

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MICROSOFT CORPORATION AND AFFIRMED NETWORKS, INC.,
Petitioners,

v.

LEMKO CORPORATION,
Patent Owner.

Case IPR2023-00530
U.S. Patent No. 7,548,763

DECLARATION OF TODOR COOKLEV, PH.D.

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	QUALIFICATIONS	2
III.	LEGAL STANDARDS	5
A.	Priority Date	5
B.	Level of Ordinary Skill in the Art	5
C.	Claim Construction	7
D.	Obviousness Legal Standard	7
IV.	TECHNOLOGY BACKGROUND: CONVENTIONAL ARCHITECTURES WERE BASED ON A HIERARCHICAL, HARDWARE PARADIGM.....	10
V.	OVERVIEW OF LEMKO’S TECHNOLOGY AND THE ’763 PATENT ..	17
VI.	OVERVIEW OF THE ASSERTED REFERENCES	23
A.	The Waylett Reference	23
B.	The Cope Reference	25
VII.	THE CHALLENGED CLAIMS	25
VIII.	IN MY OPINION THE CHALLENGED CLAIMS ARE PATENTABLE OVER WAYLETT IN VIEW OF COPE	26
A.	In My Opinion, Waylett Does Not Teach or Suggest the First and Second “DMA Servers” With First and Second “Computer Readable Medium” Having MSC, BSC, and CDR Functionality	26
1.	The Challenged Claims Require Software-Based MSC, BSC, and CDR Functionality	26
2.	Waylett’s Hardware-Based NIB Does Not Include the Claimed Computer Readable Medium and Embedded Functionality.....	28

3.	Waylett Does Not Inherently Disclose the Claimed Computer Readable Medium and Embedded Functionality.....	30
4.	It Would Not Have Been Obvious to Modify Waylett to Include a Computer Readable Medium With the Required Functionality	30
B.	In My Opinion, Waylett Does Not Disclose a “First Call Detail Record (CDR) Generation Program Embedded in the First Computer Readable Medium”	33
C.	In My Opinion, It Would Not Have Been Obvious to Modify Waylett with Cope’s P2P IP Connections to Arrive at the “Peer-to-Peer Connection for Telephony Traffic.....	35
D.	In My Opinion, Waylett Does Not Disclose a “Program to Allow a Group Call” That is “Embedded in the Second Computer Readable Medium”	41
IX.	CONCLUSION.....	43

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. 7,548,763 (“the ’763 patent”) in IPR2023-00530. 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. My analysis of the materials produced in this matter is ongoing and I will continue to review any new material as it is provided. 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, 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 '763 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 (POSITA or POSA) as of the priority date of the Patent. The '763 Patent claims priority to April 13, 2005. My opinions in this matter are from the perspective of a POSITA 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, 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 claim of the '763 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. I am readily familiar with the level of ordinary skill in the art 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.

21. Mr. Proctor opines that "Around 2005, a POSA in the field of the '763 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."), ¶ 56. For the purpose of this declaration, I will apply the same definition of the level of skill of a POSA.

22. 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. My opinions concerning the '763 Patent claims and the prior art are from the perspective of a POSA, as set forth above.

23. 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

24. 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.

25. I understand that for the purpose of this preliminary proceeding, no construction is necessary.

D. Obviousness Legal Standard

26. 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.

27. 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.

28. 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.

29. 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.

30. 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.

31. 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.

32. 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. TECHNOLOGY BACKGROUND: CONVENTIONAL ARCHITECTURES WERE BASED ON A HIERARCHICAL, HARDWARE PARADIGM

33. Cellular (also referred to as mobile) telephony was developed in response to the enormous market demand for “connectivity anytime anywhere”. Wireless communication networks that divide the service area into relatively small geographic areas are called “cellular.” An individual area within a cellular network is serviced by a single base-station (also called in 3G NodeB or in LTE evolved NodeB, etc.). Devices (also called user equipment (UE) or terminals), such as mobile phones operating within this geographic area, use that base station to communicate.

34. The BS can be located either at the corner or at the center of a cell. A cell is center-excited if the BS is in the center and corner-excited if it is at the corner. Due to the large density of subscribers several different cell sizes are used, including macro, micro and pico. Macro cells are large cells with ranges from 2 km up to 100 km. Micro cells are smaller and pico cells are even smaller.

35. Generally, a new generation emerges every ten or so years. GSM and IS-95 are major 2G cellular standards. WCDMA and CDMA2000 are 3G standards.

36. In 2005, when Lemko filed the '763 Patent, then-conventional cellular 2G and 3G networks were based on circuit-switched networks with a centralized, hierarchical paradigm. All calls were carried from cell towers to regional call centers over expensive backhaul connections. The regional call centers relied on large stacks of servers with custom hardware to manage and route calls for an entire region. In contrast, the cell towers had no functionality for managing and routing calls, since that capacity was located in the regional call centers. There were many drawbacks to this approach, including the need for expensive backhaul to and from regional call centers, even when the two parties to a phone call were in the same area (because the cell towers had no ability to manage or connect calls independent of the regional call centers).

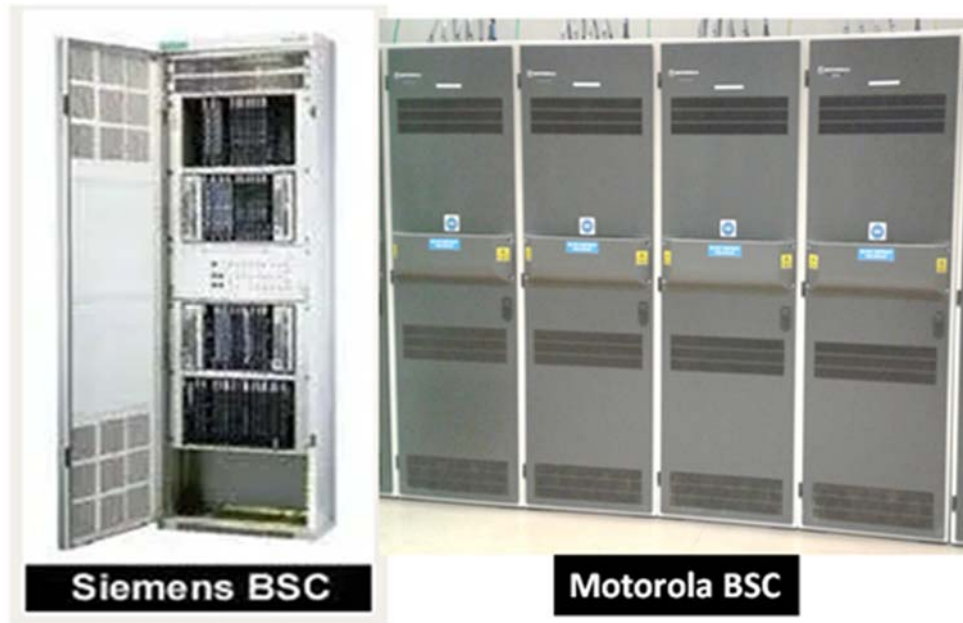
37. Conventional networks were hierarchical because each cell tower (also known as a “base transceiver station” or “BTS”) connects to a single Base Station Controller (“BSC”), which connects to a centralized mobile switching center (“MSC”) that routes calls. See '763 Patent at 1:34-47. Cell towers did not communicate directly with other cell towers, and BSCs did not communicate directly with other BSCs.

38. These conventional networks were also hardware-based. The MSCs were housed at large Digital Signal Processor (DSP) equipment server centers, shown in the photograph below, where the MSCs relied on stacks of DSP equipment servers and provided the call processing functionality for the networks, including switching functions, call set-up, call termination, and routing. See Ex. 2002 at 1-3.



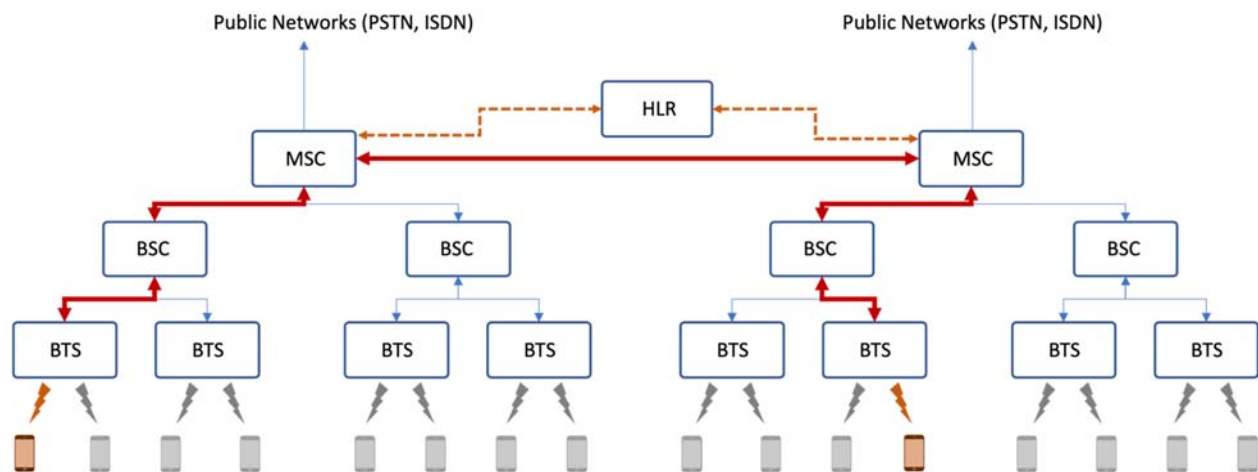
Ex. 2003.

39. The BSC (shown in the photograph below) connected a BTS (cell site) to the MSC through a “backhaul” connection. Ex. 2004.



Ex. 2005; Ex. 2006.

40. The following figure shows the hierarchical structure of these conventional networks.



In these conventional networks, the backhaul connections were based on T1/E1 communication lines. See Ex. 2007 at 2 (explaining that “E1/T1 systems were

widely used in telecommunications when 2G technologies including GSM were being rolled out and deployed”).¹

41. To place a call between two cell phones or other mobile devices (conventionally called “user equipment” or “UE”) on two different networks, call data are routed from (1) an originating UE, (2) to a BTS, (3) to a BSC, (4) to an MSC, (5) to the MSC for the second network, (6) to a BSC, (7) to a BTS, (8) to the receiving UE. This path is shown in red in the schematic diagram above. The BTS to UE connections are wireless radio connections. The other connections in this path are circuit-switched T1/E1 connections.² Thus, for two UEs to communicate, the call data are routed to centralized MSCs (stored at centralized server locations) of the public networks using the T1/E1 communication lines.

42. The hierarchical, hardware paradigm had numerous drawbacks. Such networks were expensive to deploy because they require large amounts of space,

¹ “T1/E1” refers to a telecommunications standard that is either the T1 or E1 digital transmission formats. Both T1 and E1 were developed in the 1960s and provide dedicated connections between two fixed points.

² “Circuit switched” connections establish a dedicated communication path between two devices for the duration of a session. In contrast, IP networks transmit data in small packets that travel independently over a network and are dynamically routed.

power, and hardware resources to accommodate the stacks of servers. The rigid, hardware-based approach made it difficult to integrate and operate the dedicated hardware appliances. *See* Ex. 2008 at 5 (stating the difficulty in “integrat[ing] and operat[ing] increasingly complex hardware-based appliances”). In addition, this centralized, hierarchical network structure required all calls to traverse expensive backhaul connections, even when both UEs were connecting to the same BTS or BTSs in close-proximity.

43. In 2012, a broad coalition of network operators published a whitepaper detailing these problems. *See* Ex. 2008. Entitled “Network Functions Virtualization” (the “NFV Paper”), the paper proposed a network virtualization approach to address these drawbacks, mirroring the solutions Lemko invented seven years earlier. The NFV Paper’s approach is based on the 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.

See Ex. 2008 at 5.

