

**UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD**

UNIFIED PATENTS, LLC
Petitioner,

v.

OZMO LICENSING LLC
Patent Owner

IPR2022-00193

Patent No. 9,264,991

Filing Date: November 6, 2013

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Title: APPARATUS AND METHOD FOR INTEGRATING SHORT-RANGE
WIRELESS PERSONAL AREA NETWORKS FOR A WIRELESS LOCAL
AREA NETWORK INFRASTRUCTURE

DECLARATION OF DR. ZYGMUNT J. HAAS

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I, Dr. Zygmunt Haas, declare as follows:

I. INTRODUCTION

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

2. I have been retained by Unified Patents LLC (Petitioner) as an independent, technical expert consultant in this proceeding before the United States Patent and Trademark Office. I am being compensated at my rate of \$500 per hour for my services. No part of my compensation is dependent on my opinions or on the outcome of this proceeding. I have no financial interest in any of the parties to this proceeding.

3. This Declaration is in support of the petition (“Petition”) for *inter partes* review IPR2023-00193 involving U.S. Patent No. 9,264,991 (“the ’991 Patent” or “the Patent”) (Ex-1001), entitled “Apparatus and method for integrating short-range wireless personal area networks for a wireless local area network infrastructure” and listing Katelijn Vleugels and Roel Peeters as the inventors.

4. I have been instructed to assume that the effective filing date of the claims of the ’991 Patent challenged by the Petitioner in this *inter partes* review is no later than March 14, 2005.

5. I understand that, according to USPTO records, the '991 Patent is currently assigned to Ozmo Licensing LLC ("Ozmo" or "Patent Owner"). I assume for purposes of this proceeding that Ozmo is the Patent Owner.

6. The '991 Patent is generally directed to wireless communications. More particularly, the invention relates to seamlessly integrating short-range wireless personal area networks ("WPANs") into longer-range wireless local area networks ("WLANs"). I am familiar with the technology described in the '991 Patent as of the earliest possible priority date of March 14, 2005.

7. In preparing this Declaration, I have reviewed the '991 Patent (Ex-1001) and its prosecution history (Ex-1002), as well as the patents and documents cited herein, and I have considered these documents in light of the general knowledge in the art as of March 14, 2005. In formulating my opinions, I have relied upon my experience in the relevant art. I have also considered the viewpoint of a person of ordinary skill in the art ("POSA") in the field, as of March 14, 2005, who I describe below (§ VI.A). For convenience, the materials I considered in arriving at my opinions are listed in Appendix A.

8. I have been asked to provide my technical expertise, analysis, insights, and opinions regarding the '991 Patent and relevant references that form the basis of the grounds of rejection set forth in the accompanying Petition for inter partes review of the '991 Patent. As described in detail below, I offer the following opinions in

this Declaration regarding Claims 1, 3-4, 6-7 and 14-18 (“Challenged Claims”) of the ’991 Patent:

- A POSA would have found Claims 1, 3-4, 6-7, 14, and 16-17 of the ’991 Patent to be obvious in view of *Cromer* (Ex-1004) and *Ganu* (Ex-1005) in view of the knowledge, skill, and creativity of a POSA. *Cromer* and *Ganu* in view of the knowledge, skill, and creativity of a POSA, teach each element of these claims to a POSA;
- A POSA would have found Claims 1, 3-4, 6-7, 14, and 16-17 of the ’991 Patent to be obvious in view of *Cromer*, *Ganu*, and *Sinivaara* (Ex-1006) in view of the knowledge, skill, and creativity of a POSA. *Cromer*, *Ganu*, and *Sinivaara* in view of the knowledge, skill, and creativity of a POSA, teach each element of these claims to a POSA;
- A POSA would have found Claims 15 and 18 of the ’991 Patent to be obvious over *Cromer*, *Ganu*, and *Judd* (Ex-1019) and the knowledge, skill, and creativity of a POSA. *Cromer*, *Ganu*, and *Judd*, and the knowledge, skill, and creativity of a POSA, teach each element of these claims to a POSA, and a POSA would have been motivated to combine the teachings of these references.
- A POSA would have found Claims 15 and 18 of the ’991 Patent to be obvious over *Cromer*, *Ganu*, *Sinivaara*, and *Judd* (Ex-1019) and the

knowledge, skill, and creativity of a POSA. *Cromer, Ganu, Sinivaara*, and *Judd*, and the knowledge, skill, and creativity of a POSA, teach each element of these claims to a POSA, and a POSA would have been motivated to combine the teachings of these references.

9. Unless otherwise indicated, the emphasis, including coloring and bolding, in quoted material has been added.

II. QUALIFICATIONS

10. I and the Professor and Distinguished Chair in Computer Science at the University of Texas at Dallas and Professor Emeritus of Electrical and Computer Engineering at Cornell University.

11. I received my Doctor of Philosophy (Ph.D.) degree in the field of Electrical Engineering from Stanford University in 1988. As part of my Ph.D. research, I authored the thesis titled “Packet Switching in Fiber–Optic Networks.” I received my Masters of Science (M.Sc.) degree in Electrical Engineering, *summa cum laude*, from Tel-Aviv University in 1985 and my Bachelor of Science (B.Sc.) degree in Electrical Engineering, *summa cum laude*, from the Technion.

12. After receiving my Ph.D. degree from Stanford University, I worked as a member of the technical staff at AT&T Bell Laboratories from 1988 to 1995, initially in the Network Research Department in Holmdel, New Jersey. There, I performed research in the fields of wireless communications, mobility management,

fast protocols, optical networks, and optical switching. During my tenure at AT&T, I also worked for the AT&T Wireless Center of Excellence, in Whippany, NJ. There, I studied various aspects of wireless and mobile networks.

13. After my work at AT&T Bell Laboratories, I joined the faculty of Electrical & Computer Engineering at Cornell University in 1995, and over time I was promoted to Tenured Full Professor. While at Cornell, I headed my research group – the Wireless Networks Lab – which has had extensive contributions in the area of wireless communication systems and networks. I retired from Cornell University with the title of Emeritus Professor in 2013, and subsequently I joined the Computer Science Department at the University of Texas at Dallas with the title of Professor and Distinguished Chair in Computer Science. I have taught numerous courses related to computer networking and wireless communications both, at Cornell University as well at the University of Texas at Dallas. As part of my academic career, I have also served on numerous and various committees for the benefit of the scientific community.

14. I have served on the editorial board of a number of professional journals including Wireless Communications and Mobile Computing, Wireless Networks Journal, and the Journal of High Speed Networks. I have served as guest editor for the IEEE Journal on Selected Areas in Communications on several occasions.

15. I have worked for about 35 years in the fields of Electrical Engineering and Computer Science. The primary focus of my work has been, in general, on communication and networking systems, with an emphasis on wireless communication and wireless and mobile networks. I have authored and co-authored about 300 journal papers, conference papers, magazine articles, and book chapters. Also, I am named as an inventor or co-inventor on about twenty patents in the fields of high-speed networking, wireless networks, optical switching, etc. Examples of some of my publications include:

- C. Liu, Z.J. Haas, and Z. Tian, “On the Design of Multi-Hop Tag-to-Tag Routing Protocol for Large-Scale Networks of Passive Tags,” *IEEE Open Journal of the Communications Society*, Special Issue on *Large-Scale Wireless Powered Networks with Backscatter Communications*, vol. 1, 2020, pp. 1035-1055, July 24, 2020; DOI: 10.1109/OJCOMS.2020.3011171
- Z.J. Haas and A. Yousefpour, “A Privacy Scheme for Monitoring Devices in the Internet of Things,” In: N. Oliver et al. (eds) ‘Pervasive Computing Paradigms for Mental Health,’ Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol. 207, pp. 153-165, 2018, Springer, Cham; DOI: 10.1007/978-3-319-74935-8_22; Print ISBN: 978-3-319-74934-1; Online ISBN: 978-3-319-74935-8 (March 1, 2018)
- M. Nikolov and Z.J. Haas, “Encoded Sensing for Energy Efficient Wireless Sensor Networks,” *IEEE Sensors Journal*, 2017, Special Issue on “Power-efficient sensors for long-term applications,” vol. 18, no. 2, January 2018, pp. 875–889, DOI: 10.1109/JSEN.2017.2756865
- M. Nikolov and Z.J. Haas, “Relay Placement in Wireless Networks: Minimizing Communication Cost,” *IEEE Transactions on Wireless Communications*, vol.15, no.5, May 2016

- Z.J. Haas and M. Nikolov, “Towards Optimal Broadcast in Wireless Networks,” *IEEE Transactions on Mobile Computing*, vol. 14, no. 7, pp. 1530–1544, July 2015, DOI: 10.1109/TMC.2014.2356466
- G.Y. Lee and Z.J. Haas, “Simple, Practical, and Effective Opportunistic Routing for Short-haul Multi-hop Wireless Networks,” *IEEE Transactions on Wireless Communications*, 2011, pp. 3583–3588, DOI: 10.1109/TWC.2011.11.101713
- M.F. Elhawary and Z.J. Haas, “Energy-Efficient Protocol for Cooperative Transmission,” *IEEE Transactions on Networking*, vol. 19, no.2, April 2011, pp. 561–574, DOI: 10.1109/TNET.2010.2089803
- J. Oh and Z.J. Haas, “Personal Environment Service based on the Integration of Mobile Communications and Wireless Personal Area Networks,” *IEEE Communications Magazine*, vol. 48, no. 6, June 2010, pp. 66–72; DOI: 10.1109/MCOM.2010.5473866
- S.M. Nazrul Alam and Z.J. Haas, “Hierarchical and Honhierarchical Three-Dimensional Underwater Wireless Sensor Networks,” CoRR abs/1005.3073, 2010
- Z. Wang, R.J. Thomas, and Z.J. Haas, “Performance comparison of Bluetooth Scatternet formation protocols for multi-hop networks,” Springer *Wireless Networks (WINET)*, Volume 15, Number 2 / February, 2009, pp. 209–226, published online on April 14, 2007 (color copy); DOI: 10.1007/s11276-007-0036-7
- J. Oh and Z.J. Haas, “A Scheme for Location-Based Internet Broadcasting and Its Applications,” *IEEE Communications Magazine*, vol. 45, no. 11, November 2007, pp. 136–141, DOI: 10.1109/MCOM.2007.4378333
- Z.J. Haas and R. Barr, “Density-Independent, Scalable Search in Ad Hoc Networks,” Springer *International Journal of Wireless Information Networks*, special issue on “PIMRC 2005,” vol. 14, no. 2, June 2007, pp. 93–105
- Ben Liang and Zygmunt J. Haas, “Hybrid Routing in Ad Hoc Networks with Dynamic Virtual Backbone,” *IEEE Transactions on Wireless Communications*, vol. 5, no. 6, June 2006, pp. 1392–1405; DOI: 10.1109/TWC.2006.1638660
- Z.J. Haas, J.Y. Halpern, and E.L. Li, “Gossip-based Ad Hoc Routing,” *IEEE/ACM Transactions on Networking*, vol.14, no.3, June 2006, pp.479–491

- O. Arpacioglu and Z.J. Haas, “On the Capacity of Wireless Sensor Networks with Omnidirectional Antennas,” *Revista de Sociedade Brasileira de Telecomunicações*, vol.19, no.3, December 2004, pp.81–93
- P. Samar, M.R. Pearlman, and Z.J. Haas, “Independent Zone Routing: An Adaptive Hybrid Routing Framework for Ad Hoc Wireless Networks,” *ACM/IEEE Transactions on Networking*, vol.12, no.4, August 2004, pp.595–608; DOI: 10.1109/TNET.2004.833153
- Sajama and Z. J. Haas, “Independent-Tree Ad hoc Multicast Routing (ITAMAR),” *ACM MONET* journal, special issue on “Ad Hoc Networks,” vol. 8, no. 5, October 2003, pp. 551–566
- J. Li, Z. J. Haas, M. Sheng, and Y. Chen, “Performance Evaluation of Modified IEEE 802.11 MAC For Multi-Channel Multi-Hop Ad Hoc Network,” *Journal of Interconnection Networks (JOIN)*, special issue on “Advanced Information Networking: Architectures and Algorithms,” vol. 4, no. 3, September 2003, pp. 345–359
- Z.J. Haas and I. Akyildiz, “Mobile Computing and Networking,” *Wireless Networks*, Editorial, vol.3, no. 5, October 1997, pp 309–310; DOI: 10.1023/A:1019125805388

16. I have received numerous accolades for my work. Among other organizations, I am a Fellow of the IEEE (Institute of Electrical and Electronics Engineers) and a Fellow of the ACM (Association for Computing Machinery). In 2016 I have received the IEEE ComSoc AHSN Recognition Award for “outstanding contribution to securing ad hoc and sensor networks” from the IEEE Communication Society in 2016. In 2012, I have received the IEEE ComSoc WTC¹ Recognition Award, which recognizes individuals for outstanding technical contributions in the

¹ Wireless Communications Technical Committee.

field for their service to the scientific and engineering communities. As another example, I received the “Best Paper Award” for the paper “Optimal Resource Allocation for UWB Wireless Ad Hoc Networks” from the IEEE International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC) conference in 2005. Finally, in 2003, I received the “Highly Commended Paper Award” for co-authoring “Performance Evaluation of the Modified IEEE 802.11 MAC for Multi-Channel Multi-Hop Ad Hoc Network,” directed at advanced information networking and applications. Furthermore, many of my papers have been extensively cited by other authors, as indicated by various citation indices. For example, my paper on “Securing Ad Hoc Networks,” co-authored with a Ph.D. student at the time, has been cited over 4000 times by other publications according to the *Google Scholar* index. I have also taught courses that cover wireless communications and networking technologies, at the graduate and undergraduate levels. In addition, I have been invited to many international conferences to make keynote speeches regarding wireless and mobile networks.

17. I have previously testified in multiple IPR cases, including those concerning wireless networks.

III. RELEVANT LEGAL STANDARDS

18. I am not a lawyer, I do not opine on matters of law, and I do not provide any legal opinions in this Declaration. Although I am not a lawyer, I have been

informed by counsel that certain legal standards are to be applied by technical experts in forming opinions regarding the meaning and validity of patent claims. I have been asked by counsel to provide my opinions regarding whether the claims of the '991 Patent would have been obvious to a person having ordinary skill in the art at the time of the alleged invention, in light of the prior art.

19. Further, I have been informed by counsel that a patent claim is not patentable as obvious (a requirement I have been informed by counsel to be governed by a statute, 35 U.S.C. § 103) if the differences between the patent claim and the prior art are such that the claimed subject matter as a whole would have been obvious at the time the claimed invention was made to a person having ordinary skill in the relevant art. Obviousness, as I have been informed by counsel, is based on the scope and content of the prior art, the differences between the prior art and the claim, the level of ordinary skill in the art, and, to the extent that they exist, certain objective indicia of non-obviousness.

20. I have been informed by counsel that objective indicia can be important evidence regarding whether a patent is obvious or nonobvious, if it has an appropriate nexus to the claimed invention, *i.e.*, is a result of the merits of a claimed invention (rather than the result of design needs or market-pressure advertising or similar activities). Such indicia include: commercial success of products covered by the patent claims; a long-felt need for the invention; failed attempts by others to

make the invention; copying of the invention by others in the field; unexpected results achieved by the invention as compared to the closest prior art; praise of the invention by the infringer or others in the field; the taking of licenses under the patent by others; expressions of surprise by experts and those skilled in the art at the making of the invention; the patentee proceeding contrary to the accepted wisdom of the prior art, and, the contemporaneous development of the subject matter claimed by others.

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

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

23. I have been informed by counsel that a precise teaching in the prior art directed to the subject matter of the claimed invention is not needed. I have been informed by counsel that one may take into account the inferences and creative steps that a person of ordinary skill in the art would have employed in reviewing the prior art at the time of the invention. For example, if the claimed invention combined elements known in the prior art and the combination yielded results that were predictable to a person of ordinary skill in the art at the time of the invention, then this evidence would make it more likely that the claim was obvious. On the other hand, if the combination of known elements yielded unexpected or unpredictable results, or if the prior art teaches away from combining the known elements, then this evidence would make it more likely that the claim that successfully combined those elements was not obvious.

24. I have been informed by counsel that there are recognized, exemplary, rationales for combining or modifying references to show obviousness of claimed subject matter. Some of the rationales include the following: combining prior art elements according to known methods to yield predictable results; simple substitution of one known element for another to yield predictable results; use of a known technique to improve a similar device (method or product) in the same way; applying a known technique to a known device (method or product) ready for improvement to yield predictable results; choosing from a finite number of

identified, predictable solutions, with a reasonable expectation of success; known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art; and some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art teachings to arrive at the claimed invention.

IV. OVERVIEW OF THE '991 PATENT

A. Claimed Priority

25. The '991 Patent issued from U.S. 14/073,260, filed on November 6, 2013. Ex-1001 (21, 22); Ex-1002. I have been instructed to assume, for the purpose of this proceeding, that the priority date of the '991 Patent is March 14, 2005 ("Priority Date").

B. Disclosure

26. The '991 Patent is directed to a wireless hub that integrates wireless networks, such as a Wireless Local Area Network ("WLAN") and a Wireless Personal Area Network ("WPAN"). Ex-1001 (54), Abstract, 1:17-18.

27. According to the '991 Patent, "interoperability between WPAN and WLAN networks" is hindered by "severe interference ... when devices conforming to [WPAN and WLAN] standards are ... in the same physical vicinity." Ex-1001

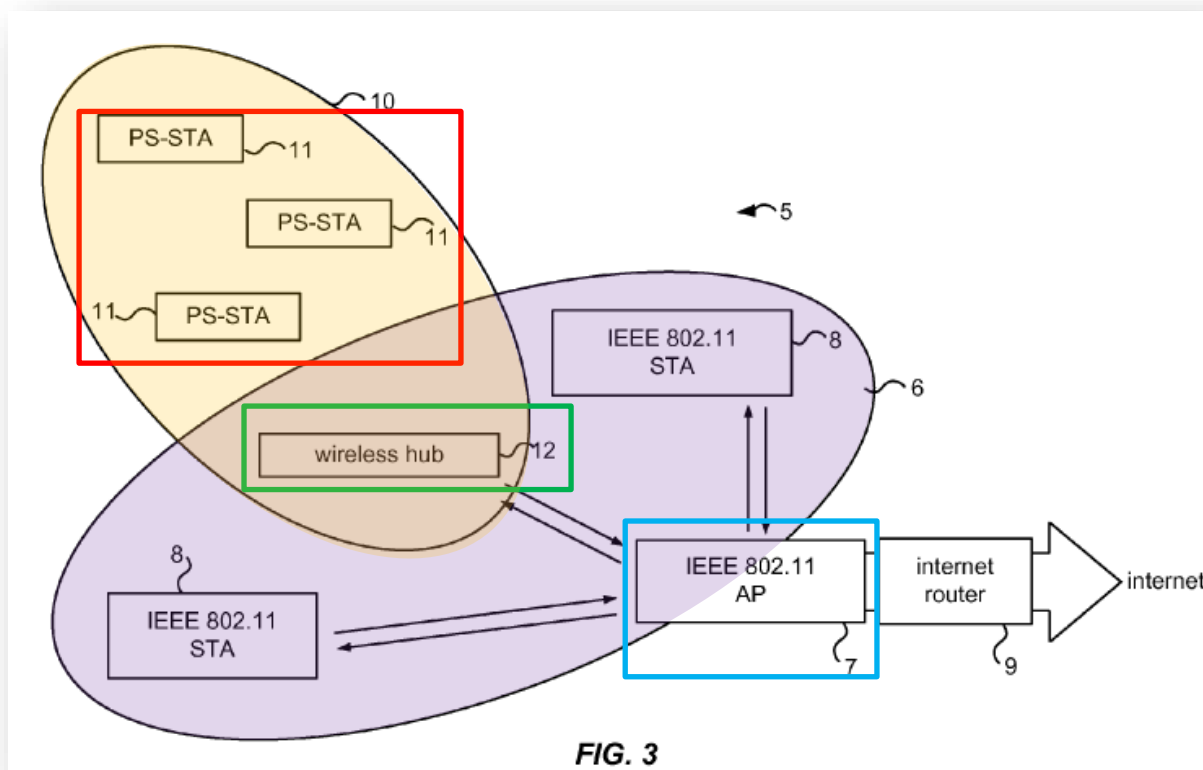
2:31-39. This interference is caused by, for example, 802.11² (WLAN) and Bluetooth (WPAN) protocols using “the same 2.4-GHz frequency band” while “the protocols use different methods of accessing the wireless medium, and are not synchronized with one another.” *Id.* 1:32-40, 2:29-36. While “[o]ne alternative for avoiding the[se] ... problems ... is to use network interface circuitry based on the WLAN protocol in WPAN [stations, “STAs”] ... the power dissipation of the resulting STA would be ... higher than what is acceptable in typical WPAN applications.” *Id.* 2:37-43. “[This] power dissipation” results from, *inter alia*, WLAN’s “high transmit powers” that enable stations “to communicate with the [access point, “AP”], which may be, for example, 300 feet away,” “stringent receiver sensitivity requirements,” and the “significant protocol overhead associated with ... establish[ing] and maintain[ing] an ... infrastructure network.” *Id.* 2:55-3:12.

28. The '991 Patent purports to address these issues with a “**wireless hub 12** adapted to facilitate seamless communication between the **WLAN** and the **WPAN**” where “**wireless hub 12** includes, in part, a wireless 802.11x-compliant wireless circuit that can communicate with the **AP 7** disposed in infrastructure

² In this Declaration, “802.11” refers to the IEEE 802.11x protocols making up the IEEE 802.11 standard. *See, e.g.*, Ex-1025 25-26.

WLAN 6 [and] ... [power-sensitive stations] PS-STAs 11 disposed in WPAN 10.”

Ex-1001 4:55-58, 5:11-12, 5:41-46.



Ex-1001 Fig. 3 (annotated). “[W]ireless hub 12 is placed within the range of the AP 7 of the infrastructure WLAN 6” and “each of the PS-STAs 11 in the WPAN 10” at ranges that “depend[] on the application.” *Id.*, 5:58-63. Wireless hub 12 may include a “wireless circuit [that] can connect to the WPAN without losing connectivity (such as association and synchronization) to the WLAN,” allowing wireless hub 12 to “act[] as a pivot and provide[] communication between the corresponding WPAN and WLAN [nodes],” thereby enabling PS-STAs 11 “to become part of the larger WLAN infrastructure[.]” *Id.* Abstract, 3:59-62, 5:58-63,

6:43-45. This connection can be maintained (such as by maintaining association/synchronization) during an “inactivity period,” wherein “communication function[s may be] disabled” by **wireless hub 12**, **PS-STA 11**, or both. *Id.* 15:39-48, 8:10-21 (“PS-STAs are typically mostly in sleep mode and only occasionally wake up ... [for] data and/or control signals.”).

29. Although the '991 Patent mentions conventional WPAN protocols such as Bluetooth (Ex-1001 2:14-29), the patent discloses embodiments using modified WLAN protocols (namely 802.11) to support WPAN environments. Ex-1001 Abstract, 7:13-17, 9:60-66, Claim 7, Claim 19 (16:59-61).

C. Prosecution History

30. I have reviewed Ex-1002, the prosecution history of the application that issued as the '991 Patent. From my review, I understand that the Applicant argued various prior art references did not use networks in overlapping areas, stating the wireless networks of the prior art “appear to be in separate spaces not in common,” and thus would not “interfere with each other in the wireless medium”—a “problem” that the art did not mention. Ex-1002 121-122, 063-065. I further understand, from my review, that the Examiner added the following limitation to the prior to allowing the '991 Patent:

and wherein at least some of the communications using the
second network protocol impinge on at least some

antennae used for communications using the first network
protocol;

Ex-1002 027-036.

31. However, the distinctions suggested by the Applicant are disclosed by the references discussed herein, and the subject matter claimed, including the Examiner's amendment, would have been obvious by in view of the obviousness analysis I present in this Declaration, which is based on different references which were not present before the Examiner. Ex-1002 (generally).

V. CLAIM CONSTRUCTION

32. I have been advised by counsel that, in order to properly evaluate the claims of the '991 Patent, the terms of the claims must first be interpreted. I am informed and understand that the terms in the '991 Patent are to be given their plain and ordinary meaning in view of the specification and prosecution history as would have been understood by a person of ordinary skill in the art ("POSA," defined below in § VI.A) as of the Priority Date. That is the meaning I have applied in my analysis.

33. I have been informed by counsel that the Board does not construe claim terms unless the terms are in controversy, and then only to the extent necessary to resolve the controversy.

34. I have followed these principles in my analysis throughout this Declaration. It is my opinion that no specific construction of any term is required

because the relied-upon prior art meets each of the claimed terms under any proper construction.

35. Additionally, I have been informed by counsel that a district court issued several claim constructions pertinent to the Challenged Claims. Ex-1010 (hereafter “*Markman Order*” or Ex-1010). I reference these constructions of Ex-1010 in the analysis below, which satisfies these constructions.

36. I also address a claim term in element [1h] (*data forwarding logic*), that I was informed by counsel that the court found was **not** governed by means plus function:

[1h] implement data forwarding logic, implemented in a network-enabled hub using hardware and/or software, that forwards data between an originating node and a destination node ...

Ex-1001 14:64-67; Ex-1010 21-22.

37. I was informed by counsel that when claim language is “governed by means plus function,” it is given a special meaning in patent law. I am instructed by counsel and understand that a means-plus-function element does not cover all of the structures that could perform the function set forth in the claim. Instead, it covers a structure or a set of structures that performs that function and that is either identical or “equivalent” to at least one of the sets of structure(s) described in the patent specification and that is necessary for performing the claimed function. I was informed by counsel that structure taught by the prior art, alone or in combination,

is an “equivalent” of the corresponding structure in the patent specification if a POSA either would have considered the differences between them to be insubstantial at the time of the invention or if that person would have found that the structures performed the identical function in substantially the same way to accomplish substantially the same result. I was informed by counsel that in deciding whether the differences would be insubstantial, I should consider whether a POSA would have known of the interchangeability of the structures. I further was informed by counsel that even if the prior art, alone or in combination, is not identical or an equivalent to the corresponding structure(s), that the claimed subject matter is still unpatentable if it would have been obvious to a POSA.

38. I have been instructed by counsel to analyze the claims under the Court’s construction, namely that plain meaning, and not means-plus-function, applies.

39. Additionally, I was instructed by counsel to provide an alternative analysis of this claim element under the assumption that means-plus-function applies. For this, alternative analysis, I have been instructed by counsel to apply the structure and function that I was notified Ozmo identified to the district court (Ex-101021):

Structure	Support
“Software platform 36 (Fig. 6), wireless circuit 27, processing unit 28, memory module 29, radio 21, baseband modem 22, and/or control and datapath logic 33, and their equivalents.”	Ex-1001 Fig. 6, 4:32-34, 6:29-32, 6:41-7:3
Function	Claim 1 [1h]
<i>“forwards data between an originating node and a destination node”</i>	

40. Thus, in my analysis below, I analyze how the references as set forth below render this claim element obvious using both the plain meaning of the claim element and the structures and functions above, using the above instructions given to me by counsel concerning means-plus-function law.

41. If a Board or Court construes any term of the '991 Patent, I reserve the right to supplement my opinions in view of such a construction(s).

VI. STATE OF THE ART

A. Level of Ordinary Skill in the Art

42. I have been advised by counsel that a person of ordinary skill in the relevant art is a hypothetical person who is presumed to be aware of all pertinent prior art, thinks along conventional wisdom in the art, and is a person of ordinary creativity.

43. Unless otherwise stated, my testimony below refers to the knowledge of one of ordinary skill in the art as of March 14, 2005, the date that I was advised by counsel to use as the priority date of the '991 Patent. I am familiar with the knowledge and capabilities of one of ordinary skill in the art as of that priority date.

44. In my opinion, as to the '991 Patent, a person of ordinary skill in the art ("POSA") in March of 2005 would have had a Bachelor degree in Electrical Engineering or a similar degree and two years of professional experience working in wireless networking, including WLAN and WPAN protocols and devices. More experience could supplement for less education and vice versa. The level of skill in the art is further demonstrated by the references cited herein. While this Declaration may occasionally use the present tense, my analysis is from the perspective of a POSA as of the time of the purported invention. Minor changes in the precise definition of a POSA would not change the obviousness analysis below.

45. By virtue of my education, experience, and training in academia and industry, I am familiar with the level of skill in the art of the '991 Patent in the 2005 timeframe. I had at least the qualifications of a POSA in 2005.

B. State of the Art and the General Knowledge of a POSA

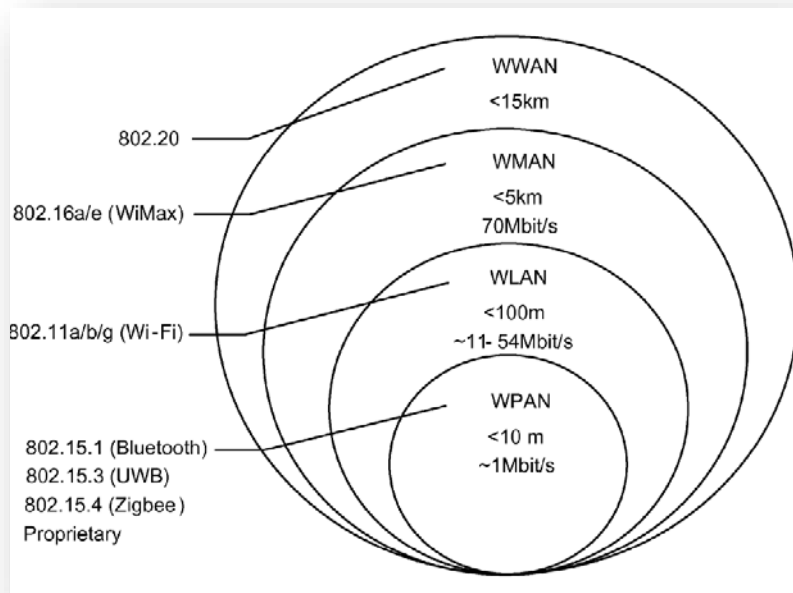
46. In this section, I describe the state of the art, including the general knowledge, skill, common sense, and creativity possessed by a POSA as of March 2005. It explains the conventional purposes and structures of conventional

components in the art, informing the motivations and reasonable expectations of success for the obviousness analysis I present in §§ VII-X .

47. As explained below, by March of 2005, WLAN and WPAN were well known networking concepts, with developed standards such as 802.11 and Bluetooth, and developed techniques for integrating WLAN and WPAN environments in dual-mode devices.

1. Well Known Wireless Networks and Standards

48. As admitted by the '991 Patent, there were several “standards for wireless connectivity ... known in the prior art” before March 2005. Ex-1001 4:15-17. As was known by a POSA, such prior art standards, which included 802.11 and Bluetooth, were commonly grouped “[b]ased on targeted range and supported data rate.” Ex-1001 1:27, 1:32-2:13 (describing 802.11), 2:17-36 (describing Bluetooth). The '991 Patent illustrated the known, typical characteristics of prior art networking environments:



Ex-1001 Fig. 1, 2:40-43 (discussing power dissipation differences between WLAN and “typical WPAN applications.”), 2:66-3:3 (discussing “typical” WLAN data rates), 4:2-6 (discussing overhead of “typical” WLAN networks.).

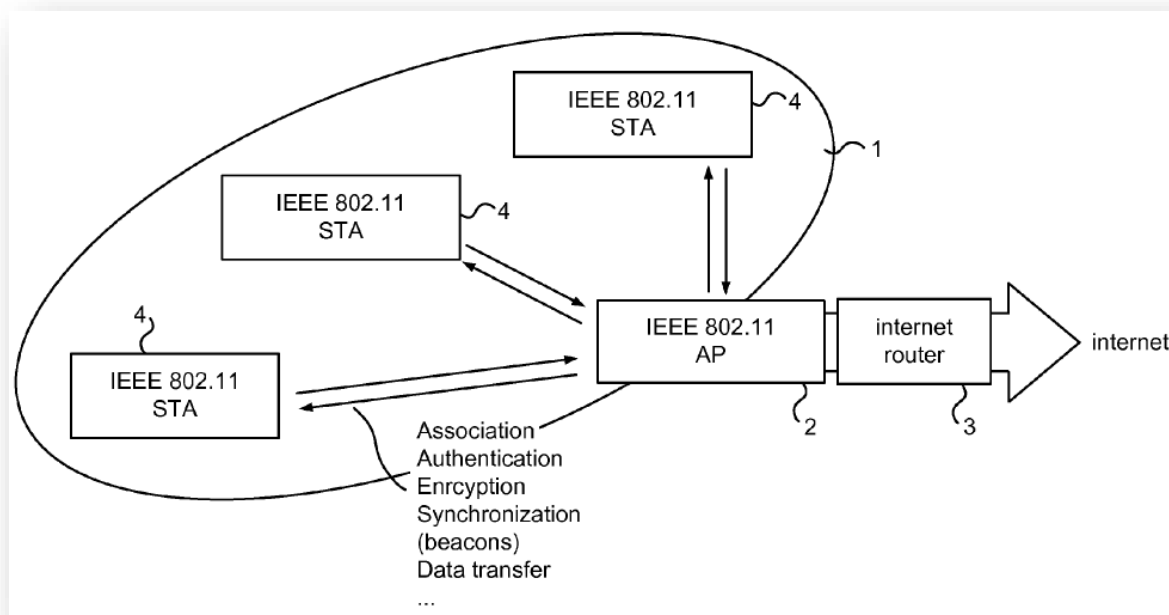
49. While Figure 1 of the ’911 Patent characterized 802.11 as a WLAN protocol, it was known that 802.11 specified “ad-hoc” protocols that supported WPAN environments. *See, e.g.*, Ex-1028 398; Ex-1020 (proposing various WPAN applications for 802.11 in 1998); Ex-1001 1:50-56 (admitting that the “802.11x standard is rapidly finding its way in new applications.”).

