Filed on behalf of: AX Wireless, LLC

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

INTEL CORPORATION,
Petitioner,

v.

AX WIRELESS, LLC,
Patent Owner.

Case IPR2023-01143
Patent 9,584,262

DECLARATION OF ZYGMUNT HAAS, PH.D. IN SUPPORT OF PATENT OWNER'S PRELIMINARY RESPONSE

AX Wireless, LLC
Exhibit AXW-2001
Intel v. AX Wireless
IPR2023-01143

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I. Introduction and Qualifications

1. I have been retained by AX Wireless, LLC ("AXW" or "Patent Owner") to provide opinions concerning the validity of U.S. Patent No. 9,584,262.

2. My complete qualifications and professional experience are described in my *Curriculum Vitae*, a copy of which is attached to this declaration as AXW-2002. The following is a brief summary of my relevant qualifications and professional experience.

3. I am a Professor and Distinguished Chair in Computer Science at the University of Texas in Dallas. I am also a Professor Emeritus at the School of Electrical and Computer Engineering at Cornell University. In addition, I have provided technical consulting services in intellectual property matters, during which I have written expert reports and provided deposition and trial testimony involving, among others, wireless communication technologies.

4. My academic credentials include a Bachelor of Science Degree in Electrical Engineering, summa cum laude, from Technion (IIT), Israel, in 1979 and a Master of Science Degree in Electrical Engineering, summa cum laude, from Tel Aviv University, Israel, in 1985. I subsequently authored the thesis titled "Packet Switching in Fiber-Optic Networks" as part of earning my Ph.D. in Electrical Engineering from Stanford University in 1988.

5. I am being compensated at the rate of $525 per hour with reimbursement for actual expenses, for my work related to this IPR. My compensation is not dependent on, and in no way affects, the substance of my statements in this Declaration.

6. I have worked or consulted for about 35 years in the fields of Electrical Engineering and Computer Science. My primary focus has been on communication and networking systems, with an emphasis on wireless communication networks. I have authored and co-authored numerous technical papers and book chapters related to wireless communication networks. I hold over twenty patents in the fields of high-speed networking, wireless networks, and optical communication/switching. My employment history following my graduation from Stanford University began at the Network Research Department of AT&T Bell Laboratories in 1988. At AT&T Bell Laboratories, I pursued research on 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, where I investigated various aspects of wireless and mobile networks.

7. In 1995, I joined the faculty of the School of Electrical & Computer Engineering at Cornell University, and with time I was promoted to a Full Tenured Professor. At Cornell, I headed the Wireless Networks Lab, a research group with

extensive contributions in the area of wireless communication systems and networks. In 2013, I retired from Cornell University with the title of Emeritus Professor, and I joined the Computer Science Department at the University of Texas at Dallas with the title of Professor and Distinguished Chair in Computer Science. At Cornell University and at the University of Texas, I have taught dozens of courses related to computer networking and wireless networks/communications.

8. My research and teaching include key wireless technologies such as, for example, MIMO, beamforming, and diversity schemes, as well as networking protocols such as the IEEE 802.11.

9. I am a member of the Institute of Electrical and Electronic Engineers (IEEE) and the Association for Computing Machinery (ACM). In 2007, I was elevated to an IEEE Fellow, and in 2022, I was elevated to an ACM Fellow, both well-known distinctions. For example, the total number of IEEE Fellows which are selected in any given year does not exceed 0.1% of the total number of voting members of IEEE. With respect to the ACM Fellow grade, ACM states that "ACM's most prestigious member grade recognizes the top 1% of ACM members for their outstanding accomplishments in computing and information technology and/or outstanding service to ACM and the larger computing community." *See* https://awards.acm.org/fellows.

10. I have delivered numerous tutorials at major IEEE and ACM conferences. I served as editor of several publications including the IEEE Transactions on Networking, the IEEE Transactions on Wireless Communications, the IEEE Communications Magazine, the Springer "Wireless Networks" journal, the Elsevier "Ad Hoc Networks" journal, the "Journal of High Speed Networks," and the Wiley "Wireless Communications and Mobile Computing" journal. I was also a guest editor of IEEE Journal on Selected Areas in Communications for the issues on "Gigabit Networks," "Mobile Computing Networks," and "Ad-Hoc Networks." Finally, I served as the Chair of the IEEE Technical Committee on Personal Communications (TCPC), today known as Wireless Communications Technical Committee (WTC). I have also served on numerous committees for the benefit of the scientific community, such as Technical Program Committees of conferences in the areas of wireless communications and wireless networks.

11. I have received several awards in the field of wireless communications and network technology. In 2016, I received the IEEE ComSoc AHSN Recognition Award "for outstanding contributions to securing ad hoc and sensor networks." In 2012, I received the IEEE ComSoc WTC Recognition Award, which recognizes individuals "for outstanding technical contributions in the field for their service to the scientific and engineering communities." In 2021, I received the "Best Paper Award" for coauthoring the paper "Engineering a

Network in the Sky" from the 35th International Conference on Information Networking, (ICOIN21). In 2012, I received the "Best Paper Award for co-authoring "Collaborating with Correlation for Energy Efficient WSN" directed at Wireless Sensor Networking. I previously received the "Best Paper Award" for co-authoring "Optimal Resource Allocation for UWB Wireless Ad Hoc Networks" directed at personal indoor and mobile radio communications. 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.

12. Additional information regarding my education, technical experience and publications, including a list of the U.S. patents of which I am an inventor/coinventor, is included in my *Curriculum Vitae*.

II. Summary Of Materials Reviewed And Considered

13. My opinions contained in this Declaration are based on the documents I reviewed as part of my work on this case and my knowledge, experience, and professional judgment. In forming the opinions expressed in this Declaration, I reviewed the following documents, adopting the naming conventions of Intel (the table below, as well as the naming and numbering of the documents have been provided to me by Counsel):

Ex.	Description
1001	U.S. Patent No. 9,584,262 ("'262 patent")
1002	File History of the '262 patent
1003	Declaration of Thomas LaPorta, Ph.D. in Support of Inter Partes Review of U.S. Patent 9,584,262
1005	IEEE 802.11-05/0149r5, "WWiSE Proposal: High Throughput Extension to the 802.11 Standard" to Kose, et al, uploaded and publicly available on July 9, 2005 ("July 2005 WWiSE")
1006	U.S. Patent Publication 2006/0182017 to Hansen, et al ("Hansen")
1007	Declaration of James L. Lansford, Ph.D.
1008	U.S. Provisional Application 61/235,909
1009	U.S. Patent 8,737,189 to Hansen, et al ("Hansen Patent')
1010	U.S. Provisional Application 60/653,429 ("Hansen Provisional")
1011	IEEE 802.11-04/0889r3, "TGn Sync Proposal Technical Specification" to Mujtaba, uploaded and publicly available on January 20, 2005
1012	IEEE 802.11-04/0886r6, "WWiSE Proposal: High Throughput Extension to the 802.11 Standard" to Hansen, et al, uploaded and publicly available on January 6, 2005 ("January 2005 WWiSE")
1013	IEEE Std. 802.11a-1999, "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: High-Speed Physical Layer in the 5 GHz Band", approved September 16, 1999 ("802.11a")
1014	Declaration of David Ringle for 802.11a-1999 - IEEE Standard for Telecommunications and Information Exchange Between Systems – LAN/MAN Specific Requirements - Part 11: Wireless Medium Access Control (MAC) and physical layer (PHY) specifications: High-Speed Physical Layer in the 5 GHz Band, date of publication December 30, 1999
1015	Heiskala, et al., "OFDM Wireless LANs: A Theoretical and Practical Guide", Sams Publishing (2002)