44. As shown in the excerpt below, the 2012 NFV Paper contrasted its proposed approach against the “Classical Network Appliance Approach.” The NFV Paper noted many drawbacks of the classical approach, including that it (1)

depended on “Fragmented non-commodity hardware,” (2) required physical installation of appliances at every site, and (3) its hardware requirements made the networks rigid and inflexible, which constrained innovation. See Ex. 2008 at 5.

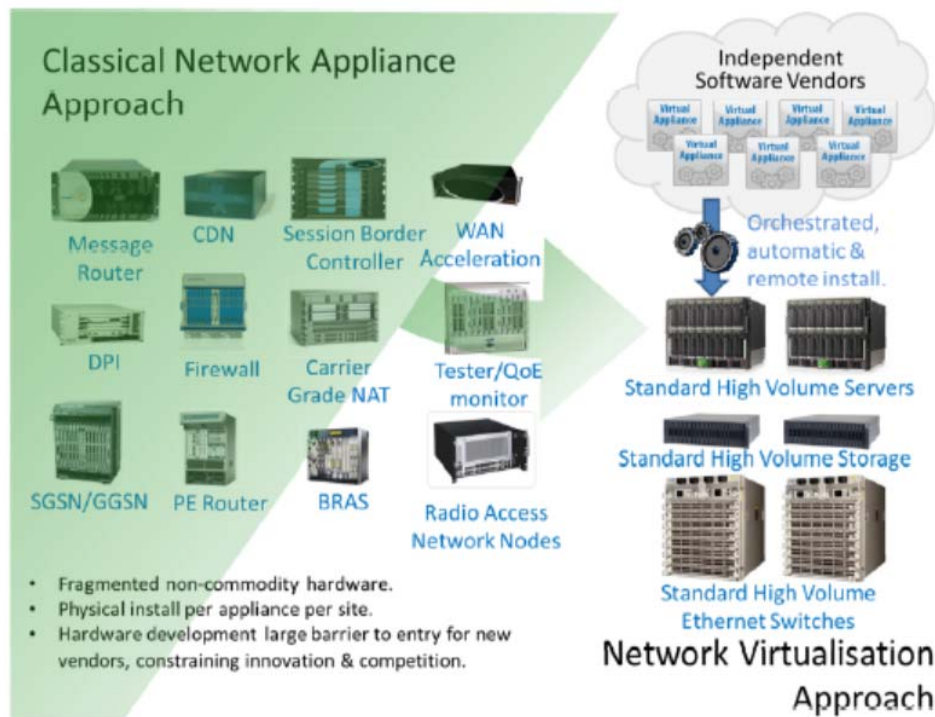


Figure 1: Vision for Network Functions Virtualisation

See *id.* at 5.

45. The '763 Patent recognized that cellular infrastructure elements such as the BSC and MSC when implemented with dedicated hardware were not only expensive, but difficult to interoperate or to manage in the field. The Patent provides a software implementation together with a novel architecture, as I explain in detail below.

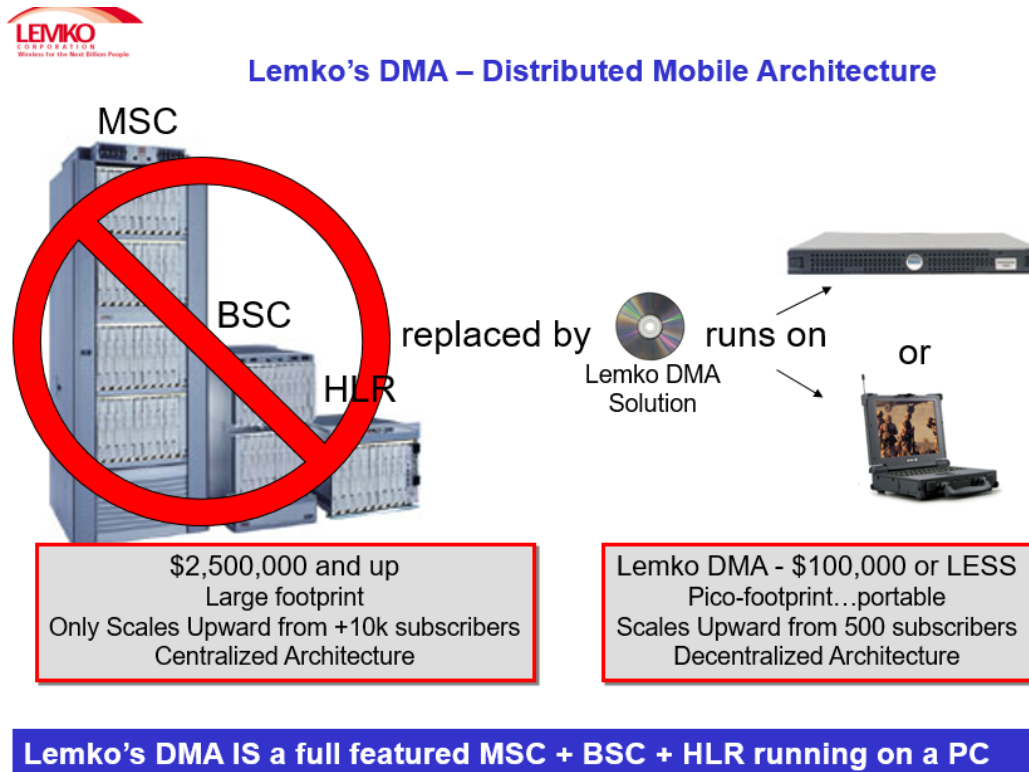
V. OVERVIEW OF LEMKO'S TECHNOLOGY AND THE '763 PATENT

46. Lemko's approach was fundamentally different, being based on a software-implemented, decentralized, peer-to-peer network paradigm. Instead of cell towers that served only as a conduit to the backhaul leading to and from regional call centers, Lemko's claimed distributed mobile architecture ("DMA") network is based on software-based DMA servers (or DMAS), which are connected to form a peer-to-peer network. Each DMA server has local cellular network management functionality that allows for calls to be connected without the centralized servers of a regional call center.

47. Seven years before the industry proposed solutions for its long-felt needs in the NPV Paper, Lemko filed the application that led to the '763 Patent. Lemko had already solved these needs with its innovative distributed mobile architecture (DMA) infrastructure, which creates a virtualized network. Ex. 2009 ("to enable distributed networks with a database that enables a customer to create a virtualized network with multiple deployments with its Nodes."). Indeed, Lemko "developed Network Functions Virtualization (NFV) before that term was coined" because its "software enables all of core network functions, databases and gateways." *Id.*

48. A POSITA would recognize that Lemko's DMA implements network functionality, such as MSC, BSC, and home location register ("HLR") functionality,

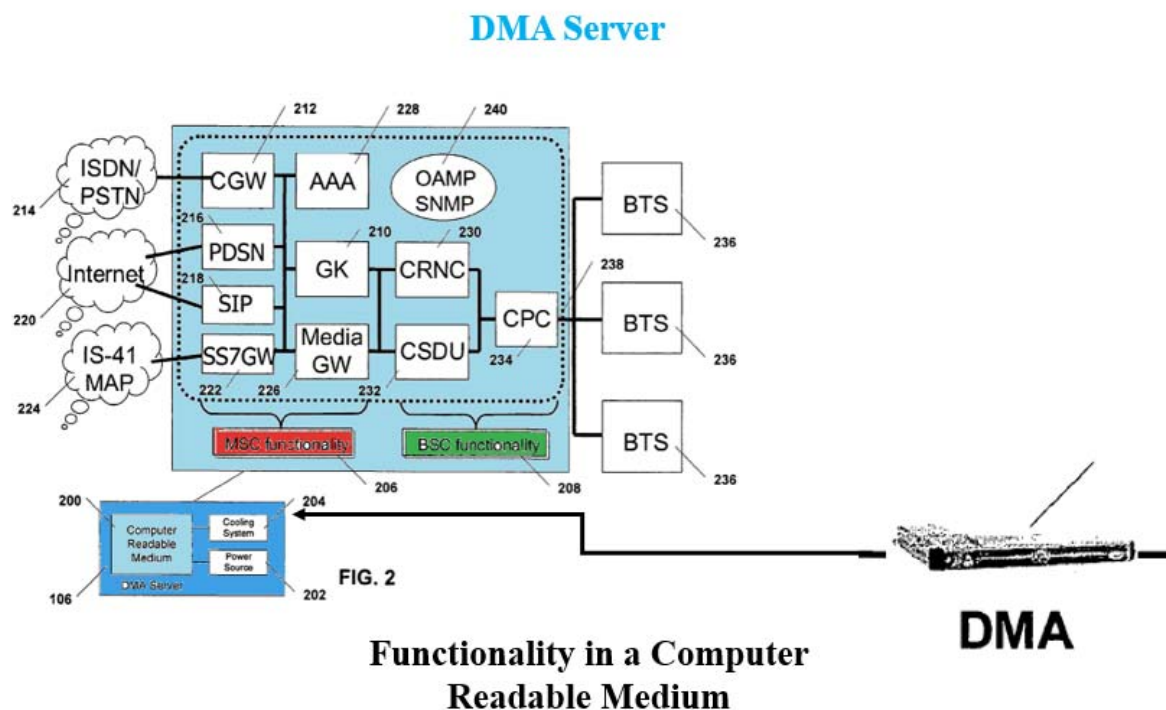
onto a computer-readable medium running on a standard server, as I illustrate below with an excerpted illustration from one of Lemko's presentations:



Ex. 2010 (“[T]he heart of DMA is an all-IP software solution,” including the network functionality of an MSC, BSC, radio network controller (RNC) location registers, and media and data gateways (MSG, GGSN, SGSN); *see also* ’763 Patent at Figs. 2, 7, 9, 11, and 14-16 (depicting the DMA servers of the above figure). Unlike the conventional network architecture, Lemko’s DMA solution implements a virtualized core of network functionality on software running on a standard server to allow “multiple cellular nodes to be linked via IP connections” thereby reducing backhaul via T1/E1 communication lines and eliminating the need for a centralized

center or hub. Ex. 2010. Lemko developed multiple product lines based on its inventions. See Ex. 2011.

49. The '763 Patent embodies Lemko's technology. The claimed DMA server is "...[i]s essentially a processor, or computer, having a housing and a computer readable medium 200," as I depict below. See '763 Patent at 4:3-5.



Id. at Figs. 2 (annotated), 9, 11, and 14-16 (depicting the DMA server).

50. 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. Ex. 2009; Ex. 2010. Figure 1 (reproduced below) illustrates that each DMA server is interconnected with other DMA servers in an Internet Protocol (IP) network via peer-to-peer connections. '763 Patent at 3:34-37

(with reference to figure 1 describing that “each DMA server 106 is interconnected with the other DMA servers 106 via an Internet protocol network” and therefore “there exists peer-to-peer connection”).