2. The 802.11 “Wi-Fi” Standard

50. A POSA knew the 802.11 standard as highly successful and widely deployed. Ex-1029; Ex-1025 25-26 (“802.11 ... is now commonly installed in offices, airports, coffee shops, etc. Many laptops now come with 802.11b built-in

... 802.11b is now the most common [WLAN].”); Ex-1001 1:41-45. The ’991 Patent further admits “[t]he majority of laptops manufactured ... include a built-in wireless circuit compliant with some variant of the 802.11x standard” that were “well known in the art.” Ex-1001 1:48-50, 6:39-40; see also Ex-1025 25-26.

51. It was known that 802.11 provided “ad-hoc” and “infrastructure” operations. Ex-1028 398; Ex-1029 10-11; Ex-1001 1:61-63. The “more often” used infrastructure protocols “incorporate[d] access points to communicate between mobile devices and the wired network or other wireless networks.” Ex-1028 398. The ’991 Patent illustrated an infrastructure 802.11 network in Figure 2:



Ex-1001 1:60-2:13, Fig. 2.

52. The coordination activities of 802.11 included association functions implemented by, *e.g.*, “association requests.” Ex-1029 iv (“The [802.11] protocol

includes authentication, **association**, and reassociation services”), 3 (“3.4 association: The service used to establish access point/station (AP/STA) mapping and enable STA invocation of the distribution system services (DSSs).”), 6 (“AID” is the “association identifier”), 10 (“To become a member of an infrastructure BSS, **a station shall become ‘associated.’**”), 18 (“Before a STA is allowed to send a data message via an AP, **it shall first become associated with the AP.**”), 25 (“For a STA to associate, the association service causes the following messages to occur: *Association request*”) (emphasis in original), 34-36 (defining MAC frame format for “association request[s]” and “beacon[s]”).

53. The coordination activities of 802.11 also included association synchronization functions implemented by, *e.g.*, “beacons.” Ex-1029 46 (defining fields of beacons, including “timestamp,” “beacon interval,” and transmission parameters), 51 (“The Beacon Interval field represents the number of time units (TUs) between target beacon transmission times (TBTTs).”), 123 (“**All STAs within a single BSS shall be synchronized** to a common clock using the mechanisms defined herein In an infrastructure network, the AP shall be the timing master and shall perform the [timing synchronization function] TSF The **AP shall periodically transmit special frames called *beacons*** that contain a copy of its TSF timer to synchronize the other STAs in a BSS”), 136 (describing the association procedure between an AP and STA); Ex-1001 2:12-13, Fig. 2.

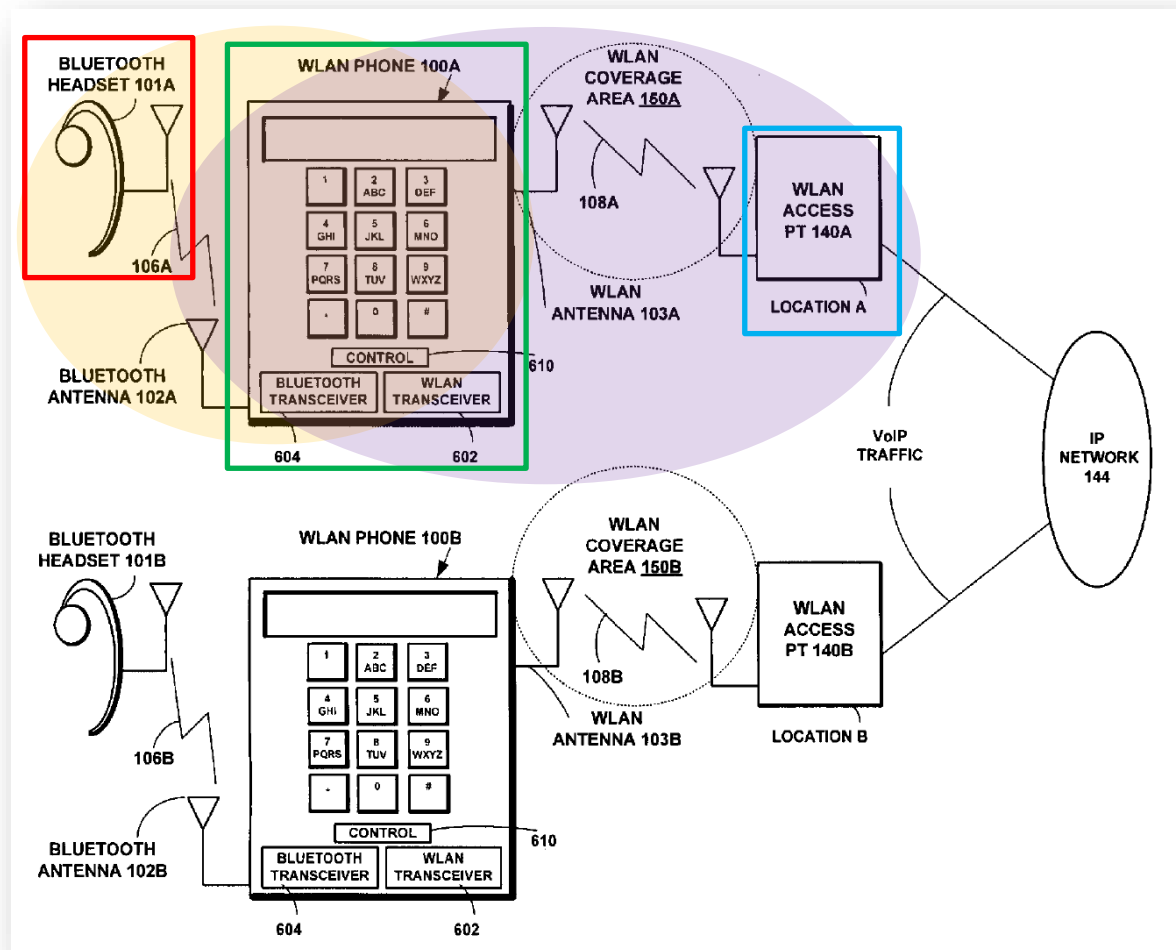
54. Conversely, ad-hoc networks “d[id] not have a backbone infrastructure,” “involve[d] at least two wireless stations,” and “[was] not intended for long-range use, but [was] normally implemented in rooms or sections of a building.” Ex-1028 398. A POSA knew that “[a]d hoc mode [was] a peer-to-peer networking paradigm in which each mobile client communicates directly with other mobile clients in the network,” and that “[c]ommunication outside of the cell [could] take place if a cell member operate[d] as a routing service.” *Id.* A POSA further knew that individual nodes managed the networking functions in an ad-hoc network, including synchronization. Ex-1029 123 (“Each STA in the BSS shall transmit beacons.”).

55. POSAs additionally recognized that 802.11 ad hoc protocols supported WPANs. *See, e.g.*, Ex-1028 398; Ex-1020 (proposing various WPAN applications for 802.11 in 1998); Ex-1001 1:50-56 (explaining that the “802.11x standard is rapidly finding its way in new applications.”).

3. Devices Utilizing Two Wireless Protocols Were Well Known

56. By March of 2005, it was well known to provide “dual-mode” devices that integrated two wireless networking protocols—including dual usage of WLAN and WPAN protocols. The concepts, techniques and considerations for integrating WLAN and WPAN protocols were well known. For example, U.S. Patent Application Publication US 2006/0194538 to Palin et al. (“*Palin*,” Ex-1021)

described a **wireless terminal/phone 100A** operating in both a “**PAN network** in a communications band [using] a first communications protocol” such as Bluetooth and in a “**WLAN network** in substantially the same communications band [using] a second communications protocol” which included 802.11:



Ex-1021 Abstract, [0005], Fig. 1 (annotated). *Palin* disclosed solutions for “reducing interference in [the] simultaneous wireless LAN (WLAN) and wireless personal area network (PAN),” allowing the WLAN and WPAN to coexist, while overlapping physically. Ex-1021 Abstract. *Palin* was not alone in disclosing such

solutions. Ex-1022 1:20-23 (describing computer communicating over “a WPAN or Bluetooth link,” “while simultaneously communicating with an 802.11 [AP]”) 4:52-58, 3:21-28; Ex-1023 Abstract (supporting simultaneous WLAN and WPAN communications); Ex-1024 Abstract (wireless terminal providing “concurrent 802.11 and Bluetooth activity”); Ex-1027 Abstract (“multi-user, multiband, and multi-protocol” wireless “repeater”); Ex-1007 23, 35 (“bridging node” enabling the “seamless integration” of WLAN and WPAN network devices “in a power efficient way.”); Ex-1008 Abstract, 5:49-51 (“dual-mode radio (DMR)” allowing Bluetooth™ and 802.11 protocol “to co-exist.”).

57. Range and communication benefits of devices that could integrate WPAN and WLAN protocols were well known to a POSA. Ex-1021 [0006, 0008] (“[c]ombining the short range PAN (*e.g.*, Bluetooth) and the longer range WLAN (*e.g.*, IEEE 802.11g) features in a unitary, mobile terminal enables a user to tap into area-wide WLAN access points and to operate local I/O devices without a cable connection” such as used during voice over IP (VOIP).”), [0004-0005, 0024] (describing VOIP operations as forwarding data packets between WLAN and WPAN).

58. The concepts, techniques and considerations for integrating WLAN and WPAN protocols were well known and predictable to a POSA. *See, e.g.*, US 7,194,642 (Ex-1022) 1:20-23 (“[A] computer may communicate with a printer, for

example, over a WPAN or Bluetooth link or network while simultaneously communicating with an 802.11 Access Point (AP) via a 802.11 WLAN network.”), 4:52-58, 3:21-28; US 8,208,449 (Ex-1023) Abstract (supporting simultaneous WLAN and WPAN communications); US 2004/0048577 (Ex-1024) Abstract (“wireless telecommunications terminal” enabling “concurrent 802.11 and Bluetooth activity”); US20020028655A1 (Ex-1027) Abstract (“multi-user, multiband, and multi-protocol” wireless “repeater”); *Manzoni* (Ex-1007) 23, 35 (“bridging node” enabling the “seamless integration” of WLAN and WPAN network devices “in a power efficient way.”); and US 7,643,463 (Ex-1008) Abstract, 5:49-51 (disclosing a “dual-mode radio (DMR) ... [that] allows Bluetooth™ protocol and 802.11 protocol devices to co-exist.”).

VII. Claims 1, 3-4, 6-7, 14, and 16-17 Are Obvious over *Cromer* in View of *Ganu*

A. The *Cromer* Reference (Ex-1004)

59. U.S. Patent No. 7,389,352 to Cromer et al. (“*Cromer*”), is titled “Concurrent WLAN and WPAN Wireless Modes from a Single Device.” Ex-1005.

I have been informed by counsel that *Cromer* is prior art.

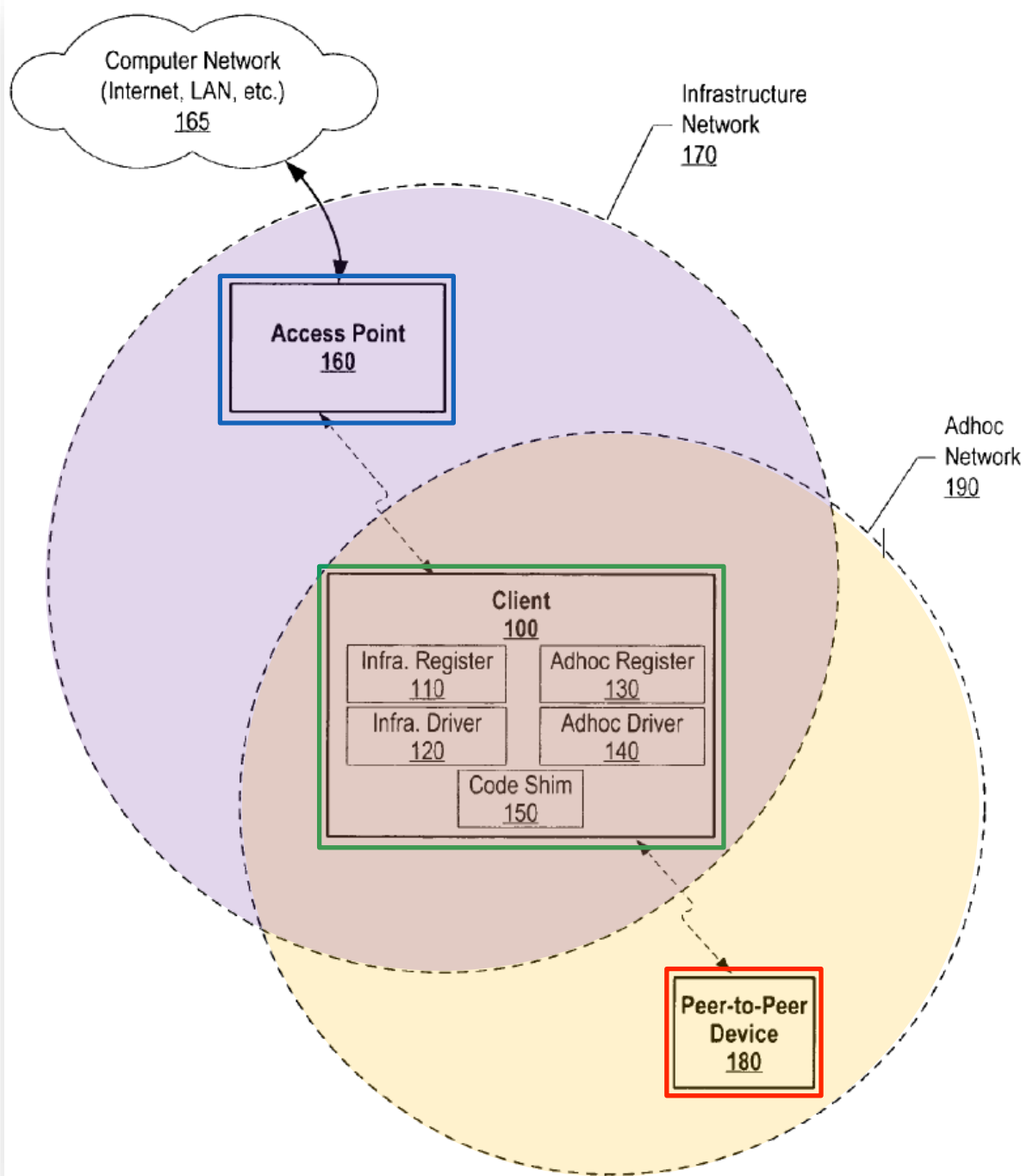
60. *Cromer* was not cited or applied by the examiner during the examination of the ’991 Patent. Ex-1002.

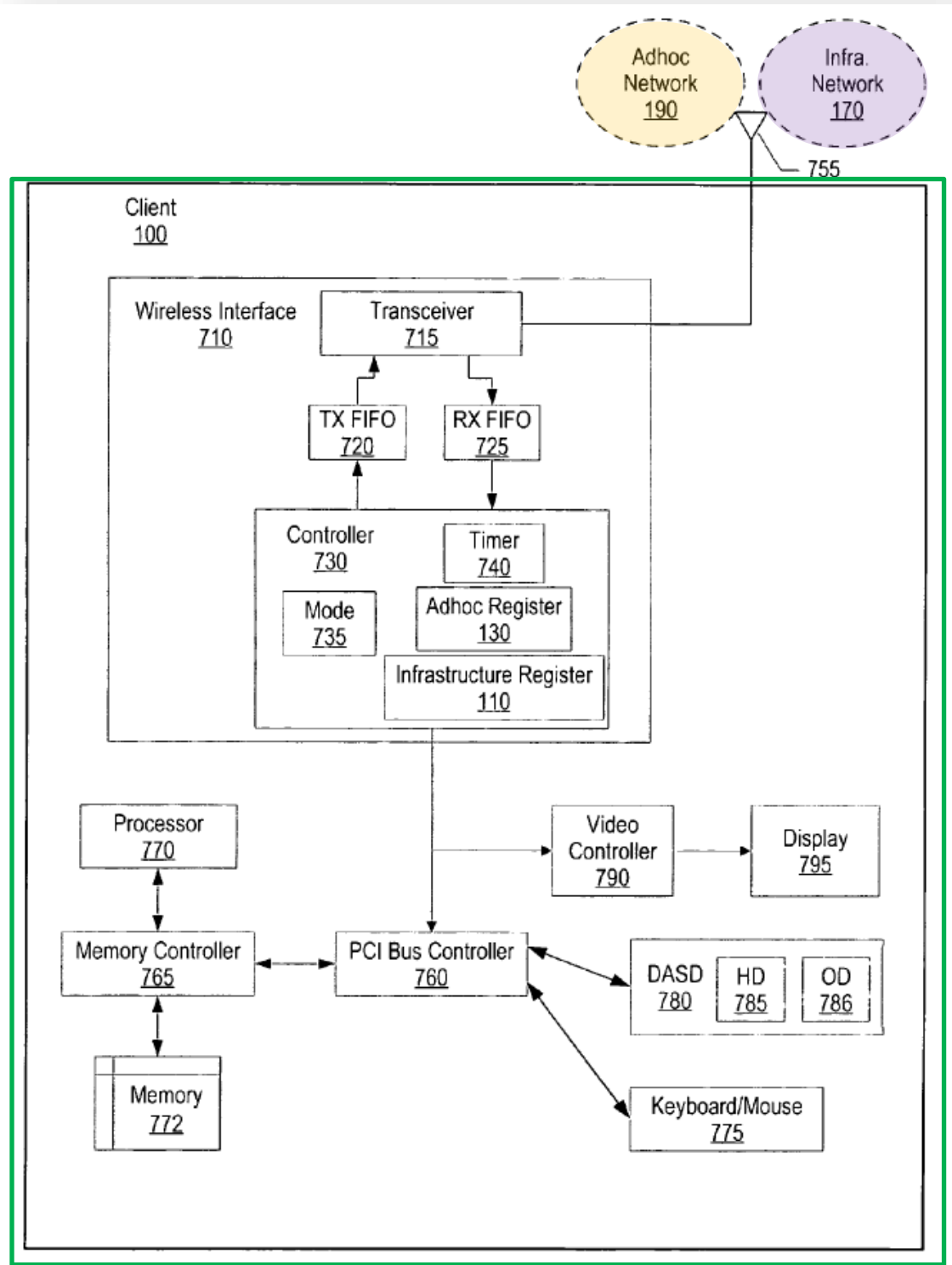
61. It is my opinion that *Cromer* is analogous art to the claimed invention of the ’991 Patent. For example, the field of endeavor of the claimed invention is

generally “wireless communications” and, particularly, “seamlessly integrating” two different wireless networks, such as a WPAN and an infrastructure WLAN. Ex-1001 (54), Abstract, 1:17-21, 14:39-45. The ’991 addresses this goal by utilizing an 802.11-complaint **wireless hub** that communicates with both an **AP 7** in an infrastructure **WLAN 6** and **PS-STAs 11** in **WPAN 10**. Ex-1001 4:55-58, 5:11-12, 5:41-46. *Cromer* is in the same field of endeavor, because it generally describes wireless communications and, particularly, “communicating concurrently in a plurality of wireless environments. Ex-1004 1:8-10. Further, *Cromer* is reasonably pertinent to the problem addressed by the claimed invention, because *Cromer* disclosed “a **single Wi-Fi device** to concurrently communicate in a **wireless LAN**” with, *e.g.*, an **AP**, “and a **wireless PAN** environment” with, *e.g.*, **handheld devices** such as a **PDA**. Ex-1004 1:8-10, 3:38-51.

62. *Cromer* taught a wireless “**client 100**” that corresponds to the wireless hub of the ’991 Patent. Specifically, *Cromer* disclosed “[a] system and method for concurrent **WLAN** and **WPAN** wireless modes from a **single device** A **client uses a Wi-Fi device’s** infrastructure mode to communicate in a **WLAN** environment and, during idle WLAN times, uses the **Wi-Fi device’s** adhoc mode to communicate in a **WPAN** environment.” Ex-1004 Abstract; *see also id.* 2:53-56 (“FIG. 1 is a diagram showing a **client using a single Wi-Fi device** to concurrently operate in both a **Wireless LAN (WLAN)** environment and a **Wireless Personal Area**

Network (WPAN) environment”), 3:1-3 (“FIG. 7 is a block diagram of an information handling system, such as a **client device**, capable of implementing the present invention”).





Ex-1004 Figs. 1, 7 (annotated).

63. “When **client 100’s** Wi-Fi device is in infrastructure mode, client 100 uses infrastructure driver 120 to send and receive information to **access point 160** over **infrastructure network 170**. **Access point 160** is a wireless LAN device that also allows **client 100** to access computer network 165, such as the Internet.” Ex-1004 3:39-46; Fig. 1 (annotated, above). “When **client 100’s** Wi-Fi device is in adhoc mode, **client 100** uses adhoc driver 140 to send and receive information to **peer-to-peer device 180** over **adhoc network 190**. **Peer-to-peer device 180** is a wireless PAN device, such as a projector, PDA, or printer.” Ex-1004 3:46-51; Fig. 1 (annotated, above).

B. The *Ganu* Reference (Ex-1005)

64. *Ganu* is a published article titled “Architecture and Prototyping of an 802.11-Based Self-Organizing Hierarchical Ad-Hoc Wireless Network (SOHAN).” Ex-1005. I have been informed by counsel that *Ganu* is prior art.

65. *Ganu* was not cited or applied by the examiner during the examination of the ’991 Patent. Ex-1002

1. Printed Publication Prior Art Status

66. I have been informed by counsel that in order to be prior art, non-patent literature, such as *Ganu*, must be disseminated or otherwise made available such that persons interested and ordinarily skilled in the subject matter or art, exercising reasonable diligence, can locate it. Based on my experience and understanding as

an expert and in consideration of a POSA, in my opinion, *Ganu*, as a paper of an IEEE conference, was both disseminated and made available by at least the IEEE such that persons interested and ordinarily skilled in the subject matter or art of *Ganu*—as well as the '991 Patent, exercising reasonable diligence, could readily locate *Ganu*.

67. *Ganu* is an article contained in the proceedings of 2004 IEEE 15th International Symposium on Personal, Indoor, and Mobile Radio Communications (“PIMRC 2004”) held 5-8 September 2004. Ex-1005. These topics—Personal, Indoor, and Mobile Radio Communications—were highly relevant to subject matter of the claimed invention of the '991 Patent (§ IV), and thus persons interested and ordinarily skilled in the art, exercising reasonable diligence in keeping apprised of the state of the art in WLAN and WPAN developments would have known about the PIMRC 2004.

68. Additionally, persons interested and ordinarily skilled in the art would have also recognized that at least *Ganu*'s title (*e.g.*, “802.11,” “Ad-Hoc,” “Wireless Network,”) would have given an ordinarily interested artisan an indication of the subject matter of *Ganu*, as well as of being highly relevant to subject matter of the claimed invention of the '991 Patent (§ IV). Such interested artisans would use such search terms when exercising reasonable diligence in keeping apprised of the state of the art in WLAN and WPAN developments.

69. I'm quite familiar with IEEE conferences generally, and specifically with the PIMRC conference series, having had my own papers published/presented at PIMRC conferences between 1994 and 2021, (including one receiving Best Paper Award):

- T.N. Do, G. Kaddoum, T. L. Nguyen, D.B. da Costa, and Z.J. Haas, "Aerial Reconfigurable Intelligent Surface-Aided Wireless Communication Systems," ***IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC'21)***, Virtual Conference, September 13–16, 2021
- C. Zou and Z.J. Haas, "Optimal Resource Allocation for UWB Wireless Ad Hoc Networks," ***16th Annual IEEE International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC 2005)***, International Congress Center (ICC), Berlin, Germany, September 11-14, 2005; DOI: 10.1109/PIMRC.2005.1651477 (Best Paper Award)
- Y. Lee and Z.J. Haas, "Authentication in Very Large Ad Hoc Networks using Randomized Groups," ***16th Annual IEEE International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC 2005)***, International Congress Center (ICC), Berlin, Germany, September 11-14, 2005; DOI: 10.1109/PIMRC.2005.1651788
- Z.J. Haas and R. Barr, "Density-independent, Scalable Search in Ad Hoc Networks," ***16th Annual IEEE International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC 2005)***, International Congress Center (ICC), Berlin, Germany, September 11-14, 2005; DOI: 10.1109/PIMRC.2005.1651669
- Z.J. Haas and Y-B. Lin, "On optimizing the location update costs in the presence of database failures," ***9th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC'98)***, pp. 650–654, Boston, MA, Sept. 8–11, 1998; DOI: 10.1109/PIMRC.1998.734326
- Z.J. Haas and C.-P. Li, "A Simple Scheme to Improve the Performance of Your Cellular System," ***IEEE PIMRC'96***, pp. 813–817, Taipei, Taiwan, October 15–18, 1996; DOI: 10.1109/PIMRC.1996.568394
- M.J. Karol, Z.J. Haas, and C.B. Woodworth, "Performance Advantages of Time-Frequency-Sliced Systems," ***6th International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC'95)***,

- pp. 1104–1111, Toronto, Canada, September 27-29, 1995; DOI: 10.1109/PIMRC.1995.477319
- Z.J. Haas and S. Paul, “Secure Access to Electronic Newspaper,” **5th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC’94)**, Wireless Networks, pp. 805–809, The Hague, Holland, September 19-23, 1994; DOI: 10.1109/WNCMF.1994.529075
- Z.J. Haas, J. H. Winters, and D. S. Johnson, “Simulation Study of Capacity Bounds in Cellular Systems,” **PIMRC’94**, The Hague, Holland, September 19-23, 1994, paper no. B.7.2, vol. 4. pp. 1114-1120
- C. B. Woodworth, M. J. Karol, Z.J. Haas, and R. D. Gitlin, “Spectrally Efficient Universal Time Slots Using Time-Frequency-Code Slicing,” **5th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, (PIMRC’94)**, pp 1009–1013, The Hague, Holland, September 19-23, 1994; DOI: 10.1109/WNCMF.1994.529110

70. Further, I have extensive knowledge of the workings of PIMRC, having been a member of the PIRMC Technical Program Committee in 2012, 2005, 1998, and 1995.

71. From my experience, the IEEE’s typical practice was to make the proceedings of a conference typically distributed at or near the first day of the conference to attendees, and typically no later than the last day of the conference.

72. The IEEE also provided lists of conferences such that persons interested and ordinarily skilled in the art would be aware of them and/or could plan to attend. For example, I understand that Ex-1017 contains an IEEE webpage archived in July 2004. Ex-1017 001. Listed here are conferences, including PIMRC 2004. Persons of ordinary skilled in the art and interested in the subject matter of *Ganu* and the

'991 Patent, would have reviewed this IEEE website, and would have been informed of this conference.

73. The IEEE also provided further details for the conference, listing that 740 persons had registered to attend, and provided a publication number—"TH8754"—that could be used to find the proceedings. Ex-1017 002. This type of information is typical in my experience, and as such persons interested and ordinarily skilled would have looked to the IEEE conference pages for such details. Further, the listed number of attendees (740) is consistent with my general PIMRC experience around those years.

74. The IEEE conference webpage (Ex-1017 002) provides a link to the specific PIMRC 2004 website. I understand that Ex-1018 is this website archived around July 2004. Ex-1018. This website shows various details about PIMRC 2004, including:

- *Ganu* was an invited paper of PIMRC 2004 (Ex-1018 002)
- The Final Program (Ex-1018 003), which I understand was downloaded from this webpage and is presented at Ex-1018 005-114, showing *Ganu* at page 035 (color highlighting in original)
- A history of the PIMRC Conference (Ex-1018 004)

75. It is my experience that such websites, like Ex-1018, were routinely relied upon by those interested in WLAN and WPAN developments. Further, the history of PIMRC at Ex-1018 004 is consistent with my experience regarding attendees of this conference

76. Persons interested and ordinarily skilled in the art would have been able to locate and obtain a copy of *Ganu* and the conference proceedings for PIMRC 2004 through the IEEE. This would include both through the IEEE Xplore online library and the IEEE Online Store (Ex-1017 004). I understand Ex-1017 003-004 are archives of these websites archived in February 2001 and August 2004, respectfully, and such websites are consistent with my experience. Such websites provided the ability to search for articles by title, author, description, IEEE publication information (such as that provided on the IEEE website (Ex-1017 002)), in addition to more advanced search techniques provide on IEEE Xplore (Ex-1017 003).

77. I understand Ex-1015 is a such copy of *Ganu* downloaded from the IEEE Xplore.

78. Finally, persons interested and ordinarily skilled would have looked to research libraries to keep apprised on developments in the subject matter of WLAN and WPANs, such as disclosed by *Ganu* and the '991 Patent. While I offer no opinions on each and every detail of the Declaration of Dr. Ingrid Hsieh-Yee (Ex-1009), I have nonetheless reviewed it and agree with her conclusion that *Ganu* would have been further accessible via research libraries, based on my own experience.

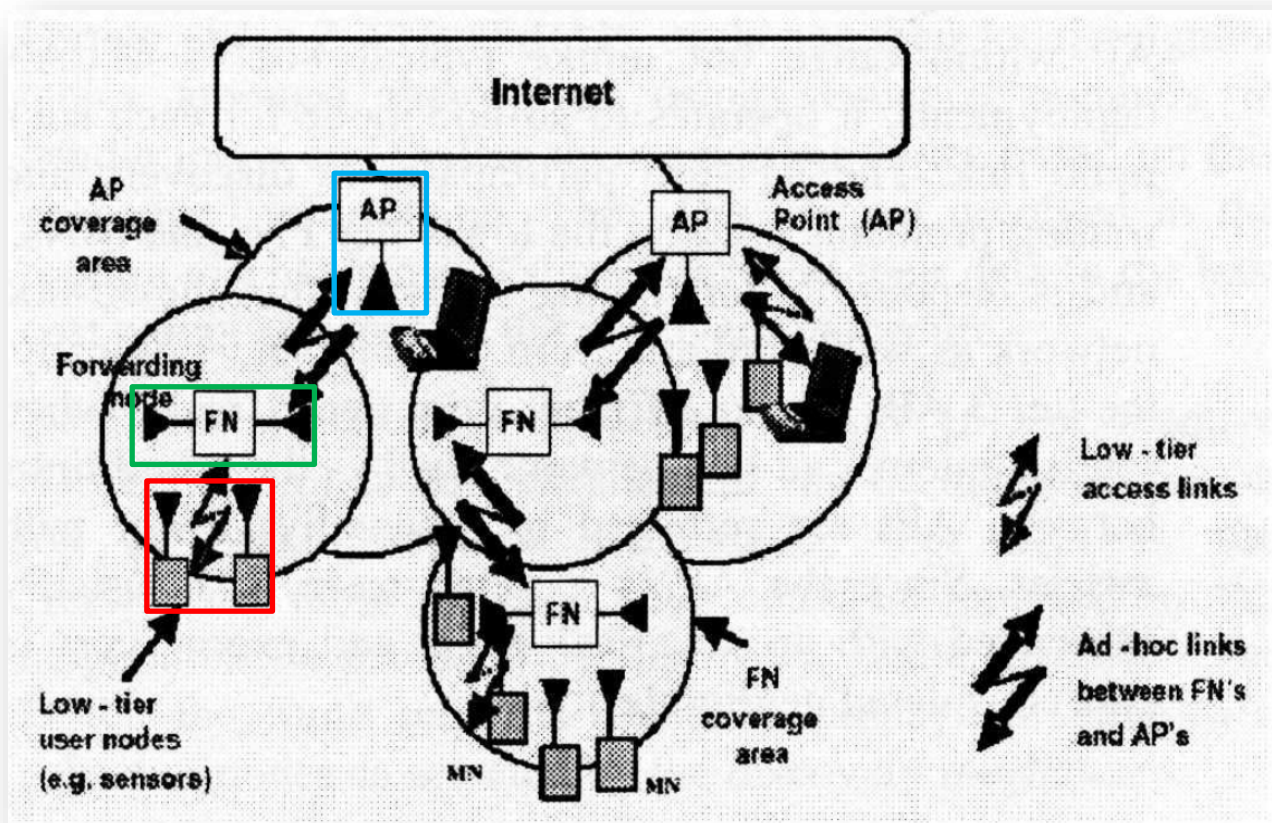
2. Analogous Art

79. It is my opinion that *Ganu* is analogous art at least because it is directed to the same field of endeavor of the '991 Patent's claimed invention, which was

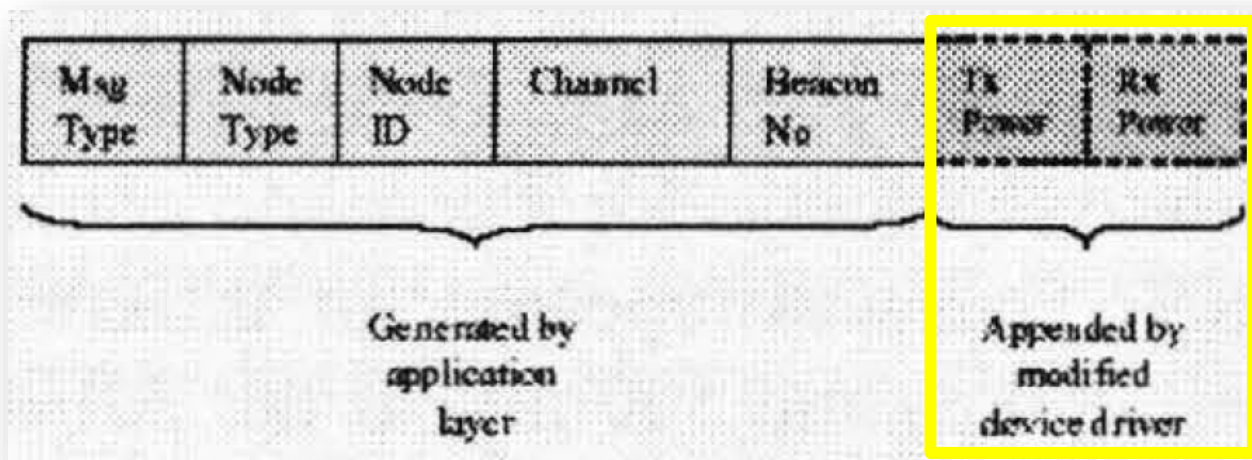
generally directed to “wireless communications” and, particularly, “seamlessly integrating” two different wireless networks, such as by a **wireless hub** that communicated with an **AP** in a **WLAN** and **power-sensitive stations** in a **WPAN**. Ex-1001 (54), Abstract, 1:17-21, 14:39-45, 4:55-58, 5:11-12, 5:41-46. Likewise, *Ganu* was directed to an “802.11-based ... Wireless Network” and similarly disclosed “**forwarding nodes (FN)** [acting] as intermediate radio relays between the **[mobile nodes] MNs** and **APs**.” Ex-1005 001. *Ganu* is also analogous art because it modified the 802.11 protocol to support WPAN environments, which was reasonably pertinent to the ’991 Patent’s modifications to 802.11 for the same purpose. Ex-1005 001; Ex-1001 7:13-16, 9:64-66, 15:32-38.

