June 2014.
- 11) T. Cooklev, A. Nishihara, "An Open RF-Digital interface for software-defined radios," *IEEE Micro*, vol. 33, no. 6, pp. 47-55, Dec. 2013.
- 12) T. Cooklev, R. Normoyle, and D. Clendenen, "The VITA 49 RF-digital interface," *IEEE Circuits Systems Magazine*, vol. 12, no. 4, pp. 21-32, Dec. 2012.
- 13) T. Cooklev, "An improved prefix for OFDM-based cognitive radios", *Electron. Lett.*, vol. 48, No. 4, Feb. 2012.
- 14) Y. Alqudah and T. Cooklev, "Hands-on open access broadband wireless technology lab", *Int. J. Interactive Mobile Tech.*, Vol. 6, No 4, 2012, pp. 13-18.
- 15) T. Cooklev, H. Dogan, R. Cintra, H. Yildiz, "Generalized prefix for OFDM wireless systems over quasi-static channels," *IEEE Transactions on Vehicular Technology*, vol. 60, No. 8, pp. 3684 – 3693, Nov. 2011.
- 16) F. Ramirez-Mireles, T. Cooklev, and G. A. Paredes-Orozco, "UWB-FSK: Performance tradeoffs for high-complexity receivers," *IEEE Transactions on Consumer Electronics*, vol. 56, no. 4, pp. 2123-2131, 2010.
- 17) S. Hossain, D. Batovski, and T. Cooklev, "Eight-channel transmultiplexer with binary matrix sequences," *Assumption Univ. Journal of Technology (Thailand)*, vol. 13, No. 4, pp. 193-202, 2010.
- 18) T. Cooklev, "Engineering standards and engineering education," *Journal of IT Standardization Research*, vol. 8, 2010, pp. 1-10.

- 19) R. Cintra and T. Cooklev, "Robust image watermarking using non-regular wavelets," *Journal of Signal, Image, and Video Processing*, 2008.
- 20) T. Cooklev, A. Pakdaman, J. Eidson, "IEEE 1588 over IEEE 802.11 for synchronization of wireless local area nodes," *IEEE Trans. Instrumentation and Measurement*, vol. 56, No. 5, pp. 1632-1639, Oct. 2007.
- 21) T. Cooklev and A. Nishihara, "Analytic constructions of complementary sequences," *IEICE Trans. Fundamentals*, November 2006.
- 22) T. Cooklev, "An efficient architecture for orthogonal wavelet transforms," *IEEE Signal Processing Letters*, Feb. 2006.
- 23) T. Cooklev, "Standards for the wireless Internet," *Annual review of communications*, vol. 57, Dec. 2004.
- 24) T. Cooklev, G. Berbecel and A. N. Venetsanopoulos, "Wavelets and differential-dilation equations," *IEEE Trans. Signal Processing*, vol. 48, pp. 2258-2268, 2000.
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