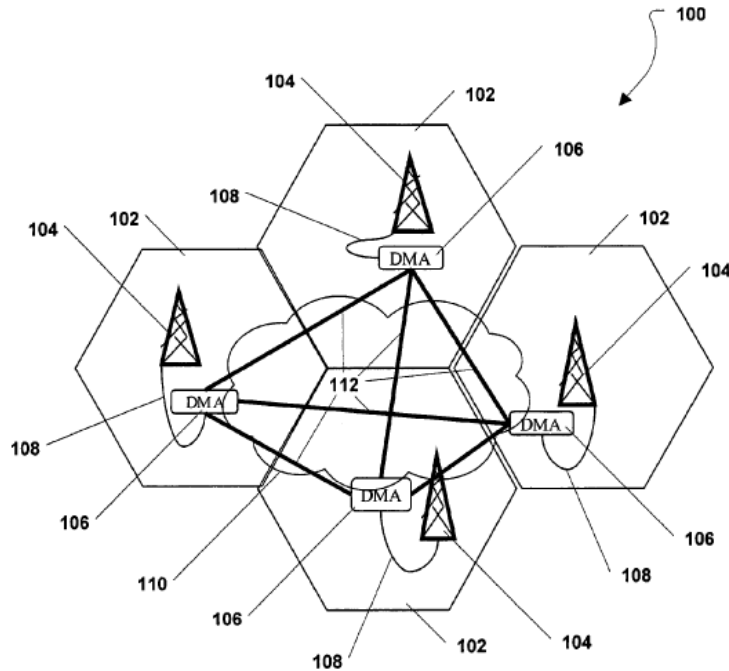
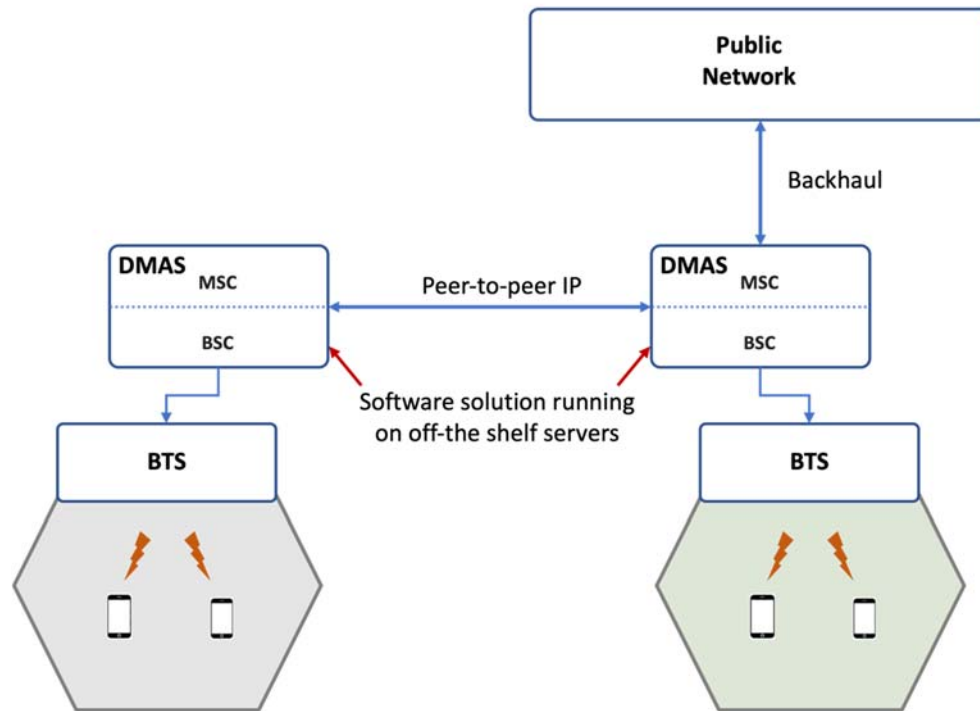


FIG. 1

Id. at Fig. 1; *see also id.* at 3:34-37, 5:49-58. The use of these peer-to-peer IP network connections between DMA servers in the same network 100 eliminates or reduces the need to route traffic through a backhaul, as I show in an expanded and annotated view of Figure 1 below:

Lemko Distributed Mobile Architecture



In Lemko's 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) to a BTS, (2) to a DMAS, (3) to a second DMAS (by a peer-to-peer IP connection), (4) to a BTS, (5) to the receiving UE.

51. In my opinion, the '763 Patent leverages this flexible and unconventional architecture in multiple ways. For example, the media gateway (226) of a DMA server can be provided with a call program that allows for greater than three (3) participants to join in a telephone communication handled by one or more DMA servers within a network via a peer-to-peer connection. *See id.* at 4:59-64, *id.* at 7:14-16, *id.* at Fig. 5. In conventional mobile networks, multi-party calls

required the use of multiple MSCs and the connecting backhaul, to the extent they were even possible. See Section II.A above.

52. Additional innovative properties of the introduced DMA server are:

With the configuration of structure described above, the present disclosure provides a flexible telecommunications device, i.e., the DMA server 106 (FIG. 1), that is distributive and associative, i.e., it can operate stand-alone or seamlessly within an existing cellular or other network. Moreover, the DMA server 106 can be integrated with virtually any third party base station. The DMA server 106 can operate with multiple air interfaces including CDMA IS-95, CDMA 1X, CDMA EVDO, GSM, GPRS, W-CDMA, 802.11 (Wi-fi), 802.16 (Wi-fi), etc. Further, the DMA server 106 can provide integrated prepaid billing, OAMP, network management, and AAA functionality. The DMA server 106 can include a Java based user interface and feature configuration system. Also, the DMA server 106 can provide real time call metering, call detail record (CDR) generation, and real time call provisioning. The DMA server 106 may be implemented in a relatively small footprint and has a relatively low power requirement. Further, the DMA server 106 may be implemented using inexpensive and widely available computer equipment.

'763 Patent at 11:14-32.

53. Thus, the '763 Patent describes and claims DMA servers including computer readable medium embedded with fully functional network capabilities, such as those conventionally located at a BSC and MSC, along with software allowing for a group call among four or more mobile communication devices on DMA servers via a peer-to-peer connection. See *id.* at Claim 1.

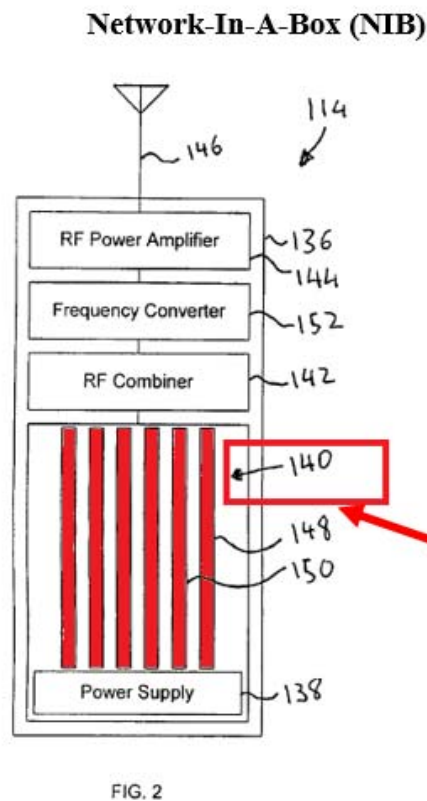
54. Mr. Proctor asserts that “a POSA would have understood that Waylett and the '763 patent thus describe the same problem of high deployment costs of

conventional telephone systems and recognize the need to serve underserved communities. Such a person would have recognized that both propose the same solution: a single enclosure that includes a MSC, a BSC, and a BTS.” Ex. 1003 ¶ 84. I disagree. Waylett is directed to hardware-based network components enclosed in a single box, the ’763 Patent is directed to network functionality in software running on a computer readable medium which overcomes the hardware-based paradigm of conventional networks as in Waylett.

VI. OVERVIEW OF THE ASSERTED REFERENCES

A. The Waylett Reference

55. A POSITA would recognize that the Waylett reference is based on the conventional network appliance approach, which depends on a hierarchical network and hardware-based components. Specifically, Waylett is directed to a network-in-a-box (NIB), such as the WaveExchange NIB platform (I have reproduced below), that located certain hardware-based components in a single enclosure. Waylett at 8:6-10, *id.* at 9:36-42 (explaining that embodiments are based upon WaveExchange’s NIB platform). These hardware-based components are referenced as cards 140 (highlighted in red below):



Ex. 2017; Waylett at Fig 2 (annotated); see *id.* at 8:7-36 (disclosing that the NIB includes a number of cards), *id.* at 9:32-46.

56. I note that Petitioners admit that Waylett does not disclose connecting NIBs through peer-to-peer connections. Instead, Waylett's stand-alone NIBs transfer call data using the standard backhaul circuit-switch T1/E1 communication lines. See Waylett at 8:8-9 (describing the "stand-alone Network-In-A-Box (NIB), such as a WAVEX-press NIB platform"); Ex. 2014, Ex. 2013 at 1 (disclosing that the NIB communicates "over E1 or T1 timeslot or Ethernet Port."); Waylett at 7:9-11, 8:33-36, 17:7-17 (disclosing the E1 or T1 trunks contained in cards).

B. The Cope Reference

57. A POSITA would recognize that Cope discloses providing IP-based connections between different land-based telephone network service providers (e.g., AT&T and Verizon) in order to communicate Voice Over IP (“VoIP”) telephony traffic between different legacy networks. See Cope at 5:51-6:6, *id.* at 5:51-6:12, *id.* at Fig. 4 (depicting a public telephone network). These IP connections are “between different service providers [and are] established by mutual agreement for the exchange of IP traffic.” *Id.* at 6:3-6.

58. Accordingly, a POSITA would also recognize that Cope does not disclose or suggest establishing peer-to-peer IP connections between anything resembling DMA servers within a mobile network, as recited in the ’763 Patent. Nor does Cope suggest substituting peer-to-peer connections in the place of T1/E1 backhaul connections.

VII. THE CHALLENGED CLAIMS

59. I understand that Petitioners have challenged claims 1, 4, 6, 9, and 15 of the ’763 Patent under a single ground, as allegedly obvious based on Waylett in view of Cope. Pet. at 1.

**VIII. IN MY OPINION THE CHALLENGED CLAIMS ARE PATENTABLE
OVER WAYLETT IN VIEW OF COPE**

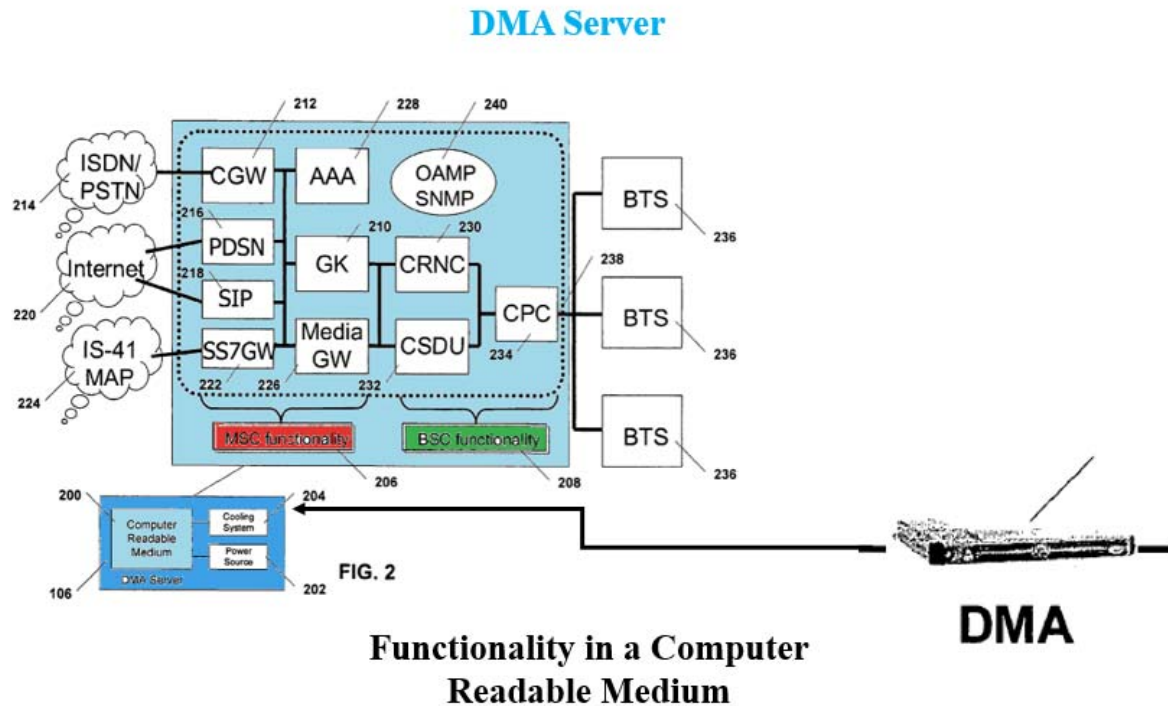
A. In My Opinion, Waylett Does Not Teach or Suggest the First and Second “DMA Servers” With First and Second “Computer Readable Medium” Having MSC, BSC, and CDR Functionality

1. The Challenged Claims Require Software-Based MSC, BSC, and CDR Functionality

60. Each Challenged Claim requires that the first and second DMA servers include computer readable media having MSC, BSC, and call detail record (“CDR”) functionality. In my opinion, Waylett does not disclose such computer readable media. Instead, Waylett is based on the conventional, hardware-implemented paradigm.