3. Teachings

80. *Ganu* disclosed modifying 802.11 protocols. Ex-1005 001. These modifications enabled 802.11 nodes to form a “self-organizing hierarchical **ad-hoc** wireless network (SOHAN)” having a “tier[ed] hierarchy consisting of low-power **mobile nodes (MNs)** at the lowest layer, **forwarding nodes (FNs)** with higher power and multi-hop routing capability at the middle layer, and wired **access points (APs)** without power constraints at the highest layer.” *Id.* (italics in original). Figure 1 showed the SOHAN:



Ex-1005 Fig. 1 (annotated). *Ganu's* SOHAN “introduce[d] ... one or more tiers of ad-hoc forwarding nodes (FN) as intermediate radio relays between the MNs [Mobile Nodes] and APs helps to scale network throughput, reduce delay and lower power consumption at end-user devices.” Ex-1005 001. Lower power consumption was achievable by modifying the 802.11 ad-hoc protocol by (1) using two new power fields—“Tx Power” and “Rx Power”—appended to 802.11 MAC beacon frames and (2) adding 802.11-like association to the ad-hoc protocol:



Ex-1005 003, Fig. 4 (annotated). MNs in the ad-hoc network achieved power savings by using the power-field information to choose “the best ‘cost’ parent”—*i.e.*, associating with the FN that required the least amount of power to reach. *Id.* 003. *Ganu* further taught that using its technique of discovering and self-organizing into FNs reduced routing overhead compared to traditional ad-hoc networks. Ex-1005 002-003 (“Discovery”), Fig. 3. The reduction in routing overhead meant fewer routing messages and, therefore, saved power. *Id.*

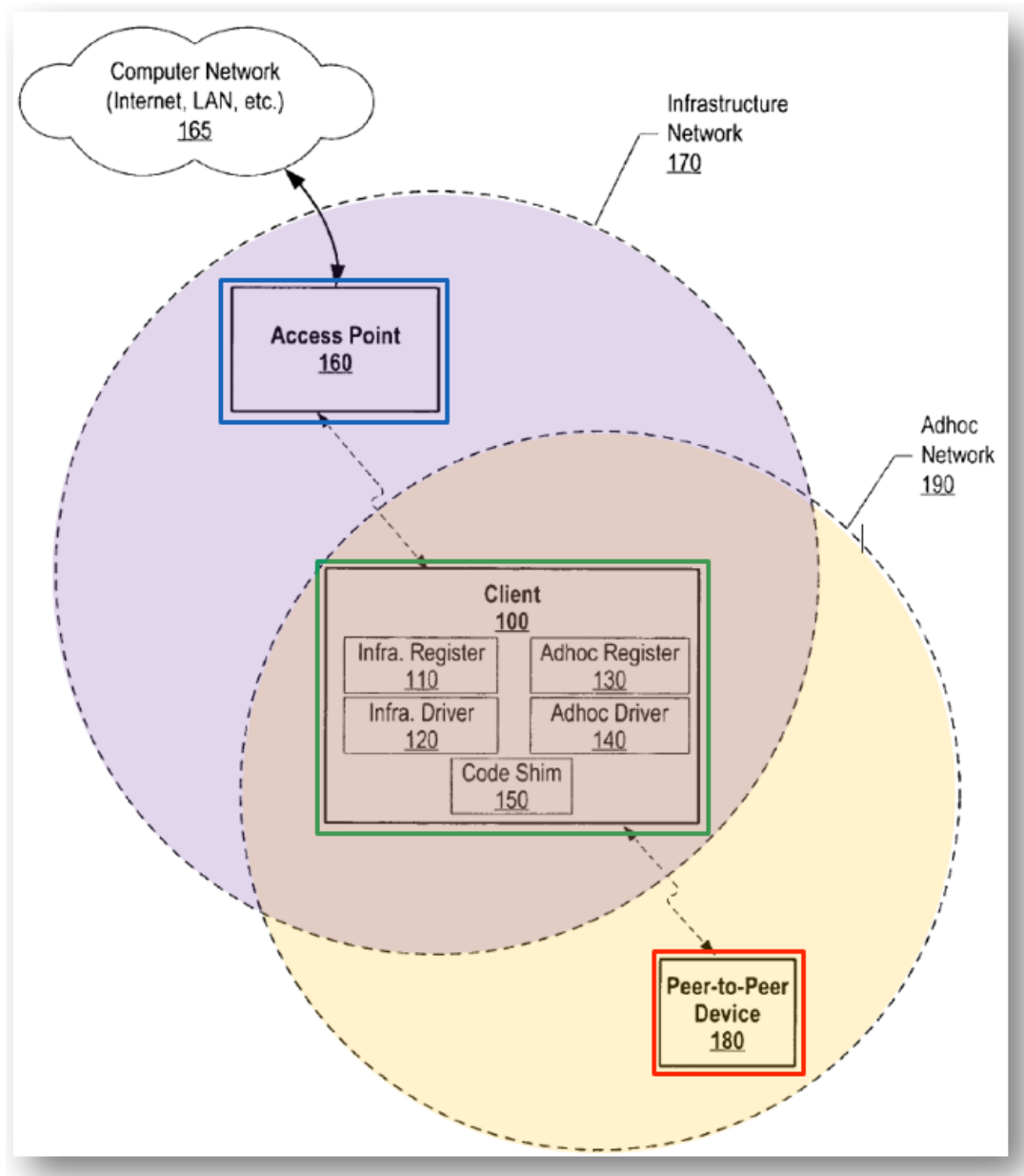
C. Detailed Application to the Claims

1. Claim 1

- a. *[1pre] A network-enabled hub, usable for facilitating data communications between two or more wireless devices that are configured to communicate indirectly with each other via the network-enabled hub, comprising:*

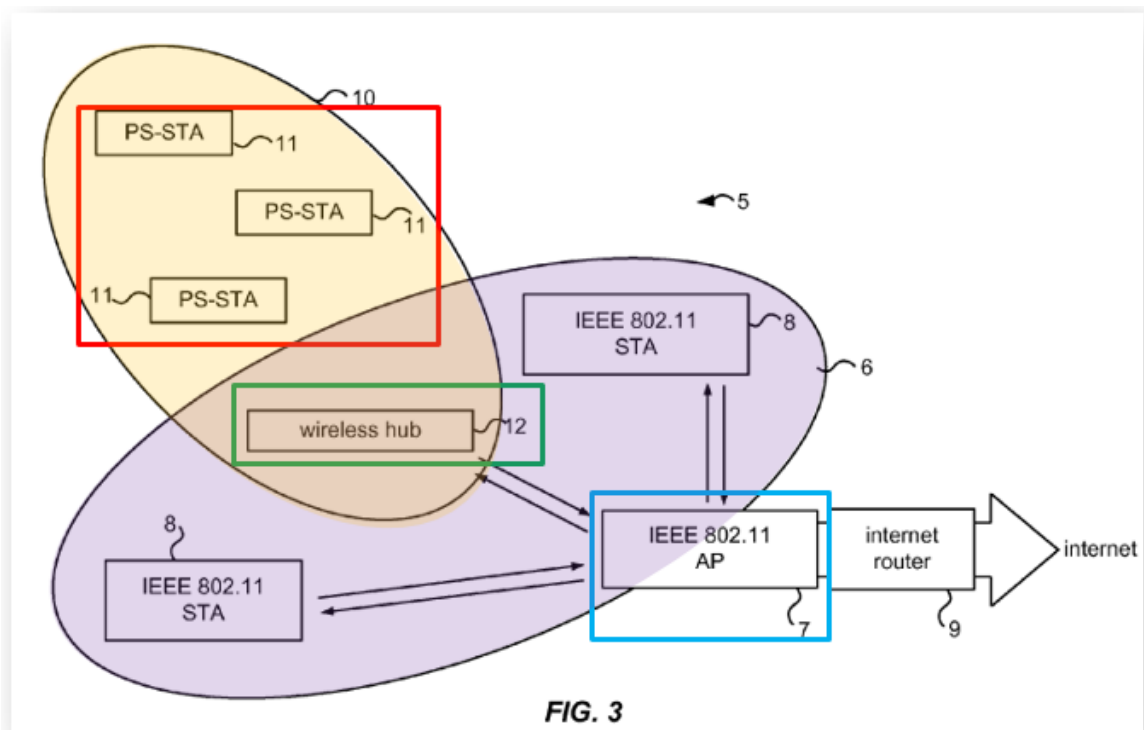
81. To the extent that the preamble is limiting, *Cromer*, at least as modified by *Ganu*, taught the preamble.

82. Cromer described a **client device 100** that, as modified by Ganu, served as a forwarding node (FN) (a network-enabled hub, usable for facilitating data communications) between **access point 160** and **peer-to-peer device 180** (two or more wireless devices that are configured to communicate indirectly with each other via the network-enabled hub).



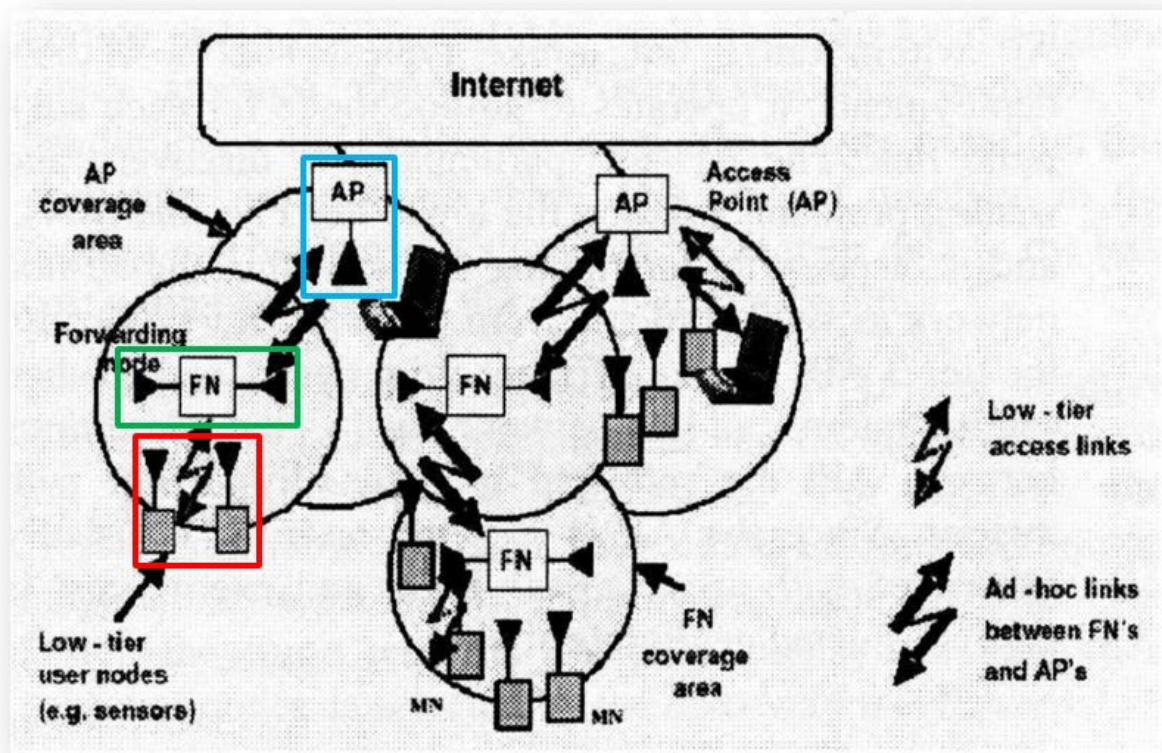
Ex-1004 Fig. 1 (annotated). Cromer's "FIG. 1 is a diagram showing a **client [100]** **using a single Wi-Fi device** to concurrently operate in both a **Wireless LAN (WLAN) [170]** environment and a **Wireless Personal Area Network (WPAN) [190]** environment." Ex-1004 3:16-23. When **client 100's** Wi-Fi device is in "infrastructure mode," client 100 "send[s] and receive[s] information to **access point 160** over infrastructure network 170," where "[a]ccess point 160 is a wireless LAN device that also allows client 100 to access computer network 165, such as the Internet"; additionally, "when client 100's Wi-Fi device is in adhoc mode, client 100 ... send[s] and receive[s] information to **peer-to-peer device 180** over adhoc network 190." Ex-1004 3:39-51, 2:1-29. *Cromer's* client 100 was a "computer system" such as a personal computer (Ex-1004 7:30-45, Fig. 7) that "concurrently communicate[d]" with the infrastructure/WLAN and ad-hoc/WPAN networks, such as a computer using the former to access the Internet, while using the latter to connect with WPAN peripherals such as printers, projectors, and handheld devices. Ex-1004 1:39-44, 2:2-4, 5:2-6, 3:49-51.

83. For context, the '991 Patent discloses similar examples of its **wireless hub** and its position relative to the **WLAN** and **WPAN**. Ex-1001 6:1-5 (personal computers etc.), 5:3-18 (WLAN for internet communications; WPAN for communications with "**peripherals and accessories** for personal computers"), 9:42-47 (**printers** etc.), Fig. 9.



Ex-1001 Fig. 3 (annotated).

84. Likewise, *Ganu* taught using “ad-hoc **forwarding nodes (FN)** as **intermediate radio relays** between the **MNs** and **APs**” for the express benefits of “help[ing] to scale network throughput, reduce delay and lower power consumption at end-user devices.” Ex-1005 001. Each forwarding node (FN) is “capable of routing multi-hop traffic” in the ad-hoc network. *Id.* 002. Thus, *Ganu* explains that **forwarding nodes (FN)** facilitate data communications between the **MNs** and **APs** to, *e.g.*, allow MNs to access the internet via the FN and AP—the “most realistic usage scenario[.]” *Id.* 001-002.



Ex-1005 Fig. 1 (annotated). Client device 100, when configured as a FN as taught by *Ganu*, was a *network-enabled hub* because it provides communication between *Cromer's* WLAN and WPAN, providing relay/repeater functionality between the two networks. Ex-1028 41 (describing hubs). Further, *Ganu's* disclosure regarding the FN is like the '991 Patent's **wireless hub**. Ex-1001 6:43-45 (“The **wireless hub** acts as a pivot and provides communication between the corresponding **WPAN** and **WLAN**.”), 5:58-61.

85. A POSA would have found it obvious to combine the FN's data forwarding technique of *Ganu* with *Cromer*, such that *Cromer's* **client 100** relayed—or, forwarded—data between **access point 160** and **peer-to-peer device**

180, thereby rendering client 100 *a network-enabled hub, usable for facilitating data communications between two or more wireless devices that are configured to communicate indirectly with each other via the network-enabled hub.*

86. Specifically, a POSA would have been motivated to incorporate *Ganu's* teaching of FNs using data forwarding techniques to relay internet traffic between MNs and APs into *Cromer's* system such that client device 100 relays data between peer-to-peer WPAN devices 180 and AP 160, allowing peer-to-peer WPAN devices 180 to communicate with AP 160 via client device 100 and access the Internet. Ex-1004 2:1-4; 3:38-51(internet); Ex-1005 001-002; *cf.* Ex-1001 6:43-45, 5:58-61; see also Ex-1028 (“Communication outside of the [ad-hoc] cell can take place if a cell member operates as a routing service.”).

87. A POSA would have understood that providing *Ganu's* relaying capability to *Cromer's* client device 100 would have enabled common and self-evident communication abilities between a remote device or server in communication with **AP 160** and a **WPAN device 180** (via AP 160 and **client device 100**) such as (a) when using a WPAN device 180 to print, display or store a file from a remote server (such as a file on the Internet); (b) forwarding software (*e.g.* driver/firmware updates) from a remote server for installation on a WPAN device 180; (c) exchanging control, status or diagnostic signals between a WPAN device 180 (*e.g.* printer ink) and a remote server (*e.g.* a web hosted dashboard for the

printer); (d) synchronizing WPAN device 180 with a remote server; or (e) streaming data communications between a WPAN device 180 (*e.g.* a headset or speaker) and a remote device (such as a remote phone, computer, or media server) to stream media (such as a VoIP call, videoconference audio, music, etc.). Ex-1004 1:39-44, 2:25-29, 3:49-51; § VI.B.2-3; Ex-1008 9:11-14 (relay synchronizing a handheld WPAN device to server via 802.11 WLAN); Ex-1028 398 (describing ad-hoc intermediate “member operat[ing] as a routing service.”).

88. A POSA further would have recognized that combining the data-forwarding techniques of *Ganu* with *Cromer* required nothing more than routine skill to achieve predictable and conventional communication abilities. Ex-1005 003; Ex-1028 398. A POSA would have had a reasonable expectation of success; indeed, *Ganu* even states that its data forwarding techniques are implementable in the “most realistic usage scenario” involving mobile traffic (Ex-1005 001) and configuring a wireless device to serve as an intermediary routing service was known. Ex-1028 398. There is nothing that a POSA would have found counter-intuitive, unpredictable, surprising or technologically challenging about the combination and providing the resulting system as discussed above. As reflected by the references themselves, and the well-developed nature of wireless networking protocols at the time, the combination was well within the skill of a POSA. *See supra* §§VI.A-B. Further, as explained more fully in [1e], a POSA would have been motivated to

incorporate *Ganu*'s forwarding techniques into *Cromer*'s system such that client 100 follows *Ganu*'s expressly taught benefits of doing so, namely to “scale network throughput,” “reduce delay” and “lower power consumption at end-user devices” such as *Cromer*'s handled devices (*e.g.*, PDAs). Ex-1005 001; *supra* [1e].

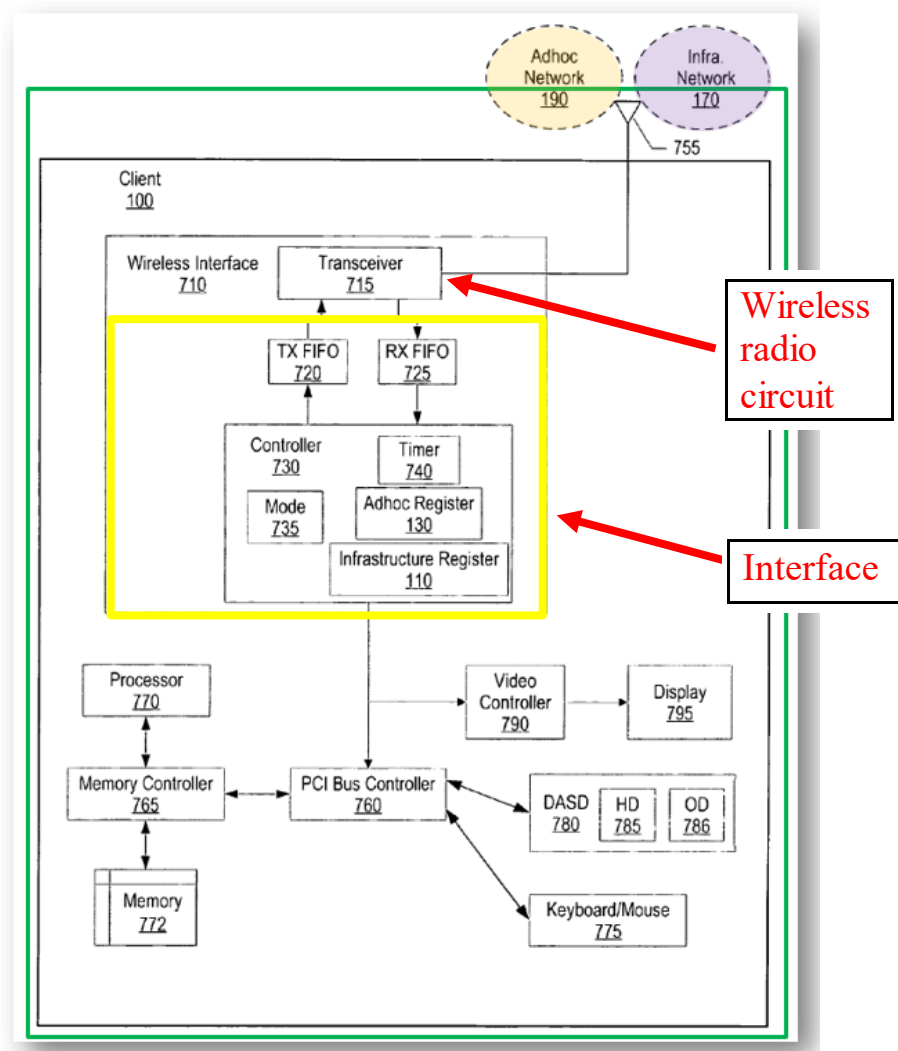
89. Thus, the combination would have been obvious for multiple reasons. Further, the combination would have involved no more than applying a simple technique known from *Ganu* to the client device of *Cromer* to yield predictable results of providing communication capabilities readily performed by *Cromer*'s client device—namely, allowing **client device 100** to relay data between **access point 160** and **peer-to-peer device 180** and facilitate data communication between devices 160 and 180 such that devices 160 and 180 communicate with each other indirectly via client device 100. Ex-1028 398. *Ganu*'s teachings and benefits as discussed would have led a POSA to modify *Cromer* to achieve those benefits, readily arriving at the claimed subject matter.

b. [1a] [the network-enabled hub, comprising] an interface to a wireless radio circuit that can send and receive data wirelessly, providing the hub with bi-directional wireless data communication capability;

90. *Cromer* taught this element.

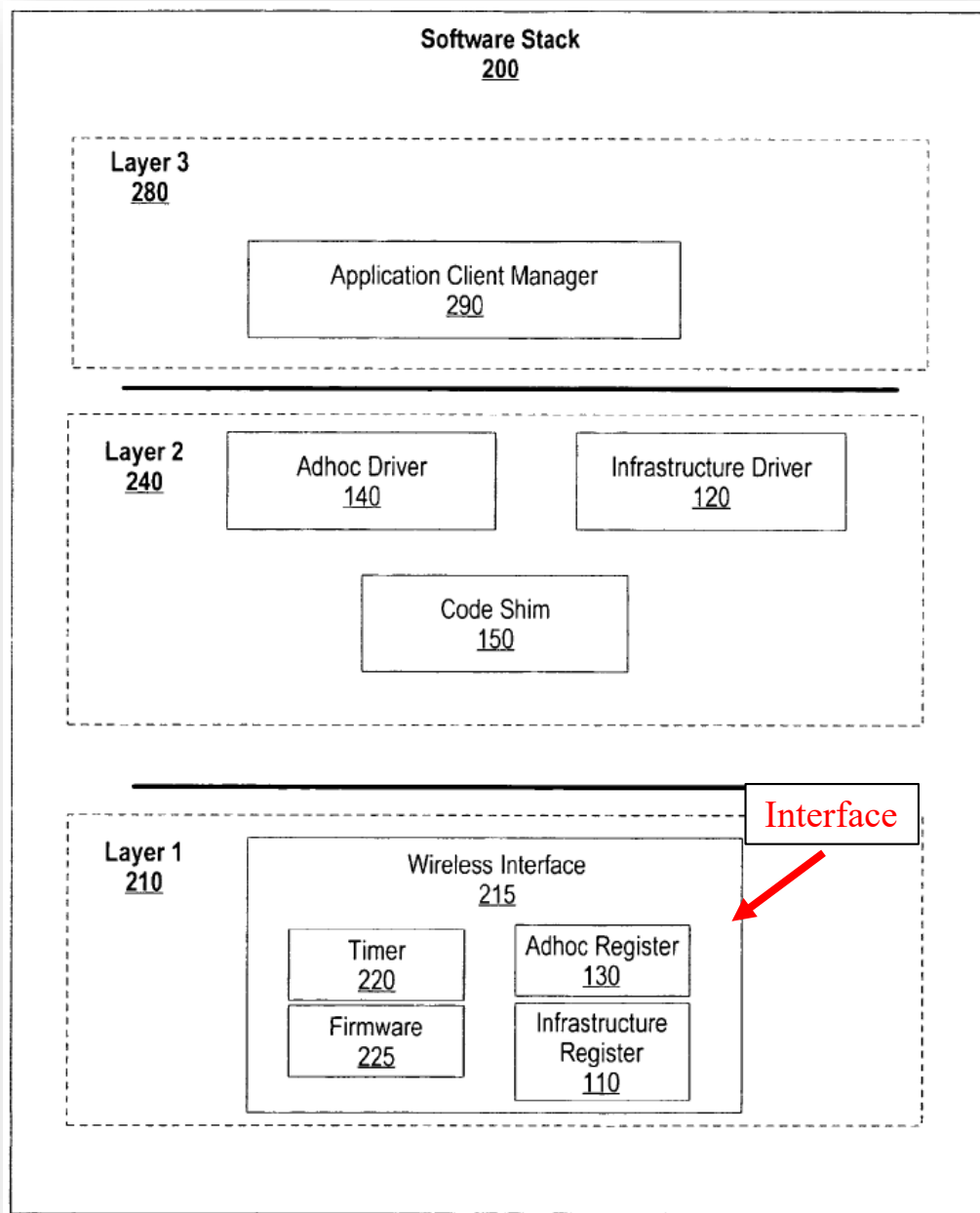
91. *Cromer* disclosed client device 100 (*network-enabled hub*) comprising Tx/Rx FIFO buffers 720/725 and controller 730 of wireless interface 710 and the associated software of wireless interface 215 (together, *an interface*) to transceiver

715 (to a wireless radio circuit that can send and receive data wirelessly,) providing
client device 100 (the hub) with bi-directional wireless data communication
capability.



Ex-1004 Fig. 7 (annotated). The transmit and receive buffers (“TX FIFO 720 and RX FIFO 725”) provide part of the *interface* as they “couple controller 730 to transceiver 715,” the *wireless radio circuit*, and “are used to buffer transmission and reception of data packets that are sent to and received from network devices,” thereby allowing controller 730 and transceiver 715 to interact and the transmission and reception of data. Ex-1004 7:18-21, Fig. 7.

93. Software is also part of the *interface*. *Cromer* disclosed a “wireless interface 215” module in the “software stack” of client 100, shown in Figure 2:



Ex-1004 3:61-67, Fig. 2 (annotated). The software stack 200 includes Layer 1 210 which “**interfaces** with a client’s wireless **interface** hardware using wireless **interface** 215.” Ex-1004 3:62-65. In particular, the modules of the wireless interface 215 (Ex-1004 3:62-65) correspond to the modules of the controller 730 in

hardware wireless interface 710 (Ex-1004 7:21-22) and provide the lowest layer (“Layer 1”) interface to transceiver 715 (*wireless radio circuit*). *Id.* Thus, that Layer 1, comprising wireless interface 215, of software stack 200 provided the software interface associated with the hardware interface coupling to transceiver 715 (*wireless radio circuit*) using the modules shown in Layer 1 210 and controller 730. Ex-1004 3:61-4:36, Figs. 2 and 7.

94. *Cromer’s* transceiver 715 is a *wireless radio circuit that can send and receive data wirelessly*. *Cromer* disclosed that “**Transceiver 715** is an RF (radio frequency) transmitter that uses **antenna 755** to **communicate** with other devices on infrastructure network 170 and adhoc network 190.” Ex-1004 7:11-21. Thus, a POSA would have understood that transceiver 715 is a *wireless radio circuit* because it provides wireless communication via radio and such transceivers were well-known to be implemented via circuitry. *Id.* A “transceiver,” such as transceiver 715 (*wireless radio circuit*), provided for both transmitting (*i.e.*, sending) and receiving data wirelessly (*that can send and receive data wirelessly*). *Id.*

95. Moreover, because Tx/Rx FIFO buffers 720/725 and controller 730 of wireless interface 710 and the associated software of wireless interface 215 (together, *interface*) “are used for transmission and reception of data packets that are sent to and received from network devices” via radio transmission (*i.e.*, RF) and interface with a communication network, they *provid[ed]* **client device 100** (*the*

hub) with bi-directional wireless data communication capability. Ex-1004 3:61-4:36, 7:18-29, Figs. 2 and 7, Fig. 1 (bidirectional arrows between client 100 and both of AP 160 and peer-to-peer device 180). Further, because transceiver 715 (wireless radio circuit) allows for both transmitting (i.e., sending) and receiving data wirelessly (i.e., bi-directional wireless data communication) as discussed using an RF transmitter and antenna 755, transceiver 715 (wireless radio circuit) provid[ed] client device 100 (the hub) with bi-directional wireless data communication capability. Id.

c. [1b] [the network-enabled hub, comprising] a processor configured to:

96. *Cromer* alone, and in combination with *Ganu*, taught this element.
97. First, *Cromer* disclosed a “processor 770” (*a processor*):

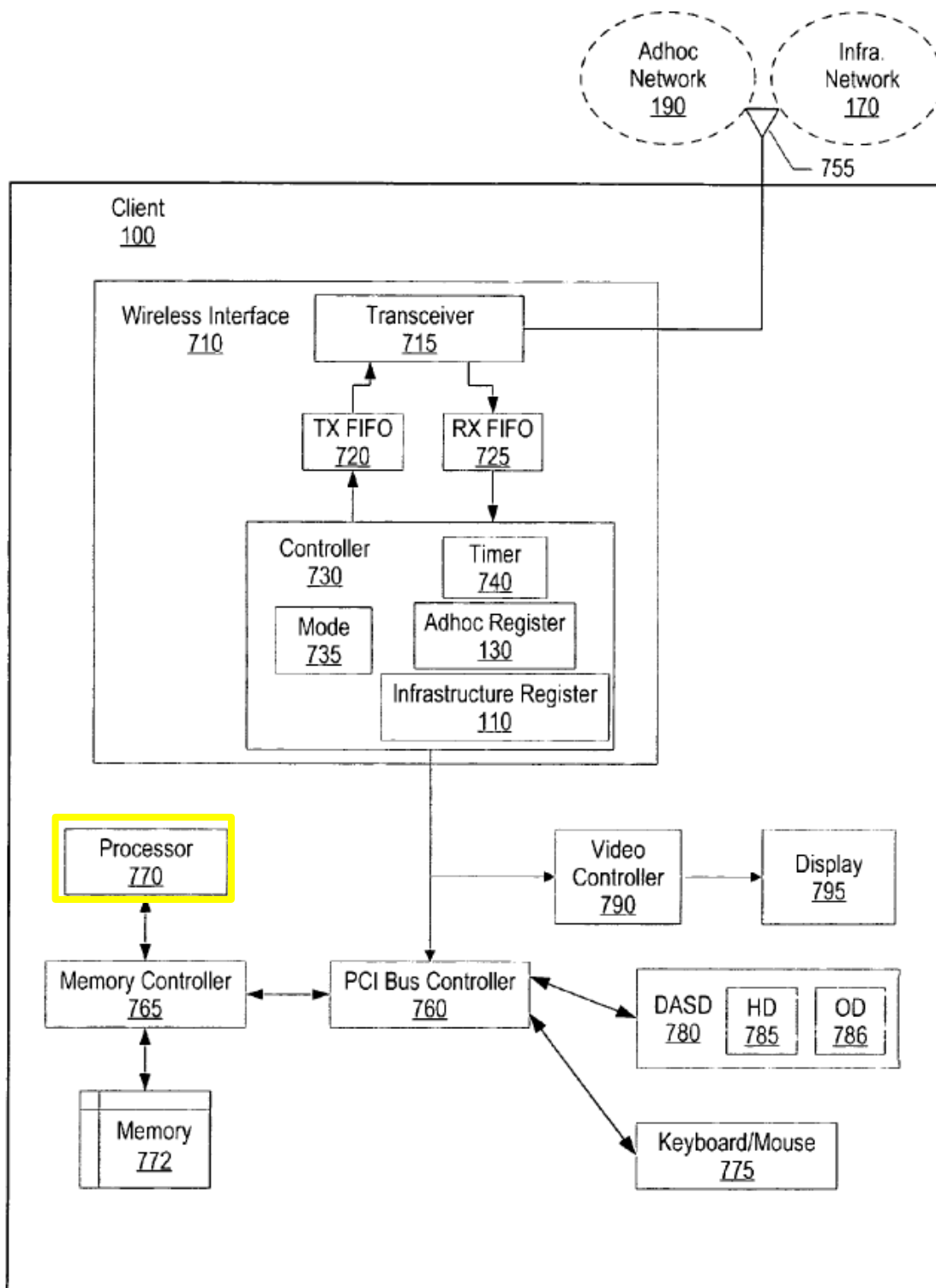
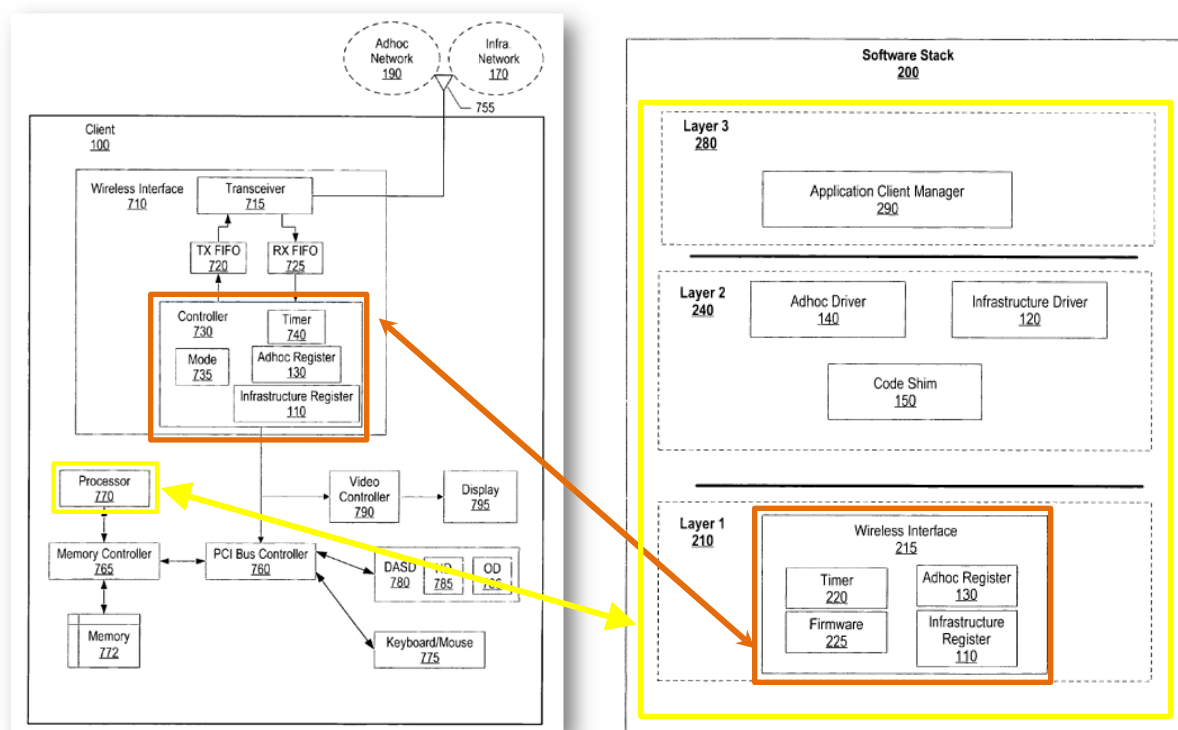


Fig. 7 (annotated); Ex-1004 7:31-33 (“A **standard processing subsection** ... consists of **microprocessor 770**”).