Ex.	Description
1016	Tse, et al., "Fundamentals of Wireless Communication", Cambridge University (2005)
1017	U.S. Application Publication No. 2010/0260159 to Zhang et al. ("Zhang")
1019	U.S. Provisional Application No. 61/229,900 ("'900PROV")
1020	IEEE 100: The Authoritative Dictionary of IEEE Standard Terms (IEEE 7th ed., 2000)
1021	Van Nee, et al., "OFDM for Wireless Multimedia Communications", Artech House Publishers (2000)
1022	Sklar, "Digital Communications: Fundamentals and Applications" (2d. 2001)
1023	Gast, "802.11 Wireless Networks: The Definitive Guide", O'Reilly (2002)
1025	CopperGate Communication, "G.hn: Using Two Symbols for the Header of a PHY frame on Coax," ITU-T SG15/Q4, 09XC-100, Xian, China July 2009, as filed in file wrapper of the '262 patent
1026	Intellon Corporation, "G.hn: Extended PHY frame header," ITU-T SG15/Q4, 09XC-119, Xian, China, July 2009, as filed in file wrapper of the '262 patent
1027	O'Hara, The IEEE 802.11 Handbook, Standards Information Network, IEEE Press, 1999
1028	Editor for G.9960, "ITU-T Recommendation G.9960 Next Generation Wire-line Based Home Networking Transceivers-Foundation", ITU-T SG15/Q4, January 2009, as filed in file wrapper of the '262 patent
1029	IEEE 802.11-04/422r4, "New Participant Orientation", presentation submission (July 2004) (Appendix A to Lansford Declaration, INTEL-1007)
1030	IEEE 802.11-04/736r1, "Approved Minutes of the IEEE P802.11 Full Working Group", Minutes (July 2004) (Appendix B to Lansford Declaration, INTEL-1007)

Ex.	Description
1031	U.S. Patent 7,415,074 (Appendix C to INTEL-1007)
1032	Stephens, "802.11 'Decrypted'", ACM SIGCOMM Computer Communication Review, Vol. 35, No. 2 (April 2005) (Appendix D to Lansford Declaration, INTEL-1007).
1033	Lörincz, et al, "Physical Layer Analysis of Emerging IEEE 802.11n WLAN Standard", 8th International Conference Advanced Communication Technology (February 20-22, 2006); added to IEEE Xplore May 8, 2006
1034	Cox, "Stage Set for Compromise on IEEE High-Speed Wireless", Network World (March 21, 2005)
1035	Kay, "Sidebar: The Battle for 11n", ComputerWorld (March 13, 2006)
1036	"'WWiSE' Consortium, Motorola Team on Proposal for IEEE 802.11n", Wireless Design Online (February 24, 2005)
1037	WWiSE Industry Organization Press Release, "'WWiSE' Consortium and Motorola Team to Offer Enhanced Proposal for IEEE 802.11n" (February 24, 2005); archived on April 6, 2005 at https://web.archive.org/web/20050406073808/http://www.WWiSE.org/pressreleasefeb23.htm.
2014	Gérald Chouinard, *Bringing broadband access to rural and remote areas: The Canadian Experience*, ITU NEWS (commem. ed. 3) (Apr. 2006) ("AXW-2014" or "ITU News")
2015	Matthew S. Gast, *802.11 Wireless Networks: The Definitive Guide* (2d ed. 2005) ("AXW-2015" or "Gast")
2016	Syed Aon Mujtaba, *TGn Sync Response to Questions* (Doc. No. IEEE 802.11-05/182r2) (Mar. 16, 2005), https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fmentor.ieee.org%2F802.11%2Fdcn%2F05%2F11-05-0182-02-000n-tgnsync-response-to-atlanta-questions.ppt&wdOrigin=BROWSELINK ("AXW-2016")
2024	IEEE Std. 802.11n-2009, *Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, Amendment 5: Enhancements for Higher Throughput* (Oct. 29, 2009)

Ex.	Description
2025	R. Kennedy, Amendment to IEEE Standard 802.11-2007 (Project No. P802.11af): Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications; Amendment: TV White Spaces Operation (PAR Request Oct. 2, 2009; PAR Approval Dec. 9, 2009) ("AXW-2025")
2026	Bruce Kraemer, Amendment to IEEE Standard 802.11-2007 (Project No. P802.11ah): Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications; Amendment: Sub 1 GHz License-Exempt Operation (PAR Request July 26, 2010; PAR Approval Sept. 30, 2010) ("AXW-2026")
2027	Xuemei Ouyang et al., Optimal Antenna Diversity Combining for IEEE 802.11A System, 48 IEEE Transactions Consumer Elecs. 738 (Aug. 2002) ("AXW-2027")
2028	Cenk Kose & Bruce Edwards, WWiSE Proposal: High Throughput Extension to the 802.11 Standard (Doc. No. IEEE 802.11-04/0886r6) (Jan. 6, 2005), https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjJq5fyur-CAxUROUQIHan7D4IQFnoECBkQAQ&url=https%3A%2F%2Fmentor.ieee.org%2F802.11%2Fdcn%2F05%2F11-05-0149-00-000n-wwise-proposal-high-throughput-extension-to-802-11-standard.doc&usg=AOvVaw2ryBNHlH79Ugg8pE4IzPVE&opi=89978449 ("AXW-2028" or "March 2005 WWiSE Proposal")
2029	Mohammad Hossein Manshaei & Thierry Turletti, Simulation-Based Performance Analysis of 802.11a Wireless LAN, Proc. Int'l Symp. Telecomms. 758 (Aug. 2003) ("AXW-2029")
2030	IEEE, IEEE P802.11 – Task Group N – Meeting Update: Status of Project IEEE 802.11n: Standard for Enhancements for Higher Throughput, https://www.ieee802.org/11/Reports/tgn_update.htm (printed 11/10/2023) ("AXW-2030")

III. Understanding of Legal Principles

14. I am not an attorney, and I do not opine on matters of law. In preparing this Declaration, I have been informed by Counsel about certain aspects of the law that are relevant to my analysis and opinions, as set forth below.

15. I have been informed by Counsel that the claims of a patent define the patented invention.

16. I have been informed by Counsel that an issued patent is presumed valid.

A. Obviousness Under 35 U.S.C. § 103(a)

17. I have been informed by Counsel that the validity analysis is a two-step process. First, the patent claims are construed to ascertain their proper scope. Second, the construed claims are compared to the identified prior art to determine if the claims are valid over the prior art.