61. The “computer readable medium” limitation requires a storage device that contains software-based functionality, unlike hardware-based implementations. Accordingly, a POSITA would recognize that the Challenged Claims require that the DMAS’ computer readable medium store software modules that implement its MSC, BSC, and CDR generation functionalities. See ’763 Patent at Claim 1.

62. Reading the specification, a POSITA would further recognize that the claimed computer readable medium stores software modules because the MSC (red) and BSC (green) are embedded within the computer readable medium (blue), which I have annotated below:



Id. at Figs. 2 (annotated with color and addition of DMAS and legend), 9, 11, and 14-16; *see id.* at 4:14-17.

63. A POSITA would appreciate that 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* '763 Patent at Cover, 1:34-47 (noting the high cost of providing a centralized, mobile switching center). Thus, a POSITA would understand that the Challenged Claims require 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 Medium and Embedded Functionality

64. In my opinion, Waylett's NIB does not include a computer readable medium with embedded MSC, BSC, and CDR functionality. See '763 Patent at Claim 1. A POSITA would recognize 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 Waylett at 8:7-32, 9:65-67, Fig. 2; Ex. 2013 at 1.

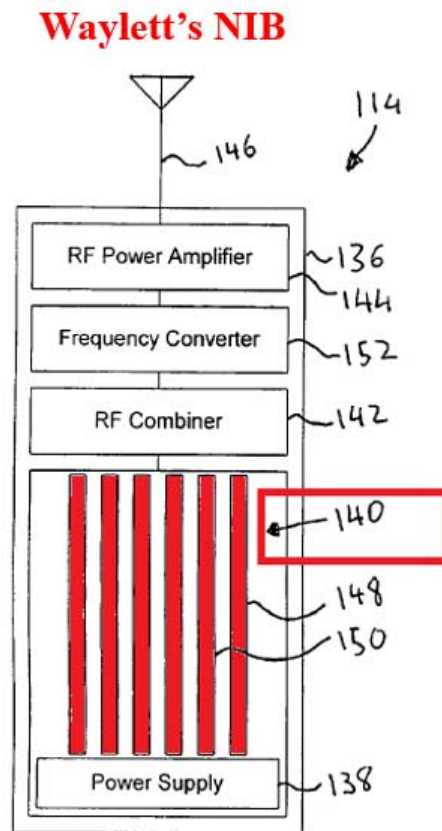


FIG. 2

Waylett at Fig 2 (annotated) (disclosing that the NIB depends on a number of cards).

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



Ex. 2012.

65. In view of the above, it is my opinion that Waylett does not disclose embedding MSC, BSC, or CDR functionalities into a computer readable medium because, like traditional networks systems, those functions are implemented in hardware.

3. Waylett Does Not Inherently Disclose the Claimed Computer Readable Medium and Embedded Functionality

66. In my opinion, Waylett also does not inherently disclose the claimed computer readable medium. I understand that Petitioners contend that because Waylett's NIB uses some software it "necessarily" includes claimed computer readable medium with MSC, BSC, and CDR functionality. Pet. at 13. I disagree.

67. Consistent with the then-conventional hardware-based paradigm, Waylett's MSC and BSC are implemented in hardware network cards, not in software. See Waylett at 8:7-36, Fig. 2; Ex. 2013. Therefore, Waylett does not inherently disclose software-based MSC, BSC, or CLR functionality embedded in a computer readable medium because a POSITA would have understood from Waylett's disclosure that the relevant functionality was provided with hardware not software.

4. It Would Not Have Been Obvious to Modify Waylett to Include a Computer Readable Medium With the Required Functionality

68. It is my opinion that it would not have been obvious to a POSITA to modify Waylett to implement MSC, BSC, and CLR functionality in a computer readable medium for at least several reasons.

69. **First**, the conventional network architecture used hardware-based components. Specifically, these conventional MSCs and BSCs were implemented using custom-built cards with DSPs and custom Application Specific Integrated

Circuits (ASICs). Ex. 2018 (discussing digital signal processors that support real-time application constraints); Ex. 2019 at 148 (discussing the DSPs used for processing); Ex. 2020 (discussing the use of digital signal processing for 2G networks); Ex. 2013 (Waylett containing multiple DSP boards for communication). MSCs and BSCs have very high processing loads and extremely tight real-time requirements. Ex. 2018. Accordingly, the conventional MSCs and BSCs depended on DSPs and ASICs to support real-time processing, with hardware accelerators, pins to trigger interrupts to the processor, high-throughput communications interfaces, and a Real-Time Operating System (RTOS), to facilitate the ability of the chip to complete processing jobs within the dedicated time window.

70. I also note that the industry did not recognize the solution of implementing this functionality with a decentralized, software-based approach until 2012, with the publication of the NFV paper, seven years after Lemko. *See* Ex. 2008 at 5, 10-12 (identifying challenges of a software-based approach using industry-standard servers in light of performance degradation and compatibility issues with existing legacy networks). The NFV paper, for example, specifically called for a collaborative effort to come up with solutions for implementing network functionality in software that can run on industry-standard servers. Ex. 2008 at 5. A POSITA would recognize that Lemko's claimed DMA infrastructure offered just

a solution, “as software enables all of core network functions, databases and gateways.” Ex. 2009 at 1; ’763 Patent at 4:14-31, Fig. 2.

71. **Second**, Petitioners provide no evidence that a POSITA would have had a reasonable expectation of success in consolidating MSC and BSC hardware network components onto computer readable medium running on industry-standard servers at the time of the invention. I understand that Petitioners assert that “applying this known technique . . . would result in similar improvements.” Pet. at 13-14. I disagree. As the NFV paper acknowledges, MSC and BSC implementation at the time of the claimed invention depended on hardware-based techniques as discussed above, there was no known software-based implementation that could meet the requirements.

72. It is also my opinion that Mr. Proctor’s testimony does not remedy the Petition’s deficiencies. I note that Mr. Proctor concludes that it would have been obvious to migrate this conventional hardware functionality into software. Ex. 1003 at ¶¶ 106-107. I disagree. Mr. Proctor does not cite any evidence identifying then-known techniques for replacing cards and DSP circuitry with software.

B. In My Opinion, Waylett Does Not Disclose a “First Call Detail Record (CDR) Generation Program Embedded in the First Computer Readable Medium”

73. I understand that each of the Challenged Claims requires that the DMAS include in its computer readable medium software for generating Call Detail Records (“CDR”).

74. A POSITA would recognize that CDRs capture information on calls made on telephone systems, including the party originating the call, the recipient of the call, the date and time of the call, and the duration of the call. Part of the invention of the Challenged Claims was moving the MSC and CDR functionality to the DMAS to enable the formation of the decentralized DMA network where calls could be managed locally instead of at centralized MSCs. ’763 Patent at 4:1-31, 11:14-32, Fig. 2, Claim 1 (claiming a “second DMA server comprising:” *inter alia* “a second computer readable medium” “a second mobile switching center module embedded in the second computer readable medium” and “a second call detail record (CDR) generation program embedded in the second computer readable medium”).

75. It is my opinion that Waylett does not disclose locating CDR generating functionality at the NIB (let alone in a computer readable medium at the NIB). Petitioners assert that the RADIUS server located in the NIB (which Petitioners contend is a DMAS) generates CDRs. See Pet. at 16. In Waylett, the RADIUS

server “receives,” but does not “generate” CDRs. The CDRs are generated at access points:

The RADIUS server 312 receives accounting packets or **call detail records (CDRs) generated by the different access points 228A, 228B, 228C**, and forwards these accounting packets to a billing server (not shown) through a RADIUS proxy interface (not shown) to bill telecommunications charges to the appropriate parties.

Waylett at 14:16-22 (emphasis added). These access points are separate and distinct from the NIB (as I show below):

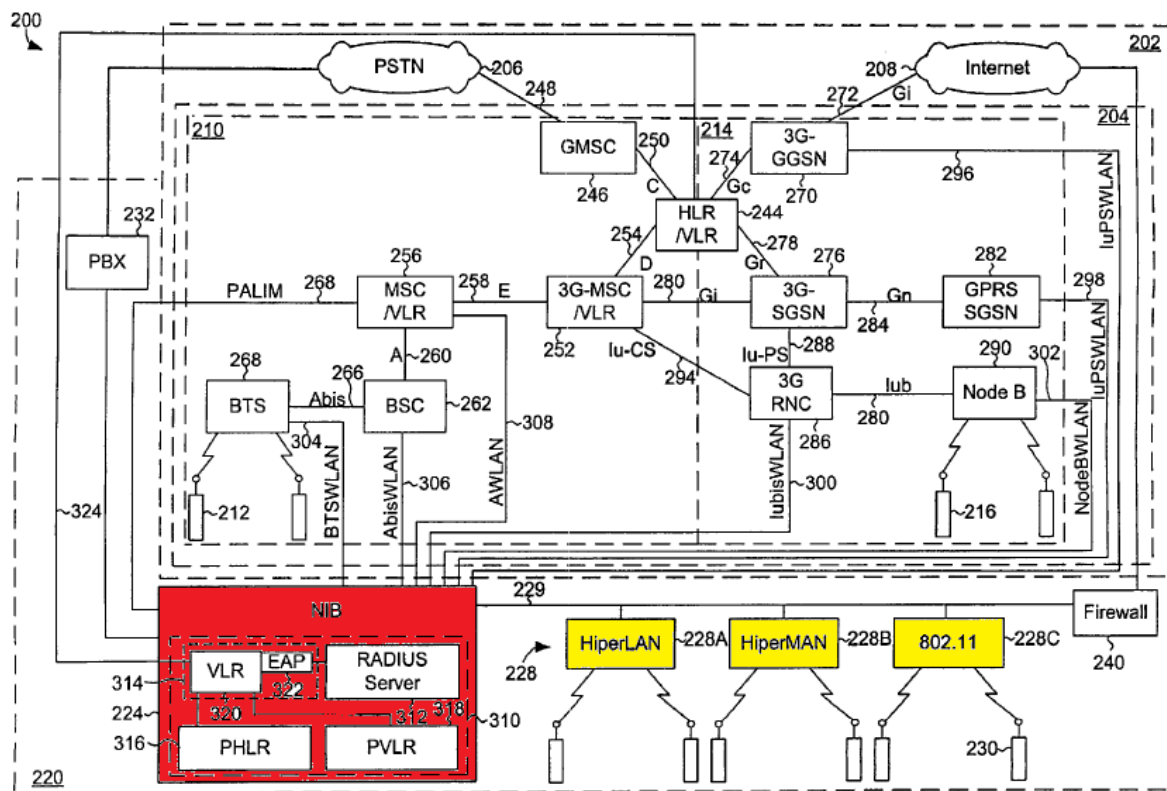


FIG. 6

Id. at Fig. 6 (annotated, illustrating that the access points (228A, 228B, and 228C, annotated in yellow) are separate and distinct from the NIB (224, annotated in red)).

76. In view of the above reasons, it is my opinion that Waylett does not disclose a “first call detail record (CDR) **generation** program embedded in the first computer readable medium” of the DMA, as is required by each of the Challenged Claims because Waylett’s NIB does not generate CDRs, let alone using a program embedded in computer-readable media.