98. Second, processor 770 was *configured to* carry out the functionality of client device 100. For example, a POSA would have understood that processor 770, in conjunction with software stack 200, was configured to control client device 100’s operations, including printing, accessing the internet, displaying presentations, that involved wireless communications etc. Ex-1004 Figs. 2, 7, 7:30-33, 4:20-36.



Ex-1004 Figs. 7 (annotated, illustrating the relationship between the hardware of the Client 100 and the Software Stack 200), 2 (annotated), 7:30-33, 4:20-36.

99. Drivers, including Cromer’s “Adhoc Driver 140” and “Infrastructure Driver 120”, were software modules known to be used by a central processor, *i.e.*,

processor 770, for supporting peripherals and physical layer communications. Ex-1004 7:30-33, 4:20-36; Ex-1025 271 (defining “driver” as using a “central processing unit”). Likewise, an operating system such as Cromer’s “operating system” was software that manages the basic operations of a computer system, including network communications, and ran on central processors like processor 770. Ex-1004 7:30-33, 4:20-36; Ex-1025 599 (“operating system”).

100. In addition, a POSA would have understood or at least found it obvious, for example, that processor 770 would be configured to determine the connection needs of client device 100, because it is running the user, application-layer software that requires those connections, and control lower layer software accordingly. Ex-1004 2:1-4 (“A user wishes to concurrently communicate over a WLAN network and a WPAN network. For example, the user's client may display a presentation by interfacing to a projector over a WPAN, and request access to the Internet over a WLAN.”), 5:42-45 (“Processing commences at 500, whereupon a determination is made as to ... whether both WLAN and WPAN network connections are required by the client (decision 510). This is dynamically decided based upon applications that are being run by a user, such as printing to a WPAN-based printer while connected to an infrastructure WLAN.”); 4:34-36 (describing “Layer 3” “application client manager 290” “used to set up” client device 100 for “connecting to a WLAN

and/or a WPAN device”). This would have been obvious as the expected and conventional use of processor 770.

101. *Cromer* further provided a broad teaching to implement its disclosure in conventional computer structures, which additionally disclosed processor-based implementations of *Cromer*’s wireless data exchange functionality, including, *e.g.*, printing, web-browsing, displaying, etc. (Ex-1004 2:1-4, 2:25-29, 5:36-7:6, 8:51-57), as well as the data-relaying functionality of *Cromer* as modified by *Ganu* (Ex-1005 001-002).

102. Thus, processor 770, in conjunction with software stack 200, was *configured to* carry out the wireless functionality of client device 100, including the functionality discussed below for [1c]-[1h].

d. [1c] process data received via the wireless radio circuit;

103. *Cromer* alone, and as modified by *Ganu*, taught this element.

104. *Cromer*’s client device 100 acted on (*process[ed]*) information received using transceiver 715 (*data received via the wireless radio circuit*). Wireless messages received by client 100 arrived *via* transceiver 715, are *data received via the wireless radio circuit*. Ex-1004 7:18-21 (“RX FIFO 725 couple controller 730 to transceiver 715 and [is] used to buffer ... reception of data packets ... received from network devices.”); *see* [1a].

105. Processor 770, in conjunction with software stack 200, was configured to *process* this received data. For example, a POSA would have understood that client device 100's processor 770 used software stack 200 and higher layer software to receive and interpret data, unpacking data from a frame formatted for one layer and passing the data up in a format for the next layer. Ex-1004 3:61-4:36. This interpretation and unpacking of data is *processing* that forms part of the data-reception process of data communications.

106. For example, *Cromer* disclosed Layer 2 of software stack 200 including "infrastructure driver 120" and "ad hoc driver 140" used to "transfer data ... from" the network as part of this data-reception process. Ex-1004 4:22-26, Figs. 2 and 7; Ex-1025 271 ("driver" used by operating system to interface with hardware ports); [1b]. At a lower layer handling 802.11 communications, client device's processor 770 would process incoming data in the form of 802.11 messages, such as beacons and association messages from AP 160. *See* [1e.1]; §VI.B.2; Ex-1029 3, 46, 51, 123.

107. Even when merely forwarding data between devices as taught by *Ganu*, *Cromer's* processor 770 would still use at least the software stack 200 to unpack frames and interpret incoming data, and then processing that data according to the framing and protocols that would then be used for transmission. *See infra* [1e.2]; [1pre]; Ex-1004 2:2-4, 3:42-4:46. For example, the 802.11 of *Cromer* would utilize a "*frame check sequence (FCS)*," field in the MAC frame of each 802.11

transmission that facilitated detection of errors from corrupted transmissions (or receptions).³ Ex-1029 34, 40-41

108. Ultimately, a POSA would have understood that processor 770 would engage in data reception processing at the application layer. Ex-1025 604 (“Applications layer contains functions for particular applications services, such as file transfer, remote file access[.]”). For example, during Internet browsing or file transfers, client device 100’s processor 770 engaged in data-reception processing at the application layer, where user-interface software (*e.g.*, web browsers) reside. Ex-1004 2:2-4 (“user’s client may ... request access to the Internet over a WLAN”), Fig. 2. Indeed, any normal operation of client device 100 (*e.g.*, receiving a document for editing, browsing the internet) would entail processor 770 being configured to *process received data*, or would at least have been obvious to a POSA as a conventional and predictable usage of *Cromer* because, in addition its function with *Cromer*’s driver (see above), processors, such as processor 770, ran applications

³ A POSA would have understood the modified-802.11 protocol of *Ganu* utilized in *Cromer* (see [1e.2]) retained this error-detecting functionality located in “[e]ach [MAC] frame,” (Ex-1029 34) or found it obvious to include it to maintain the integrity of the ad-hoc, WPAN network communications.

(e.g., word processor, web browser), thereby processing the received data (document, browsing). Ex-1004 2:2-4, 3:42-4:46.

e. [1d] generate data to be transmitted by the wireless radio circuit;

109. *Cromer*, at least as modified by *Ganu*, taught this element.

110. First, *Cromer* taught transceiver 715 transmitted “data packets,” *i.e.*, *data to be transmitted by the wireless radio circuit* (see [1a]). Ex-1004 4:22-26, Fig. 7, 7:18-21 (“TX FIFO 720 ... used to buffer transmission ... of data packets that are sent to ... network devices.”); *see* [1a].

111. Second, processor 770, in conjunction with software stack 200, was configured to create data packets layer-by-layer (*generate data*). For example, when transferring data, client device 100’s processor 770 would have used software stack 200 and higher layer software to take a frame of data formatted for one layer and create a new data packet to be passed as data for the next lower layer protocol, generating data packets layer-by-layer, until ready for transceiver 715. Each step of generating a data packet at a layer constitutes *generating data*. *Id.*

112. For example, at the highest application layer software, processor 770 generated data, including new user data, as part of normal applications of computers such as *Cromer*’s client device 100. Ex-1025 604 (“Applications layer”); Ex-1004 Fig. 7, 7:30-45. For example, during conventional user operations of client device 100 (e.g., running applications to edit, send, print, or display documents, generating

and sending files requested via the internet, e.g., during web browsing) processor 770 would generate user and application data, or that would at least have been obvious to a POSA as part of the conventional and predictable uses of processor 770. Ex-1004 2:2-4 (“user’s client may display a presentation by interfacing to a projector over a WPAN”), 5:42-45 (configuration mode decided “based on applications that are being run by a user, such as printing to a WPAN-based printer”).

113. As another example, at lower layers, processor 770, in conjunction with “adhoc driver 140” or “infrastructure driver 120” would generate Layer 2 data packets according to the relevant protocol to either “**transfer data to ... a peer-to-peer device over an adhoc network**” or “**transfer data to ... an access point over an infrastructure network,**” respectively. Ex-1004 4:20-26.

114. As yet another example, a POSA would have understood that certain, lower layer messages would be created (*generated*) by client device 100. For example, *Cromer’s* client 100, alone and as modified by *Ganu*, would periodically create association and/or beacon messages, thereby *generat[ing] data*. See [1e.1] (discussing beacon and association messages); §VI.B.2; Ex-1029 3, 46, 51, 123; Ex-1005 001-002, Fig. 4 (describing generating association and beacon messages). A POSA would have understood, and would have found it at least obvious, that processor 770, in conjunction with software stack 200, was configured to generate these 802.11 control messages. See [1b].

115. Additionally, while merely forwarding data between devices as taught by *Ganu*, the processor 770 would use at least software stack 200 to generate the forwarded data packets, including the new framing, payload and header information, and passing that to the next lower layer as a new data packet, according to the protocols used for transmission, packets used different protocols in *Cromer-Ganu's* WLAN and WPAN. *See infra* [1e.2]; [1pre]; Ex-1004 2:2-4, 3:42-4:46.

- f. [1e] initiate and maintain network connections with nodes of a wireless network external to the network-enabled hub, maintaining at least a first network connection using a first network protocol and a second network connection using a second network protocol, that can be maintained, at times, simultaneously with each other,*

116. *Cromer* alone, and as modified by *Ganu*, taught this element.

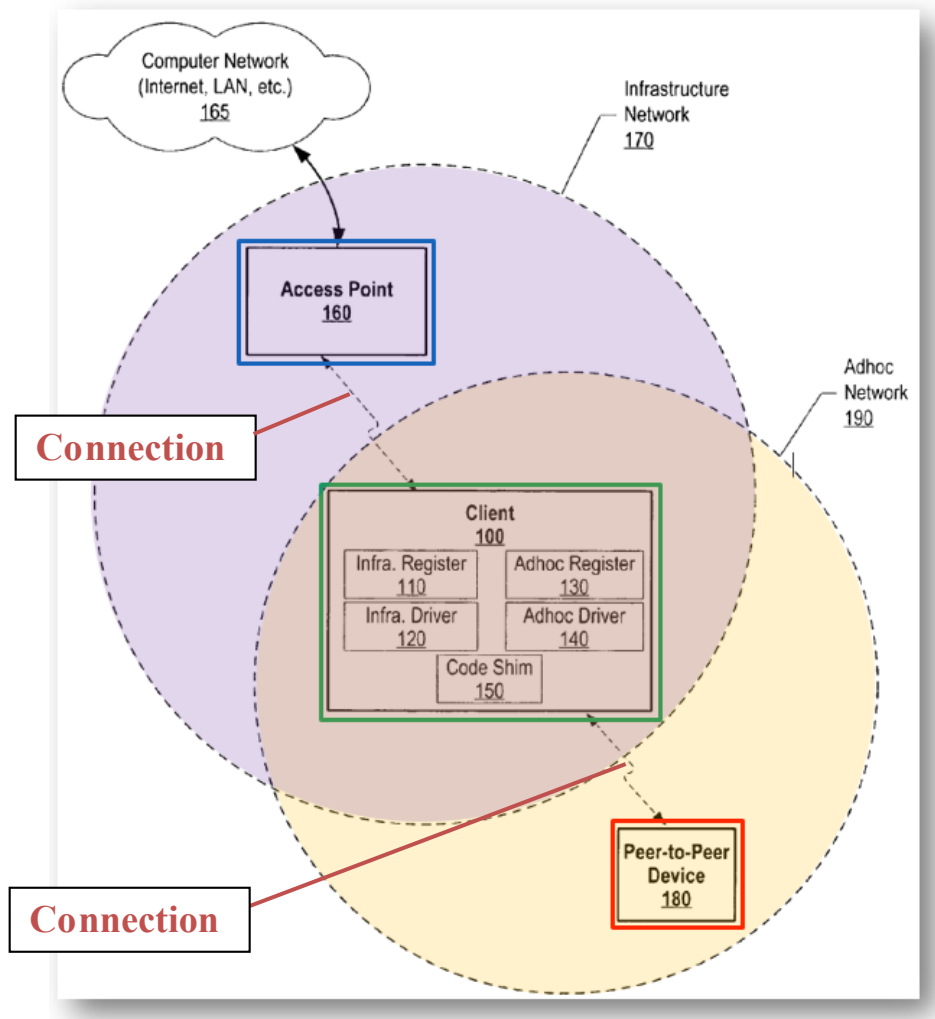
117. I organize my analysis into subparts [1e.1-1e.3] below, which partially overlap due to the repetitive nature of the claim language.

- i. [1e.1] initiate and maintain network connections with nodes of a wireless network external to the network-enabled hub*

118. *Cromer* alone, and as modified by *Ganu*, taught [1e.1].

119. *Cromer*, alone and as modified by *Ganu*, disclosed processor 770 setting up, using and otherwise retaining 802.11, and modified-802.11, **network connections** (*initiate and maintain network connections with*) with **WLAN AP 160**

and **peer-to-peer WPAN device 180**, respectively (*nodes of a wireless network external to the network-enabled hub*).



Ex-1004 Fig. 1 (annotated).

120. **First**, *Cromer* alone taught *initiating and maintaining network connections*. *Cromer* disclosed client device 100 having “**WLAN** and **WPAN network connections**,” and consequently disclosed *initiating and maintaining* such connections. Ex-1004 5:36-45, 2:1-13, Fig. 5.

121. *Cromer* further disclosed details of the *initiating and maintaining*, such as client device 100 establishing and preserving in “registers” the “configuration profiles” of the “WLAN and WPAN connections.” *Id.*; Ex-1004 4:3-19 (“configuration profile[s] include[d] settings ... use[d] to communicate”), 4:34-36 (“set[ting] up the wireless client for connecting to a WLAN and/or a WPAN.”), 6:9-7:6, 9:24-27 (“establishing an infrastructure network connection corresponding to the infrastructure configuration profile”), Figs. 2, 5, 6; [1b]-[1d].

122. *Cromer* further taught using software “code shims” such that client device 100 operated as if it had two wireless interfaces, one preserving (*maintaining*) the WPAN connection and one preserving (*maintaining*) the WLAN connection. Ex-1004 2:23-29, 3:16-23, 4:20-64, 1:45-58, 6:24-7:6, Figs 3 and 6.

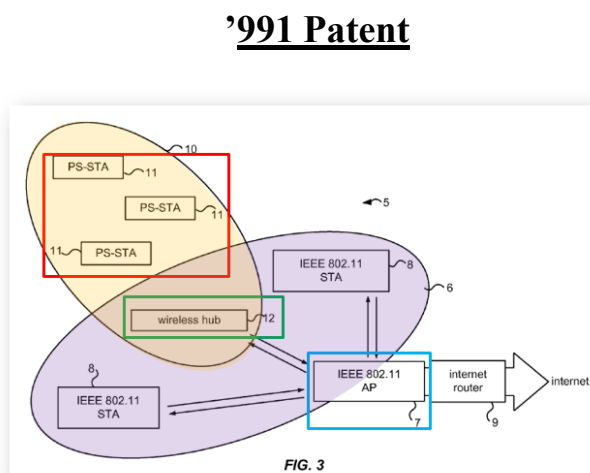
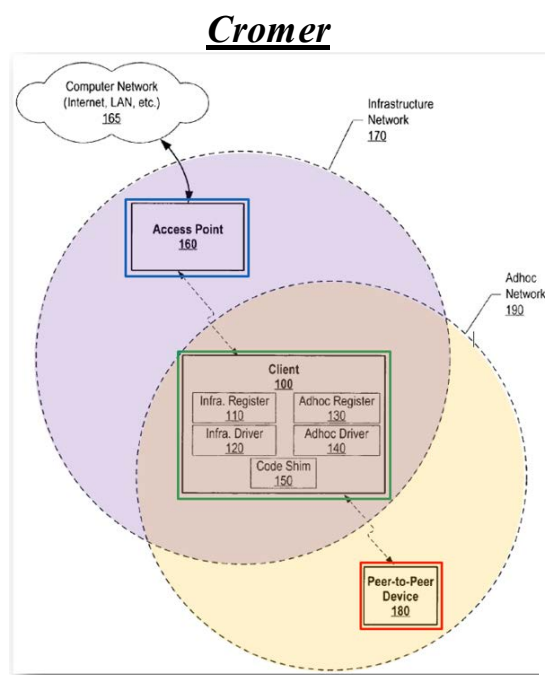
123. Additionally, because *Cromer*’s client device 100 was a “WiFi device” (*i.e.*, an 802.11 device), a POSA would have understood that it setup and preserved its WLAN and WPAN connections using 802.11, such as 802.11 “synchronization” and, for at least the WLAN connection, 802.11 “association,” similar to the ’911 Patent. Ex-1004 2:53-56; *cf.* Ex-1001 Abstract (referring to keeping “association and synchronization” as way of maintaining WLAN “connectivity”). For example, 802.11 specified the processes by which WiFi devices, such as client device 100, would scan for other wireless devices (*e.g.*, AP 160, peer-to-peer devices 180), synchronize clocks, and, for at least AP 160, associate with it. Ex-1029 101-103

(scanning management, including probes requests/responses) 125-127 (acquiring synchronization, scanning, via probes requests/responses); 103-105 (joining management), 123-125 (stations “synchronized to a common clock” using “beacons”), 125-127; 109-11 (describing association management), 136 (association procedures), 18-19 (describing association as the mapping of access points to stations, allowing stations to send messages via an AP). A POSA would have understood that 802.11 connections were *initiated* using these processes, and then were *maintained* by the wireless devices remembering and complying with the 802.11 parameters governing for the connection. *Id.*

124. **Second**, *Cromer*, as modified by *Ganu*, disclosed additional details showing *initiating and maintaining* for the **WPAN network connections** of client device 100. *See* [1pre], *infra* [1e.2]. As modified, *Cromer*’s client device 100 would additionally use *Ganu*’s 802.11-like “association” messaging for its WPAN connections to configure the client device as a *Ganu* forwarding node (FN). *Id.* The additional *initiating and maintaining* would include *Ganu*’s discovery phase in which ad-hoc nodes (MNs) searched for, and then associated and synchronized with the “best ‘cost’” FNs, and the preserving the synchronization and association to support subsequent periods of communications. Ex-1005 002-003, Fig. 3; *supra* [1e.2].

125. **Third**, client device 100's "WLAN and WPAN connections" were with *nodes of a wireless network*. Ex-1004 5:36-45. Wireless devices, like *Cromer's* AP 160 and peer-to-peer device 180, became *nodes of a wireless network* when they operate[d] as part of that network, such as *Cromer's* WLAN and WPAN, respectively. Ex-1025 573 ("node" a "point connection in a network."). This is the same use of "nodes" as found in the '991 Patent. Ex-1001 4:38-42 ("devices operating as part of a ... network" as "node[s]."), 11:25-27, 11:18-28 (describing stations as "nodes" of the WLAN). At least due to the *initiating and maintaining connections* (as discussed above), the connected wireless devices were *nodes* of the respective networks.

126. **Fourth**, *Cromer's* WLAN AP and WPAN peer-to-peer devices were *nodes of a wireless network external to the network-enabled hub* because they were separate from client device 100 and the WPAN and WLAN, respectively, (Ex-1004 3:39-52, Fig. 1); this is the same as preferred embodiments of the '991 Patent:



Ex-1004 Fig. 1 (annotated); Ex-1001 Fig. 3(annotated). For example, client device 100 (*network-enabled hub*) as a hub of WLAN 170 is able to initiate and maintain connections with external WPAN devices in the same manner as the preferred embodiments of the '991 Patent. *Id.*; Ex-1001 13:4-14:3.

127. **Finally**, a POSA would have understood or at least would have found it obvious that *Cromer's* processor 770, in conjunction with software stack 200, was configured to initiate and maintain the wireless connections discussed for this element, and for [1e.2-1e.3]. *See* [1b].

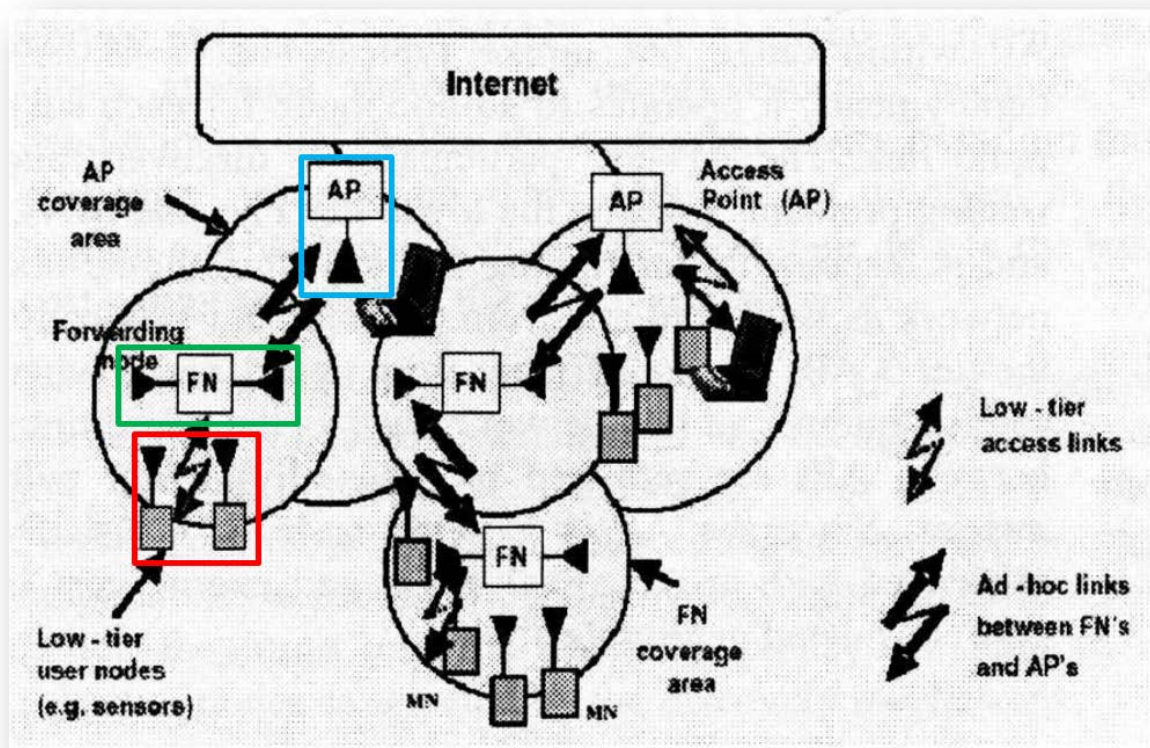
ii. ***[1e.2] maintaining at least a first network connection using a first network protocol and a second network connection using a second network protocol,***

128. *Cromer* alone, and as modified by *Ganu*, taught [1e.2].

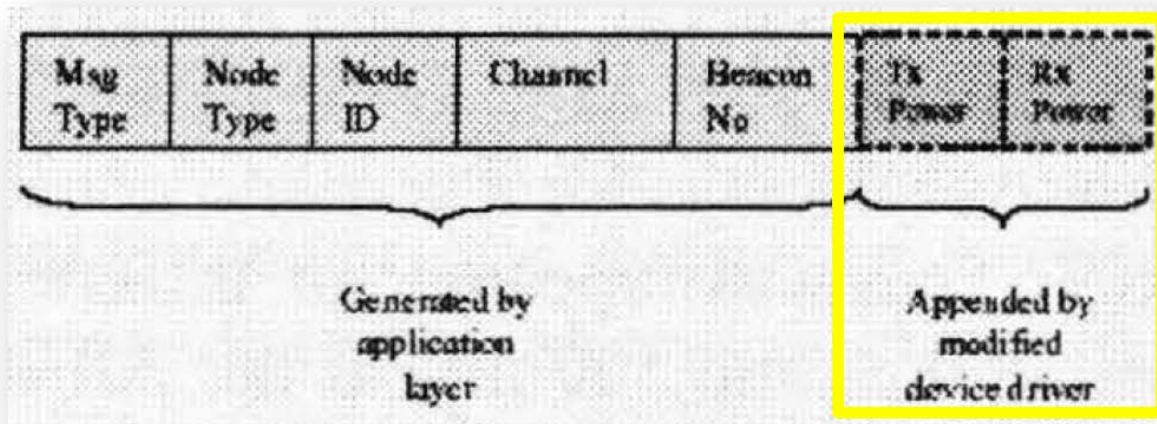
129. **First**, *Cromer* disclosed client device 100's processor 770 maintaining an 802.11 "**WLAN connection**" (*maintaining at least a first network connection*) with **AP 160** using 802.11's "infrastructure" protocol (*using a first network protocol*), for all of the reasons explained in [1e.1]. See [1e.1].

130. **Second**, it would have been obvious to modify *Cromer*'s WPAN connection with *Ganu*'s teachings of using a modified version of the 802.11 ad-hoc protocol. *Cromer*, as modified by *Ganu*, taught maintaining a "**WPAN connection**" (*maintaining a second network connection*) with **WPAN peer-to-peer devices 180** using *Ganu*'s modified-802.11 ad-hoc protocol (*using a second network protocol*). As a preliminary observation, *Cromer* disclosed this WPAN connection (*second network connection*) was *maintained* for at least the same reasons discussed for the *maintain* limitation of [1e.1]. See [1e.1].

131. *Ganu* taught a *second network protocol* by disclosing **forwarding node (FN)** using a **modified-802.11 ad-hoc protocol** (*second network protocol*) to communicate with **mobile nodes (MNs)**:



Ex-1005 001, Fig. 1 (annotated). *Ganu* taught modifying the 802.11 ad-hoc protocol by (1) having FNs “**append transmit power to each outgoing beacon**” and MNs “**append ... the received signal strength for each incoming beacon**” and (2) adding 802.11-like association to organize MNs into cells with power-efficient selections of FNs: “MNs scan different channels, listen to the beacons and send an **association message** to the best ‘cost’ parent using [a] discovery metric” to “lower power consumption at end-user devices” Ex-1005 001, 003.



Ex-1005 Fig. 4 (annotated). Applying *Ganu*'s teaching to *Cromer*, *Cromer*'s client device 100 would transmit beacons (synchronization messages) with modified power fields and *Cromer*'s peer-to-peer devices 180 would scan channels, listening to the modified-beacons, and select and send an "association message to the best 'cost' parent" (*i.e.*, client device 100) to "lower power consumption at" peer-to-peer devices 180. Ex-1005 001, 003.

132. A POSA would have understood that *Ganu*'s modifications to the **802.11 ad-hoc protocol** made it a *second network protocol*. For context, 802.11 and modified 802.11 are preferred embodiments of the *first and second network protocols* of [1e.2]. Ex-1001 Claims 1 and 7 ("... *hub of claim 1, wherein the first network protocol is an 802.11x wireless protocol and the second network protocol is a modification of the 802.11x wireless protocol.*"), Abstract, 7:13-17; 9:60-66.

133. The *Cromer-Ganu* combination would have been obvious for all of the reasons explained for [1pre]. [1pre]. Additionally, a POSA would have modified

Cromer's 802.11 ad-hoc protocol to include *Ganu's* teachings to achieve the power savings and overhead reduction taught by *Ganu*. Ex-1005 001-003, Fig. 4. The combination would involve nothing more than improving *Cromer's* 802.11 ad-hoc protocol in the manner *Ganu* taught for the 802.11 ad-hoc protocol, to predictably achieve the same benefits taught by *Ganu* with a reasonable expectation for success. *Ganu* itself suggested modifying software and firmware “for ease of implementation.” Ex-1005 003. As reflected by *Cromer* and *Ganu*, and the well-developed nature of wireless networking protocols, the combination was well within the skill of a POSA. *See supra* §VI.A-B.

134. Furthermore, it would have been obvious to use *Ganu's* teachings to modify *Cromer's* WPAN connection while retaining *Cromer's* WLAN connection. For example, doing so would have had the readily apparent benefit of being able to communicate with the existing base of 802.11-compliant access points already installed in the marketplace, avoiding the need for potential customers to replace their access points. Ex-1025 25-26; Ex-1028 398 (describing an ad hoc “member operat[ing] as a routing service.”); Ex-1001 1:41-45, 1:48-50, 6:39-40 (admitting prior art knowledge and popularity of 802.11). Moreover, a POSA would have been motivated to maintain *Cromer's* embodiment where the connected AP had an “802.11 **compliant** wireless local area network interface” for infrastructure functionality. Ex-1004 7:52-54, Abstract. Finally, a POSA would have recognized

that the power savings taught by *Ganu* were most beneficial to WPAN environments, known to commonly include short-range, battery-powered devices such as *Cromer's* WPAN handheld devices and PDAs. Ex-1004 3:48-51. *Ganu*, taught its solution provided “energy conservation at the [mobile nodes] MNs” (Ex-1005 003), benefiting the energy constraints of typical “battery-operated” devices (Ex-1005 001-002). *See also* Ex-1005 002 (AP and FNs can typically be plugged in).

iii. [1e.3] [first network connection ... and a second network connection,] that can be maintained, at times, simultaneously with each other,

135. *Cromer* taught [1e.3].

136. As a preliminary observation, the WLAN and WPAN connections discussed below are “*maintained*” for at least the same reasons discussed for the *maintain* limitations of [1e.1] and [1e.2]. *See* [1e.1-2]. As further explained below, *Cromer* taught that the two connections were *maintained, at times, simultaneously with each other*.