18. I have been informed by Counsel that patent claims can be deemed invalid if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the pertinent art ("POSA"). While such conclusions are often based on more than one piece of prior art, only one is required. It is not sufficient that a collection of prior art references merely recites the various elements of a challenged patent claim. Rather, as I have been

informed by Counsel, the prior art must present the elements in a manner that is consistent with their arrangement or use in the challenged claims. I have been informed by Counsel that obviousness cannot be based on the hindsight combination of components selectively culled from the prior art.

19. I have been informed by Counsel that a POSA is a hypothetical person who is presumed to have known the relevant art at the time that the invention was made. I have been informed by Counsel that the condition "at the time the invention was made" is imposed to rule out impermissible hindsight. I also have been informed by Counsel that an expert is to analyze the prior art from the perspective of a POSA and not simply to provide an expert's own personal conclusions.

20. I have also been informed by Counsel that an obviousness determination includes several factual inquiries, including (1) determining the scope and content of the prior art; (2) ascertaining the differences between the claimed invention and the prior art; (3) resolving the level of ordinary skill in the pertinent art; and (4) taking into consideration any objective indicia of nonobviousness.

21. I have been informed by Counsel that obviousness must be determined as of the date of the invention (i.e., the effective filing date or priority date of the patent). Thus, in considering the reason or motivation to combine

references, it is essential to avoid using hindsight. For example, the problem examined when considering obviousness is the general problem that confronted the inventor before the invention was made, not the specific problem solved by the invention. Defining the problem in terms of its solution reveals improper hindsight in the selection of the prior art relevant to obviousness. Further, an overly narrow statement of the problem can represent a form of hindsight, because often the inventive contribution lies in defining the problem in a new revelatory way. Similarly, an assertion that a POSA could combine the references, rather than that they would have been motivated to do so, is an impermissible form of hindsight. Moreover, knowledge of a problem and motivation to solve it are entirely different from the motivation to combine particular references to reach the particular claimed invention.

22. I have been informed by Counsel that whether a POSA would be motivated to make a combination includes whether he/she would select particular references in order to combine their elements.

23. I have been informed by Counsel that the analysis of the motivation to combine should be explicit. Additionally, it must include articulated reasoning with rational underpinnings to support the conclusion of obviousness. Providing a full explanation of the motivation to combine the references and the reasonable expectation of success is a necessary component of the obviousness inquiry, as

invention in most, if not all, instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be combinations of what, in some sense, was already known. However, conclusory statements fail to adequately explain to a lay person why a POSA would have a motivation to combine the potential prior art references and therefore do not provide evidentiary value.

24. I have been informed by Counsel that common sense, common wisdom, and common knowledge may be used to support a motivation to combine, so long as the use of common sense in the analysis is explained with sufficient reasoning. But common sense can only be used to supply a limitation missing from the prior art where the technology is unusually simple and straightforward.

25. I also have been informed by Counsel that evidence suggesting reasons to combine cannot be viewed apart from evidence suggesting reasons not to combine. In analyzing motivation, both advantages and disadvantages must be considered. Teaching away, for example, is a statement in the prior art that either (i) discourages one from following the path of the claimed invention, or (ii) encourages one to follow a path that diverges from the path of the claimed invention. The concept of teaching away bears directly on whether there was a reason to combine prior art. Known disadvantages in prior art technology or

devices which would naturally discourage a search for new inventions may also be taken into account in determining obviousness.

B. Written Description Under § 112(a)

26. I have been informed by Counsel that a published patent application, which was filed in the United States before the invention of the applicant of the '262 Patent (August 21, 2009) is prior art even though it published after the '262 Patent was filed, as long as at least one claim of the alleged prior art published patent application has written description support and is enabled by a provisional application filed with the U.S. Patent and Trademark Office before the '262 Patent.

27. I have been informed by Counsel that for a claim in published application to have written description support in a provisional application requires showing that the provisional application conveys with reasonable clarity to a POSA that as of the provisional application's filing date, the applicant was in possession of the invention by way of disclosures of the invention in the specification of the provisional application. I have been informed by Counsel that a mere wish or plan for obtaining the claimed invention is not enough to satisfy the written description requirement.

28. I have further been informed by Counsel that to find written description support for a specific claim, the claim must be viewed as a whole rather than as independent limitations. Accordingly, it is not enough that each individual

limitation of a claim find support in a provisional, but that the claimed invention as a whole must be adequately described and disclosed in the specification of the provisional application. Accordingly, even if a written description could render the invention obvious, this alone does not satisfy the written description requirement. Rather, the specification must describe the invention in sufficient detail such that a POSA could conclude that the inventor invented the claimed invention.

C. Person of Ordinary Skill in the Art

29. I understand that Intel and Intel's expert, Dr. La Porta, assert that a person of ordinary skill in the art ("POSA") at the time of the invention of the '262 patent would have had "at least a master's degree in electrical engineering or similar discipline, and/or two to three years of experience working or conducting research in the field of wireless communication protocols, or an equivalent combination of education and experience." Pet. 8; INTEL-1003 ¶69. While at this time I did not form an opinion on the level of ordinary skill in the art, I have applied Intel's assertion for a POSA in rendering my opinions.

D. Claim Construction

30. I have been informed by Counsel of the process of claim construction in patent disputes. I understand that Intel and Dr. La Porta do not assert any specific claim constructions to any of the terms of the challenged claims. Thus, I

have applied the plain and ordinary meaning of the claim terms to a POSA in rendering my opinions in this Declaration.

IV. Summary of the '262 Patent (INTEL-1001)

31. The '262 patent relates to improving communications in wireless Orthogonal Frequency Division Multicarrier ("OFDM") networks. The '262 patent claims priority from a provisional application filed on August 21, 2009 (INTEL-1008), and issued on February 28, 2017. I have been instructed by Counsel to use August 21, 2009 as the priority date for these patents.

32. The Background section of the specification grounds the description in frame- or packet-based communication systems using Orthogonal Frequency Division Multiplexing (OFDM). *See* '262 patent at 1:27-35. It notes that a packet generally consists of a preamble, header, and payload portions. *See* '262 patent at 1:33-35. The specification identifies exemplary systems in this category that include "IEEE 802.11 (Wireless LAN), IEEE 802.16 (WiMAX), and ITU G.9960 (G.hn)." '262 patent at 1:35-37; *see also* '262 patent at 4:27-48 (further identifying DSL, ADSL, xDSL, VDSL, MOCA, Homeplug, and IEEE 802.3, along with others). A POSA would have understood that these various protocols and standards would generally have different information to include in headers and different requirements for reliable reception of header information, which would drive their implementation. *See, e.g.*, '262 patent at 1:28-63.

33. The '262 patent generally describes a flexible approach to the number of OFDM symbols carrying header information and the number of repeated OFDM symbols per header symbol. *See, e.g.*, '262 patent at Title, 2:6-53. Figure 1 shows "exemplary header repetition schemes" and is reproduced below. '262 patent at 3:62. The patents use "D" to refer to the number of times a header symbol is repeated, and "H" to refer to the number header symbols containing different information. *See* '262 patent at 2:21-34, 5:44-6:7, Fig. 1. In each example, the header field is preceded by a preamble and followed by a payload portion. *See* '262 patent at 5:44-6:7, Fig. 1.