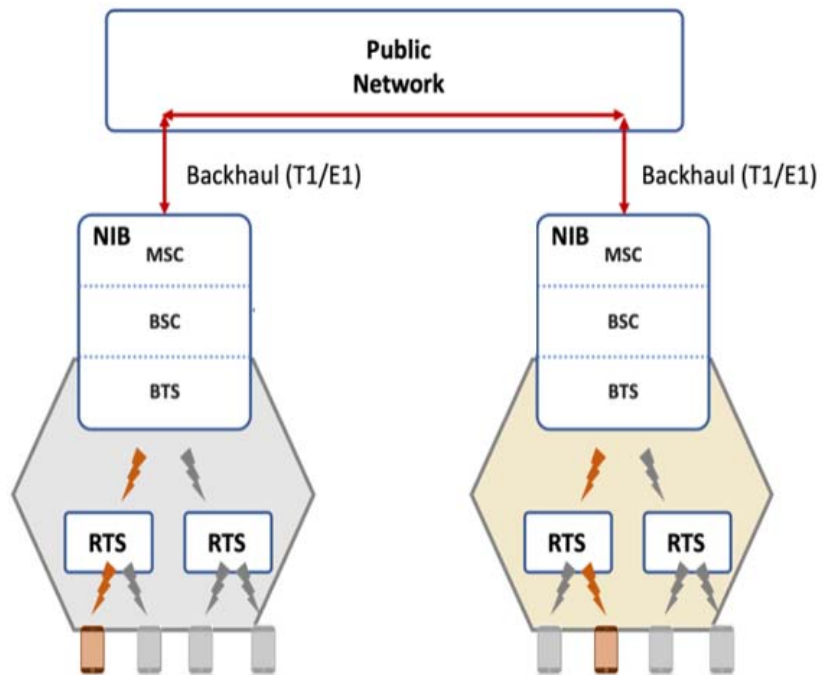
C. In My Opinion, It Would Not Have Been Obvious to Modify Waylett With Cope’s P2P IP Connections to Arrive at the “Peer-to-Peer Connection for Telephony Traffic

77. Each of the Challenged Claims requires that “telephony traffic received at the first wireless transceiver of the first distributed mobile architecture server is transmitted from the first distributed mobile architecture server to the second distributed mobile architecture server **via a peer-to-peer connection.**” ’763 Patent at Claim 1. Neither Waylett nor Cope shows the use of such peer-to-peer connections to connect DMAS, nor do Petitioners show how and why, absent hindsight and use of the ’763 Patent as a roadmap, a POSITA would have been motivated to modify Waylett with Cope’s alleged teaching of peer-to-peer IP connections and have a reasonable expectation of success in doing so.

78. I understand that Petitioners acknowledge that Waylett does not disclose transmitting telephony traffic over a peer-to-peer connection. See Pet. at 24 (“Waylett does not, however, expressly disclose that such a transmission of telephony traffic occurs over a ‘*peer-to-peer connection.*’”). As such, Petitioners

rely on Cope to assert that “[a] skilled artisan would have been **motivated to incorporate Cope’s P2P connections** in the system of Waylett.” Pet. at 28 (emphasis added). In so doing, Petitioners contend that because “peer-to-peer IP connections were known and conventional” it would have been “nothing more than the simple substitution of one known element . . . for another.” Pet. at 29-30. I disagree.

79. As I discussed above, Waylett describes a private network formed by multiple hardware-based NIBs. Like traditional, centralized MSCs, the NIBs are connected with conventional T1/E1 communication backhaul links that carry voice and data communications. Waylett also discloses connecting NIBs via a private wide area network (PWAN) for non-telephony functions, such as “distributing HLR registration and authentication loads.” Waylett at 17:10-12; *see also* Ex. 2013 (disclosing the T1/E1 ports for communication); Waylett at 7:9-11, 9:65-10:6, 17:7-17, Fig. 11. I have illustrated this setup below with respect to figure 11:



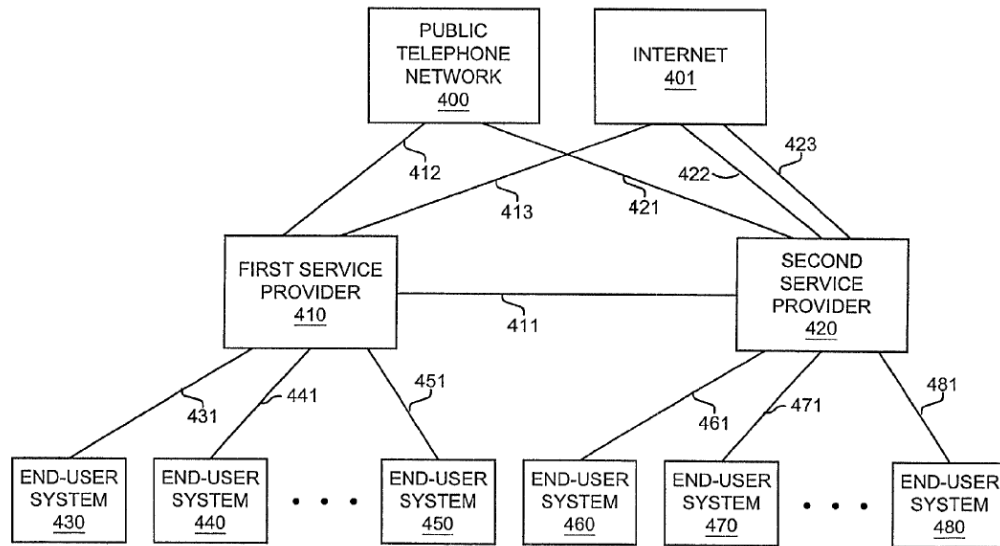
Waylett at Fig. 11 (annotated); Ex. 2014, Ex. 2013 at 1 (disclosing that the NIB has “all E1 or all T1” ports for voice and data communication); Waylett at 7:9-11. Accordingly, all calls from a first NIB are connected to the public network and the public network routes the calls to the second NIB through T1/E1 connections. *Id.*

80. As I show above, the call path from one UE under the first NIB coverage to another UE under the second NIB coverage goes from the first NIB, over T1/E1 backhaul, to a public network, over T1/E1 backhaul to a second NIB, to the recipient UE. Other than the radio connection between the UE and the NIB, all of these connections are T1/E1. Circuit-switched, dedicated T1/E1 connections were used by industry for such connections because they provided dedicated,

reliable, fixed bandwidth connections between known points (such as between a NIB and a public telephone network). As Petitioners admit, these were not peer-to-peer connections between NIBs (which I note Petitioners contend are DMA servers).

81. Significantly, Cope discloses carrying traditional telephony data from the UEs to service providers using connection links, such as T1/E1 connections. Cope at 6:13-21, Fig. 4. Only native IP data (*e.g.* VoIP calls) are routed over Cope's IP network between different service providers. *Id.* at Abstract, 2:15-28, 4:24-62 (describing "telephony signals for the telephone and IP packets for the IP interface"). It is my opinion that Cope does not suggest replacing these types of communications lines with peer-to-peer IP connections, which is the apparent basis for Petitioner's allegation that replacing Waylett's backhaul connections with peer-to-peer connections would have been obvious. *See* Pet. at 29-30; Ex. 2014, Ex. 2013 at 1 (disclosing that the NIB is an "all E1 or all T1" ports for voice and data communication).

82. Also, Cope does not show peer-to-peer connections between anything resembling DMA servers. Instead, as I discussed in my overview of Cope in Section VI.B above, Cope is limited to routing IP packets over the Internet to connect different service providers. Cope at 5:51-63, Fig. 4. Specifically, Cope describes that a first service provider (*e.g.*, AT&T) routes IP packets to a second service provider (*e.g.*, Verizon) over a P2P IP connection:



Id. at Fig. 4; *see also id.* at 5:51-6:6, *id.* at 5:51-6:12, *id.* at Fig. 4. In my opinion, Cope, like Waylett, is still based on a hierarchical network paradigm, and does not show a decentralized, distributed peer-to-peer network, where DMA servers within a network connect as peers to avoid the need to traverse centralized MSCs, as is shown in the '763 Patent. *See* '763 Patent at Figs. 1 (depicting DMAs within a network communicating via peer-to-peer), Fig. 2 (depicting the MSC functionality embedded in the computer readable medium). Moreover, Cope is specifically described in the context of land-based wired communications networks which are fixed and static in nature between two service providers. There is no mention that its peer-to-peer connections could be applied to a mobile network application where the situation is much more dynamic (with users moving throughout the network).

83. I understand that Petitioners rely on Cope's statement that "peer-peer connections allow for 'far more efficient' routing of IP traffic through an internet gateway and over the internet to other service providers." Pet. at 28 (quoting Waylett at 3:4-20, 3:65-4:3). But in my opinion this reasoning misunderstands the point of Cope. Cope discloses replacing an existing IP connection, established over the public Internet, with another type of IP connection, which it calls peer-to-peer between two different service providers. Cope at 3:56-64, Fig. 4. Cope does not disclose or suggest replacing the traditional T1/E1 backhaul with a peer-to-peer IP connection, let alone creating an entirely new network architecture with peer-to-peer connections between BTSs or BSCs, let alone between network elements bearing any resemblance to Lemko's DMA servers.

84. I understand that Petitioners further state that Waylett and Cope are both focused on expanding networks in rural areas. Pet. at 29. While Waylett identifies the expanding rural networks problem a POSITA would have recognized that it solves it with its hardware-based NIB approach using T1/E1 connections with no need for a P2P connection. See Waylett at 1:60-65, 8:7-32. Indeed, the benefits that Lemko's DMA infrastructure derive from using peer-to-peer IP connections are not benefits envisioned by either Cope or Waylett. The P2P IP connections between DMAS in the Lemko system enable local call routing between users within the DMAS network without the need to route calls through the public network. It also

allows the network to have a self-healing capability whereby the routing of calls can be accomplished even if a single DMAS fails leading to a more robust system overall. See '763 Patent at 3:51-59, 11:54-65.

D. In My Opinion, Waylett Does Not Disclose a “Program to Allow a Group Call” That is “Embedded in the Second Computer Readable Medium”

85. In my opinion, Waylett also does not disclose a “program to allow a group call” which is “embedded in the second computer readable medium.” '763 Patent at Claim 1.

86. **First**, as I discussed in Section VIII.A above, Waylett does not disclose a computer readable medium, which requires software implementation. There is no disclosure of **software** in the NIB for allowing group calls.

87. **Second**, Waylett does not teach any functionality within the NIB (software or hardware based) for allowing group calls. I understand that Petitioners cite Waylett’s disclosure of a voice group call service (VGCS) for user equipment. Pet. at 22. However, Waylett does not disclose that the program to allow a group call is located at the NIB. Instead, a POSITA would understand that such functionality (voice group call service (VGCS)) is provided at the network core (*e.g.*, of a GSM core network) for execution:

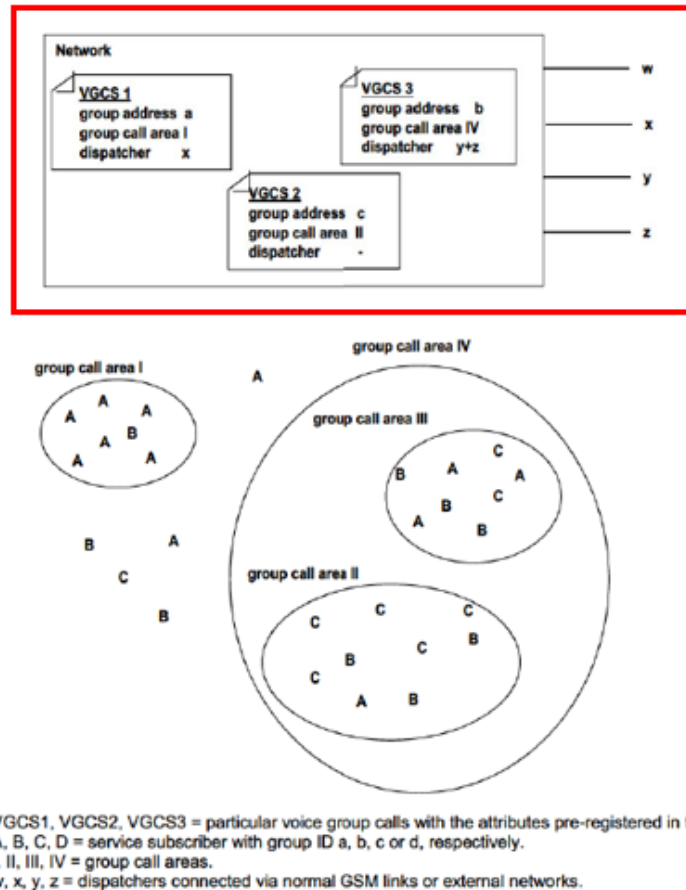


Figure 1: Logical concept of the VGCS

Ex. 1009 at 10 (annotated); Ex. 2021 at 11 (same), *id.* at 7 (describing a “network operator” as “an entity which provides the network operating elements and resources for the execution of the VGCS”), *id.* at 12 (“The VGCS shall be *automatically initiated by the network* when a service subscriber or dispatcher dials a particular short code or address at call set-up”) (emphasis added).