137. *Cromer* taught *maintain[ing] simultaneous connections* at least *at times* because it taught (i) “concurrent” WPAN and WLAN operations (Ex-1004 Title, Abstract, 1:8-13, 2:1-13, 2:53-56, 3:16-24), (ii) including concurrent “communications” which required concurrent connections (Ex-1004 2:1-13), and (iii) “maintaining” one “connection” (WLAN) in an idle state while actively

communicating over the other connection (WPAN) (Ex-1004 9:30-33, 5:41-45). Thus, *Cromer* disclosed *maintaining both the first and second network connections simultaneously* in multiple ways, including for at least the periods in which client device 100 was actively communicating over the WPAN connection, while preserving its WLAN connection with AP 160. Ex-1004 9:30-33, 5:41-45.

138. *Cromer's* reference to idle periods of WPAN or WLAN **communications** does not negate the **connections** being maintained during those periods. *Id.* For example, a POSA would have understood that in 802.11 networks, a wireless connection existed not only during active communication, but also during idle periods (*e.g.*, when connection parameters are stored and complied with such that communications can resume over the connection without having to redo steps such as association and synchronization *see* [1e.1-2]). Ex-1029 70-71; *cf.* Ex-1001 claim 8 (“maintain[ing] ... connection during ... inactivity period[.]”), Abstract (“without losing connectivity (such as association and synchronization) to the WLAN”).

- g. [1f] wherein the second network protocol is an overlay protocol with respect to the first network protocol in that communications using the second network protocol are partially consistent with the first network protocol and*

139. *Cromer*, at least as modified by *Ganu*, taught this element.

140. Because the *overlay protocol* portion of [1f] builds on the *partially consistent* portion, I address the *partially consistent* portion first.

141. First, *Cromer-Ganu* taught *communications using the second network protocol are partially consistent with the first network protocol*. For example, the two protocols of *Cromer-Ganu* satisfy the construction of “partially consistent” that, as I was informed by counsel, was issued by a district court as: “conforms to a part, but not the entirety of.” Ex-1010 27-31; §V. Specifically, the modified-802.11 ad-hoc, WPAN protocol communications of *Cromer-Ganu* (*communications using the second network protocol*) “conforms to a part” because they share the un-modified aspects of the 802.11 standard used by the 802.11 infrastructure, WLAN protocol (*the first network protocol*). See [1e]. Shared aspects would include, *e.g.*, physical layer formatting of the 802.11 physical frames, MAC frame formatting, including, *e.g.*, the non-appended portions of *Ganu*’s beacon frames. Ex-1029 (generally). Conversely, these communications do not conform to “the entirety of” the 802.11 infrastructure, WLAN protocol (*first network protocol*) at least because of the modifications taught by *Ganu* (making non-compliant 802.11 beacon frames, adding association messages to the 802.11 ad-hoc protocol in a non-compliant discovery phase). The shared use of the 802.11 standard would result in extensive, but not complete, commonalities (*partially consistent*).

142. Second, *Cromer-Ganu* taught *wherein the second network protocol is an overlay protocol with respect to the first network protocol in that* communications using the modified-802.11 adhoc, WPAN protocol communications of *Cromer-Ganu* (communications using the second network protocol) are partially consistent. In *Cromer-Ganu*, the modified-802.11 ad-hoc, WPAN protocol (*second network protocol*) overlaps and extends the connectivity of the underlying WLAN, and is thus a protocol that *overlays* the WLAN. Ex-1004 Fig. 1 (showing physical overlap); [1pre] (data-forwarding combination). Further, the claim limitations explain what constitutes an *overlay protocol* by virtue of the phrase “*in that*.” Specifically, the second protocol is an overlay protocol because (*in that*) its communications are *partially consistent* with the first protocol communications, which was taught by *Cromer-Ganu* as explained above.

143. Additionally, the modified-802.11 adhoc, WPAN protocol (*second network protocol*) of *Cromer-Ganu* also satisfies the construction of “overlay protocol” that, as I was informed by counsel, was issued in a parallel district court proceeding as: “a protocol governing a second network, which protocol has aspects in common with a first network protocol to reduce interference such that the second and first networks can co-exist.” Ex-1010 23-26; §V. The modified-802.11 ad-hoc, WPAN protocol controls the WPAN, *i.e.* it is “a protocol governing a second network.” See [1e.2]; Ex-1010 23-26; §V. Next, as explained for the *partially*

consistent limitation, the second “protocol has aspects in common with a first network protocol.” Further, the WLAN and WPAN protocols of *Cromer-Ganu* share common aspects of 802.11, which a POSA would have understood reduced interference and allowed their co-existence, consistent with *Cromer*’s teaching of “concurrent” operations of the WPAN and WLAN. Ex-1029 1 (“This [802.11] standard ... Permits the operation of an IEEE 802.11 conformant device within a wireless local area network (LAN) that **may coexist** with multiple overlapping IEEE 802.11 wireless LANs.”); Ex-1004 1:11-13 (“present invention” allowed “single Wi-Fi device to concurrently communicate in a wireless LAN environment and a wireless PAN environment.”), 2:1-2, 2:53-56; Ex-1005.

144. Finally, at least as modified by *Ganu*, client device 100 would use 802.11 synchronization to control the WPAN network and would use 802.11 synchronization with the AP of the WLAN. *See* [1e.1]. A POSA would have understood, or at least would have found it obvious, for client device 100 to issue its WPAN beacons at times that minimized interference with AP 160, *e.g.*, during WLAN beacons, and for that further reason, *Cromer-Ganu* “reduced interference such that the second and first networks can co-exist.” Ex-1010 23-26; Ex-1029 123 (“Each STA in the [ad-hoc] BSS shall transmit beacons.”); §V.

h. [1g] wherein at least some of the communications using the second network protocol impinge on at least some

antennae used for communications using the first network protocol; and

145. *Cromer*, at least as modified by *Ganu*, taught this element.

146. *At least some of the communications* using the *Cromer-Ganu* modified-802.11 ad-hoc WPAN protocol (*the second network protocol*) would reach (*i.e., impinge*) on the antennae of the AP 160, client 100, and/or other WLAN 802.11 devices associated with AP 160, all of which communicate using the infrastructure 802.11 protocol (*on at least some antennae used for communications using the first network protocol*). *Id.* (citing, *e.g.*, Ex-1004 Figs. 1, 7). This impingement would occur whenever AP 160 and other WLAN 802.11 devices associated with AP 160 were within range of client device 100's communications using the *Cromer-Ganu* modified-802.11 ad-hoc, WPAN protocol. Ex-1004 Fig. 1 (overlapping network ranges). Similarly, impingement would occur whenever AP 160, client device 100, and other WLAN 802.11 devices associated with AP 160 are within range of peer-to-peer, WPAN device 180's communications. *See* Ex-1004 Fig. 1 (overlapping network ranges), Fig. 7 (client device having single antennae for both protocols); Ex-1029 12-13, Fig. 5, (discussing "collocated coverage areas" contemplated by 802.11 standard). For example, *Cromer* gives the example of a personal computer connecting to an access point for Internet connectivity over a WLAN and connecting to peripherals (wireless printers or projectors) on the WPAN. Ex-1004 2:2-4; 5:2-6; 3:49-51. Such computers and wireless devices would have commonly been within

close proximity to each other to provide the best 802.11 data rates and due to typical physical layouts (e.g., in an office), making each of these devices well within range of WPAN communications. Ex-1004 5:2-4 (describing connections at a worksite); Ex-1001 Fig. 1 (WLAN ranges of up to 10m); Ex-1025 26 (“802.11b is a low power wireless system so the closer you are to a transmitter, the faster it will be.”).

- i. [1h] implement data forwarding logic, implemented in a network-enabled hub using hardware and/or software, that forwards data between an originating node and a destination node, wherein the originating node is a node in one of the first and second networks and the destination node is a node in the other of the first and second networks.***

147. *Cromer*, at least in combination with *Ganu*, taught this element.

148. As explained in [1pre], *Cromer* as modified by *Ganu*, taught a client device 100 (*network-enabled hub*) that would organize as a forwarding node (FN) following *Ganu*’s FN teachings. *See* [1pre]. For the same reasons, the data handling structures of *Cromer*’s client device 100 would have logic for carrying out *Ganu*’s data relaying, which includes data forwarding (*implement data forwarding logic*). *See* [1pre].

149. For example, a POSA would have understood that *Cromer*’s processor 770, in conjunction with software stack 200, (*see* [1b]) was configured, when modified by *Ganu*’s data forwarding, to implement *Ganu*’s data forwarding logic because processor 770, wireless interface 710, and software stack 200 controlled all

of the wireless data operations and connections of client device 100. *See* [1b]; [1c] and [1d]. This implementation in client device 100 (*network-enabled hub*) used processor 770, wireless interface 710, and software stack 200 and thus was *implemented in a network-enabled hub using hardware and/or software. See* [1pre], [1b]; *see also* Ex-1004 8:5-64 (describing implementation in “a general purpose computer” using “software”, or in “hardware,” “firmware,” or a “specialized apparatus”).

150. As modified by *Ganu's* data forwarding (*see* [1pre]), *Cromer's* processor 770 would further use hardware and software components of client device 100 to implement the data forwarding logic, including memory 772, software stack 200, wireless interface 215/710, and transceiver 715 (*see* [1a], Ex-1004 Figs 1 and 7) (*using hardware and/or software*) to provide indirect communication (*that forwards data*) between an AP 160 (*an originating node*) and a peer-to-peer device 180 (*a destination node*). *See* [1pre]. As modified, *Cromer's* AP 160 in a first network WLAN 170 would send data (*originating node is a node in one of the first and second networks*) and peer-to-peer device 180 in second network, WPAN 190, would receive the data (*and the destination node is a node in the other of the first and second networks*). *See* [1pre]; Ex-1004 Fig. 1. The reverse would also apply (*i.e.*, the peer-to-peer device 180 is the *originating node* and AP 160 is the

destination node). *Id.* For context, the '991 Patent discloses a similar arrangement in its preferred embodiments. Ex-1001 Fig. 6.

151. Additionally, should the Board find this limitation to be governed by means plus function, and even if the Board further accepted all of the structures that, as I am informed by counsel, Ozmo alternatively identified in district court, *Cromer* at least as modified by the data forwarding teachings of *Ganu*, rendered obvious the same or equivalent structures to a POSA:

'991 Structure ⁴	<i>Cromer</i> Structure
• software platform 36, • wireless circuit 27, • processing unit 28, • memory module 29, • radio 21, • baseband modem 32, and/or • control and datapath logic 33, • and their equivalents.	• software stack 200, • wireless interface 710 • processor 770, • memory 772, • transceiver 715 • wireless interface 215/710, and • controller 730

See [1pre], [1a], [1b], §V.

152. The function of *forwards data between an originating node and a destination node* is taught by *Cromer* and *Ganu* as discussed above in this section and [1pre]. See [1pre].

⁴ Ex-1010 21; §V; Ex-1001 Fig. 6, 4:32-34, 6:29-32, 6:41-7:3.

2. Claim 3

- a. **3. *The network-enabled hub of claim 1, wherein the first network connection provides a link via an access point of a wireless LAN and the second network connection provides a link to a personal area network (“PAN”) serving PAN devices, such that network nodes that have access to the wireless LAN can address packets to PAN devices that are nodes on the PAN.***

153. Cromer, as modified by Ganu, renders claim 3 obvious.

154. Cromer’s client device 100 (*the network-enabled hub of claim 1*) used the 802.11 infrastructure WLAN connection to connect via AP 160 to, e.g., other WLAN 170 nodes and the Internet (*first network connection provides a link via an access point of a wireless LAN*). See [1pre]. At least as modified by Ganu, Cromer’s client device 100 used the WPAN connection (*the second network connection*) to connect to WPAN 190 having peer-to-peer devices 180 of the PAN network, and thus *the second network connection provides a link to a personal area network (“PAN”) serving PAN devices*. See [1pre], [1e], and [1h]; Ex-1028 398 (describing using an ad-hoc “member operat[ing] as a routing service.”).

155. These connections allowed AP 160 and other WLAN nodes (*network nodes*) to send data packets to peer-to-peer devices 180, a configuration *such that network nodes that have access to the wireless LAN can address packets to PAN devices that are nodes on the PAN*. See [1pre], [1e], and [1h]; Ex-1028 398. A POSA would have understood that the data exchanged between AP 160 and peer-to-

peer devices 180 via client device 100 in *Cromer* as modified by *Ganu* would have been transmitted in the form of packets and addressed using network addressing of the destination devices 180 (e.g. IP addresses); additionally, POSA would have understood that the *Cromer*'s client device as modified by *Ganu* would use MAC addressing as defined by the 802.11 specification on the wireless LAN side, as well as on the PAN side that uses a modified-802.11 protocol. Ex-1029 34 (defining MAC frame having "address" fields), 38 ("four address fields" indicate "source address, destination address, transmitting station address, and receiving station address."); Ex-1025 26 (describing 802.11 exchanging "packets" having "source and destination addresses"); Ex-1028 398 (describing using an ad-hoc "member operat[ing] as a routing service.").

156. Given *Cromer*'s express disclosures regarding "WPAN," the art teaches claim 3 under any reasonable construction. *Cromer* likewise satisfies the construction of "personal area network" issued in parallel litigation: "a short-range network usable to connect peripherals to devices in close proximity." Ex-1010 34; §V. For example, *Cromer* disclosed its WPAN 190 having peer-to-peer devices 180, and described that "a **wireless personal area network** uses ... **a very short range, such as ten meters**. A WPAN may serve to interconnect **ordinary computing and communicating devices that many people carry with them today**. ... [M]any **peripheral devices**, such as printers and handheld devices, are required to support

... WPAN interoperability for point-to-point communications.” Ex-1004 1:33-45, 2:25-29 (disclosing use of WPAN for such peripheral devices).

3. Claim 4

- a. 4. The network-enabled hub of claim 3, wherein the network-enabled hub is configured to accept packets from the PAN devices where the packets are addressed to network devices that are accessible only via the network-enabled hub.*

157. *Cromer*, as modified by *Ganu*, renders claim 4 obvious.

158. *Cromer*, as modified by *Ganu*, taught client device 100 (*the network-enabled hub*) acting as a forwarding node (FN) accepting data from peer-to-peer devices 180 (*the PAN devices*) being sent to WLAN devices (*e.g.*, to AP 160 and other nodes reachable via the WLAN) (*network devices*). See [3], [1pre], [1h] Ex-1028 398. The data received by client device 100 would be transmitted in the form of packets and addressed to AP 160 and other nodes reachable via the AP 160 using network addressing schemes (*e.g.*, IP addresses). Additionally, POSA would have understood that the *Cromer*’s client device as modified by *Ganu* would use MAC addressing on the wireless LAN side, as well as on the PAN side that uses a modified-802.11 protocol. Thus client device 100 constituted a *network-enabled hub configured to accept packets addressed to network devices*. Ex-1025 26 (describing 802.11a and 802.11b exchanging “packets” having “source and destination addresses”); Ex-1029 34.

159. *Cromer* as modified by *Ganu* also taught that these WLAN devices (e.g., AP 160 and other nodes reachable via the WLAN) were *network devices that are accessible only via the network-enabled hub*, in at least four contexts. **First**, a POSA would have understood that ad-hoc networking was “a peer-to-peer networking paradigm” in which devices communicated with other devices “in the network and only [devices] within the same cell can communicate” unless “a [device]”—like *Cromer*’s client 100—“operate[d] as a routing service.” Ex-1028 398. A POSA would have understood this to be the case in *Cromer* because it removes the problem that WPAN devices “are required to support both WLAN interoperability for infrastructure network communication as well as WPAN interoperability for point-to-point communication.” Ex-1001 1:41-44. **Second**, as modified by *Ganu*, client device 100 (*the network-enabled hub*) was configured as a forwarding node (FN) and thus peer-to-peer devices 180 (*the PAN devices*) connected to device 100 were designed to contact the WLAN of AP 160 only **via the FN-configured client device 100, i.e. only via the network-enabled hub**. See Ex-1004 1:41-44; [3], [1pre], [1h]. **Third**, *Cromer* as modified by *Ganu*, would include situations in which the peer-to-peer devices 180 were out of range of AP 160 and, therefore, could not communicate with *Cromer*’s infrastructure network 170 but for communicating via client device 100. See Ex-1004 Fig. 1; [3], [1pre], [1h]. **Fourth**, *Cromer* taught peer-to-peer devices that did not support the infrastructure

protocol necessary to communicate directly with Access Point 160, and thus those peer-to-peer devices 180 (*the PAN devices*) could only communicate with *Cromer's* infrastructure network 170 via client device 100. Ex-1004 1:39-45 (addressing the “challenge ... that many peripheral devices, such as printers and handheld devices, are required to support both WLAN interoperability for infrastructure network communication as well as WPAN interoperability for point-to-point communication.”).

4. Claim 6

- a. ***6. The network-enabled hub of claim 1, wherein the second network protocol is a protocol that requires lower average power consumption over time relative to the first network protocol.***

160. *Cromer*, as modified by *Ganu*, renders claim 6 obvious.

161. A POSA would have understood that the 802.11-modified protocol of *Cromer-Ganu* (*second network protocol*) *requires lower average power consumption over time relative to 802.11, WLAN protocol (the first network protocol)* because the 802.11-modified protocol expressly chooses the lowest “cost,” *i.e.*, least energy, topology, which also reduced ad-hoc routing overhead, thereby “reducing delay and **lower power consumption** at end-user devices” than an unmodified, 802.11 protocol, which is also consistent with the general power consumption of WPAN relative to WLAN. Ex-1005 001; *see* [1e]. By specifically reducing transmission powers, this would reduce average power consumption.

5. **Claim 7**

- a. ***7. The network-enabled hub of claim 1, wherein the first network protocol is an 802.11x wireless protocol and the second network protocol is a modification of the 802.11x wireless protocol that is not entirely compliant with the 802.11x wireless protocol of the first network but can be maintained in a common wireless space as the 802.11x wireless protocol.***

162. *Cromer*, as modified by *Ganu*, renders claim 7 obvious.

163. *Cromer* disclosed that the 802.11 protocol (*first network protocol*) is an 802.11x wireless protocol and, in view of *Ganu*, the 802.11-modified protocol (*the second network protocol*) is a modification of the 802.11x wireless protocol that is not entirely compliant with the 802.11x wireless protocol of the first network as explained above in [1e] and [1f]. See [1e], [1f]. *Cromer* further disclosed that both protocols can be maintained in a *common wireless space*: “establishing an infrastructure network connection”—*i.e.*, the 802.11 WLAN—“using a first transmitter included in a wireless device; and **maintaining** the infrastructure network connection while using the first transmitter to concurrently communicate over an adhoc network”—*i.e.*, the 802.11-modified WPAN. Ex-1004 9:26-32, Fig. 1 (illustrating overlapping WLAN and WPAN networks).

6. **Claim 14**

- a. ***14. The network-enabled hub of claim 1, further comprising a housing into which electronic components can be housed internally.***

164. *Cromer*, as modified by *Ganu*, renders claim 14 obvious.

165. For example, it would have been obvious to enclose *Cromer's* electronics in a protective housing.

166. *Cromer* disclosed client device 100 is a “computer system” and that *Cromer's* system, including client device 100, can be “implemented in a general purpose computer.” Ex-1004 7:40-45, 8:48-65, Fig. 7. Such computing systems and computers routinely had a protective casing (*housing*) that encloses their various electronic components such as processors, memory, and other circuitry (*into which electronic components can be housed internally*) given the sensitivity of these components, to, e.g., maintain mechanical integrity, protect components against exposure to environmental elements, and prevent/reduce electromagnetic interference. At least for these same reasons, such computing systems and computers comprising a *housing into which electronic components can be housed internally* was notoriously well known to a POSA.

7. Claim 16

- a. 16. The network-enabled hub of claim 1, wherein the network-enabled hub is embedded into a personal computer, a cellular phone, or home entertainment equipment.***

167. *Cromer*, as modified by *Ganu*, renders claim 16 obvious.

168. *Cromer* disclosed using any “computer system” for client device 100, which *Cromer* described as being possessed by a user (“user’s client device”). Ex-1004 7:40-45, 2:1-4 (“user’s client” to display a presentation on a projector, and

access the Internet), 5:2-6 (user traveling to worksite and needs to use overhead projector). A POSA would have understood or at least found obvious that a computer system possessed by a user in such scenarios included client device 100 being *embedded in a personal computer*, as the normal, expected implementation for client device 100. *See* [1pre].

8. Claim 17

- a. 17. The network-enabled hub of claim 1, wherein a device that is a node of the second network is one of a wireless mouse, wireless keyboard, wireless headset, personal digital assistant (“PDA”), or portable printer.*

169. *Cromer*, as modified by *Ganu*, renders claim 17 obvious.

170. *Cromer* disclosed that “[p]eer-to-peer device 180 is a wireless PAN device”—*a node of the second (WPAN) network*—including “a projector, **PDA, or printer.**” Ex-1004 3:49-51.

VIII. Claims 1, 3-4, 6-7, 14, 16 and 17 Are Obvious over *Cromer* in View of *Ganu* and *Sinivaara*

A. The *Sinivaara* Reference (Ex-1006)

171. The international publication WO 2006/000617 to Sinivaara et al. titled “Control of a Short-Ranged Wireless Terminal” (“*Sinivaara*”). Ex-1006. I have been informed by counsel that *Sinivaara* is prior art.

172. *Sinivaara* was not cited or applied by the examiner during the examination of the ’991 Patent. Ex-1002

173. *Sinivaara* is analogous art to the claimed invention of the '991 Patent. For example, the field of endeavor of the claimed invention is generally “wireless communications” and, particularly, “seamlessly integrating” two different wireless networks, such as a WPAN and an infrastructure WLAN. Ex-1001 (54), Abstract, 1:17-21, 14:39-45. The '991 Patent addresses this goal by utilizing a 802.11-complaint **wireless hub** that communicates with both an **AP 7** in an infrastructure **WLAN 6** and **PS-STAs 11** in **WPAN 10**. Ex-1001 4:55-58, 5:11-12, 5:41-46. *Sinivaara* is in the same field of endeavor. Ex-1006 1:4-7 (“wireless communication systems,” “operating in at least two different networks”). Further, *Sinivaara* is reasonably pertinent to the problem addressed by the '991 Patent in that *Sinivaara* disclosed techniques for “a short-range wireless terminal capable of operating in at least two different networks.” Ex-1006 1:5-7.

174. Like *Cromer*, *Sinivaara* is similarly directed to “a short-range wireless **terminal** capable of operating in at least two different networks.” Ex-1006 1:6-7. “[S]hort-range wireless systems include[d] wireless personal area networks (PANs) and wireless local area networks (WLANs),” including 802.11. Ex-1006 1:15-2:4. *Sinivaara* described that “[a] drawback related to [] current networks is that if the user enters the ad-hoc operation mode, the existing association in the infrastructure network is removed. Ex-1006 2:30-34. In other words, the user of the terminal has to be authenticated again and a new association has to be created when the user

leaves the ad-hoc mode and re-enters the infrastructure network.” *Id.* *Sinivaara* taught a solution for maintaining simultaneous network connectivity by sending a message feigning a power-save state to an **access point** of a **WLAN**, resulting in a WLAN connection with reduced WLAN activity (communications) thereby allowing for **WPAN** activity (communications) over a **WPAN connection**, and then periodically suspending WPAN activity so as to sustain the **WLAN connection**. Ex-1006 3:18-30.

175. *Sinivaara* taught that this feigning of the power-save state in the WLAN achieved beneficially **“allow[ed] the retention of the association** in the infrastructure network although the **mobile terminal** becomes active in an ad-hoc network. **Consequently, no authentication or establishment of a new association is needed** when the terminal returns to operate in the infrastructure network, **which enables seamless operation in the two networks.**” Ex-1006 4:32-5:1; *cf.* Ex-1001 Abstract (“The wireless circuit can connect to the WPAN without losing connectivity (such as association and synchronization) to the WLAN.”).

B. Detailed Application to the Claims

1. Claim 1

176. Claim 1 is obvious as demonstrated above. *See* § VII.A-C.1.h.i.

a. [1e] “maintained, at times, simultaneously with each other,”

177. To the extent the combination of *Cromer* and *Ganu* does not sufficiently disclose or render obvious that the 802.11 infrastructure WLAN and modified-802.11 WPAN connections are “*maintained, at times, **simultaneously** with each other,*” ([1e]) a POSA would have nonetheless found this obvious in view of *Sinivaara*’s teachings.

178. As discussed in the overview above, *Sinivaara* taught a solution to maintaining simultaneous connectivity in a WLAN and WPAN by sending a message feigning a power-save state to the access point of a WLAN, while actually communicating in a WPAN:

A terminal moves to a power save state with respect to a first beacon-based network, such as an infrastructure network, if operation in a ... ad-hoc network[] is required. However, the first beacon-based network is only informed that the terminal moves to the power save state and instead of powering down, the terminal becomes active in the second beacon-based network.

Ex-1006 3:18-23. The terminal periodically suspended activity in the second network long enough to maintain its WLAN connection under the reduced demands of the feigned power save state. Ex-1006 3:18-30.

179. *Sinivaara* taught maintaining connections at least in the same context of the ’991 Patent preferred embodiment, because *Sinivaara*’s technique taught

maintaining association and synchronization. Ex-1001 Abstract (“The wireless circuit can connect to the WPAN without losing connectivity (such as association and synchronization) to the WLAN.”). For example, *Sinivaara* taught that this feigning of the power-save state in the WLAN achieved the benefit of “**allow[ing] the retention of the association** in the infrastructure network although the mobile terminal becomes active in an ad-hoc network. **Consequently, no authentication or establishment of a new association is needed** when the terminal returns to operate in the infrastructure network, **which enables seamless operation in the two networks.**” Ex-1006 4:32-5:1. As to synchronicity, *Sinivaara*’s terminal continued its reception of “beacons of the first beacon-based network,” which were used in 802.11 for maintaining synchronicity. Ex-1006 3:18-30; Ex-1029.⁵

⁵ Ex-1029 46 (defining fields of beacon frames, including “timestamp,” “beacon interval,” and transmission parameters), 51 (“The Beacon Interval field represents the number of time units (TUs) between target beacon transmission times (TBTTs).”), 123 (“**All STAs within a single BSS shall be synchronized** to a common clock using the mechanisms defined herein In an infrastructure network, the AP shall be the timing master and shall perform the [timing synchronization function] TSF **The AP shall periodically transmit special**

180. A POSA would have found it obvious for *Cromer*'s client device 100 from the *Cromer-Ganu* combination to utilize *Sinivaara*'s feigning of the power-save state. For example, combined with *Sinivaara*, *Cromer*'s client device 100 would operate in "infrastructure mode" to transmit *Sinivaara*'s "power save state with respect to ... an infrastructure network," to "inform [*Cromer*'s AP 160] that [client device 100] move[d] to the power save state" but "instead of powering down," client device 100 "becomes active in the [ad hoc, WPAN network 190]." Ex-1006 3:18-30. Such a modification to effect "the **retention of the association** [of *Cromer*'s client device 100] in the infrastructure network [with *Cromer*'s AP 160] although the mobile terminal becomes active in an ad-hoc network," and synchronization between client 100 and AP 160 by "receiv[ing] beacons of the [WLAN 170 via AP 160] at substantially regular intervals" thus ensuring that the *first and second network connections are maintained simultaneously*. Ex-1006 4:32-5:1.

181. A POSA would have been motivated to combine *Sinivaara*'s teaching with the system of *Cromer* and *Ganu* for multiple reasons. First, doing so would provide a POSA with a mechanism for improving *Cromer*'s "concurrent" operations

frames called *beacons* that contain a copy of its TSF timer to synchronize the other STAs in a BSS.").

in the two networks. For example, a POSA would have understood that *Sinivaara*'s power-state messaging teachings would reduce communications with Access Point 160 and thereby increase WPAN access to the wireless medium being shared with the retained 802.11 infrastructure connection. A POSA would have recognized the predictable benefits of reducing interference and contention for the shared wireless medium. Thus, the combination of teachings would involve the use of a known technique (*Sinivaara*'s feigned 802.11 power save state) to improve a similar device (*Cromer-Ganu*'s client device 100—a dual mode terminal like *Sinivaara*'s) in the same way.

182. Second, a POSA would have been motivated by *Sinivaara*'s express teaching that “**no authentication or establishment of a new association is needed** when the terminal returns to operate in the infrastructure network,” thereby “enabling **seamless** operation in the two networks.” Ex-1006 4:32-5:1. A POSA have would readily recognized that avoiding the need to repeat authentication and association procedures would avoid delays of reconnection, providing the benefit of “seamless operation,” and reduced overhead. *Id.* Thus, a POSA would have also been motivated by the express teaching, suggestion, and motivation in *Sinivaara* to modify the *Cromer-Ganu* combination, arriving at the claimed subject matter.

183. Further, a POSA would have had a reasonable expectation of success for the modification because the combination would have at most required minor

and predictable software modifications well within the skill of a POSA, and because *Sinivaara* discloses performing its techniques in an analogous context to *Cromer* and *Ganu*. This is particularly so, given that the combination would not have involved developing challenging, counter-intuitive or unexpected technology, but following the teachings of the references themselves. Ex-1004 (modifying to allow simultaneous ad-hoc/WLAN operations); Ex-1005 (modifying 802.11 frames fields to achieve power savings); Ex-1006 (utilizing known power-save state to enable simultaneous ad-hoc/WLAN connectivity). As reflected by the references themselves, and the well-known adaptability of wireless networking protocols for dual-mode operation, the combination was predictable and well within the skill of a POSA. Ex-1007 (Bluetooth-802.11 adaptations to interfaces and routing algorithms to provide concurrent operations); Ex-1008 (modifying 802.11 and Bluetooth to allow dual-protocol operation); *see supra* §VI.A-B.

184. Thus, *maintaining* the 802.11 WLAN infrastructure connection (*first network connection*) would have been obvious over *Cromer* as modified by *Sinivaara* and this connection would have been maintained simultaneously with the *Cromer-Ganu* ad-hoc WPAN connection (*first network connection*) (see §VII.C.1.f.iii) as taught by both *Cromer* and *Sinivaara*.

b. [1f] “overlay protocol”

185. To the extent the combination of *Cromer* and *Ganu* does not sufficiently disclose or render obvious an *overlay protocol*, *Cromer*, *Ganu*, and *Sinivaara* taught it.

186. As described in [1e] above, with the modification taught by *Sinivaara* (feigning a power-save state), *Cromer*’s client device 100 would further reduce interference and conflicting requests to access the shared wireless medium of the WLAN and WPAN networks by reducing communications between the AP 160 and the client device 100 in the feigned power-saving state, allowing the modified-802.11 ad-hoc, WPAN protocol (*second network protocol*) to co-exist with the WLAN protocol (*first network protocol*), further demonstrating it to be an overlay protocol under the court’s construction. Ex-1010 23-26; §V. Additionally, in the combination, client 100 would not transmit its beacons in the WPAN network during the times scheduled for it to receive WLAN beacons, further reducing interference.

2. Claims 3-4, 6, 14, 16-17

187. *Cromer* as modified by *Ganu* and *Sinivaara*, render claims 3-4, 6, 14, and 16-17 obvious for the reasons stated above in §VII.

3. Claim 7

- a. 7. *The network-enabled hub of claim 1, wherein the first network protocol is an 802.11x wireless protocol and the second network protocol is a modification of the 802.11x wireless protocol that is not entirely compliant with the 802.11x wireless protocol of the first network***

but can be maintained in a common wireless space as the 802.11x wireless protocol.

188. To the extent that *Cromer*, at least as modified by *Ganu* did not render claim 7 obvious, it would have been obvious in further view of *Sinivaara*.

189. *Sinivaara* further taught how to operate (*maintain*) both the 802.11 and modified-802.11 protocols simultaneously in a *common wireless space* by maintaining association and synchronization as explained above in [1e]. Ex-1006 3:18-30; 4:32-5:1; §VIII.B.1.a.

IX. Claims 15 and 18 are Obvious over *Cromer* in view of *Ganu* and further in view of *Judd*

A. Overview of *Judd* (Ex-1019)

190. The international publication WO 01/52447 to Judd et al. titled “Repeater for Wireless Communication System” (“*Judd*”) published on July 19, 2001. Ex-1019. I have been informed by counsel that *Judd* is prior art.

191. *Judd* was not cited or applied by the examiner during the examination of the ’991 Patent. Ex-1002.

192. *Judd* is analogous art to the claimed invention of the ’991 Patent because it is in the same field of endeavor, namely devices for forwarding “wireless communications” (Ex-1019 (54), Abstract) and is also reasonably pertinent to the problem addressed by the claimed invention, because *Judd* disclosed power supply solutions for wireless repeaters for wireless network technologies such as 802.11.

Ex-1019 18:13-29. *Judd* taught that **integrated wall plug 14** was a suitable power supply for a wireless repeater. Ex-1019 Fig. 21, 16:32-17:1.

B. Detailed Application to Claims 15 and 18

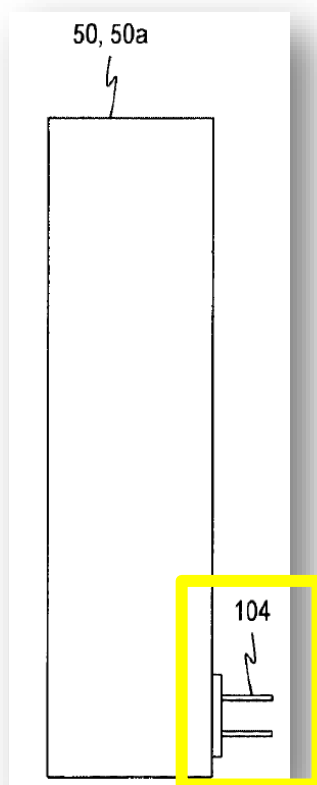
1. Claim 15

- a. 15. The network-enabled hub of claim 1, further comprising a power module that receives power from an integrated wall plug.*

193. *Cromer* in view of *Ganu* and *Judd* rendered obvious Claim 15.