34. In the first row of Figure 1, D and H are both set to 1, and a single "Header" field is included. In the second row, H is set to 1 but D is set to 2. This results in the "Header" field being repeated. In the third row, D is set to 1, but H is now set to 2. This results in the header field extending to two symbols, one denoted "Header" the other denoted "Header Ext," and both are included. In the fourth row, D and H are both set to 2, resulting in the "Header" symbol being repeated, followed by the "Header Ext" symbol being repeated. In the fifth row, D and H are again both set to 2 and the same result as the fourth row occurs. The fifth row provides an example showing that the "Header" and "Header Ext" not only contain different information, but can contain a different number of information bits in each symbol. *See* '262 patent at 5:58-6:7.

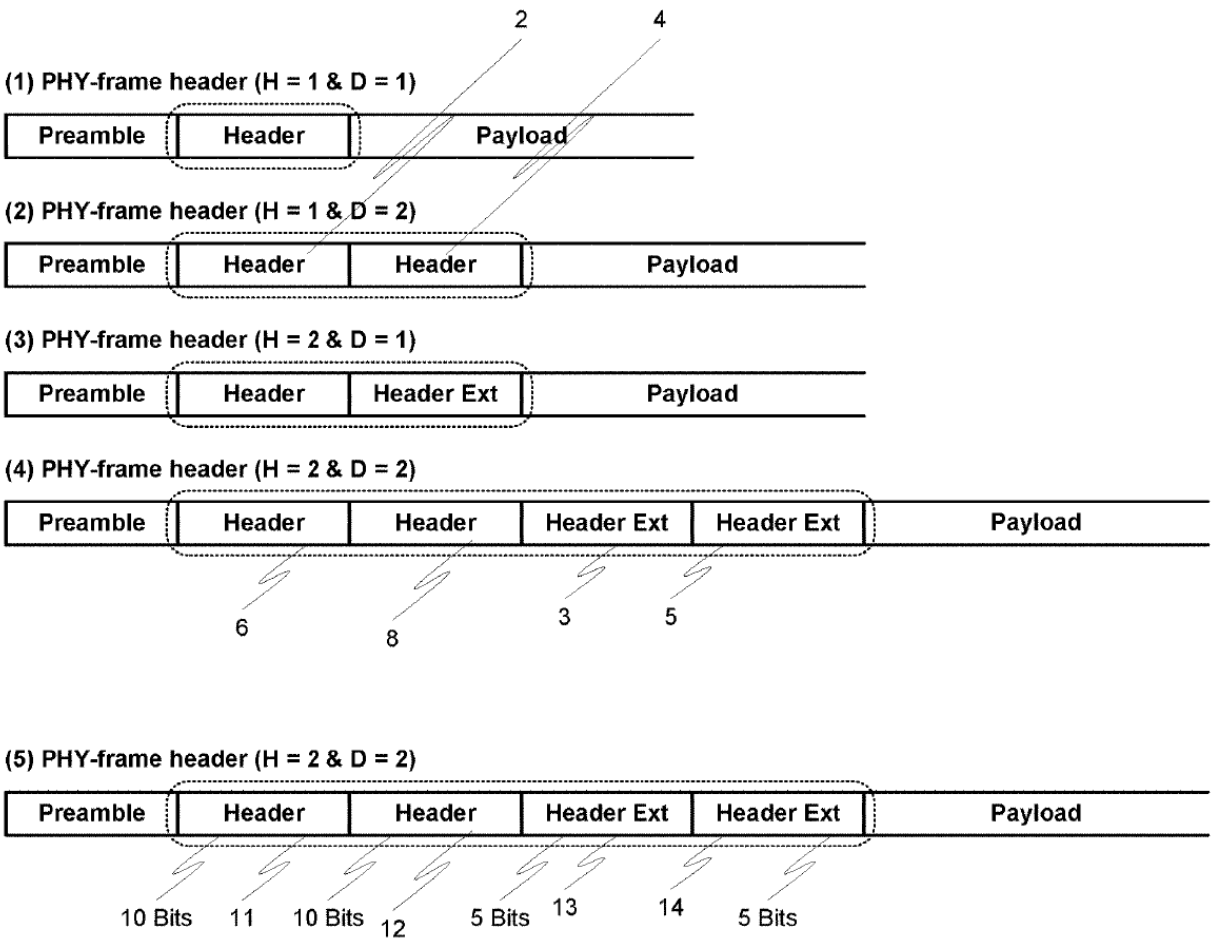


Fig. 1

35. In addition to the variable header repetition, the patents describe a number of ways in which the nodes of a network can understand what header repetition scheme is being used. *See, e.g.*, '262 patent at 2:40-3:55. For example, one scheme assumes that a receiver will be able to decode the header (or at least the D value), which will inform it of how many repetitions to expect. The diversity achieved from the repetitions increases the likelihood that the entire header is decoded correctly. *See* '262 patent at 2:54-67. Another example requires a domain master to communicate the scheme to all nodes, and nodes must determine the

scheme in order to properly decode the header. *See* '262 patent at 3:1-12. Another approach involves certain packets having a fixed repetition value, while at the same time communicating a different repetition value for all other packets that can be variable. *See* '262 patent at 3:22-31. These and other different approaches are described in further detail in the patents, with reference to the figures. *See* '262 patent at 6:8-10:27, Figs. 2-8.

36. The '262 patent further emphasizes that its invention allows for different values of D in a single domain, "where nodes are operating in different portions of frequency bands." '262 patent at 2:6-8. As an example, the '262 patent explains that for the "power-line medium" G.9960, there is "defined two overlapped baseband bandplans, 50 MHz-PB and 100 MHz-PB," and that in SmartGrid applications there exists "[t]he possibility of having narrower bandplans such as 25 MHz-PB and 12.5 MHz-PB." '262 patent at 2:8-13. This "frequency diversity" depends on the bandplan, and provides for "different header decodability if D is fixed to 1. If D is fixed to 2, then it increases reliability for the narrowband devices, but may also unnecessarily increase overhead for the wide-band devices." '262 patent at 2:14-20.

V. Relevant Technical Background

37. As described above, the '262 patent generally relates to methods and systems related to Orthogonal Frequency Division Multiplexing (OFDM)

transmission and reception of frames or packets. Within that broader context, they relate to variable header repetition with OFDM signals, and the claims relate to wireless communication. As explained in Section IV, the teachings of the '262 patent can be applied to various communications systems. Because the references forming the grounds raised in the Petition are primarily 802.11 references, much of my discussion in this section will be primarily focused on the relevant technical background principles of 802.11 wireless networks.