88. In my opinion, there is nothing in Waylett (or Cope) even suggesting that group-call functionality would have deviated from the then-conventional approach of locating the group call functionality at the network core as shown above.

Thus, Petitioners fail to show that Waylett's NIB explicitly or inherently discloses a "program to allow a group call" which is "embedded in the second computer readable medium" located at the DMA server.

IX. CONCLUSION

89. 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.

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

91. 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.

92. 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.

June 30, 2023

Respectfully Submitted,

A handwritten signature in black ink, appearing to read 'T Cooklev', with a long horizontal stroke extending to the right.

Todor V. Cooklev, Ph.D.

Appendix A

Todor Cooklev, PhD.

Curriculum Vitae

Personal

1336 Sycamore Hills Parkway, Fort Wayne, IN 46814

Contact e-mail: tcooklev@gmail.com

Cell: 925-984-5283

Citizenship: United States (by naturalization)

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

1. Office of Naval Research Summer Fellow 2020, Naval Surface Warfare Center Crane
2. National Science Foundation S²ERC I/UCRC, “FPGA implementation of shared-memory middleware”, 2017-2019, PI
3. National Science Foundation S²ERC 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 S²ERC I/UCRC, “The performance of middleware solutions for SDR”, 2013-2014, PI
8. National Science Foundation S²ERC 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 S²ERC 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>
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, 4th 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, *Modern Communication Systems: A first course*, University of Michigan Press, 2022 (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.
- 25) T. Cooklev and A. Nishihara, "Biorthogonal coiflets," *IEEE Trans. Signal Processing*, vol. 47, pp. 2582-2588, 1999.
- 26) T. Cooklev, A. Nishihara, T. Yoshida, and M. Sablatash, "Multidimensional two-channel linear phase FIR filter banks and wavelet bases with vanishing moments," *Journal of Multidimensional Systems and Signal Processing*, vol. 9, pp. 39-76, January 1998.
- 27) T. Cooklev, A. Nishihara and M. Sablatash "Regular orthonormal and biorthogonal wavelet filters," *Signal Processing*, vol. 57, pp. 121-137, Feb. 1997.
- 28) T. Yoshida, T. Cooklev, A. Nishihara, and N. Fujii, "Design of non-separable 3-D QMF banks using McClellan transformations," *IEICE Trans. Fundamentals*, vol. E79-A, No. 5, May 1996, pp. 716-720.
- 29) M. Sablatash and T. Cooklev "Coding of high-quality audio signals by wavelets and wavelet packets," *Digital Signal Processing: A Review Journal*, vol. 6, No. 2, pp. 96-107, April 1996.
- 30) V. Dimitrov, T. Cooklev, and B. Donevsky "Number-theoretic transforms over the golden-section quadratic field," *IEEE Trans. Signal Processing*, No. 8, pp. 1790-1797, August 1995.
- 31) V. Dimitrov and T. Cooklev, "Hybrid algorithm for computing the matrix polynomial," *IEEE Trans. Circuits Syst.*, No. 7, pp. 377-380, July 1995.
- 32) V. Dimitrov and T. Cooklev "Two algorithms for modular exponentiation based on nonstandard arithmetics," Special issue on cryptography and information security, *IEICE Transactions on Fundamentals*, Jan. 1995.

- 33) M. Sablatash, Todor Cooklev and Takuro Kida, "The coding of image sequences by wavelets, wavelet packets and adaptive wavelet packets," *IEEE Trans. Broadcasting*, Dec. 1994.
- 34) T. Cooklev and A. Nishihara, "Partial and generalized FFT," *IEICE Trans. on Fundamentals*, Sept. 1994.
- 35) V. Dimitrov, T. Cooklev and B. Donevsky, "Generalized Fermat-Mersenne number theoretic transforms," *IEEE Trans. Circuits Syst.*, vol. 41, pp. 133-139, Feb. 1994.
- 36) T. Cooklev, T. Yoshida and A. Nishihara, "Maximally flat half-band diamond-shaped FIR filters using the Bernstein polynomial," *IEEE Trans. Circuits Syst.*, vol. 40, pp. 749-751, Nov. 1993.
- 37) T. Cooklev and A. Nishihara, "Maximally flat FIR Hilbert transformers," *Int. Journal Circuit Theory and Applications*, vol. 21, pp. 563-570, 1993.
- 38) T. Cooklev, S. Samadi, A. Nishihara and N. Fujii, "Efficient implementation of all maximally flat FIR filters of a given order," *Electronics Lett.*, vol. 29, No. 7, pp. 598-599, 1993.
- 39) S. Samadi, T. Cooklev, A. Nishihara and N. Fujii, "Multiplierless structure for maximally flat linear phase FIR filters," *Electronics Lett.*, vol. 29, No. 2, pp. 184-185, 1993.
- 40) V. Dimitrov, T. Cooklev and B. Donevsky, "Generalized Fermat number transforms," *ASME Journal on Numerical Modeling*, 1992, N. 4 pp. 11-22.
- 41) T. Cooklev, V. Dimitrov and B. Donevsky, "Systolic implementation of the complex Chebyshev structure," *Int. J. Electronics*, vol. 73, pp. 1247-1252, Dec. 1992.
- 42) T. Cooklev and A. Nishihara, "Efficient design of N-D hyperspherically symmetric FIR filters," *IEICE Transactions on Fundamentals of Electronics, Inform. and Comput. Sci.*, vol. E75-A, pp. 1739-1742, Dec. 1992.
- 43) T. Cooklev, V. Dimitrov and B. Donevsky, "An improved systolic implementation of complex digital filters," *Archiv fuer Elektronik und Uebertragungstechnik (Germany)*, vol. 46, pp. 434-436, Nov.-Dec. 1992.
- 44) V. Dimitrov, T. Cooklev and B. Donevsky, "On the multiplication of reduced biquaternions and applications," *Information Processing Letters*, vol. 43, pp. 161-164, Sept. 1992.

Conference Papers

- 45) Plamen Semov, Pavlina Koleva, Vladimir Poulkov, and Todor Cooklev, "Evolution of Mobile Networks and C-RAN on the Road Beyond 5G," 43rd Int. Conf. on Telecommunications and Signal Processing, Milan, Italy, July 2020.

- 46) Y. Acar, S. Colak, T. Cooklev, "Dual-Mode Index Modulation Aided OFDM with Generalized Prefix", *Int. Symp. Networks, Computers, and Communications*, June 2019, Istanbul, Turkey.
- 47) T. Cooklev, "Making Software Defined Networks Semantic," *Proc. WINSYS*, July 2015, Colmar, France.
- 48) T. Cooklev, L. Stanchev, "A comprehensive and hierarchical ontology for wireless systems," *Wireless World Research Forum*, Marrakech, Morocco, May 2014.
- 49) Yusuf Acar, H. Yildiz, H. Dogan, and H. Dogan, "Generalized Prefix Approach for Alamouti Coded OFDM Systems over Gaussian Channels Correlated in Space," *IEEE 2014 World Congress on Computer Applications and Information Systems (WCCAIS)*, Hammamet, Tunisia, January 17-19, 2014.
- 50) Yusuf Acar, H. Yildiz, H. Dogan, and H. Dogan, "Performance Improvement for Correlated 4x4 MIMO-OFDM Systems by Generalized Prefix Approach," *2013 Int. Conference on Signal Processing and Communications*, Dec. 12-14, Noida, Uttar Pradesh, India.
- 51) T. Cooklev, L. Stanchev, C. Chen, "Wireless cloud architecture based on thin clients and ontologies," *Proc. IEEE Midwest Symp. Circuits and Systems*, Columbus, OH, Aug. 2013
- 52) Acar, Y.; Yildiz, H.; Cooklev, T.; Dogan, H., "High-performance MIMO OFDM wireless systems with generalized prefix," *21st Signal Processing and Communications Applications Conference (SIU)*, 2013, 24-26 April 2013, North Cyprus.
- 53) Dogan, H. Yildiz, T. Cooklev, Y. Acar, "Coded OFDM wireless systems with generalized prefix", *Int. Conf. on Application of Information and Communication Technologies*, Tbilisi, Georgia, Oct. 2012.
- 54) A. Madanayake, C. Wijenayake, Nghi Tran, T. Cooklev, Sean V Hum, L. T. Bruton, "Directional Spectrum Sensing using Tunable Multi-D Space-Time Discrete Filters," *First IEEE International Workshop on Emerging COgnitive Radio Applications and aLgorithms (IEEE CORAL)*, San Francisco, CA June 2012.
- 55) Yazan A. Alqudah and T. Cooklev, Hands-On Open Access Broadband Wireless Technology Lab, *Proc. IEEE Global Engineering Education Conference (IEEE EDUCON)*, Marrakech, Morocco, April 2012.
- 56) Yazan A. Alqudah and T. Cooklev, Hands-On Open Access Broadband Wireless Technology Lab, *ASEE Illinois/Indiana Section Conference*, Valparaiso, IN, March 2012.
- 57) D. Mueller, T. Cooklev, H. Oloomi, C. Pomalaza-Ráez, and S. Walter, "A Graduate Program In Wireless Technology And Systems Engineering: Overview And Initial Experiences", *ASEE Illinois/Indiana Section Conference*, Valparaiso, IN, March 2012.
- 58) L. Stanchev and T. Cooklev, "Describing Radio Hardware and Software Using OWL for Over-The-Air Software Download," *SDR Forum Tech. Conference*, Washington, DC, Dec. 2010.

- 59) A. Marcum, T. Cooklev, and Carlos Pomalaza-Raez, "Simple OFDM," Virginia Tech Wireless Summer School, June 2010.
- 60) C. Chen, Z. Chen, T. Cooklev, and C. Pomalaza-Raez, "On spectrum probing in cognitive radio networks: does randomization matter," IEEE Int. Conf. Communications, May 2010.
- 61) Z. Chen, T. Cooklev, C. Chen, and Carlos Pomalaza-Raez, "Modeling primary user emulation attacks and defenses in cognitive radio networks," Int. Performance Computing and Communications Conference, Dec. 2009, Phoenix, AZ
- 62) T. Cooklev and M. Cummings, "Changing metalanguage landscape," SDR Forum Technical Conference, Washington, DC, Dec. 2009.
- 63) F. Ramirez-Mireles, T. Cooklev, and M. Sablatash, "Analysis of filter-based non-coherent detection of UWB FSK with antenna and multipath effects," IEEE MILCOM 2008.
- 64) T. Cooklev and M. Cummings, "Networking description language for ubiquitous cognitive networking," SDR Forum Technical Conference, Washington, DC, Nov. 2008.
- 65) M. Cummings, T. Cooklev, B. Lyles, P. A. Subrahmanyam, "Commercial wireless metalanguage scenario," Software Defined Radio Technical Conference, Denver, CO, November 2007.
- 66) T. Cooklev and A. Abedi, "Teaching the IEEE wireless communication standards dynamically," 2007 Frontiers in Education Conference, Milwaukee, WI, Oct. 10-13, 2007.
- 67) S. Gaur and T. Cooklev, "Using Finer AIFSN granularity to Accurately Tune the Flow Ratios in IEEE 802.11e," The 18th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), Sept. 2007, Athens, Greece.
- 68) S. Gaur and T. Cooklev, "'Performance Enhancement of IEEE 802.11e EDCA by Random AIFSN", 2007 3rd International Conference on Testbeds and Research Infrastructures for the Development of Networks & Communities (TridentCom), Grosvenor Resort, Orlando, FL, May 21-23, 2007.
- 69) F. Ramirez-Mireles, and T. Cooklev, "Effects of Antenna and Multipath Frequency Selectivity on UWB Using Non-coherent FSK," World Wireless Forum, Stanford, CA, May 18-20 2007.
- 70) F. Ramirez-Mireles, and T. Cooklev, "An Investigation of Antenna and Multipath Effects on Pulse-Based UWB Using FSK," IEEE Globecom, San Francisco 2006.
- 71) T. Cooklev and P. Siohan "Vector-transform-based OFDM", Asilomar Conf. On Computers and Comm., Pacific Grove, Nov. 2006.
- 72) S. Gaur and Cooklev, T. "Performance enhancement of IEEE 802.11e EDCA by random AIFSN," IEEE Wireless multimedia communication conf., Vancouver, BC, Canada, July 2006.