194. *Cromer* broadly disclosed that client 100 (*network-enabled hub of claim 1*) was a “computer system” (Ex-1004 7:30-45, Fig. 7). As modified by *Ganu*, client 100 was configured as a forwarding node (FN). Ex-1005 001-002. *See* §VII.C.1.a ([1pre]). Computer system required a power supply and a common means of supplying power was via a *wall plug*.

195. In that respect, *Judd* taught suitable power supply solutions. Ex-1019 Abstract, 7:33-8:2, 16:29-17:6, Fig. 1, Fig. 19. Specifically, *Judd* taught a “DC power converter” (*a power module*) to convert AC power from a wall outlet to supply DC power for use by the repeater. Ex-1019 15:14-15. *Judd* further taught receiving AC power using plug 104 “built directly into” the repeater (*that receives power from an integrated wall plug*):



Ex-1019 Fig. 21 (annotated), 16:32-17:1 (“120-volt plug connection 104, **built directly into** the repeater”), 30:6-16, 40:27-31, Figs. 20 and 21.

196. A POSA would have found it obvious to utilize *Judd’s* power supply teaching with *Cromer’s* client 100. A POSA would have been motivated to utilize *Judd’s* DC converter to get DC power, which a POSA knew was suitable for electronics, and to do so using *Judd’s* integrated wall plug because, as *Judd* taught, it would avoid “requiring wire runs” (Ex-1019 30:14), make it “more aesthetic” (*id.*), and provide a “very simple installation, by the customer” (*id.* 17:1). Further, a POSA would have recognized that using *Judd’s* power supply teachings required nothing more than using *Judd’s* known method of supplying power to one known device—

Judd's repeater—with another similar wireless device—*Cromer-Ganu's* client 100 configured as a forwarding node (FN)—to achieve predictable results (simple, customer-performed, aesthetic installations, without need for cable runs). Further, a POSA would have had a reasonable expectation of success because a POSA would readily recognize that *Judd's* power supply teachings were a suitable design choice for powering *Cromer's* client 100.

2. Claim 18

- a. 18. The network-enabled hub of claim 17, further comprising a power module that receives power from an integrated wall plug.**

197. *Cromer* in view of *Ganu* and further in view of *Judd* rendered obvious Claim 18, for the reasons discussed for Claim 15. *See* Claim 15.

X. Claims 15 and 18 are Obvious over *Cromer* in view of *Ganu* and *Sinivaara* and further in view of *Judd*

198. Claims 15 and 18 are also obvious over the combination of *Cromer*, *Ganu* and *Sinivaara* (§ VIII) and further in view of *Judd*, for the reasons explained above in §I X. Nothing in my analysis in § VIII of the addition of *Judd* to *Cromer-Ganu* would be altered for the addition of *Judd* to *Cromer-Ganu-Sinivaara*.

XI. CONCLUSION AND DECLARATION

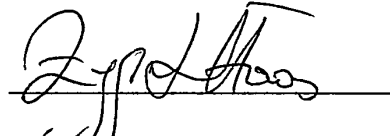
199. My findings and opinions set forth in this Declaration are based on my work and examination to date. I may continue my examinations in view of additional documents or other factual evidence over the course of this proceeding that may necessitate supplementing and/or refining my opinions. I reserve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

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

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

Executed at Richardson, TX on December 06, 2022:

By:


Dr. Zygmunt J. Haas

APPENDIX A – MATERIALS RELIED UPON

<i>Exhibit #</i>	<i>Description</i>
1001	U.S. Patent 9,264,991 (“the ’991 Patent”)
1002	Prosecution history of the ’991 Patent (“File History”)
1004	U.S. Patent 7,389,352 to Cromer et al. (“ <i>Cromer</i> ”)
1005	S. Ganu et al., <i>Architecture and Prototyping of an 802.11-Based Self-Organizing Hierarchical Ad-Hoc Wireless Network (SOHAN)</i> (“ <i>Ganu</i> ”)
1006	WO 2006/000617 to Sinivaara et al. (“ <i>Sinivaara</i> ”)
1007	P. Manzoni et al., <i>Providing Interoperability Between IEEE 802.11 and Bluetooth Protocols for Home Area Networks</i> (“ <i>Manzoni</i> ”)
1008	U.S. Patent 7,643,463 to Linsky et al. (“ <i>Linsky</i> ”)
1009	Declaration of Petitioner’s Expert Dr. Ingrid Hsieh-Yee (“ <i>Librarian Declaration</i> ”)
1010	Claim Construction Order and Memorandum from <i>Ozmo Licensing LLC v. Acer Inc.</i> , Dkt. 36, Case No. 6:21-cv-01225 (W.D. Tex Sep. 20, 2022) (“ <i>Markman Order</i> ”)
1015	IEEE Xplore Digital Library copy of <i>Ganu</i> , obtained on September 29, 2002
1017	Compilation of archived IEEE webpages, available at: https://web.archive.org/web/20040710111848/http://www.ieee.org:80/portal/index.jsp , archived July 10, 2004; https://web.archive.org/web/20040718051206/http://webapps1.ieee.org/conferenceSearch/details.do?tagNo=9573 , archived July 18, 2004; https://web.archive.org/web/20010207003457/http://ieeexplore.ieee.org/lpdocs/epic03 , archived February 7, 2001; and https://web.archive.org/web/20040823035644/http://shop.ieee.org/store/search.asp?mscssid=SQWFCQGUPSG59LETBWMTGL9713B63BEE&CID_LDAP=&PROMO_SRC_CODE=&BUYER_TYPE=&account_type=&member_grade=&hftype=&AUTH= , archived August 23, 2004.
1018	PIMRC 2004 Conference Website, and Conference Program Schedule downloaded from the same website, available at: https://web.archive.org/web/20040721000953/http://www.pimrc2004.org/ , archived July 21, 2004.
1019	WO 01/52447 to Judd et al. (“ <i>Judd</i> ”)

<i>Exhibit #</i>	<i>Description</i>
1020	“WPAN Applications” IEEE submission dated 1998, available at: https://www.ieee802.org/11/Documents/DocumentArchives/1998_docs/82957S-Shell-WAPAN-Applications.pdf .
1021	U.S. Patent Application Publication 2006/0194538 to Palin et al. (“ <i>Palin</i> ”)
1022	U.S. Patent 7,194,642
1023	U.S. Patent 8,208,449
1024	U.S. Patent Application Publication 2004/0048577
1025	Excerpts from Newton’s Telecom Dictionary (20 th ed. 2004)
1027	U.S. Patent Application Publication 2002/0028655
1028	Excerpts from Eric Cole, Network Security Bible (2005)
1029	IEEE Std 802.11, 1999 Edition (Reaffirmed 2003)
1030	U.S. Patent No. 8,599,814 (“the ’814 Patent”)—parent (by continuation) to the ’991 Patent

APPENDIX B – CURRICULUM VITAE

Zygmunt J. Haas

<u>Section #</u>	<u>Title</u>	<u>Pages</u>
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I. GENERAL INFORMATION

(i) Personal Information

Name: Zygmunt J. Haas

Titles: ① Professor and Distinguished Chair in Computer Science (Univ. of Texas at Dallas)

② Professor Emeritus (Cornell University; Electrical and Computer Engineering)

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② Cornell University:

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(ii) Main Research Interests

*** Wireless and Mobile Systems and Networks**

- * Wireless Communications
- * Communication Protocols for Wireless Networks
- * Security in mobile and wireless networks
- * Ad Hoc and Sensor Networking Technologies
- * Energy-efficient Protocols

*** Information Assurance and Network Security**

*** Cyber-Physical Systems (CPS) and Internet of Things**

*** Design, Modeling, and Implementation of Multimedia Protocols and Systems**

*** Modeling of Communication Systems**

- * Complex Networks
- * Stochastic Routing

*** Cross-Disciplinary Research Initiatives**

(iii) Education/Degrees (in reverse chronological order)

- * **Ph.D.**, Electrical Engineering, Stanford University, CA, May 1988
Advisor: Prof. David Cheriton, Computer Science, Stanford University
Thesis: “Packet Switching in Fiber-Optic Networks”
- * **M.Sc.**, (*Summa Cum Laude*) Electrical Engineering, Tel-Aviv University, Israel, Feb. 1985
- * **B.Sc.**, (*Summa Cum Laude*) Electrical Engineering, Technion (IIT), Israel, August 1979

(iv) Employment History (in reverse chronological order)

- 8/13 – present:** University of Texas at Dallas, Computer Science Department
Erik Jonsson School of Engineering and Computer Science, Richardson, TX
Title: Professor and Distinguish Chair in Computer Science
- 8/95 – present:** Cornell University, School of Electrical and Computer Engineering, Ithaca, NY
Title: Professor Emeritus (as of 10/13)
7/2004 – 10/2013: Tenured Full Professor
11/1998 - 6/2004: Tenured Associate Professor
8/1995 - 10/1998: Associate Professor
- 5/10 – 6/11:** National Science Foundation, Engineering Directorate, Arlington, VA; **Title:** Program Director; **Comment:** on leave from Cornell University
- 1/03-05/03:** Visiting Fellow, Princeton University, EE Department
- 09/94 - 7/95:** AT&T Business Communication Services, Murry Hill, NJ; **Title:** Member of Technical Staff
- 05/88 - 7/95:** AT&T Bell Laboratories, Network Research, Holmdel, NJ; **Title:** Member of Technical Staff
- 09/85 - 5/88:** Electrical Eng. Dept., Stanford University, CA, **Title:** Research Assistant
- 10/79 - 8/85:** R&D Department of Government of Israel, Tel-Aviv, Israel; **Title:** Engineer
- 10/81 - 6/85:** Electrical Eng. Dept., Tel-Aviv University, Israel; **Title:** Teaching Assistant
- 8/79 - 10/79:** Philips Research Laboratories, Eindhoven, Holland; **Title:** Engineer

(v) Selected Awards and Honors

- * Fellow of the *Association for Computing Machinery (ACM)*, 2021 (UTD ann.) (certificate)
- * “How 5G Technology May Improve and Impact Our Lives” *Authority Magazine* Interview, June 4, 2021 (link) (UTD Announcement)
- * Fellow of the AAIA (Asia-Pacific Artificial Intelligence Association), 6/2021 (9/28/2021)
- * Best Paper Award for the paper [Z.J. Haas and Z. Zheng, “Engineering a Network in the Sky,” The 35th International Conference on Information Networking, (*ICOIN21*), January 13–16, 2021, Jeju Island, S. Korea] (UTD announc.) (Cornell announc.)
- * *Guide2Research* Scientists 2020 Ranking: 315th (US) and 495 (Worldwide)
- * Distinguished Member of the European Alliance for Innovation (EAI), 2021
- * Fellow of the *European Alliance for Innovation (EAI)*, May 2019 (Fellow selection)
- * Fellow of *The Institute of Engineering and Technology (IET)*, March 2019
- * “5 Things to Know About 5G” *UT Dallas Magazine*, October 14, 2019
- * 2016 IEEE ComSoc AHSN Recognition Award (“for outstanding contributions to securing ad hoc and sensor networks”) presented at *IEEE Globecom 2016*, December 5, 2016, Washington DC (*AHSN Recognition Award*); Cornell’s faculty awards
- * Elevation to *IEEE Fellow*, January 2007, “for contribution to wireless and mobile ad hoc networks” (award letter)
- * Status of “Professor Emeritus” at Cornell University (as of October 15, 2013)

- * 2012 IEEE ComSoc WTC Recognition Award (the award recognizes individuals for "outstanding technical contributions in the field and for his service to the scientific and engineering communities") presented at *IEEE Globecom 2012*, December 5, 2012, Anaheim, CA (*WTC Recognition Awards*)
- * Distinction of *Classic Paper by Google Scholar* for the paper "Gossip-based Ad Hoc Routing," *IEEE/ACM Transactions on Networking*, vol.14, no.3, June 2006
- * "Best Paper Award" for the paper "Collaborating with Correlation for Energy Efficient WSN," [M. Nikolov and Z.J. Haas], *First ACM Annual International Workshop on Mission-oriented Wireless Sensor Networking (ACM MiSeNet 2012)*, in conjunction with *ACM MobiCom 2012*, Istanbul, Turkey, August 26, 2012
- * IEEE Distinguished Lecturer Tour, Scandinavian Countries, May 25 – June 5, 2009
- * Promotion to the rank of *Full Professor*, School of ECE, Cornell Univ., July 1, 2004
- * Distinguish Lecturer, IEEE Communications Society, (two terms) 01/2004 - 12/2005, 01/2005 - 12/2007
- * IEEE Distinguished Lecturer Tour, Australia, September 26-October 3, 2005
- * Expert Lecturer, IEEE Communications Society, 2002-2004
- * Michael Tien'72 Excellence in Teaching Award, Cornell College of Engineering for 2002-2003 academic year, November 2003
- * "Best Paper Award" for the paper "Optimal Resource Allocation for UWB Wireless Ad Hoc Networks," [C. Zou and Z.J. Haas], *IEEE 16th International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC'05)*, ICC Berlin, Germany, September 11-14, 2005
- * Michael Tien'72 Excellence in Teaching Award, Cornell College of Engineering for 2002-2003 academic year, November 2003
- * "Highly Commended Paper Award" for the paper "Performance Evaluation of the Modified IEEE 802.11 MAC for Multi-Channel Multi-Hop Ad Hoc Network," [J. Li, Z.J. Haas, M. Sheng, and Y. Chen], *IEEE International Conference on Advanced Information Networking and Applications (AINA 2003)*
- * Elected Chair of the IEEE Technical Committee on Personal Communications (TCPC), Jan. 2001 – Nov. 2002 (previously elected Vice Chair and Secretary)
- * Michael Tien'72 Excellence in Teaching Award, Cornell College of Engineering for 1999-2000 academic year, September 2000
- * Election to *Indefinite Tenure*, Cornell University, October 1998
- * Michael Tien'72 Excellence in Teaching Award, Cornell College of Engineering for 1996-1997 academic year, September 1997 (letter) (banquet)
- * AT&T Foundation Award, September 1995
- * President Award, Technion, Israel (1976, 1977, 1978, and 1979)
- * B.Sc. w/ "*Summa Cum Laude*," Aug. 1979; M.Sc. w/ "*Summa Cum Laude*," Feb. 1985

(vi) Memberships in Professional Societies

- * IEEE Communications Society (ComSoc)
- * Association for Computing Machinery (ACM)
- * Special Interest Group on Mobile Communications (SIGMOBILE)

(vii) Membership in Graduate Fields + Affiliate Membership (date awarded)

- * Electrical and Computer Engineering, Cornell University, August 1995
- * Computer Science, Cornell University, February 2001
- * Center for Applied Math, Cornell University, April 2003
- * Electrical Engineering, University of Texas at Dallas, April 4, 2015

II. TALKS, INVITED TALKS, & KEYNOTE SPEECHES

Invited and Keynote Talks (in reverse chronological order)

- * Zygmunt J. Haas, “Reconfigurable Distributed MIMO for Physical-layer Security in Mobile Networks,” *Invited Talk*, 40th IEEE Sarnoff Symposium, NJIT, Newark, NJ, Sep. 23, 2019 (Invited Talks) (plaque)
- * Z.J. Haas, “Reconfigurable Distributed MIMO for Physical-layer Security in Mobile Networks,” *ECE Seminar Series*, Stevens Institute of Technology, March 27, 2019 (announcement)
- * Z.J. Haas, “Reconfigurable Distributed MIMO for Physical-layer Security in Mobile Networks,” *Invited Talk*, Joint ECE/CS Seminar, Stony Brook University, February 28, 2019 (announcement)
- * Z.J. Haas, “Reconfigurable Distributed MIMO for Physical-layer Security in Mobile Networks,” *ACCESS Distinguished Lecture*, KTH Royal Institute of Technology, Stockholm, Sweden, September 13, 2018 (announcement)
- * Z.J. Haas, “Challenges of Internet of Things,” Spring 2017 Computer Science Distinguished Lecture Series, Norfolk State University, Computer Science Department, April 6, 2017 (plaque)
- * Z.J. Haas, “Research Directions of the Wireless Networks Lab,” Computer Science Department, Wesleyan University, Fort Worth, TX, March 31, 2016
- * Z.J. Haas, “Challenges of Internet of Things,” Fourth Annual International Workshop on Mission-Oriented Wireless Sensor Networking (*MiSeNet 2015*), Dallas, TX, October 19, 2015
- * Z.J. Haas, “Security of Big Data,” Third Annual International Workshop on Mission-Oriented Wireless Sensor Networking (*MiSeNet 2014*), Philadelphia, PA, October 27, 2014
- * Z.J. Haas, “Big Data and Its Security Implications,” National Taiwan University (NTU), Taipei, Taiwan, December 16, 2013
- * Z.J. Haas, “Big Data and Its Security Implications,” National Sun Yat-sen University, Kaohsiung, Taiwan, December 18, 2013
- * Z.J. Haas, “Big Data and Its Security Implications,” National Tsing Hua University, Hsinchu, Taiwan, December 19, 2013
- * Z.J. Haas, “Big Data and Security Implications,” Keynote Speech, *EUSPN’13, 4th International Conference on Emerging Ubiquitous Systems and Pervasive Networks*, Niagara Falls, Ontario, Canada, October 21-24, 2013
- * Z.J. Haas, “Security of Big Data,” at the Cornell Engineering Alumni Association conference, Washington, DC, May 13, 2013
- * Z.J. Haas, “Stochastic Routing,” DIMACS Workshop on Connectivity and Resilience for Large-Scale Networks, Rutgers University, Piscataway, NJ, April 12-13, 2012
- * Z.J. Haas, “*Information Assurance for Sensor Networks*,” Winter 2012 CIS Distinguished Lecture Series, Computer and Information Science Department, College of Engineering and Computer Science, University of Michigan-Dearborn, March 16, 2012
- * Z.J. Haas, “*Information Assurance for Sensor Networks*,” Invited Talk, Department of Electrical Engineering and Computer Science, UC Berkeley, Berkeley, CA, September 7, 2011
- * Z.J. Haas, “*Information Assurance for Vehicular Sensor-based Networks*,” Closing Keynote, 4th *IEEE International Symposium on Wireless Vehicular Communications (WiVeC’11)*, San Francisco, CA, September 6, 2011

- * Z.J. Haas, “*Information Assurance for Sensor Networks*,” Invited Talk, Department of Electrical Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan, August 15, 2011 (program)
- * Z.J. Haas, “*New Directions and Challenges in Information Assurance with Applications for Sensor Networks*,” Invited Talk, Department of Electrical Engineering, NCTU, Hsinchu, Taiwan, August 12, 2011
- * Z.J. Haas, “*New Directions and Challenges in Information Assurance with Application to Sensor Networks*,” Invited Talk, Department of Electrical Engineering, Boston University, July 14, 2011
- * Z.J. Haas, “*Information Assurance and Sensor Network Security*,” Department of Electrical and Computer Engineering, University of Florida, Gainesville, FL, April 14, 2011
- * Z.J. Haas, “*Information Assurance and Sensor Network Security*,” Computer and Information Sciences department, Temple University, Philadelphia, PA, March 31, 2011
- * Z.J. Haas, “*Information Assurance for Sensor Networks*,” Keynote Speech, *IEEE PerCom 2011 (Information Quality and Quality of Service (IQ2S) Workshop)*, Seattle, WA, March 21, 2011
- * Z.J. Haas, “*Stochastic Routing for Delay Tolerant Networks*,” Invited Talk, IEEE Communications Society North Jersey Chapter, NJIT Department of ECE, Newark, NJ, November 29, 2010
- * Z.J. Haas, “*Stochastic Routing for Delay Tolerant Networks*,” Keynote Talk, *Symposium for Emerging Trends in Mobile, Sensor, and Social Networks (MSS 2010)*, *CReWMaN 10th Anniversary Celebration*, University of Texas at Arlington, October 7-8, 2010
- * Z.J. Haas, “*On Networking in the ‘Final Frontier’*,” Invited Talk, Air Force Research Laboratory, Rome, NY, August 6, 2010
- * Z.J. Haas, “*The Ad Hoc and Sensor Networking Technology: Past, Presence, and Future*,” Keynote Speech, *The Second International Conference on Ubiquitous and Future Networks (ICUFN’10)*, Jeju Island, South Korea, June 16-18, 2010
- * Z.J. Haas, “*Engineering Education for the 21st Century*,” Invited Talk, Kookmin University, Seoul, South Korea, June 21, 2010
- * Z.J. Haas, “*3D Wireless Networks*,” Plenary Speaker, *Wireless Telecommunications Symposium (WTS 2010)*, April 21-23, 2010, Tampa, FL (*WTS 2010*)
- * Z.J. Haas, “*Stochastic Routing for Delay Tolerant Networks*,” Electrical and Computer Engineering Seminar, Technion, Israel Institute of Technology, July 13, 2009
- * Z.J. Haas, “*Stochastic Routing for Delay Tolerant Networks*,” Nordic IEEE/ComSoc Distinguish Lecturer Tour (DLT), May 24, 2009 – June 5, 2009:
 - KTH Royal Institute of Technology, Stockholm, Sweden
 - Helsinki University of Technology (TKK), Helsinki, Finland
 - Linköpings Universitet, Dept. of Computer & Info. Science, Linköpings, Sweden
 - Lund Technical University and Ericsson, Lund, Sweden
 - Oulu University, Oulu, Finland
 - Aalborg University, Aalborg, Denmark
 - Danmarks Tekniske Universitet (DTU), Copenhagen, Denmark
- * Z.J. Haas, “*Implications of Reconfiguration at the Network Layer*,” US-Australia NSF Workshop: Self-Organizing Wireless Networks Based on Cross-Layer Interactions, Darling Harbour, Sydney, Australia, December 17-19, 2008

- * Z.J. Haas, “*Stochastic Routing*,” US-Australia NSF Workshop: Self-Organizing Wireless Networks Based on Cross-Layer Interactions, Darling Harbour, Sydney, Australia, December 17-19, 2008
- * Z.J. Haas, “*Stochastic Routing for Sensor- and Ad Hoc-Networks*,” Keynote Speech, *International Conference on Intelligent Sensors, Sensor Networks, and Information Processing* (ISSNIP 2008), December 15-18, 2008, Sydney, Australia
- * Z.J. Haas, “What’s in My Crystal Bowl,” Keynote Speech, *Australasian Telecommunication Networks and Applications Conference 2008 (ATNAC 2008)*, Adelaide, South Australia, December 7-10, 2008
- * Z.J. Haas, “*On Networking in the Final Frontier*,” University of South Florida, Tampa, FL, December 5, 2008
- * Z.J. Haas, “*On Networking in the Final Frontier*,” CSE Colloquium, Department of Computer Science and Engineering, University of Buffalo, Buffalo, NY, Nov. 6, 2008
- * Z.J. Haas, “*On Networking in the `Final Frontier`*,” ECE Seminar Series, Carnegie Mellon University, Pittsburgh, PA, November 20, 2008
- * Z.J. Haas, “*Stochastic Routing*,” *Brown-Bag Series*, Computer Science Department, Cornell University, Ithaca, NY, March 4, 2008
- * Z.J. Haas, “The Untold Story about the Romance between Mr. *A.H Network* and Mrs. *S. Network* and about their Son, Mr. *D.-T Network*,” *ECE Colloquium*, Department of Electrical and Computer Engineering, Boston University, February 22, 2008
- * Z.J. Haas, “Research in Wireless Ad Hoc Networks at the Cornell's Wireless Networks Laboratory,” Iowa State University, Computer Science Department, July 6, 2007
- * Z.J. Haas et al, “How to Circumvent the Scalability Curse,” IMANET Workshop, Arlington, VA, March 7, 2006
- * Z.J. Haas, “On Some Choices in QoS Design of Ad Hoc and Sensor Networks,” *Bell Laboratories, Lucent Technologies*, Murray Hill, NJ, January 27, 2006
- * Z.J. Haas, “On Some Choices in QoS Design of Ad Hoc and Sensor Networks,” Keynote Speech, 2nd *IEEE International Conference on Mobile Ad-hoc and Sensor Systems (MASS 2005)*, Washington, DC, November 9, 2005
- * Z.J. Haas, “Research in Wireless Ad Hoc Networks at the Cornell's Wireless Networks Laboratory,” Keynote Speech, *2005 Asia-Pacific Conference on Communications*, Perth, Australia, October 3-5, 2005
- * Z.J. Haas, “Mobility and its Effects on Networks Performance,” *MinEMA Summer School 2005*, Klagenfurt University, Klagenfurt, Austria, July 11-15, 2005
- * Z.J. Haas, “Research in Wireless Ad Hoc Networks at the Cornell's Wireless Networks Laboratory,” *IEEE Communications Society and IEEE Aerospace and Electronics Systems*, Joint Chapter, Rochester, NY, *Rochester Institute of Technology*, Rochester, NY, October 19, 2004
- * Z.J. Haas, “Research in Wireless Ad Hoc Networks at the Cornell's Wireless Networks Laboratory,” *University of Pennsylvania, Electrical Engineering Department*, Philadelphia, PA, November 8, 2004
- * P. Papadimitratos and Z.J. Haas, “Secure Routing for Mobile Ad Hoc Networks,” *Working Session on Security in Wireless Ad Hoc Networks*, Swiss Federal Institute of Technology – Lausanne (EPFL), Switzerland, June 12, 2002
- * Z.J. Haas and E.Y. Hua, “Multipath Routing – A Cross-Layer Design Tool for QoS Provisioning in MANETs,” *Cross-Layer Design Workshop*, Naval Research Laboratory, Washington, DC, June 2, 2004

- * Z.J. Haas, "Ad Hoc Research at the Wireless Networks Laboratory (WNL) at Cornell University," EE Seminar, Columbia University, April 16, 2001
- * Z.J. Haas, "Predictive Distance-Based Mobility Management for PCS Networks," Telcordia, Morristown, NJ, April 7, 2000
- * Z. Haas, "The Design and Performance of Mobile TCP for Wireless Networks," *Seminar on Networks Research, Center for Advanced Technology in Telecommunications*, March 26, 1999
- * Z.J. Haas, "Scalability of Wireless Ad Hoc Networks," *The International Workshop on Theoretical and Algorithmic Aspects of Sensor, Ad Hoc Wireless and Peer-to-Peer Networks*, Keynote Speech, Fort Lauderdale, FL, February 20–21, 2004
- * Speaker at the "NSF Networking Principal Investigators' Workshop," session on Wireless/Mobile, Loews L'Enfant Plaza Hotel, Washington, DC, January 21–23, 1999
- * Z. Haas, "Networking Issues in Wireless Technologies," *IEEE Multiaccess, Mobility and Teletraffic for Personal Communications Workshop 1998*, Washington, DC, October 21, 1998
- * Z.J. Haas, "Zone Routing: A New Routing Protocol for the Reconfigurable Wireless Networks," *Science Advisory Board Associates (SABA)*, Motorola, Arlington Heights, November 18, 1997
- * Z.J. Haas, "Routing in Highly Reconfigurable Wireless Networks," *8th Maryland Workshop on Very High Speed Networks*, University of Maryland Baltimore County, November 12-13, 1997
- * Z. J. Haas, "The Multiply-Detected Macrodiversity Scheme for Wireless Cellular Systems," *EE Colloquium, School of Electrical Eng.*, Cornell University, April 22, 1997
- * Z. J. Haas, J. H. Winters, and D. S. Johnson, "Simulation Results of Cellular Capacity Bounds," *5th Maryland Workshop on Very High Speed Networks*, Baltimore, MD, March 14-16, 1994
- * Z. J. Haas, J. H. Winters, and D. S. Johnson, "On the Capacity Bounds in Cellular Systems," *Allerton Conf. on Comm., Control, and Comp.*, Monticello, IL, Sept. 29 - Oct. 1, 1993
- * Z. Haas, "Gigabit Connectivity with the 'Staggering Switch': An Electronically Controlled Optical Packet Switch," *4th Maryland Workshop on Very High Speed Network*, March 15-17, 1993
- * Z. Haas, "The 'Staggering Switch' – A Scheme for Collision Resolution in Optical Packet Switches," ECE Seminar, Amherst University, Feb. 22, 1993
- * Zygmunt Haas, "Communication in the Gbps Era: Some Answers," *Washington University at St. Louis*, St. Louis, MO, September 1990

Tutorial Courses:

- * Z.J. Haas, "The Ad Hoc Networking Technology," *Thales Communications, Land and Joint Systems Division*, Clarksburg, MD, May 21-24, 2006
- * Z.J. Haas, "Mobility and Its Effects On Network Performance," ESF'05 Workshop, November 7, 2005
- * Z.J. Haas, "Mobility and Its Effects On Network Performance," *Middleware for Network Eccentric and Mobile Applications (MiNEMA) Workshop, MiNEMA Summer School*, Klagenfurt University, Klagenfurt, Austria, July 11-15, 2005
- * Z.J. Haas, "Inside the Communication Protocols: Teletraffic Engineering & Performance Evaluation," *Telefocal Asia*, Singapore, March 22, 2004
- * Z. Haas, Ad Hoc Networks – A New Communication Paradigm?" *Mobile Terrestrial & Space Networking Workshop*, NASA Ames Research Center, Moffett Field, CA, June 26, 2001

- * Z.J. Haas, "Mobile Ad Hoc Networks," IEEE Wireless Communications and Networking Conference (WCNC'00), Chicago, IL, September 23-28, 2000
- * Z.J. Haas, "Mobile Ad-Hoc Networks," *DIMACS Summer School on Foundations of Wireless Networks and Applications*, Rutgers University, Piscataway, NJ, Aug. 7 - 18, 2000
- * Z.J. Haas, "Wireless Networks: from Cellular to Ad-Hoc," *DIMACS Summer School on Foundations of Wireless Networks and Applications*, Rutgers University, Piscataway, NJ, August 7 - 18, 2000
- * Z.J. Haas, "Queueing Theory for Network Engineering," *MITRE Corporation*, Eatontown, NJ, 2000
- * Z.J. Haas, "Wireless Networks - from Cellular to Ad Hoc," IEEE Military Communications Conference (MILCOM'99), Atlantic City, NJ, Oct. 31 – Nov. 3, 1999
- * Z.J. Haas, "Mobile Ad Hoc Networks," IEEE Wireless Communications and Networking Conference (WCNC'99), New Orleans, LA, September 21-24, 1999
- * Z.J. Haas, "Mobile Ad Hoc Networks," IEEE Military Communications Conference (MILCOM'98), Bedford, MA, October 20-23, 1998
- * Z.J. Haas, "Mobile Ad Hoc Networks," Tutorial 9, 48th IEEE Vehicular Technology Conference, Pathway to Global Wireless Revolution (VTC'98), Ottawa, Ontario, Canada, May 18–21, 1998
- * Z.J. Haas, "Mobility Management in TCP/IP Networks," IEEE Military Communications Conference (MILCOM'97), Monterey, CA, November 2-5, 1997
- * Z.J. Haas, "Wireless Cellular Networks," ACM/IEEE Mobicom'97, Budapest, Hungary, September 27- 30, 1997
- * Z.J. Haas, "Mobility Management in TCP/IP Networks," IEEE ICC'97, Montreal, Quebec, Canada, June 8-12, 1997
- * Z.J. Haas, "Mobility Management in TCP/IP Networks," IEEE GLOBECOM'97, London, United Kingdom, November 22, 1996
- * Z.J. Haas, "Mobility Management in Wireless Networks," ICUPC'96, Cambridge, MA, September 29, 1996
- * Z.J. Haas, "Mobility Management in Wireless Networks," ICC'96, Dallas, TX, June 23-27, 1996
- * Z.J. Haas, "Mobile Communication Networks," *6th IFIP International Conference on High Performance Networking (HPN'95)*, Palma De Mallorca, Balearic Islands, Spain, September 11-15, 1995
- * Z.J. Haas, "Mobility in TCP-IP Networks," IEEE Wireless'95, 1995
- * Z.J. Haas, "Mobile Communication Networks," ICC'95, Seattle, WA, June 18-22, 1995
- * Z.J. Haas, "Mobile Communication Networks," APCC, Osaka, Japan, June 13-16, 1995
- * Z.J. Haas, "Mobile Communication Networks," IPCCC, Scottsdale, AZ, March 28, 1995
- * Z.J. Haas, "Mobile Communication Networks," GLOBECOM'94, San-Francisco, CA, November 27, 1994
- * Z.J. Haas, "Personal Communication Services and Networks," SIGCOMM'94, University College London, London, UK, August 30 – September 2, 1994
- * Z.J. Haas, "Optical Networks," GLOBECOM'93, Houston, TX, December 3, 1993
- * Z.J. Haas, "Optical Networks," SIGCOMM'92, Baltimore, Maryland, USA, August 17-20, 1992

III. PUBLICATIONS

(i) Refereed Journal/Archival Publications (in reverse chronological order)