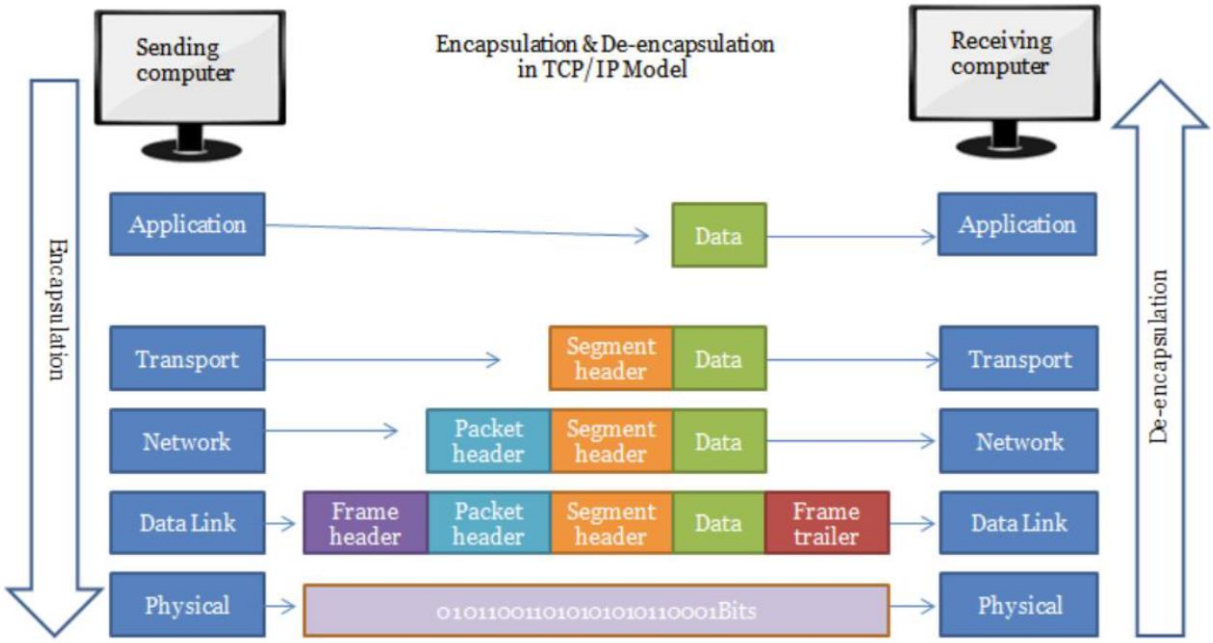
38. It should be understood that much of the explanation below, such as the networking overview and discussion of modulation and coding, are applicable to numerous communications systems, including those discussed in the '262 patent. For example, Dr. La Porta describes various aspects related ITU G.hn. *See* INTEL-1003 ¶¶52-63. He does not, however, describe modulation modes in detail anywhere in his declaration. The OFDM subcarriers in ITU G.hn are also modulated with various constellations. *See, e.g.*, INTEL-1028 at 58-62.

39. I go into much more detail than Dr. La Porta and the Petition in this background section, because the details are important to understanding why a POSA would not combine the prior art as in the Petition. By skipping over the details, Dr. La Porta and the Petition miss important aspects of the prior art.

A. Networking Overview

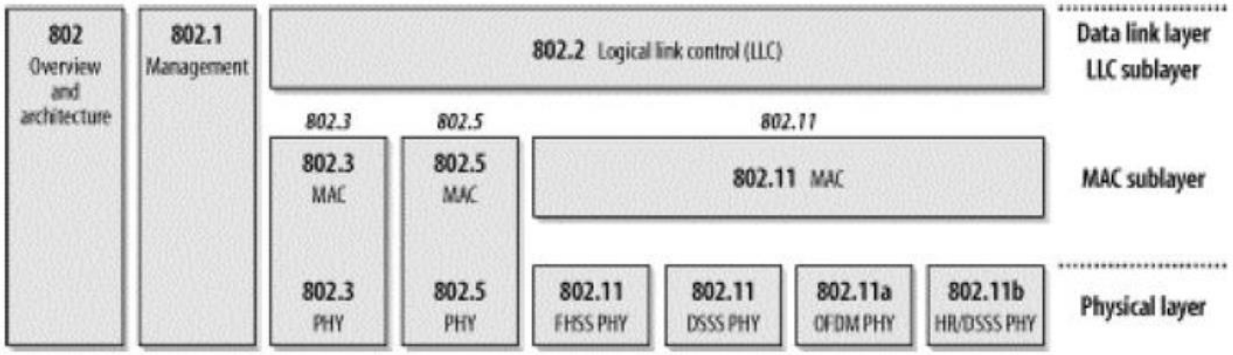
40. In networking, devices communicate by sending and receiving messages. Depending on their size, the messages may be broken up into portions often called packets. These packets are the unit of data that are sent and received in a network, whether that network is wired or wireless, private or public.

41. Networking is often performed at various layers according to the Open Systems Interconnection (OSI) Model. Dr. La Porta provides the below figure illustrating this concept. Dr. La Porta displays the TCP/IP reference model, which layers are a subset of the 7 layers of the OSI model. Specifically, he illustrates the Physical Layer (OSI Layer 1), Data Link Layer (OSI Layer 2), Network Layer (OSI Layer 3), Transport Layer (OSI Layer 4), and Application Layer (OSI Layer 7).



42. The application layer is the highest and most closely related to the user's application, such as a web browser that generates an HTTP request. The data from the upper layers makes it way down the protocol stack to the lower layers, with various "header" information added at each layer. TCP at the Transport Layer and IP at the Network Layer are well-known protocols. TCP controls the end-to-end (process-to-process) flow of the data packets between endpoints across a network, while IP controls the packet routing across the network, providing, for example, addressing information to allow the packets to be passed through the network. The Data Link Layer prepares the data for transmission onto the physical medium between two adjacent nodes (as opposed to across a network as at the Network Layer) with its own specific protocol providing, for example, flow control and error control capabilities. The Physical Layer deals with the actual transmission and reception of bits by way of electrical, radio, or optical signals as examples.

43. Some examples of networking standards that people are typically familiar with include IEEE standards 802.11, often called WiFi, and 802.3, often called Ethernet. Both are umbrellas for a number of underlying Data Link Layers and Physical Layers. The IEEE 802 family of standards are often depicted as below.



INTEL-1003 ¶64; *see also* AXW-2015 at 13. As depicted above, in the IEEE 802 family, the Data Link Layer is broken up into an LLC sublayer and a Medium Access Control ("MAC") sublayer. IEEE 802.2 defines a common logical link control for a number of standards such as WiFi and Ethernet. Those, in turn, have their own specific MAC sublayer. The MAC is a set of rules to determine how to access the medium and send data, but the details of transmission and reception are left to the Physical Layer, or PHY. AXW-2015 at 13. The MAC defines numerous frame types that define various messages to implement the MAC's rules among the devices of the 802.11 network. *See, e.g.*, AXW-2015 at 32-113.

44. As shown above, there are different 802.11 PHYs, often referred to by letters corresponding with amendments to the base 802.11 standard that added them. The above figure is from 2005, and shows 802.11, 802.11a, 802.11b, and 802.11g PHYs. Since 2005 additional PHYs have been defined, including 802.11n, which will be discussed herein. While the figure above shows a common 802.11 MAC, the various amendments that added different PHYs required

consideration at the MAC as well, because of the relationship between the MAC and Physical Layer in 802.11. *See* AXW-2015 at 13-14.