- 73) T. Cooklev, Keh-Gang Lu "A wavelet transform approach to the design of complementary sequences for communications, 39th Asilomar Conference on Systems, Signals, and Computers, Pacific Grove, CA Nov. 2005.
- 74) M. Goins, T. Cooklev, and J. W. Hines, "System-on-a-chip design for lab-on-a-chip in space-flight systems," Proc. Information Systems: New Generations, Las Vegas, NV, April 2005.
- 75) Y. Bai and T. Cooklev, "An improved method for lossless data compression" IEEE Data Compression Conference, Snowbird, Utah, March 2005.
- 76) A. Pakdaman, J. Eidson, T. Cooklev, "Synchronization of wireless LAN over IEEE 1588," Int. Conference on IEEE 1588, Baltimore MD, Sept. 2004.
- 77) T. Cooklev, "Dynamic bandwidth allocation and channel coding for providing QoS in wireless networks," Int. Conference on Telecommunications, Feb. 2003, Papeete, Tahiti.
- 78) T. Cooklev and M. Sablatash "A wavelet transform approach to the design of sequences for communications," Wireless Communications'97, Calgary, July 1997.
- 79) M. Sablatash, John Lodge, and T. Cooklev "Transmitter and receiver filter bank designs for bandwidth-on-demand multiple access communications combining wavelet packet filter bank trees and DFT polyphase filter banks" IEEE Int. Conference on Communications, Montreal, 1997.
- 80) G. Berbecel, T. Cooklev and A. N. Venetsanopoulos, "A practical wavelet-based approaches to watermarking digital images," IEEE Conf. on Consumer Electronics, Chicago, IL, 1997.
- 81) T. Cooklev, G. Berbecel, A. N. Venetsanopoulos, "Wavelets and differential-dilation equations" Canadian Workshop on Information Theory, Toronto, June 1997.
- 82) T. Cooklev, G. Berbecel, and A. N. Venetsanopoulos, "Construction of an infinitely differentiable continuous-time wavelet and differential dilations equations," Int. Workshop on Signal and Image Processing, Manchester, UK, Nov. 1996.
- 83) T. Cooklev, A. Nishihara, M. Kato, and M. Sablatash "Lattice structures for two-channel paraunitary filter banks that yield symmetric wavelet bases," EUSIPCO'96, Trieste, Italy, Sept. 1996
- 84) D. Androustos, T. Cooklev, A. N. Venetsanopoulos, "Multifilter banks and multiwavelets for multispectral image compression," World Congress of Nonlinear Analysts, Athens, July 1996.
- 85) T. Cooklev, "On the design of orthogonal filter banks and wavelets with complex coefficients," Queen's Biennial Symposium on Communications, Kingston, June 1996.
- 86) T. Cooklev, "Filter banks and wavelet transforms over finite fields," Queen's Biennial Symposium on Communications, Kingston, June 1996.

- 87) T. Cooklev, "1-D and 2-D biorthogonal filter banks with vanishing moments and biorthogonal wavelet packets" Queen's Biennial Symposium on Communications, Kingston, June 1996.
- 88) T. Cooklev, "Multichannel filter banks, vector transforms, and multiwavelets with applications in color image compression," Queen's Biennial Symposium on Communications, Kingston, June 1996.
- 89) T. Cooklev, A. Nishihara, M. Kato, and M. Sablatash "Two-channel multifilter banks and multiwavelets," IEEE ICASSP'96, Atlanta, GA, pp. 2769-2773, May 1996.
- 90) T. Cooklev, et. al., "Multifilters and multiwavelets," Wavelets in signal and image processing, Centre de recherche mathematique, Universite de Montreal, Montreal, Quebec, Canada, March 1996.
- 91) T. Cooklev, et al "Regular biorthogonal filter banks and wavelet bases: new design and implementation," Int. Conf. Digital Signal Processing,, Limmasol, Cyprus, 1995.
- 92) T. Cooklev, A. Nishihara, T. Yoshida, and M. Sablatash "Regular multidimensional linear phase FIR perfect-reconstruction filter banks and wavelet bases," IEEE ICASSP'95, Detroit, MI, May 1995.
- 93) T. Cooklev, A. Nishihara, and M. Sablatash "Theory of digital filter banks over finite fields," IEEE Asia-Pacific Conf. Circuits Systems (APCCAS), Taipei, Taiwan, Dec. 1994.
- 94) T. Cooklev, T. Yoshida, A. Nishihara, "Multidimensional linear phase FIR perfect-reconstruction filter banks," DSP Symposium, Nov. 1994, Kyoto, Japan.
- 95) M. Sablatash , Todor Cooklev and Takuro Kida, "The coding of image sequences by wavelets, wavelet packets and adaptive wavelet packets," Int. Broadcasting Convention, Amsterdam, Holland, Sept. 1994.
- 96) Mike Sablatash , Todor Cooklev, "Compression of high quality audio signals by wavelet packets and other methods," Kingston Biennial Symp. Communications, Kingston, Ontario, Canada, June 1994.
- 97) M. Sablatash , Todor Cooklev and Takuro Kida, "The coding of image sequences by wavelets, wavelet packets, adaptive wavelet packets and other subband coding schemes," Kingston Biennial Symp. Communications, Kingston, Ontario, Canada, June 1994.
- 98) M. Sablatash , J. Lodge, and Todor Cooklev, "Wavelets, matrices and filter banks," Canadian Applied Mathematics Symp., Montreal, Canada, June 1994.
- 99) Todor Cooklev, Toshiyuki Yoshida, Akinori Nishihara and Mike Sablatash, "Multidimensional perfect reconstruction linear phase digital filter banks and wavelets," Canadian Applied Mathematics Symp., Montreal, Canada, June 1994.

- 100) V. Dimitrov and T. Cooklev, "Hybrid algorithm for computing the matrix polynomial using a fractal number system," Proc. IEEE ISCAS, pp. 5.129-5.132, London, UK, 1994.
- 101) T. Cooklev and A. Nishihara, "Multidimensional perfect-reconstruction linear-phase digital filter bank," Karuizawa Workshop on Circuits Systems, Karuizawa, Japan, April 1994.
- 102) T. Cooklev and A. Nishihara, "Partial FFT," Proc. 8th Digital Signal Processing Workshop, Sendai, Japan, pp. 37-42, Oct. 1993.
- 103) T. Cooklev, S. Samadi, A. Nishihara and N. Fujii, "Maximally flat approximation for two-dimensional FIR digital filters with applications in sampling structure conversion," ECCTD'95, Davos, Switzerland, pp. 385--390, Aug. 1993.
- 104) T. Cooklev and A. Nishihara, "Maximally flat FIR filters," IEEE ISCAS, Chicago, IL, pp. 96-99, May, 1993.
- 105) T. Cooklev and A. Nishihara, "Maximally flat FIR Hilbert transformers," Karuizawa Workshop on Circuits and Systems, Karuizawa, Japan, pp. 37-42, April 1993.
- 106) T. Cooklev and A. Nishihara, "Systolic structures for linear-phase FIR filters," 1st IEEE Asia Pacific Conference on Circuits and Systems, pp. 304-306, Sydney, Australia, Dec. 1992.
- 107) T. Cooklev and A. Nishihara, "A new class of 2--D FIR maximally-flat digital filters," 7th Digital Signal Processing Symposium, Fuji Res. Inst., Japan, pp. 115-120. Nov. 1992.
- 108) T. Cooklev and A. Nishihara, "Design of N-D hyper spherically symmetric FIR filters," IEICE Fall Conference, pp. A-82, Tokyo, Sept. 1992.
- 109) V. Dimitrov, T. Cooklev, B. Donevsky, "Fibonacci-based complex number theoretic transform," IASTED Int. Symposium Circuits Systems, Zurich, Switzerland, pp. 69-72, July 1991.

United States Patents

- 1) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 9,949,148, April 17, 2018.
- 2) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 9,936,401, April 3, 2018.
- 3) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 9,461,857, October 4, 2016.
- 4) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 9,450,794, September 20, 2016.
- 5) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 9,148,806, September 29, 2015.
- 6) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, Multicarrier packet communication system, U.S. Patent 9,148,801, September 29, 2015.

- 7) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 8,958,350, February 17, 2015.
- 8) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 8,842,570, September 23, 2014.
- 9) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 8,755,264, June 17, 2014.
- 10) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 8,553,579, Oct. 8, 2013.
- 11) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, Multicarrier packet communication system, U.S. Patent 8,537,703, September 17, 2013.
- 12) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, Systems and methods for high rate OFDM communications using first and second cyclic prefix lengths and first and second pilot tones, U.S. Patent 8,416,677, April 9, 2013.
- 13) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, OFDM communications using bit allocation tables, U.S. Patent 8,284,800, October 9, 2012.
- 14) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, Systems and methods for high rate OFDM communications using first and second cyclic prefix lengths, U.S. Patent 8,159,969, April 17, 2012.
- 15) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, High rate OFDM communications using bit allocation tables, 7,924,841, May 17, 2011
- 16) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, Method for packet communication using training packets, U. S. Patent 7,944,851, May 17, 2011
- 17) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, Method for variable cyclic length in OFDM communications, 7,916,625, March 29, 2011
- 18) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, High rate OFDM communications with a variable cyclic prefix, 7,804,765, September 28, 2010
- 19) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, Multicarrier packet communication method, 7,729,281, June 1, 2010
- 20) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, Systems and methods for high rate OFDM communications, 7,590,071, September 15, 2009
- 21) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, Systems and methods for high rate OFDM communications, 7,522,514, April 21, 2009
- 22) Kenneth Morley; Todor Cooklev, Mark Gray; Darrin Gibbs; Video signal processing method and apparatus for internet appliances or embedded systems, US Patent 6,795,869, September 2004.
- 23) Todor Cooklev, Darrin Gibbs; Mark Gray; Ken Morley; Method and system for performing speech recognition for an internet appliance using a remotely located speech recognition application, US Patent 6,772,123, August 2004.
- 24) T. Cooklev, Device and method for compensating or creating doppler effect using digital signal processing, US Patent, 6,633,617, Oct. 2003.
- 25) S. Messerly, T. Cooklev, "Adaptive filter size for the efficient computation of wavelet packet trees," US Patent 6,581,081, June 2003.
- 26) T. Cooklev, "Method and system for spatially-disjoint joint source and channel coding for high-quality real-time multimedia streaming over connection-less networks via circuit-switched interface links," US Patent 6,574,218, June 2003.
- 27) T. Cooklev, M. Gray, "System and method for precise DTMF detection," US Patent 6,560,331, May 2003.

- 28) T. Cooklev, K. Smart, "High-speed modem operating over two or more telephone lines," US Patent 6,490,295, Dec. 2002.
- 29) T. Cooklev, M. Gray, D. Gibbs, K. Morley, "Method and apparatus for continuously variable slope delta modulation coding of signals," US Patent 6,486,810, Dec. 2002.
- 30) S. Messerly, T. Cooklev, "Reduced computation system for wavelet transforms," US Patent 6,466,957, Oct. 2002.
- 31) T. Cooklev, "Method and apparatus for wavelet-based digital watermarking of signals", US Patent, March 2002.
- 32) T. Cooklev, "Method for real-time lossless data compression of computer data, US Patent 6,289,130, Sept. 11, 2001.