1. K. Singh, A.F. Makarim, H. Albinsaid, C.-P. Li, and Z.J. Haas, "Passive Beamforming Design and DNN-Based Signal Detection in RIS-Assisted MIMO Systems with Generalized Spatial Modulation," *IEEE Transactions on Vehicular Technology*, Sept. 23, 2022; DOI: 10.1109/TVT.2022.3208830
2. T.-L. Nguyen, G. Kaddoum, T.-N. Do, D.B. da Costa, and Z.J. Haas, "Adaptive Decoding Mechanisms for UAV-enabled Double-Uplink Coordinated NOMA," arXiv:2206.13370v1 [cs.IT] 27 Jun 2022
3. T.-L. Nguyen, T.-N. Do, G. Kaddoum, D.B. da Costa, and Z.J. Haas, "Channel Characterization for RIS-aided Terahertz Communications: A Stochastic Approach," *IEEE Wireless Communications Letters*, June 24, 2022, pp. 1890–1894; DOI: 10.1109/LWC.2022.3185977
4. L. Xi, R. Wang, and Z.J. Haas, "Data-correlation-aware Unsupervised Deep-Learning Model for Anomaly Detection in Cyber-Physical Systems," *IEEE Internet of Things Journal*, vol.9, no.22, pp.22410–22421, Nov. 15, 2022; DOI: 10.1109/JIOT.2022.3150048
5. T.-N. Do, G. Kaddoum, T.-L. Nguyen, D.B. da Costa, and Z.J. Haas, "Multi-RIS-aided Wireless Systems: Statistical Characterization and Performance Analysis," *IEEE Transactions on Communications*, vol. 69, no. 12, pp: 8641–8658, December 2021; DOI: 10.1109/TCOMM.2021.3117599
6. T.N. Do, G. Kaddoum, T. L. Nguyen, D.B. da Costa, and Z.J. Haas, "Aerial Reconfigurable Intelligent Surface-Aided Wireless Communication Systems," arXiv:2106.05380v1 [cs.IT] 9 Jun 2021 (arXiv)
7. Z.J. Haas, T.L. Culver, and K. Sarac, "Vulnerability Challenges of Software-Defined Networks," *IEEE Communications Magazine*, July 2021, vol. 59, no. 7, pp. 88–93; DOI: 10.1109/MCOM.001.2100128
8. H. Albinsaid, K. Singh, A. Bansal, S. Biswas, C.-P. Li, and Z.J. Haas, "Multiple Antenna Selection and Successive Signal Detection for SM-based IRS-aided Communication," *IEEE Signal Processing Letters*, vol. 28, April 9, 2021, pp. 813–817; DOI: 10.1109/LSP.2021.3071981
9. T.N. Do, G. Kaddoum, T. L. Nguyen, D.B. da Costa, and Z.J. Haas, "Multi-RIS-aided Wireless Systems: Statistical Characterization and Performance Analysis," arXiv:2104.01912v1 [cs.IT] 5 Apr 2021 (arXiv)
10. M. Stanacevic, A. Athalye, Z.J. Haas, S. Das, and P. Djuric, "Backscatter Communications with Passive Receivers: From Fundamentals to Applications," *ITU Journal on Future and Evolving Technologies*, volume 1 (2020), issue 1, December 11, 2020
11. C. Liu, Z.J. Haas, and Z. Tian, "On the Design of Multi-Hop Tag-to-Tag Routing Protocol for Large-Scale Networks of Passive Tags," *IEEE Open Journal of the Communications Society*, Special Issue on *Large-Scale Wireless Powered Networks with Backscatter Communications*, vol. 1, 2020, pp. 1035-1055, July 24, 2020; DOI: 10.1109/OJCOMS.2020.3011171
12. T.-N. Do and Z.J. Haas, "On the Design of RD-MIMO: Spatial Multiplexing versus Opportunistic Transmission Schemes," *IEEE Access*, vol.8, no.1, pp. 22733–22747, January 29, 2020; DOI: 10.1109/ACCESS.2020.2970049

13. R. Duan, Z. Zheng, R. Jäntti, J. Hämäläinen, and Z.J. Haas, "Asymptotic Analysis for Spectrum-sharing Systems with TAS/MRC Using Extreme Value Theory: An Overlooked Aspect," *IEEE Access*, vol. 7, September 23, 2019, pp. 138062–138078, DOI: 10.1109/ACCESS.2019.2943083
14. A. Jindal and Z.J. Haas, "On the Performance of Distributed MIMO with Full-Duplex Jamming," *IEEE Transactions on Communications*, vol. 67, no. 3, pp. 1972–1985, March 2019, DOI: 10.1109/TCOMM.2018.2884721
15. Z. Zheng, Z.J. Haas, and M. Kieburg, "Secrecy Rate of Cooperative MIMO in the Presence of a Location Constrained Eavesdropper," *IEEE Transactions on Communications*, vol. 67, no. 2, pp. 1356–1370, ISSN: 0090-6778, February 2019; DOI: 10.1109/TCOMM.2018.2877329; arXiv:1709.05383v3 [cs.IT] 15 Oct 2018
16. Y.-M. Chen, W.-C. Cheng, C.-P. Li, and Z.J. Haas, "Low-complexity Generalized Spatial Modulation Schemes Using Codebook-assisted MIMO Detectors," *IEEE Transactions on Vehicular Technology*, vol. 67, no. 12, pp. 12358–12362, September 2018, DOI: 10.1109/TVT.2018.2871577
17. J. Huang, Z. Liu, Q. Duan, M. Atiquzzman, M. Jo, and Z.J. Haas, "Green Computing and Communications for Smart Portable Devices," Editorial, *Hindawi Wireless Communications and Mobile Computing*, Vol. 2018, Article ID 6839604, DOI: <https://doi.org/10.1155/2018/6839604>
18. Z.J. Haas and A. Yousefpour, "A Privacy Scheme for Monitoring Devices in the Internet of Things," In: N. Oliver *et al.* (eds) 'Pervasive Computing Paradigms for Mental Health,' Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol. 207, pp. 153-165, 2018, Springer, Cham; DOI: 10.1007/978-3-319-74935-8_22; Print ISBN: 978-3-319-74934-1; Online ISBN: 978-3-319-74935-8 (March 1, 2018)
19. M. Nikolov and Z.J. Haas, "Encoded Sensing for Energy Efficient Wireless Sensor Networks," *IEEE Sensors Journal*, 2017, Special Issue on "Power-efficient sensors for long-term applications," vol. 18, no. 2, January 2018, pp. 875–889, DOI: 10.1109/JSEN.2017.2756865
20. J. Huang, C.C Xing, Y. Qian, and Z.J. Haas, "Resource Allocation for Multi-cell Device-to-Device Communications Underlying 5G Networks: A Game-Theoretic Mechanism with Incomplete Information," *IEEE Transactions on Vehicular Technology*, vol. PP, no. 99, October 23, 2017, DOI: 10.1109/TVT.2017.2765208
21. J. Ugrumurera and Z. J. Haas, "Optimal Sizing of a Completely Green Charging System for Electric Vehicles," *IEEE Transactions on Transportation Electrification*, vol. 3, no. 3, Sept. 2017, pp. 565–577, DOI: 10.1109/TTE.2017.2713098
22. Z. Zheng and Z.J. Haas, "On the Performance of Reconfigurable Distributed MIMO in Mobile Networks," *IEEE Transactions on Communications*, vol. 65, no.4, April 2017, pp. 1609–1622; DOI: 10.1109/TCOMM.2017.2656129
23. S.N. Premnath and Z.J. Haas, "Supporting Privacy of Computations in Mobile Big Data Systems," *Future Internet* 2016, 8(2), 17; DOI: 10.3390/fi8020017
24. M. Nikolov and Z.J. Haas, "Relay Placement in Wireless Networks: Minimizing Communication Cost," *IEEE Transactions on Wireless Communications*, vol.15, no.5, May 2016
25. Z. Li and Z.J. Haas, "On Residual Path Lifetime in Mobile Networks," *IEEE Communications Letters*, vol. 20, no.3, March 2016, DOI: 10.1109/LCOMM.2016.2520467

26. S.N. Premnath and Z.J. Haas, "Security and Privacy in the Internet-of-Things under Time-and-Budget-limited Adversary Model," *IEEE Wireless Communications Letters* 4(3), pp. 277–280, 2015, DOI: 10.1109/LWC.2015.2408609
27. S.M.N. Alam and Z.J. Haas, "Coverage and Connectivity in Three-Dimensional Networks with Random Node Deployment," Elsevier *Ad Hoc Networks Journal*, special issue on *Underwater Communications*, 2014, DOI: 10.1016/j.adhoc.2014.09.008, <http://dx.doi.org/10.1016/j.adhoc.2014.09.008>
28. Z.J. Haas and M. Nikolov, "Towards Optimal Broadcast in Wireless Networks," *IEEE Transactions on Mobile Computing*, vol. 14, no. 7, pp. 1530–1544, July 2015, DOI: 10.1109/TMC.2014.2356466
29. E.Y. Hua and Z.J. Haas, "Mobile-Projected Trajectory Algorithm with Velocity-Change Detection for Predicting Residual Link Lifetime in MANET," *IEEE Transactions on Vehicular Technology*, March 2015, vol. 64, no. 3, pp. 1065–1078, <http://dx.doi.org/10.1109/TVT.2014.2327232>
30. Z.J. Haas and M. Nikolov, "Towards Optimal Broadcasting," CoRR abs/1301.7101 (2013)
31. M.Z. Chowdhury, Y.M. Jang, and Z.J. Haas, "Priority based Bandwidth Adaptation for Multi-class Traffic in Wireless Networks," *International Journal of Multimedia and Ubiquitous Engineering* vol. 7, no. 2, pp. 445–450, April 2012 (also in <https://arxiv.org/abs/1412.4322>)
32. M.Z. Chowdhury, Y.M. Jang, and Z.J. Haas, "Call Admission Control based on Adaptive Bandwidth Allocation for Wireless Networks," *IEEE/KICS Journal of Communications and Networks (JCN)*, vol. 15, no. 1, pp. 15–24, Feb. 2013. (SCI)
33. F. Losilla, A.-J. Garcia-Sanchez, F. Garcia-Sanchez, J. Garcia-Haro, and Z.J. Haas, "A Comprehensive Approach to WSN-based ITS Applications: A Survey," *Sensors* 2011, 11, 10220–10265, October 28, 2011, doi:10.3390/s111110220
34. C. Garcia-Costa, E. Egea-Lopez, J. Tomas-Gabarron, J. Garcia-Haro, Z.J. Haas, "A stochastic model for chain collisions of vehicles equipped with vehicular communications," *IEEE Transactions on Intelligent Transportation Systems*, vol. 13, no.2, June 2012, pp. 503–518; DOI: 10.1109/TITS.2011.2171336
35. G.Y. Lee and Z.J. Haas, "Simple, Practical, and Effective Opportunistic Routing for Short-haul Multi-hop Wireless Networks," *IEEE Transactions on Wireless Communications*, 2011, pp. 3583–3588, DOI: 10.1109/TWC.2011.11.101713
36. M.F. Elhawary and Z.J. Haas, "Energy-Efficient Protocol for Cooperative Transmission," *IEEE Transactions on Networking*, vol. 19, no.2, April 2011, pp. 561–574, DOI: 10.1109/TNET.2010.2089803
37. M.Z. Chowdhury, Y.M. Jang, and Z.J. Haas, "Cost-Effective Frequency Planning for Capacity Enhancement of Femtocellular Networks," *Wireless Personal Communications*, vol. 60, pp. 83–104, March 2, 2011, DOI: <https://doi.org/10.1007/s11277-011-0258-y>
38. ChuanYun Zou, Zygmunt J. Haas, and Sheng Zou, "Throughput maximization in UWB-based ad hoc networks," *SCIENCE CHINA, Information Sciences*, vol.53, no.12: 2538–2547, DOI: 10.1007/s11432-010-4120-8
39. M.Z. Chowdhury, Y.M. Jang, and Z.J. Haas, "Network Evolution and QoS Provisioning for Integrated Femtocell/Macrocell Networks," *International Journal of Wireless & Mobile Networks (IJWMN)*, vol.2, no.3, August 2010 (.pdf)

40. J. Oh and Z.J. Haas, "Personal Environment Service based on the Integration of Mobile Communications and Wireless Personal Area Networks," *IEEE Communications Magazine*, vol. 48, no. 6, June 2010, pp. 66–72; DOI: 10.1109/MCOM.2010.5473866
41. S.M. Nazrul Alam and Z.J. Haas, "Hierarchical and Honhierarchical Three-Dimensional Underwater Wireless Sensor Networks," CoRR abs/1005.3073, 2010
42. E.Y. Hua and Z.J. Haas, "An Algorithm for Prediction of Link Lifetime in MANET Based on Unscented Kalman Filter," *IEEE Communications Letters*, vol.13, no.10, October 2009, pp. 782–784
43. Z. Wang, R.J. Thomas, and Z.J. Haas, "Performance comparison of Bluetooth Scatternet formation protocols for multi-hop networks," Springer *Wireless Networks (WINET)*, Volume 15, Number 2 / February, 2009, pp. 209–226, published online on April 14, 2007 (color copy); DOI: 10.1007/s11276-007-0036-7
44. G.Y. Lee, Y. Lee, and Z.J. Haas, "Hybrid Location-Update Scheme for Mobile Networks," *IEEE Transactions on Vehicular Technology*, vol. 58, no. 1, January 2009, pp. 338–348
45. J. Jeong and Z.J. Haas, "Predeployed Secure Key Distribution Mechanism in Sensor Networks: Current State-of-the-Art and a New Approach Using Time Information," *IEEE Wireless Communication*, August 2008, pp. 42–51
46. S.M.N. Alam and Z.J. Haas, "Coverage and connectivity in three-dimensional underwater sensor networks," *Wireless Communications and Mobile Computing*, vol. 8, no. 8, pp. 995–1009, October 2008; (Published online 10 July 2008 in Wiley InterScience, www.interscience.wiley.com); DOI: 10.1002/wcm.661
47. J. Oh and Z.J. Haas, "A Scheme for Location-Based Internet Broadcasting and Its Applications," *IEEE Communications Magazine*, vol. 45, no. 11, November 2007, pp. 136–141, DOI: 10.1109/MCOM.2007.4378333
48. Z.J. Haas and T. Small, "Quality of Service and Capacity in Constrained Intermittent-Connectivity Networks," *IEEE Transactions on Mobile Computing*, vol.6, no.7, July 2007, pp. 803–814, DOI: 10.1109/TMC.2007.1033
49. Z.J. Haas and R. Barr, "Density-Independent, Scalable Search in Ad Hoc Networks," Springer *International Journal of Wireless Information Networks*, special issue on "PIMRC 2005," vol. 14, no. 2, June 2007, pp. 93–105
50. J. Jeong and Z.J. Haas, "An Integrated Security Framework for Open Wireless Networking Architecture," *IEEE Wireless Communications Magazine*, special issue on "Technologies On Future Converged Wireless And Mobility Platform," vol.14, no.2, April 2007, pp.10–18, DOI: 10.1109/MWC.2007.358959
51. O. Arpacioglu and Z.J. Haas, "On the Scalability and Capacity of Single-User-Detection Based Wireless Networks with Isotropic Antennas," *IEEE Transactions on Wireless Communications*, vol.6, no.1, January 2007, pp.8–15
52. S.M. Nazrul Alam, Z.J. Haas "Topology Control and Network Lifetime in Three-Dimensional Wireless Sensor Networks," September 11, 2006, arXiv:cs/0609047
53. Ben Liang and Zygmunt J. Haas, "Hybrid Routing in Ad Hoc Networks with Dynamic Virtual Backbone," *IEEE Transactions on Wireless Communications*, vol. 5, no. 6, June 2006, pp. 1392–1405; DOI: 10.1109/TWC.2006.1638660
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(iii) Books & Book Chapters

1. Q. Wang, and Zygmunt J. Haas, "Performance Analysis of Epidemic Routing for Delay-Tolerant Networks," in *Resource Management in Mobile Computing Environments, Modeling and Optimization in Science and Technologies*, volume 3, (2014), *Springer International Publishing*, DOI: 10.1007/978-3-319-06704-9_26
2. Zygmunt J. Haas, Lin Yang, Meng-Ling Liu, Qiao Li, and Fangxin Li, "Current Challenges and Approaches in Securing Communications for Sensors and Actuators," Chapter 17 in the "Art of Wireless Sensor Networks," H.M. Ammari, ed., Springer-Verlag Berlin Heidelberg, 2014, pp. 569-608; DOI: 10.1007/978-3-642-40009-7_17
3. Zygmunt J. Haas, Seung-Keun Yoon, and J.H. Kim, "Energy-Efficient Routing in Delay-Tolerant Networks," in "Green IT: Technologies and Applications," chapter 5, Springer-Verlag, 2011
4. Seung-Keun Yoon and Zygmunt J. Haas, "Energy-aware Routing Protocol for Delay Tolerant Networks," in "Delay Tolerant Networks: Protocols and Applications," CRC Press, Editors: Edited by A. Vasilakos, Y. Zhang, and T. Spyropoulos, 2010, ISBN: 978-1-4398110-8-5
5. S.M. Nazrul Alam and Zygmunt J. Haas, "Topology Control of Three-Dimensional Underwater Wireless Sensor Networks," in *Underwater Acoustic Sensor Networks*, Y. Xiao, editor, CRC Press, Chapter 3, pp.45-70, May 2010; ISBN: 9781420067118 (book)
6. J. Jeong, G.Y Lee, and Z.J. Haas, "Prevention of Black-Hole Attack Using One-Way Hash Chain Scheme in Ad Hoc Networks," T. Vazão, M.M. Freire, and I. Chong (eds.), LNCS 5200, Springer-Verlag Berlin Heidelberg, pp. 564-573, 2008, (revised paper from ICOIN 2007, Estoril, Portugal, January 22-25, 2007)
7. Z.J. Haas, J.Y. Halpern, L. Li, S.B. Wicker, "A Decision-Theoretic Approach to Resource Allocation in Wireless Multimedia Networks," in *Resource Allocation in Next Generation Wireless Networks, Volume 5*, W. Li and Y. Pan (eds), Nova Science Publishers, May 14, 2006, chapter 1, pp.1-23; ISBN-13: 978-1594545832
8. R. Barr, Z.J. Haas, and R. van Renesse, "Scalable Wireless Ad Hoc Network Simulation," *Handbook on Theoretical and Algorithmic Aspects of Sensor, Ad Hoc Wireless, and Peer-to-Peer Networks*, Jie Wu, Editor, CRC Press, 2005 (announcement)

9. P. Papadimitratos, and Z.J. Haas, "Securing Mobile Ad Hoc Networks," *Mobile Computing Handbook*, M. Ilyas and I. Mahgoub, Editors, Auerbach Publication, Chapter 21, pp. 457 -- 481, 2005
10. T. Small, Z.J. Haas, A. Purgue, and K. Frstrup, "A Sensor Network for Biological Data Acquisition," *Handbook of Sensor Networks: Compact Wireless and Wired Sensing Systems*, M. Ilyas and I. Mahgoub, Editors, CRC Press, 2004, ISBN 9780849319686, pp. 11-1 -- 11-17
11. D-S. Kim and Z.J. Haas, "Virtual Factory Communication Systems using ISO 9506 standard and Its Application to Networked Factory Machine," *The Industrial Communication System Handbook*, CRC Press, FL, January, 2005
12. P. Papadimitratos, and Z.J. Haas, "Secure Communication in Adverse Mobile Ad Hoc Networks," *Ad Hoc Wireless Networking*, X. Cheng, X. Huang, and D-Z. Du eds., Kluwer Academic Publisher, 2004, pp. 447-485
13. P. Samar, M. R. Pearlman, and Z.J. Haas, "Hybrid Routing: The Pursuit of an Adaptable and Scalable Routing Framework for Ad Hoc Networks," *Ad Hoc Wireless Networking*, X. Cheng, X. Huang, and D-Z. Du eds., Kluwer Academic Publisher, 2004, pp. 529-560
14. D-S. Kim, Z.J. Haas, and W.H. Kwon "Implementation of Virtual Factory Communication Systems using Manufacturing Message Specification," in *Industrial Information Technology Handbook*, R. Zurawski, ed., CRC Press, 2005, 1-14
15. P. Papadimitratos, and Z.J. Haas, "Secure Communication in Adverse Mobile Ad Hoc Networks," *The Handbook of Ad Hoc Wireless Networks*, CRC Press, Chapter 31, pp. 31-1 -- 31-17, 2003
16. Zygmunt J. Haas, Jing Deng, Ben Liang, Panagiotis Papadimitratos and S. Sajama, "Wireless Ad Hoc Networks," *Wiley Encyclopedia of Telecommunications*. Ed. John G. Proakis, vol. 5, New York, NY: Wiley, 2003, pp. 2883-2899
17. P. Samar, M. R. Pearlman, and Z.J. Haas, "Hybrid Routing: The Pursuit of an Adaptable and Scalable Routing Framework for Ad Hoc Networks," *The Handbook of Ad Hoc Wireless Networks*, CRC Press, Chapter 14, pp. 14-1 -- 14-18, 2003
18. Z.J. Haas "On the Performance of a Medium Access Control Scheme for the Reconfigurable Wireless Networks," in *Advances in Wireless Communications*, J.M. Holtzman and M. Zorzi (eds), *The International Series in Engineering and Computer Science*, vol. 435, pp. 269-284, Springer, Boston, MA, 2002
19. Z.J. Haas and M.R. Pearlman, "Evaluation of the Ad-Hoc Connectivity with the Zone Routing Protocols," *Wireless Personal Communications*, W.H. Tranter, T.S. Rappaport, B.D. Woerner, and J.H. Reed (eds), *International Series in Engineering and Computer Science*, vol. 482, 2002, pp. 201-212; Springer, Boston, MA, DOI: 10.1007/0-306-47046-2_19; presented at the 8th Virginia Tech/MPRG Symposium on Wireless Personal Communications, June 10-12, 1998, Blacksburg, VA
20. Z.J. Haas and M.R. Pearlman, "ZRP: a hybrid framework for routing in Ad Hoc networks," *Ad Hoc Networking*, C. Perkins, ed., pp. 221-253, Addison Wesley, March 2001
21. M. Sanchez, P. Manzoni, and Z.J. Haas, "Determination Of Critical Transmission Range In Ad-Hoc Networks," in *Multiaaccess, Mobility and Teletraffic in Wireless Communications: Volume 4*, eds. Biglieri, Fratta, and Jabbari, pp.293-304, Kluwer Academic Publ., 1999
22. Z.J. Haas and M.R. Pearlman,, "Providing Ad-Hoc Connectivity with the Reconfigurable Wireless Networks," *Ad-Hoc Networks*, edited by Charlie Perkins, Addison Wesley, 1999
23. Z.J. Haas, "Mobile-TCP: An Asymmetric Transport Protocol Design for Mobile Systems," in *Mobile Multimedia Communications*, D. J. Goodman and D. Raychadhuri, (eds), pp. 117-128, Springer, Boston, MA, 1997

24. Z. Haas, "Optical Network Architectures," contributed chapter in *High Performance Networks: Technology and Protocols*, edited by A. N. Tantawy, Springer Science, 1994, Chapter 4, pp.85-107; DOI: 10.1007/978-1-4615-3194-4_4
25. Z. Haas, "Packet Switching," article in *Encyclopedia of Computer Science and Technology*, vol. 27, supplement 12, pp. 215–222, 1993

(iv) Miscellaneous Publications

1. S. Milner, C. Davis, Z. Haas, and P.R. Kumar, "Quantifying and Assuring Information Transfer in Dynamic Heterogeneous Wireless Networks," Final Report for Contract number: AFOSR FA9550-09-1-0121, July 31, 2012
2. Z.J. Haas, "A Quest for the Future of Wireless Communications or It's Tough to be a Seer," *Connections*, School of Electrical and Computer Engineering, Cornell University, Fall 2005, pp. 12-14
3. O. Arpacioglu, T. Small, and Z.J. Haas, "Notes on Scalability of Wireless Ad Hoc Networks," Internet Draft, October 20, 2003, draft-irtf-ans-scalability-notes-01.txt
4. O. Arpacioglu, T. Small, and Z.J. Haas, "Notes on Scalability of Wireless Ad Hoc Networks," Internet Draft, August 2, 2003, draft-irtf-ans-scalability-notes-00.txt
5. P. Papadimitratos, Z. J. Haas, and P. Samar, "The Secure Routing Protocol (SRP) for Ad Hoc Networks," Internet Draft, draft-papadimitratos-secure-routing-protocol-00.txt, December 2002
6. Z. J. Haas, M.R. Pearlman, P.Samar, "The Interzone Routing Protocol (IERP) for Ad Hoc Networks," Internet Draft, draft-ietf-manet-zone-ierp-00.txt, January 2001, (draft-ietf-manet-zone-ierp-01.txt, June 2001), (draft-ietf-manet-zone-ierp-02.txt, July 2002)
7. Z.J. Haas and M.R. Pearlman, "The Zone Routing Protocol (ZRP) for Ad Hoc Networks," Internet Draft, draft-haas-zone-routing-protocol.00.txt, November 1997 (draft-haas-zone-routing-protocol.01.txt, August 1998), (draft-ietf-manet-zone-zrp-02.txt, June 1999), (draft-ietf-manet-zone-zrp-03.txt, March 2000), (draft-ietf-manet-zone-zrp-04.txt, July 2002)
8. Zygmunt Haas, "Routing Protocol for Smart Radio Ad-Hoc Networks," AFRL-IF-RS-TR-1999-138, Air Force Research Laboratory, Information Directorate, Rome Research Site, Rome, NY, June 1999
9. Z.J. Haas, R-H. Gau, and E. McCarthy, "Reliable Mobile Multicast Protocols," Cornell University Report, 1999
10. Zygmunt Haas, "Packet-Switching in Future Fiber-Optic Wide-Area Networks," Ph.D. thesis, Stanford University, Electrical Engineering Department, May 1988
11. Z. Haas and D.R. Cheriton, "Blazenet and the Arguments for Very High-Speed Photonic Packet-Switching," *unpublished*, March 15, 1988
12. Z. Haas and D. Cheriton, "Blazenet: A Photonic Implementable Wide-Area Network," Technical Report, STAN-CS-87-1185 (and CSL-TR-87-346), Stanford University, Oct. 1987
13. Zygmunt Haas, "Local Area Networks and Access Techniques in Local Area Networks," *M.Sc. thesis*, Tel-Aviv University, Spring 1985
14. Zygmunt Haas, "Measuring Lag Phenomena in Plumbicons," Technical Report, Philips Research Labs., ELCOMA division, September 1979

IV. TEACHING & ADVISING

(i) Courses Taught (semester; course #/title; number of students/credit hours)

- * Fall 2021: 3341.HON/Probability and Statistics for CS; 28 students; UTD/CS
- * Spring 2021: CS 6340/Wireless Networks; 14 students/42 credit hours; UTD/CS
- * Spring 2021: CS/CE 4390/Computer Networks; 68 students/204 credit hours; UTD/CS
- * Fall 2020: 3341.HON/Probability and Statistics for CS; 31 students; UTD/CS
- * Fall 2019: 3341.HON/Probability and Statistics for CS; 21 students; UTD/CS
- * Spring 2019: CS 6390/Advanced Computer Networks; 19 students; UTD/CS
- * Fall 2018: 3341.HON/Probability and Statistics for CS; 31 students; UTD/CS
- * Fall 2018: CS 6301/Wireless Networks; 7 students; UTD/CS
- * Spring 2018: CS 4390/Computer Networks; 43 students; UTD/CS
- * Spring 2018: CS 6390/Advanced Computer Networks; 18 students; UTD/CS
- * Fall 2017: CS 6301/Wireless Networks; 11 students; UTD/CS
- * Spring 2017: CS 4390/Computer Networks; 40 students; UTD/CS
- * Spring 2017: CS 6390/Advanced Computer Networks; 28 students; UTD/CS
- * Fall 2016; CS 6301/Wireless Networks; 7 students; UTD/CS
- * Spring 2016: CS 6390/Advanced Computer Networks; 31 students; UTD/CS
- * Spring 2016: CS 4390/Computer Networks; 23 students; UTD/CS
- * Spring 2015: CS 6301/Wireless Networks; 23 students; UTD/CS
- * Spring 2015: CE/CS 6390/Advanced Computer Networks; UTD/CS
- * Spring 2014: CS 6301/Wireless Networks; 42 students/126 credit hours; UTD/CS
- * Fall 2013: CE/CS 6390/Advanced Computer Networks; 48 students/144 credit hours; UTD/CS
- * Spring 2013:ECE 4960/Wireless Networks; 30 students/120 credit hours; Cornell/ECE
- * Fall 2012: ECE 3100/Probability and Inference; 60 students/240 credit hours; Cornell/ECE
- * Spring 2012: ECE 5660/Fundamentals of Networks; 11 students/44 credit hours; Cornell/ECE
- * Fall 2011: “Wireless Networks”, Technion, Israeli Institute of Technology, Haifa, Israel
- * Spring 2011: Leave of Absence (NSF)
- * Fall 2010: Leave of Absence (NSF)
- * Spring 2010: ECE 3200/Networks and Systems; 36 students/144 credit hours; Cornell/ECE
- * Fall 2009: ECE 5660/Fundamentals of Networks; 15 students/60 credit hours; Cornell/ECE
- * Spring 2009: Sabbatical Leave; Cornell/ECE
- * Fall 2008: ECE 5660/Fundamentals of Networks; 20 students/80 credit hours; Cornell/ECE
- * Spring 2008: ECE 3100/Introduction to Probability and Random Phenomena; 79 students/316 credit hours; Cornell/ECE
- * ECE 566/ Fundamentals of Networks; Fall 2007; 10 students/40 credit hours; Cornell/ECE
- * ENGRG150/Freshmen Seminar; Fall 2007; 19 students/19 credit hours; Cornell/ECE

- * ECE 310/Introduction to Probability and Random Phenomena; Spring 2007; 77 students/308 credit hours; Cornell/ECE
- * ECE 566/ Fundamentals of Networks; Fall 2006; 27 students/108 credit hours
- * ECE 691/ECE Colloquium; Fall 2006 (Plus); ECE Colloquium; 28 students; 28 student credit hours; Cornell/ECE
- * ECE 310/Introduction to Probability and Random Phenomena; Spring 2006; 75 students/300 credit hours; Cornell/ECE
- * ECE 566/Wireless Networks; Fall 2005; 26 students/104 credit hours; Cornell/ECE
- * ECE 310/Introduction to Probability and Random Phenomena; Spring 2005; 71 students/284 credit hours; Cornell/ECE
- * ECE 566/Wireless Networks; Fall 2004; 16 students/64 credit hours; Cornell/ECE
- * ECE 566/Wireless Networks; Spring 2004; 28 students/112 credit hours; Cornell/ECE
- * ECE 563/Communication Networks; Fall 2003; 19 students/76 credit hours; Cornell/ECE
- * Spring 2003: Sabbatical Leave - no teaching assignment
- * ECE 230/Introduction to Digital Logic Design; Fall 2002; Cornell/ECE
- * ECE 563/Communication Networks; Fall 2002; 19 students/76 credit hours; Cornell/ECE
- * ENGRG150/Freshmen Seminar; Fall 2003; 18 students/18 credit hours; Cornell/ECE
- * ECE 566/Wireless Networks; Spring 2002; 73 students/292 credit hours; Cornell/ECE
- * ECE 445/Computer Networks; Fall 2001; 146 students/584 credit hours; Cornell/ECE
- * ECE 566/Wireless Networks; Spring 2001; 74 students/296 credit hours; Cornell/ECE
- * ECE 445/Computer Networks; Fall 2000; 144 students/576 credit hours; Cornell/ECE
- * EE 597/Wireless Information Technology Seminar (WITS); Fall 2000; 12 students/24 credit hours; Cornell/ECE
- * ENGRG 150/Engineering Seminar; Fall 2000; 19 students/19 credit hours; Cornell/ECE
- * EE 566/Wireless Networks; Spring 2000; 58 students/232 credit hours; Cornell/ECE
- * EE 595/Wireless Information Technology Seminar (WITS); Spring 2000; 13 students/26 credit hours; Cornell/ECE
- * ELE 936/Wireless Networks I; Fall 1999; 43 students; Polytechnic University, NYC, NY
- * EE 566/Wireless Networks; Spring 1999; 42 students/168 credit hours; Cornell/ECE
- * EE 445/Computer Networks; Fall 1998; 147 students/588 credit hours; Cornell/ECE
- * EE 597/Wireless Information Technology Seminar (WITS); Fall 1998; 9 students/18 credit hours; Cornell/ECE
- * EE 566/Wireless Networks; Spring 1998; 43 students/172 credit hours
- * EE 597/Wireless Information Technology Seminar (WITS); Spring 1998; 11 students/22 credit hours
- * EE 445/Computer Networks; Fall 1997; 99 students/396 credit hours
- * EE 566/Wireless Networks; Spring 1997; 45 students/180 credit hours
- * EE 445/Computer Networks; Fall 1996; 122 students/366 credit hours
- * EE 595/Wireless Information Technology Seminar (WITS); Fall 1996; 20 students/40 credit hours
- * EE 566/Wireless Networks; Spring 1996; 74 students/296 credit hours
- * EE 445/Computer Networks; Fall 1995; 155 students/465 credit hours