B. Modulation, Coding, and Error Correction

45. At the Physical Layer of a wireless network, the individual bits to be transmitted are modulated onto a carrier signal for transmission across the medium. Because the 802.11 OFDM PHYs are most relevant here, I will briefly describe the OFDM modulation modes used in 802.11a/g/n. 802.11a was standardized in 1999, and defines an OFDM PHY in the 5 GHz band. AXW-2015 at 276. The 802.11g PHY "is essentially running 802.11a in the ISM frequency band (2.4 GHz), with a few minor changes to provide backwards compatibility." AXW-2015 at 298-99. 802.11n was published in 2009 and defines an OFDM PHY that can operate in both 2.4 GHz and 5 GHz bands, using OFDM and MIMO capabilities, as well as number of other enhancements, some of which will be discussed below. *See, e.g.*, AXW-2015 at 311-42.

46. OFDM stands for Orthogonal Frequency Division Multiplexing. "OFDM encodes a single transmission into multiple subcarriers." AXW-2015 at 277. In this way, a fast stream of data can be divided into slower streams, distributed to the subcarriers/subchannels, and sent at the same time. "OFDM devices use one wide-frequency channel by breaking it up into several component subchannels. Each subchannel is used to transmit data." AXW-2015 at 277. The

slower subchannels can then be put back together into the original fast stream of transmitted data. "OFDM works because the frequencies of the subcarriers are selected so that at each subcarrier frequency, all other subcarriers do not contribute to the overall waveform." AXW-2015 at 278-79. This property is the "orthogonal" part of the name OFDM. The subcarriers in the frequency domain also have a time domain waveform, and in the time domain, the OFDM signal is separated into OFDM symbols with guard intervals. In 802.11a, the general OFDM symbol time duration is 4 µs. *See, e.g.,* AXW-2015 at 283.

47. In 802.11a/g the OFDM occupies a 20 MHz channel composed of 52 subcarriers, generally numbered from -26 to 26. *See, e.g.,* AXW-2015 at 283. Generally, 4 of the subcarriers, at subcarriers -21, -7, 7, and 21, are used as pilot carriers that help with reception of the signal. *See, e.g.*, AXW-2015 at 283. And generally, the remaining 48 subcarriers are used to transmit data. *See, e.g.*, AXW-2015 at 283. Additionally, the subcarrier 0 is not used. *See, e.g.,* AXW-2015 at 283. This is depicted in the figure below, where data subcarriers are in the gray areas, while the pilot carriers and 0 carrier are represented by white space.

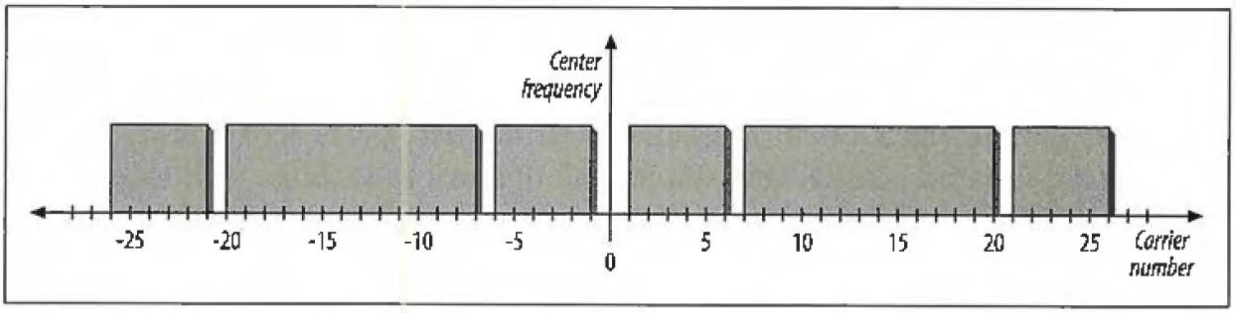


Figure 13-8. Structure of an OFDM channel

AXW-2015 at 284.

48. Each subcarrier is modulated with a slower bit stream assigned to it. Relevant to the Petition, we can assume that each subcarrier is modulated with modulation techniques used in 802.11n and prior OFDM-related 802.11 standards. The modulation techniques used in 802.11a are BPSK, QPSK, 16-QAM, and 64-QAM. The signal constellations for these modulation techniques are depicted below.