Selected non-refereed publications

Contributions to 3GPP

- 1) "CQI Definition for CoMP," 3GPP TSG-RAN WG1 Meeting #68 R1-120243, Dresden, Germany, February 6th – 10th 2012. (on behalf of Hitachi)
- 2) "Specification Impact of Non-Zero Power ABS", 3GPP TSG-RAN WG1 Meeting #68R1-120241, Dresden, Germany, February 6th – 10th 2012. (on behalf of Hitachi)
- 3) "Way Forward on CSI Feedback for CoMP," R1-120901, (authored by a group of companies)
- 4) "WF on CSI-RS based measurement," R1-120895 (authored by a group of companies)
- 5) LS to RAN3 – "X2 enhancements in support of non-zero power ABS," 3GPP TSG RAN WG1 Meeting #69, Prague, Czech Republic, May 2012 (on behalf of Hitachi)
- 6) "WF on signalling details for non-zero transmit power ABS," R1-123948, (co-authored with representatives from several companies), Prague, Czech Republic, May 2012 (on behalf of Hitachi)
- 7) "WF on X2 signalling for reduced power ABS for FeICIC," (co-authored with representatives from several companies) R1-123881, Prague, Czech Republic, May 2012

Contributions to IEEE 802.11

- 8) G. Venkatesan, A. Ashley, Ed Reuss, and T. Cooklev, "IEEE 802 Tutorial: Video over 802.11," March 2007. (on behalf of Hitachi America Ltd)
- 9) T. Cooklev, "Video over WLAN", doc. 11-07-0105r0, 2007. (on behalf of Hitachi America Ltd)
- 10) S. Gaur, T. Cooklev, "MAC improvement using random AIFSN," doc. 802.11-06/0657, July 2006. (on behalf of Hitachi America Ltd)
- 11) C. Tavares, T. Cooklev, S. Gaur, "On video over 802.11," doc. 802.11-06/0039, Jan. 2006. (on behalf of Hitachi America Ltd)
- 12) C. Tavares, T. Cooklev, "MAC extensions for HDTV," doc. 802.11-05/0632, July 2005. (on behalf of Hitachi America Ltd)
- 13) M. Tzannes, T. Cooklev, D. Lee, C. Lanzl, "Extended data rate 802.11a", doc. 802.11-02/232, March 2002. (on behalf of Aware, Inc.)
- 14) S. Prestwich, D. Ostermiller, K. Dobson, T. Cooklev, "Dynamic frequency hopping," IEEE 802.15, Tel Aviv, Israel, January 2000. (on behalf of Aware, Inc.)

Contributions to ITU-T SG15 Q4 on DSL technology

- 15) T. Cooklev, A. Freedman, and M. Tzannes, "Low-density parity check codes (LDPC) for ADSL," ITU-T SG15 Q4 BI-068, Bangalore, India, Nov. 2000. (on behalf of Aware, Inc.)
- 16) T. Cooklev, M. Tzannes, A. Freedman, "Low-density parity check coded modulation for ADSL," ITU-T SG15 Q4 BI-081, Bangalore, India, 2000. (on behalf of Aware, Inc.)
- 17) T. Cooklev, "Error-correcting codes for ADSL," ITU-T SG15 Q4, BA-108, Antwerp, Belgium, June 2000. (on behalf of Aware, Inc.)

Other non-referred publications and technical reports

- 18) T. Cooklev, "Standards, regulation, and compliance," IEEE Standards University, [online] <https://www.standardsuniversity.org/e-magazine/september-2017/standards-regulation-compliance/>
- 19) T. Cooklev A wavelet transform approach to the design of sequences for communications, Communications Research Centre, Ottawa, Tech. Report U6800-6-2438, 1997.
- 20) I. Rabinovitch, A. N. Venetsanopoulos, and T. Cooklev, "Perceptually lossless still image compression using the wavelet transform, considering the properties of the Human Visual System," ITRC, Kingston, Ontario, 1996.
- 21) T. Cooklev, On the design and implementation of filter banks and filter bank trees with finite wordlength, Communications Research Centre, Ottawa, Tech. Report 67CRC-5-3315, 1996.
- 22) T. Cooklev, M. Kato, A. Nishihara, M. Sablatash "Multifilter banks and multiwavelets," IEICE Tech. Report, Tokyo, Japan, May 1995.
- 23) T. Cooklev, A. Nishihara, "Regular biorthogonal filter banks and wavelet bases: new design and implementation," IEICE Tech. Report, presented at KDD Research Institute, Kamifukuoka, Saitama, Japan, April 1995.
- 24) V. Dimitrov and T. Cooklev, "Two algorithms for modular exponentiation using non-standard arithmetics," IEICE Tech. Report, ISEC93-98, 1994. (in Japanese), presented at the IEICE meeting on information security and cryptography, Osaka, Japan, March 1994.
- 25) T. Cooklev and A. Nishihara, "Pruning the real-valued FFT algorithms for efficient time-domain interpolation and linear convolution," IEICE Tech. Report, CAS93-14, VLD93-14, DSP93-24, May 1993.
- 26) T. Cooklev and A. Nishihara, "Band pass maximally flat FIR filters and Hilbert transformers," IEICE Tech. Report, CS92-88, DSP92-88, Jan. 1993.

Expert witness experience

- 2020 – Expert for Smart Mobile Technologies LLC
- Law firm: Hagens Berman Sobol Shapiro, Pasadena, CA (2020-2022); Graves and Shaw LLP (2022 – present).
 - Case names: *Smart Mobile Technologies LLC v. Apple Inc.*, and *Smart Mobile Technologies LLC v. Samsung Electronics Co. Ltd. and Samsung Electronics America, Inc.*
 - Case Nos: 6:21-cv-00603, 6:21-cv-00701 (W.D. Tex.)
 - PTAB case Nos. IPR2022-00766, IPR2022-00807, IPR2022-00808, IPR2022-01002, IPR2022-01003, IPR2022-01004, IPR2022-01005, IPR2022-00979, IPR2022-00980, IPR2022-00981, IPR2022-00982, IPR2022-01222, IPR2022-01223, IPR2022-01248, IPR2022-01249
 - Submitted multiple declarations
 - Testified at multiple depositions
- 2023 – Expert for WSOU Investments, LLC d/b/a Brazos Licensing and Development
- Law firm: Folio Law Group
 - Case name: *WSOU Investments, LLC d/b/a Brazos Licensing and Development v. Google, LLC.*,
 - Case Nos. 6:20-cv-00585-ADA (W.D. Tex.)
 - Submitted a validity report
 - Testified at a deposition
 - Technology at issue: determining a location of a mobile device and location-based services
- 2021 – 2023 Expert for TQ Delta, Austin, TX
- Law firm: Davis Law Firm, P.C., Longview TX, and McAndrews, Chicago, IL
 - Case name: TQ Delta, LLC, v. Commscope Holding Company, Inc., Commscope Inc., Arris International Limited, Arris Global Ltd, Arris US Holdings, Inc., Arris Solutions, Inc., Arris Technology, Inc., and Arris Enterprises, LLC
 - Civil Action No: 2:21-cv-310-JRG, 2:21-cv-309-JRG (E.D. Tex.)
 - Submitted a declaration in connection with claim construction, infringement report, validity report, and reports on testing and simulation
 - Testified at two depositions and at trial
- 2021 – 2022 Expert for WSOU Investments, LLC d/b/a Brazos Licensing and Development
- Law firm: Kasowitz Benson Torres LLP
 - Case name: *WSOU Investments, LLC d/b/a Brazos Licensing and Development v. Canon, Inc.*,
 - Case Nos. 6:20-cv-00980-ADA, 6:20-cv-00981-ADA (W.D. Tex.)
 - Submitted a declaration in connection with claim construction, infringement and validity reports.
 - Testified at a deposition

- Technologies at issue: frequency-hopping wireless communication; image processing and compression

2021 – 2022 Expert for NXP

- Law firm: Jones Day, Washington, DC
- Case name: Certain Integrated Circuits, Chipsets, and Electronic Devices, and Products Containing the Same, ITC 337-TA-1287
- Technology at issue: IEEE 802.11
- Submitted a validity report
- Testified at a deposition

2019 – 2022 Expert for Evolved Wireless LLC, Austin, TX

- Law firm: Nelson Bumgardner Albritton P.C., Fort Worth, TX (2019–22); Bruster PLLC, Southlake, TX (2022–present)
- PTAB Case No. IPR2021-00943
- Submitted a declaration
- Testified at a deposition
- Technology at issue: 4G cellular communications

2021 – Expert for Flexiworld Technologies

- Law firm: Nelson Bumgardner Conroy, Dallas, TX
- Case name: *Roku, Inc. v. Flexiworld Technologies*
- PTAB Case Nos. IPR2021-00713, IPR2021-00714, IPR2021-00715, PGR2021-00112, IPR2022-00775
- Submitted multiple declarations
- Testified at multiple depositions

2021 – 2022 Expert for 3G Licensing

- Law firm: Devlin Law Firm LLC
- Case name: *Cradlepoint, Inc., Dell Inc., Honeywell International, Inc., Sierra Wireless, Inc., TCL Communication Technology Holdings Limited, TCT Mobile International Limited, TCT Mobile, Inc., TCT Mobile (US) Inc., TCT Mobile (US) Holdings Inc., Thales DIS AIS Deutschland Gmbh, ZTE Corporation, and ZTE (USA) Inc. v. 3G Licensing, S.A.*
- PTAB Case Nos. IPR2021-00640, IPR2021-01141
- Technology at issue: cellular communications
- Submitted declarations
- Testified at a deposition

2021 – 2021 Expert for Barkan Wireless IP Holdings, L.P.

- Law firm: Heim, Payne & Chorush, LLP, Houston, TX
- Case name: *Barkan Wireless v. T-Mobile, Inc. and Nokia of America Corp.*
- Civil Action No. 2:21-CV-00034-JRG (E. D. Tex.)
- Submitted a validity report
- Testified at a deposition

- Technology at issue: cellular network architecture involving home base stations

2020 – 2021

Expert for General Access Solutions, Dallas, TX

- Law firm: Bartlit Beck, Denver, CO
- Case name: *General Access Solutions, LTD. v. Virgin Mobile USA, L.P., Boost Mobile, LLC, and Sprint Spectrum L.P.*
- Civil Action No. 2:20-cv-00007-RWS (E. D. Tex.)
- Submitted a report on standards essentiality
- Testified at a deposition
- Technology at issue: beamforming in 4G and 5G cellular standards

2014 –

Expert for TQ Delta, Austin, TX

- Law firm: McAndrews, Chicago, IL
- Case name: TQ Delta, LLC v. Adtran
Civil Action No. 14-cv-00954-RGA (D-Del.), Civil Action No. 15-cv-00121-RGA (D-Del.)
- Case name: TQ Delta, LLC v. 2Wire
Civil Action No. 13-cv-1835-RGA (D-Del.)
- Case name: TQ Delta, LLC v. Zhone Technologies, Inc.
Civil Action No. 13-cv-1836-RGA (D-Del.)
- Case name: TQ Delta, LLC v. Zyxel Communications, Inc. and Zyxel Communications Corporation
Civil Action No. 13-cv-2013-RGA (D-Del.)
- Submitted product testing reports, computer simulation reports, a report on the terms of a license agreement, a report on standards essentiality, infringement reports, validity reports
- Testified at depositions and trials
- Technology at issue: Digital signal processing in Digital Subscriber Line communication systems

2015 – 2019

Expert for Evolved Wireless, Austin, TX

- Law firm: Robins Kaplan, Minneapolis, MN
- Civil Actions No. 15-cv-542-SLR-SRF, No. 15-cv-543-SLR-SRF, No. 15-cv-544-SLR-SRF, No. 15-cv-545-SLR-SRF, No. 15-cv-546-SLR-SRF, and No. 15-cv-547-SLR-SRF (D-Del.) brought against Apple, HTC, Lenovo, Samsung, ZTE, and Microsoft.
- Submitted infringement and validity reports
- Testified at deposition and trial
- Technologies at issue:
 - Random-access procedure in the LTE cellular standard
 - Generation and format of the random-access preamble in LTE
 - Handover and contention-free random access in LTE
 - Constant-amplitude zero-autocorrelation sequences in LTE