V. PROFESSIONAL & SCIENTIFIC SERVICE

(i) University Committees

- * Member of the Search Committee for the Inaugural Associate Dean for Diversity and Strategic Initiatives, Eric Jonsson School of Engineering and Computer Science, UTD, 2021
- * Member of Annual Review Committee, Computer Science Department, UTD, 2019-present
- * Member of Committee on Qualifications of Academic Personnel, UTD, 09/01/2020-08/31/2022
- * Member of Dean's Teaching Task Force for Fall 2020, Jonsson School of Engineering and Computer Science, UTD, June 2020
- * Member of Committee on Qualifications of Academic Personnel, UTD, 09/01/2018-08/31/2020
- * Chair of Committee for Affiliated Faculty Appointment Rules, CS/UTD, Fall 2017
- * Member of UTD Committee on Qualifications of Academic Personnel, UTD, 09/01/2016-08/31/2017
- * Chair of "Ph.D. Committee," Computer Science Department, UTD, Fall 2016 - now
- * Member of "Graduate Admission Committee," Computer Science Department, UTD, 2014-2019
- * Member of "Web Design and Marketing Committee," Computer Science Department, UTD, 2014-present
- * Member of "Recruiting Committee," Computer Science, UTD, 2014-2016
- * Member of *Center for Applied Math (CAM) Graduate Admission Committee*, Cornell University, 2012-2013
- * Member of the *College Admissions Advisory Committee*, College of Engineering, Cornell University, June 2012 - June 2013
- * Member of the *Engineering Courses Subcommittee*, CCGB, College of Engineering, Cornell University, 2009 – 2010
- * Member of the *Technical Writing Subcommittee*, CCGB, College of Engineering, Cornell University, 2009 – 2010
- * Member of the *College Curriculum Governing Board (CCGB)*, College of Engineering, Cornell University, 2009 – 2010
- * Member of the *Faculty Admissions Advisory Committee*, College of Engineering, Cornell University, (third term) June 2009 - June 2012
- * Multiple *Ad Hoc Tenure Promotion*, School of Electrical Engineering, Cornell University 1998 – 2013
- * Multiple *Ad Hoc Promotion Committees*, *Ad Hoc Reappointment Committees*, and *Ad Hoc Tenure Promotion*, College of Engineering, Cornell University 1998 – 2013
- * Member of Policy Committee, School of Electrical and Computer Engineering, Cornell University, 2008 – 2010 (elected)
- * Member of Graduate Committee, School of Electrical and Computer Engineering,

Cornell University, 2007 – 2008

- * Member of Recruiting Committee, School of Electrical and Computer Engineering, Cornell University, 2007 – 2008
- * Member of the *Faculty Admissions Advisory Committee*, College of Engineering, Cornell University, (second term) June 2006 – June 2009
- * *Associate Director for Academic Affairs*, School of Electrical and Computer Engineering, Cornell University, 2005 – 2006
- * Review Board Member, *Learning Initiatives For Engineers (LIFE)*, Undergraduate Research Program, College of Engineering, Cornell University, 2005 – 2006
- * Member of the *Policy Committee*, School of Electrical and Computer Engineering, Cornell University, 2005 – 2006 (elected)
- * Member of *Curriculum and Standards Committee*, School of Electrical and Computer Engineering, Cornell University, 2005 – 2006
- * Member of the *M. Eng Committee*, School of Electrical and Computer Engineering, Cornell University, 2004 – 2007
- * Member of the *Faculty Admissions Advisory Committee*, College of Engineering, Cornell University, June 2004 – June 2006
- * Member of *Recruiting Committees*, School of Electrical and Computer Engineering, Cornell University, 2004 – 2006
- * Member of the *College of Engineering Nomination Committee*, Cornell University, 1997 – 1999
- * Member of *Faculty Advisory Board on Information Technologies (FABIT)*, Cornell University, 1997/98 and 1999/00 (Cornell Faculty Senate appointment)
- * Member of the *Computer Science Recruiting Committee*, Cornell University, 1996
- * Member of the *Circuit Recruiting Committee*, Cornell Univ., School of EE, 1996 – 1997
- * Member of the *Long Term Recruiting Committee*, Cornell Univ., School of EE, 1996 – 1997 (elected)
- * Member of the *Engineering Distribution CCGB Standing Committee*, Cornell University, 1995 – 1998

(ii) Editorial Service

- * Member of the Editorial Board of *MDPI Drones*, *Section Board for Drone Communications*
- * Member of the Editorial Board of *MDPI Sensors*, *Section Board for Intelligent Sensors*
- * Editor-in-Chief of *eScripts*, a novel publication enterprise of the European Commission
- * Served on the Advisory Board and the Editorial Board of the *Wireless Communications and Mobile Computing* journal (John Wiley & Sons)
- * Served on the Editorial Board of Springer *Wireless Networks (WINET)* Journal
- * Serving on the Editorial Board of *Journal of High Speed Networks (JHSN)*
- * Served on the Editorial Board of *ACM/IEEE Transactions on Networking*
- * Served on the Editorial Board of *IEEE Transactions of Wireless Communications*
- * Served on the Editorial Board of *IEEE Communications Magazine*
- * Served on the Editorial Board of *Computer Networks and ISDN Systems Journal*
- * Served on the Editorial Board of *IEEE Personal Communications Magazine*

- * Served on the Editorial Board of *Elsevier Ad Hoc Networks* journal
- * Lead guest editor for the *IEEE Journal on Selected Areas in Communications*, issue on “Mobile Computing Networks,” vol.13, no.5, June1995
- * Lead guest editor for the *IEEE Journal on Selected Areas in Communications*, issue on “Wireless Ad Hoc Networks,” vol.17, no.8, August 1999
- * Co-guest editor of special issue of *Wireless Networks* journal on “Mobicom'96,” 1997
- * Lead guest editor for the *IEEE Journal on Selected Areas in Communications*, issue on “Protocols for Gigabit Networks,” vol. 12, no. 2, February 1993

(iii) **Service to the Scientific Community at Large**

- * General co-Chair of *EAI WiCON 2022*, November 17, 2022, Dallas, TX and Cyberspace
- * Steering Committee co-Chair of the “Workshop on Securing Next-Generation Connected Healthcare Systems using Futuristic Technologies,” *IEEE GLOBECOM'21*, December 7-11, 2021, Madrid, Spain (Hybrid: In-Person and Virtual) (abstract)
- * International Advisory Committee Member of the 11th International Conference on ICT Convergence (ICTC 2020) Conference, October 21 – 23, 2020, Jeju Island, Korea
- * International Advisory Committee of the 12th International Conference on Ubiquitous and Future Networks (ICUFN) Conference, June 30 – July 3, 2020, Porto, Portugal
- * Technical Program Vice-Chair of the Research Track of Mobile and Wireless Computing of 39th IEEE International Conference on Distributed Computing System (ICDCS 2019), Dallas, Texas, July 7-10, 2019
- * General and Technical Program Chair of the “Signal Processing for Wireless Network Security” Symposium at the 2018 6th IEEE Global Conference on Signal and Information Processing (GlobalSIP), Anaheim, CA, November 26–29, 2018
- * International Advisory Committee of the International Conference on Ubiquitous and Future Networks (ICUFN) Conference
- * General Chair of the Fifth IEEE Annual International Workshop on Mission-Oriented Wireless Sensor Networking (IEEE MiSeNet 2016), in conjunction with IEEE INFOCOM 2016
- * Workshop Technical Program Co-Chair of the 2015 IEEE International Conference on Healthcare Informatics, Dallas, TX, October 21-23, 2015 (CFP)
- * Member of the Advisory Committee of the *American Amazing Teens (AAT)* program (Role: Educator)
- * Member of International Advisory Committee of the *IEEE ICUFN 2014, Sixth International Conference on Ubiquitous and Future Networks 2014*, Shanghai, China, July 8-11, 2014 (CFP)
- * Member of the International Advisory Committee of the *International Conference on Information and Communication Technology Convergence 2013 (ICTC 2013)*, Jeju Island, S. Korea, October 14-16, 2013 (CFP)
- * Member of the Steering Committee of *The Second ACM Annual International Workshop on Mission-oriented Wireless Sensor Networking (ACM MiSeNet 2013)*, in conjunction with ACM MobiCom 2013, Miami, FL, September 30, 2013

- * Member of International Advisory Committee of the *IEEE ICUFN 2013, Fifth International Conference on Ubiquitous and Future Networks 2013*, Da Nang, Vietnam, July 2-5, 2013 (CFP)
- * Member of the Steering Committee of *The First ACM Annual International Workshop on Mission-oriented Wireless Sensor Networking (ACM MiSeNet 2012)*, in conjunction with ACM MobiCom 2012, Istanbul, Turkey, August 26, 2012 (technical program)
- * Member of the International Advisory Committee of the *IEEE International Conference on Information and Communication Technology Convergence 2012 (ICTC 2012)*, Jeju Island, S. Korea, October 15-17, 2012
- * Member of the Steering Committee of *ACM MSWiM, 2012*, Istanbul, Turkey, August 26, 2012
- * General co-chair of “*The Fourth International Workshop on Information Quality and Quality of Service for Pervasive Computing (IQ2S’12)*,” in Conjunction with *IEEE PERCOM 2012*, Lugano, Switzerland, March 19-23, 2012 (website) (CFP)
- * Member of International Advisory Committee of the *IEEE ICUFN 2012 (The Fourth International Conference on Ubiquitous and Future Networks)*, Puket, Thailand, July 4-6, 2012
- * Moderator and Presenter at the *2010 NSF ECSS Grantees’ Conference, Hilton Hawaiian Village, Honolulu, Hawai’i, Nov. 30-Dec 2, 2010*
- * Moderator and Panelist of the “What’s Next for Underwater Networks?” Panel, “*The Fifth International Workshop on UnderWater Networks (WUWNets’10)*,” Woods Hole, MA, September 30 – October 1, 2010
- * Member of the International Advisory of the “*International Conference on ICT Convergence 2010 (ICTC 2010)*,” Jeju, Jeju Island, South Korea, Nov. 17-19, 2010
- * Member of International Advisory Committee of the “*Second IEEE International Conference on Ubiquitous and Future Networks (ICUFN 2010)*,” June 16-18, 2010, Jeju Island, Korea (*ICUFN 2010*)
- * Member of International Advisory Committee of the “*First IEEE International Conference on Ubiquitous and Future Networks (ICUFN 2009)*,” June 7-9, 2009, Hong Kong, China
- * Chair of the Steering Committee of *IEEE Pervasive Computing* magazine, January 1, 2005 – December 31, 2007
- * Member of the *IEEE TCPC Award Committee*, September 2004 - September 2007
- * Chair, Technical Program Committee, “*First Workshop on free and commercial Wireless Mesh Networks (OpComm’2006)*,” Berlin, Germany, September 18-19, 2006 (cfp) (tpc)
- * Member of the Steering Committee, *ACM MOBICOM*, 2004
- * General Chair, Workshop on “Intermittently Connected Mobile Ad Hoc Networks (ICMAN), in conjunction with *IEEE PerCom 2007*, New York, NY, March 26-30, 2007
- * Member of Advisory Committee of “*The First International Conference on Sensor Technologies and Applications (SENSORCOMM 2007)*,” sponsored by IARIA, Valencia, Spain, October 14-20, 2007 (cfp)
- * General Co-Chair, “*Fifth Workshop on Applications and Services in Wireless Networks (ASWN 2005)*,” Maison de la Chimie, Paris, France, June 28 - July 1, 2005 (cfp)
- * General Chair, *ACM MOBICOM 2004*, Philadelphia, PA, Sept. 26 – Oct. 1, 2004

- * Panelist and Moderator of the “Ad Hoc Networks” panel, *IEEE MILCOM'97*, Monterey, CA, November 2-5, 1997
- * Steering Committee and TPC Member of the *Fourth High Performance Communication Subsystems Workshop*, Sani Beach, Chalkidiki, Greece, June 23-25, 1997
- * Elected and served as the secretary (01/01/1997-12/31/1998), vice-chair (01/01/1999-12/31/2000), and chair (01/01/2001-12/31/2002) of *IEEE Technical Committee on Personal Communications (TCPC)*, later renamed as *IEEE Wireless Communications Technical Committee*
- * Member of the NSF-NCR Workshop on “Research Priorities in Networking and Communications,” May 12-14, 1994, Airlie House, Virginia
- * Representing AT&T on the *Personal Conferencing Specification Working Group*
- * Served on National Science Foundation review panels
- * Vice-chair of the *2nd Workshop on High Performance Communication Subsystems (HPCS'93)*
- * Organized and chaired "Who needs all-optical networks?" panel at *INFOCOM'93*
- * Organized a session “Packet-switched Lightwave Networks: Comparison of Approaches” at the *Computer Communications Workshop*, Hilton Head Island, SC, October 20-22, 1992
- * Member of *High-speed Protocols Panel* at *INFOCOM'91*, San-Francisco, CA, June 5-7, 1991

(iv) **Technical Program Committees (chairing, co-chairing, and membership)**

- * Member of Technical Program Committee of the IEEE Wireless Communications and Networking Conference (WCNC 2023), March 26-29, 2023, Glasgow, Scotland, UK
- * Member of Technical Program Committee of the 13th International Conference on Information and Communication Technology Convergence (ICTC 2022), October 19-21, 2022, Jeju Island, South Korea
- * Member of Technical Program Committee of the 2022 IEEE Autonomous and Trusted Vehicles Conference (ATC 2022), December 15-18, 2022, Haikou, China
- * Member of Technical Program Committee of the 37th International Conference on Information and Networking (ICOIN 2023), January 11-14, 2023, Bangkok, Kingdom of Thailand
- * Member of Technical Program Committee of the 2022 International Conference on Internet of Things and Intelligent Systems (IoTaIS'2022) Nov. 24-26, 2022, Bali, Indonesia
- * Member of Technical Program Committee of the IEEE 9th International Conference on Communications and Electronics (ICCE 2022), July 27-29, 2022, Nha Trang City, Vietnam
- * Member of Technical Program Committee of the 4th International Conference on Artificial Intelligence in Information and Communication (ICAHC 2022), February 21-24, 2022, Guam, U.S.A and Cyberspace
- * Member of Technical Program Committee of the 36th International Conference on Information Networking (ICOIN 2022), January 12-15, 2022, Thailand
- * Member of Technical Program Committee of the Internet of Things and Intelligence Systems (IoTaIS'21), November 22-23, 2021, Cyberspace
- * Member of Technical Program Committee of the 5th Symposium on Future Telecommunication Technologies (SOFTT'21), Dec. 6 – 7, 2021, Cyberspace (cert)

- * Member of Technical Program Committee of the IEEE Wireless Communications and Networking Conference (WCNC'22), April 10-13, 2022, Austin, TX
- * Member of Technical Program Committee of the *2021 IEEE International Conference on Industry 4.0, Artificial Intelligence, and Communication Technology (IAICT'21)*, July 27-28, 2021, Indonesia
- * Member of Technical Program Committee of the 2021 International Conference on Advanced Technologies for Communications (ATC'21), October 7 – 9, 2021, Ho Chi Minh City, Vietnam
- * Member of Technical Program Committee of the 3rd International Conference on Artificial Intelligence in Information and Communication (ICAIIIC'21), April 20 – 23, 2021, Jeju Island, S. Korea (CFP)
- * Member of Technical Program Committee of IEEE Wireless Communications and Networking Conference (WCNC'21), March 29 – April 1, 2021, Nanjing, China
- * Member of Technical Program Committee of the 2021 International Symposium on Electrical and Electronics Engineering (ISEE 2021), April 15–16, 2022, HCMUT, Ho Chi Minh City, Vietnam (CFP)
- * Member of Technical Program Committee of the 2020 International Conference on Advanced Technologies for Communications (ATC-2020), October 8–10, 2020, Nha Trang, Vietnam
- * Member of Technical Program Committee of the 2021 Asia Pacific Conference on Wireless and Mobile (APWiMob'21), April 8 – 10, 2021, Bandung, Indonesia (CFP)
- * Member of Technical Program Committee of The 35th International Conference on Information Networking (ICOIN 2021), January 13–16, 2021, Jeju Island, Korea (CFP)
- * Member of Technical Program Committee of 2019 International Symposium on Electrical and Electronics Engineering (ISEE2019), October 10–12, 2019, Ho Chi Minh City, Vietnam
- * Member of Technical Program Committee of 8th International Conference on Advances in Computing, Communications and Informatics (ICACCI'19), December 18–21, 2019, Trivandrum, Kerala, India
- * Member of Technical Program Committee of *IEEE ATC 2019*, International Conference on Advanced Technologies for Communications, Oct. 17–19, 2019, Hanoi, Vietnam
- * Member of Technical Program Committee of *IAICT 2019*, International Conference on Artificial Intelligence and Communications Technology, July 1–3, 2019, Bali, Indonesia
- * Member of Technical Program Committee of *IEEE IoTaIS 2019*, International Conference on Internet of Things and Intelligence Systems, Nov. 5–7, 2019, Bali, Indonesia
- * Member of Technical Program Committee of *IEEE ICUFN 2019*, 11th International Conference on Ubiquitous and Future Networks, July 2–5, 2019, Zagreb, Croatia
- * Member of Technical Program Committee of *IEEE Wireless Communications and Networking Conference (WCNC)*, 15–19 April 2019, Marrakech, Morocco
- * Member of Technical Program Committee of the 3rd *International Conference on Circuits, System and Simulation (ICCSS 2019)*, June 13–15, 2019, Nanjing, China
- * Member of Technical Program Committee of 4th *International Conference on Computer, Communication, and Control Technology*, 20 – 22 March 20-22, 2018, Krabi, Thailand

- * Member of International Advisory Committee of the *IEEE ICUFN 2017, Eight International Conference on Ubiquitous and Future Networks 2017*, July 3 – July 7, 2017, Milan, Italy
- * Member of Technical Program Committee of the *Second International Conference on Computing and Network Communications (CoCoNet'18)*, August 15-17, 2018, Astana, Kazakhstan
- * Member of Technical Program Committee of the *IEEE Asia Pacific Conference on Wireless and Mobile (APWiMob 2016)*, September 13-15, 2016, Bandung, West Java, Indonesia
- * Member of Technical Program Committee of the *22nd Asia-Pacific Conference on Communications (APCC 2016)*, August 25-27, 2016, Yogyakarta, Indonesia
- * Member of Technical Program Committee of the *The Eighth International Conference on Ubiquitous and Future Networks (ICUFN 2016)*, July 5-8, 2016, Vienna, Austria (CFP)
- * Member of Technical Program Committee of the *4th International Conference on Connected Vehicles and Expo*, October 19-23, 2015, Shenzhen, China (CFP)
- * Member of Technical Program Committee of the *6th International Conference on Data Communication Networking (DCNET 2015)*, July 20-22, 2015, Colmar, Alsace, France
- * Member of Technical Program Committee of the *18th ACM International Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWiM'15)*, November 2-6, 2015, Cancun, Mexico
- * Member of Technical Program Committee of *IEEE International Conference on Advanced Technologies for Communications 2015 (ATC'15)*, October 14-16, 2015, Ho Chi Minh City, Vietnam (CFP)
- * Member of the Technical Program Committee of *IEEE 2014 Globecom, Wireless Networks Track*, December 8-12, 2014, Austin, TX
- * Member of the Technical Program Committee of the *Workshop on Security in Ad Hoc Networks (SecAN)*, Benidorm, Spain, June 22-27, 2014 (CFP)
- * Member of the Technical Program Committee of *IEEE Wireless Communications and Networking Conference, (WCNC'14) Track 3:NET*, Istanbul, Turkey, April 6-9, 2014
- * Member of the Technical Program Committee of *IEEE 5th International Congress on Ultra Modern Telecommunications and Control Systems (ICUMT 2013)*, Almaty, Kazakhstan, September 10-13, 2013
- * Member of the Technical Program Committee of *IEEE IFIP Networking 2013 Conference*, Brooklyn, New York, May 22-24, 2013 (CFP)
- * Member of the Technical Program Committee of *IEEE ICUFN 2013, Fifth International Conference on Ubiquitous and Future Networks 2013*, Da Nang, Vietnam, July 2-5, 2013 (CFP)
- * Member of Technical Program Committee of *IEEE WCNC 2013*, Shanghai, China, April 7-10, 2013 (CFP)
- * Member of Technical Program Committee of *IEEE PIMRC'12 (23rd IEEE International Symposium on Personal, Indoor and Mobile Radio Communications)*, Sidney, Australia, September 9-12, 2012 (CFP)
- * Member of the Technical Program Committee of *ACM MSWiM 2012*, Paphos, Cyprus Island, October 21-25, 2012 (CFP)
- * Member of Technical Program Committee of *ICUFN 2012 (The Fourth International Conference on Ubiquitous and Future Networks)*, Puket, Thailand, July 4-6, 2012 (CFP)

- * Member of Technical Program Committee of IEEE WCNC 2012, Track 3 Mobile and Wireless, Paris, France, April 1-4, 2012
- * Member of Technical Program Committee of IEEE ICUMT 2011, Budapest, Hungary, October 5-7, 2011
- * Member of Technical Program Committee of the "IEEE WCNC 2011, Network Track," Cancun, Mexico, March 28-31, 2011
- * Member of Technical Program Committee of the "International Conference on ICT Convergence 2010 (ICTC 2010)," Jeju, Jeju Island, South Korea, Nov. 17-19, 2010
- * Member of the International Program Committee of the "IASTED Asian Conference on Robotics and Control (AsiaRC 2010)," November 24-26, 2010, Bangkok, Thailand
- * Member of the International Program Committee of the "IASTED International Conference on Robotics and Applications (RA 2010)," November 1-3, 2010, Cambridge, MA
- * Member of the Technical Program Committee of "The 16th Asia-Pacific Conference on Communications (APCC 2010)," October 31-Nov. 3, 2010, Auckland, New Zealand
- * Member of the International Program Committee (IPC) of the "IASTED International Conference on Wireless Communications (WC 2010)," July 15 – 17, 2010, Banff, Alberta, Canada
- * Member of Technical Program Committee of the "IEEE Wireless Communication and Networking Conference (WCNC 2010)," April 18-21, 2010, Sydney, Australia
- * Member of the International Technical Committee of the "IASTED International Conference on Robotics, Telematics and Applications (RTA 2009)," October 12-14, 2009, Beijing, China
- * Member of Technical Program Committee of the "IEEE Vehicular Technology Conference (VTC'09/Fall)," Anchorage, Alaska, September 20-23, 2009
- * Member of Technical Program Committee of the "IFIP Second Joint IFIP Wireless and Mobile Networking Conference (WMNC)," Gdansk, Poland, Sept. 9-11, 2009
- * Member of the International Program Committee of the "IASTED International Conference on Robotics, Telematics and Applications (RTA 2009)," October 12 – 14, 2009, Beijing, China (<http://www.iasted.org/conferences/home-661.html>)
- * Member of the Technical Program Committee of the "Fifth IEEE International Conference on Mobile Ad-hoc and Sensor Systems (IEEE MASS 2008)," Atlanta, GA, October 6-9, 2008
- * Member of the Technical Program Committee of the "27th IEEE Conference on Computer Communications (INFOCOM 2008)," Phoenix, AZ, April 13-19, 2008
- * Chair, Technical Program Committee, "Third IEEE International Conference on Mobile Ad Hoc and Sensor Systems (MASS 2006)," Vancouver, Canada, October 9-12, 2006 (message from TPC chairs)
- * Member of the Technical Program Committee of the "Third International Conference on Broadband Communications, Networks, and Systems (BROADNETS 2006)," San Jose, CA, October 1-5, 2006
- * Member of the Technical Program Committee of the "1st International Workshop on Decentralized Resource Sharing in Mobile Computing and Networking," in conjunction with ACM MOBICOM 2006, Los Angeles, CA, September 25, 2006
- * Member of the Technical Program Committee of the "26th Annual IEEE Conference on Computer Communications (INFOCOM'07)," Anchorage, Alaska, May 6-12, 2007

- * Member of the Technical Program Committee of the “*IEEE VANET Workshop*, in conjunction with the *IEEE INFOCOM 2007* conference,” May 6-12, 2007, Anchorage, AL
- * Member of the Technical Program Committee of the “*Seventh ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc’06)*,” Florence, Italy, May 22-25, 2006
- * Member of the Technical Program Committee of “*MADNES’06*,” Pythagorion, Samos, Greece, 2006
- * Technical Program Committee member of the “*2006 IEEE International Conference on Networking, Sensing and Control*,” Ft. Lauderdale, FL, April 23-25, 2006
- * Member of the Technical Program Committee of “*International Workshop on Delay Tolerant Mobile Networks (DTMN)*,” in conjunction with IWCNC 2006, Vancouver, Canada, July 3-6, 2006
- * Member of the Technical Program Committee, “*The 16th Annual IEEE International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC 2005)*,” International Congress Center (ICC), Berlin, Germany, September 11-14, 2005
- * Member of the Technical Program Committee, “*1st International Workshop on Security, Privacy and Trust in Pervasive and Ubiquitous Computing (SecPerU’05)*,” Santorini Island, Greece, July 14, 2005
- * Member of the Technical Program Committee, “*The First International Workshop on Security, Privacy and Trust in Pervasive and Ubiquitous Computing (SecPerU 2005)*,” Santorini Island, Greece, July 14, 2005
- * Member of the Technical Program Committee, “*ACM MobiHoc 2005*,” Urbana-Champaign, IL, May 24-28, 2005
- * Member of the Technical Program Committee, “*MADNES’05*,” Singapore, 2005
- * Member of the Technical Program Committee, “*2004 ACM Workshop on Security of Ad Hoc and Sensor Networks (SASN 2004)*,” October 25, 2004, Wyndham City Hotel, Washington DC
- * Technical Program Committee member, “*First IEEE International Conference on Sensor and Ad hoc Communications and Networks (SECON 2004)*,” October 4-7, 2004, Santa Clara, CA
- * Technical Program Committee member of the “*Fourth Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom’98)*,” Dallas, TX, October 25-30, 1998
- * Technical Program Committee member of the *IEEE Multiaccess, Mobility and Teletraffic for Personal Communications Workshop* 1998, Washington, DC, October 21-23 , 1998
- * Technical Program Committee member of the “*Fourth Mobile Multimedia Communications Workshop (MoMuC’98)*,” Berlin, Germany, October 12-14, 1998
- * Technical Program Committee member of the “*Ninth IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC’98)*,” Boston, MA, September 8-11, 1998
- * Technical Program Committee member of the “*IEEE International Conference on Universal Personal Communications (ICUPC’98)*,” Florence, Italy, October 5-9, 1998
- * Technical Program Committee member of the “*Ninth IEEE Workshop on Local and Metropolitan Area Networks*,” Banff, Alberta, Canada, May 17-20, 1998
- * Technical Program Committee member of the “*Workshop on Nomadic Computing*,” Geneva, Switzerland, April 1-5, 1997

- * Technical Program Committee member of “*MOBICOM'97*”
- * Technical Program Committee member of “*IEEE INFOCOM'97*”
- * Technical Program Committee member of “*The Seventh IFIP Conference on High Performance Networking (HPN'97)*”
- * Technical Program Co-Chair of “*ACM MOBICOM'96*”
- * Technical Program Committee member of “*The 3rd International Workshop on Mobile Multimedia Communications (MoMuc-3)*,” Princeton, NJ, Sept. 25-27, 1996
- * Technical Program Committee member of “*The 6th IFIP International Conference on High Performance Networking (HPN'95)*,” Palma De Mallorca, Balearic Islands, Spain, September 11-15, 1995
- * Technical Program Committee member of the “*IEEE MILCOM'95*” conference
- * Technical Program Committee member of the “*IEEE PIMRC'95*” conference
- * Technical Program Committee member of the “*IEEE Wireless Computer Networks'94*” conference
- * Technical Program Committee member of the “*IEEE GLOBECOM'94*,” representing the *IEEE Personal Communication Committee*
- * Served on the Technical Program Committee of “*ACM SIGCOMM'93*”
- * Technical Program Committee member of the “*4th IFIP Conference on High Performance Networking*,” Liège, Belgium, December 14-18, 1992
- * Served on the Technical Program Committees of “*IEEE INFOCOM'90*,” “*IEEE INFOCOM'91*,” “*IEEE INFOCOM'92*,” “*IEEE INFOCOM '93*,” and “*IEEE INFOCOM '94*”

VI. PATENTS: GRANTED & PENDING

(i) Granted

1. Z.J. Haas and Z. Zheng, “Waveform Design for RF Power Transfer,” US Patent Number: 10,931,148, date: Feb 23, 2021, assignee: The Board of Regents of the University of Texas System
2. Richard Gitlin, Zygmunt J. Haas, Huseyin Arslan, Gabriel E. Arrobo, and Chao He, “System and Method for User-Specific Quality of Service Scheduling in Wireless Systems,” US Patent Number: 9,826,541, date: November 21, 2017, assignees: University of South Florida and Cornell University
3. Sriram Nandha Premnath and Zygmunt J. Haas, “System And Method For A Practical, Secure And Verifiable Cloud Computing For Mobile Systems,” US Patent Number: 9,736,128, date: August 15, 2017, assignees: The Board of Regents of the University of Texas System and Cornell Research Foundation
4. Rimón Barr, Zygmunt J. Haas, and Robbert Van Renesse, “System for and Method of Improving Discrete Event Simulation Using Virtual Machines,” U.S. patent number: 7,624,383, date: November 24, 2009, assignee: Cornell Research Foundation (D-3413)
5. Zygmunt J. Haas and S. Sajama, “Independent-Tree Ad hoc Multicast Routing,” U.S. Patent Number: 7,035,937, date: April 25, 2006, assignee: Cornell Research Foundation
6. Rung-Hung Gau and Zygmunt J. Haas, “Methods and Systems for Concurrent Paging of Mobile Users in Cellular Networks,” U.S. Patent Number: 7,031,731, date: April 18, 2006, assignee: Cornell Research Foundation
7. Zygmunt J. Haas and Miguel Sanchez, “Adaptive Patent Control for Wireless Networks,” Patent Number: WO02/03567 A3, date: January 10, 2002, assignee: Cornell Research Foundation
8. Zygmunt J. Haas, “Routing and Mobility Management Protocols for Ad-Hoc Networks,” U.S. Patent Number: 6,304,556, date: October 16, 2001, assignee: Cornell Research Foundation
9. Richard D. Gitlin, Zygmunt Haas, and Mark J. Karol, “System and Method for Optimizing Spectral Efficiency Using Time-Frequency-Code Slicing,” U.S. Patent Number: 6,064,662, date: May 16, 2000, assignee: AT&T Corp.
10. Richard D. Gitlin, Zygmunt Haas, et al “System and Method for Optimizing Spectral Efficiency Using Time-Frequency-Code Slicing,” U.S. Patent Number: 6,018,528, date: January 25, 2000, assignee: AT&T Corp.
11. Zygmunt J. Haas, “Multiply-Detected Macrodiversity Method and System for Wireless Communications,” U.S. Patent Number: 5,774,814, date: June 30, 1998, assignee: Cornell Research Foundation
12. Zygmunt Haas and Sanjoy Paul, “Methods for Providing Secure Access to Shared Information,” U.S. Patent Number: 5,719,938, date: February 17, 1998, assignee: Lucent Technologies

13. Zygmunt Haas, "Simultaneous Verify Local Database and Using Wireless Communication to Verify Remote Database," U.S. Patent Number: 5,598,534, date: January 28, 1997, assignee: Lucent Technologies
14. Zygmunt Haas and Chih-Lin I, "Beacon Based Packetized Cellular System with Real Time Processing," U.S. Patent Number: 5,577,168, date: November 19, 1996, assignee: Lucent Technologies
15. Zygmunt Haas, "Wireless Data Communications System for Detecting a Disabled Condition and Simulating a Functioning Mode in Response to Detection," U.S. Patent Number: 5,566,225, date: October 15, 1996, assignee: Lucent Technologies
16. Zygmunt Haas, "Progressive Execution Technique for Mobile Computing Devices," European Patent Number: EP0705014A1, date: April 3, 1996, assignee: AT&T Corp.
17. Zygmunt Haas, "Optical Packet Synchronization Circuit," U.S. Patent Number: 5,485,298, date: January 16, 1996, assignee: AT&T Corp.
18. Zygmunt Haas, "Optical Packet Switch," U.S. Patent Number: 5,469,284, date: November 21, 1995, assignee: AT&T IPM Corp.
19. Zygmunt Haas and Mario A. Santoro, "Lightwave Transmission System Using Selected Optical Modes," U.S. Patent Number: 5,416,862, date: May 16, 1995, assignee: AT&T Corp.
20. Zygmunt Haas, et al, "Fiber-Optic Transmission Polarization-Dependent Distortion Compensation," U.S. Patent Number: 5,311,346, date: May 10, 1994, assignee: AT&T Bell Laboratories
21. Richard D. Gitlin and Zygmunt Haas, "Gigabit Per-Second Optical Packet Switching with Electronic Control," U.S. Patent Number: 5,278,689, date: January 11, 1994, assignee: AT&T Bell Laboratories
22. Zygmunt Haas, "Communications Architecture for High-speed Networking," U.S. Patent Number: 5,115,432, date: May 19, 1992, assignee: AT&T Bell Laboratories
23. Zygmunt Haas, "Photonic Local/Metropolitan Area Network," U.S. Patent Number: 4,970,717, date: November 13, 1990, assignee: AT&T Bell Laboratories

(ii) Pending (in reverse order of filing dates)