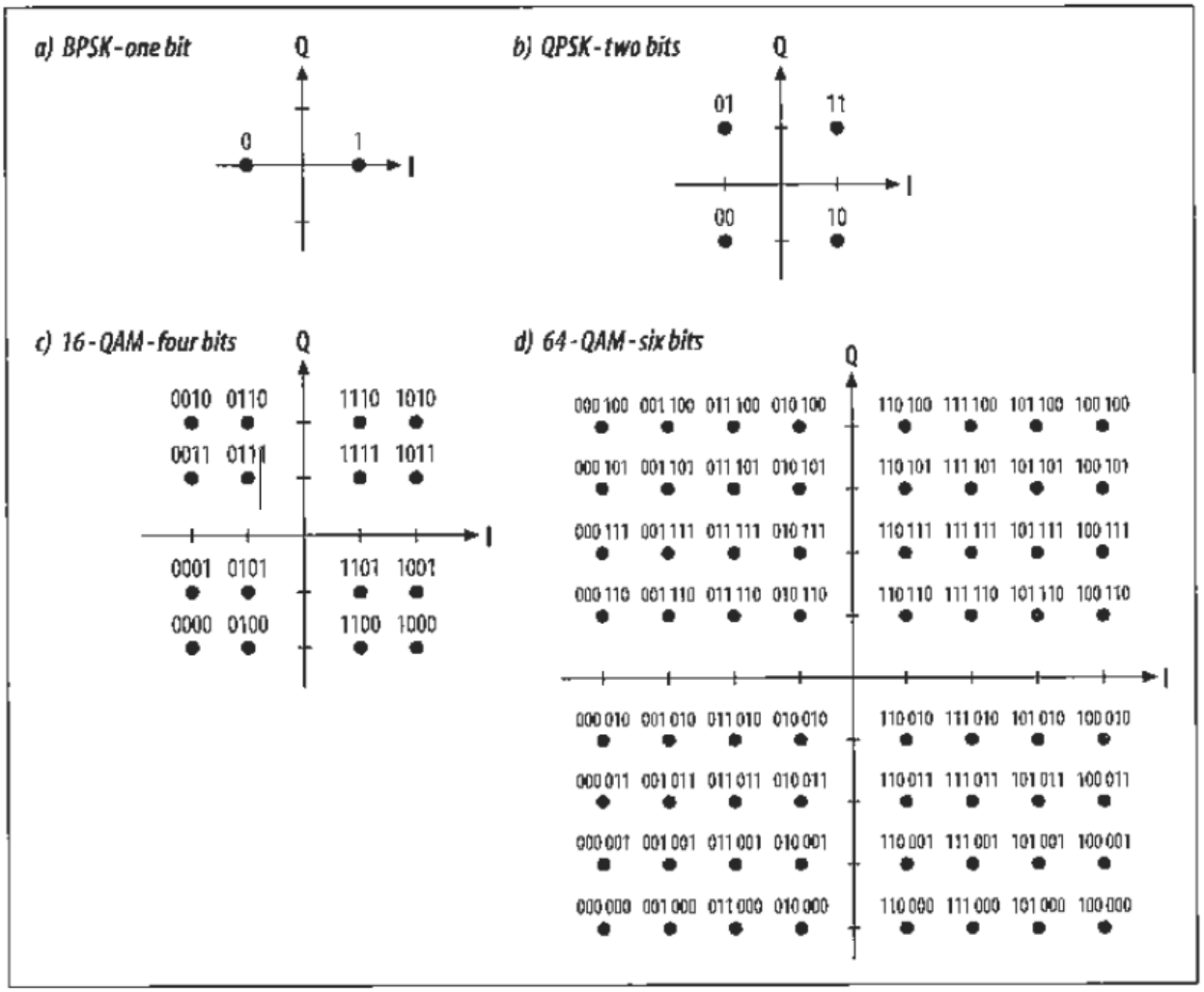


Figure 13-9. Constellations used by 802.11a

AXW-2015 at 285. Each dot represents a signal that can be modulated onto a subcarrier of the OFDM signal. As indicated in the figure above, each BPSK signal transmits 1 bit, each QPSK signal transmits 2 bits, each 16-QAM signal transmits 4 bits, and each 64-QAM signal transmits 6 bits. Because symbol durations are the same, higher data rates are achieved using higher order modulation with more constellation dots. But the receiver must be able to distinguish between these constellation dots. Because transmit power is generally limited, more constellation

dots mean the signals are harder to distinguish from each other at the receiver because they are closer together. *See, e.g.*, AXW-2015 at 284-85. This is sometimes referred to as the minimum distance of the constellation. *See* INTEL-1015 at 88-89. This ability to distinguish is generally a function of the signal-to-noise ratio (SNR) of the received signal; higher SNR is required for higher-order constellation to receive the same probability of bit error, often referred to as Bit Error Rate (BER). Said differently, higher-speed modulations pack more bits into a given time interval, but require higher SNRs for the same BER. AXW-2015 at 235. For example, the constellation dots of QPSK will be closer together than BPSK, generally requiring a 3dB increase in SNR to achieve the same error rate in an additive white gaussian noise (AWGN) channel. *See* INTEL-1015 at 93-94. Moving from QPSK to 16-QAM would require another 6.99dB increase in SNR. *See* INTEL-1015 at 94-96. This is sometimes depicted in waterfall curves.

49. 802.11 also applies various convolutional codes to the bit stream to create redundancy in order to be more protective against (robust to) errors. The original bit stream is called the data bits, while the bit stream after the convolutional encoder is called the coded bits. 802.11a/g used either R=1/2 (2 coded bits for every 1 data bit), R=2/3 (3 coded bits for every 2 data bits), or R=3/4 (4 coded bits for every 3 data bits) for different modulation modes. A higher ratio of coded bits to data bits has more redundant information and is more robust to

errors, but at the expense of overall data rate because fewer data bits are being transmitted in the same unit of time. *See, e.g.*, AXW-2015 at 285-87. 802.11 also uses interleaving of bits across OFDM subcarriers for further robustness. *See, e.g.*, AXW-2015 at 287-88. For 802.11a/g, the resulting modulation and coding schemes are given in the table below.

Table 13-3. Encoding details for different OFDM data rates

Speed (Mbps)	Modulation and coding rate (R)	Coded bits per carrier[a]	Coded bits per symbol	Data bits per symbol[b]
6	BPSK, R=1/2	1	48	24
9	BPSK, R=3/4	1	48	36
12	QPSK, R=1/2	2	96	48
18	QPSK, R=3/4	2	96	72
24	16-QAM, R=1/2	4	192	96
36	16-QAM, R=3/4	4	192	144
48	64-QAM, R=2/3	6	288	192
54	64-QAM, R=3/4	6	288	216
72[c]	64-QAM	6	288	288

[a] Coded bits per subchannel is a function of the modulation (BPSK, QPSK, 16-QAM, or 64-QAM).
[b] The data bits per symbol is a function of the rate of the convolutional code.
[c] Although no rate has been standardized without a convolutional code, many products offer a mode where it is dropped for additional throughput.

AXW-2015 at 293-94.

C. 802.11a PHY Framing

50. As I described in Section V.A above, the data and headers from upper layers make their way down the protocol stack. This is depicted below for the MAC and PHY from the 802.11a standard.

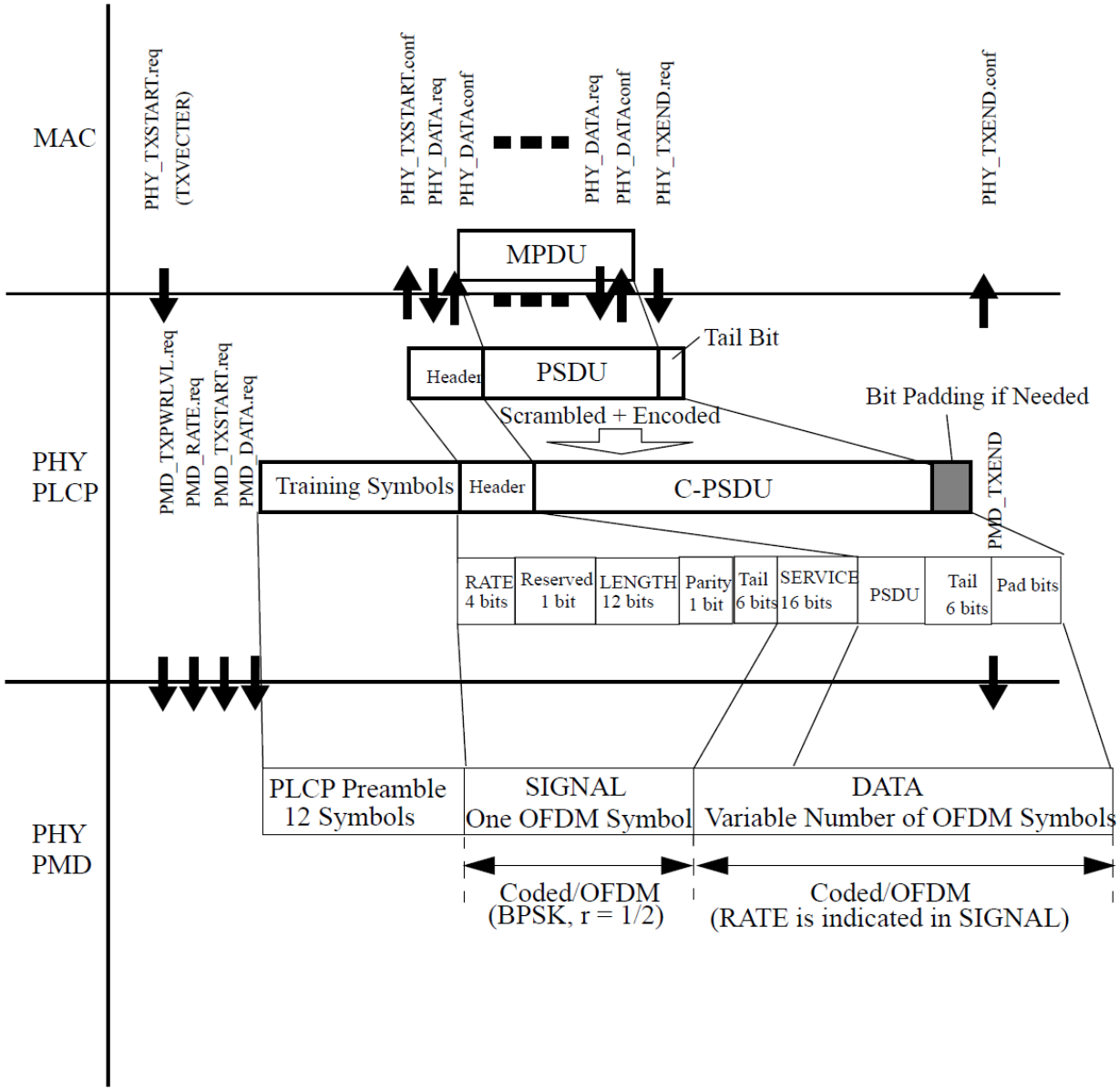


Figure 122—PLCP transmit procedure

INTEL-1013 at 33. Simplified, the MAC provides its MPDU to the PHY Physical Layer Convergence Protocol (PLCP), along with control information, which helps prepare the frame for transmission onto the air interface. Training symbols are added to a preamble; a PLCP header comes next, and then the PSDU containing

that data to be transmitted, forming a complete PLCP frame. *See* INTEL-1013 at 7-8; *see also* INTEL-1013 at 12.

51. As shown in the figure above, a portion of the PLCP header is referred to as the SIGNAL field in 802.11a. *See* INTEL-1013 at 7. As shown above, the SIGNAL field contains "the LENGTH, RATE, reserved bit, and parity bit (with 6 'zero' tail bits appended)" and "is transmitted with the most robust combination of BPSK modulation and a coding rate of R = ½." INTEL-1013 at 7; *see also* INTEL-1027 at 140 ("The PLCP preamble and the signal field are always transmitted at 6 Mbps, binary phase shift keying (BPSK)-OFDM modulated using convolutional encoding rate R = ½."). This is "to ensure reliable reception." INTEL-1015 at 35. The SIGNAL field contains 24 bits of information, and the R = ½ code turns that into 48 bits to be transmitted, which fits into a "single OFDM symbol." INTEL-1013 at 7. Thus, for 802.11a (and 802.11g), the SIGNAL field always occupies a single OFDM symbol that is modulated with BPSK and R = ½ coding.

52. As noted in the figure above, the number of data OFDM symbols is variable. Further, these symbols can be modulated at any of the modulation modes and code rate combinations described in the previous section.

53. A more detailed timing diagram for the frame is shown below, from 802.11a, annotated to match the above diagram. The preamble "is composed of 12 OFDM symbols that synchronize various timers between the transmitter and the

receiver. The first 10 symbols are short training sequences, which the receiver uses to lock on to the signal, select an appropriate antenna if the receiver is using multiple antennas, and synchronize the large-scale timing relationships required to begin decoding the following symbols." AXW-2015 at 291. "Two long training sequences follow the short training sequences. Long training sequences fine-tune the timing acquisition and are protected by a guard interval." AXW-2015 at 291-92.

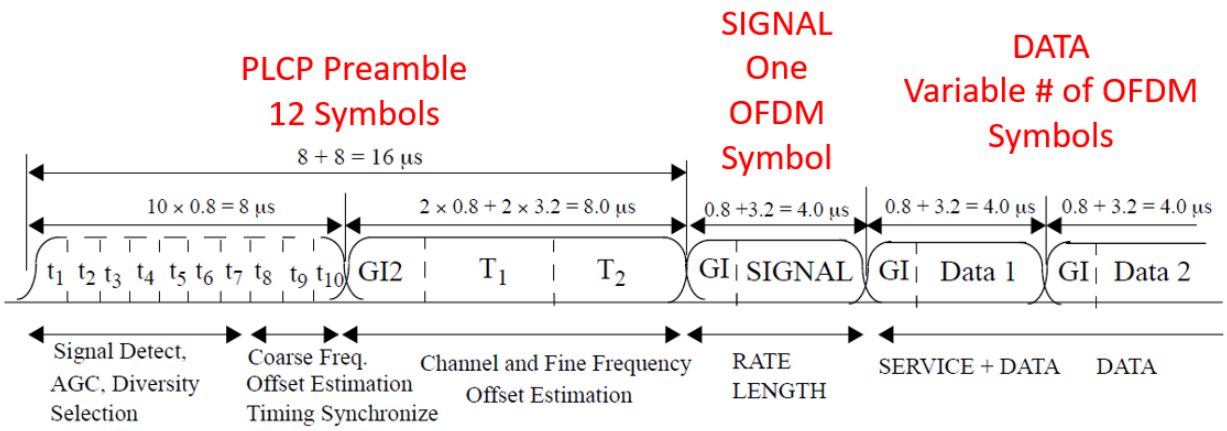


Figure 110—OFDM training structure

INTEL-1013 at 12 (annotated in red). Thus, training sequences like those defined in 802.11a are necessary to prepare the receiving hardware to receive the information-bearing portions of the packet by setting the gain of the RF chain, making antennas selections, synchronizing timing with the received signal, and/or making adjustments to remove error sources during demodulation. *See, e.g.*, INTEL-1015 at 48 ("Without accurate synchronization algorithms, it is not possible to reliably receive the transmitted data."), 53-81.

D. The Wireless Medium and 802.11

54. In this section I provide an overview of the wireless medium and 802.11. This overview is not meant to be exhaustive, as there are many considerations for, and environments in which, wireless communications may be used.

55. Two primary differences between wireless networks, like WiFi, and wired networks, like Ethernet, are the lack of a wired interface and the resulting mobility due to the lack of wires. INTEL-1027 at 2, 161. The wireless channel is generally a shared medium, while many modern wired interfaces serve physical connections between only two devices. The wireless spectrum is generally segmented into different frequency bands. *See, e.g.*, AXW-2015 at 3-5. These bands are generally regulated in different countries to put constraints on use of the wireless channel in a particular frequency band. *See, e.g.*, AXW-2015 at 5. The wireless channel is not only shared with other devices on a particular network, but different other devices using the frequency band. *See, e.g.*, AXW-2015 at 5; INTEL-1027 at 161. This shared nature of the wireless channel creates an interference problem. *See, e.g.*, INTEL-1016 at 1-2; AXW-2015 at 34, 44; INTEL-1027 at 171-72.

56. The wireless channel is also subject to numerous electromagnetic propagation effects beyond interference from other devices. A primary one is path

loss, which refers to the loss in signal strength as the radio wave propagates. The further the signal travels, the more its signal strength diminishes. *See, e.g.*, AXW-2015 at 235 ("As radio signals travel through space, they degrade."). In free space, the signal degrades as the square of the distance traveled. *See, e.g.*, INTEL-1027 at 166; INTEL-1015 at 114-17. In other environments, such as indoor environments, the degradation is sometimes modeled as related to more than the square of the distance traveled to try to account for effects such as those discussed below, but often other wireless channel models are more appropriate to understand such effects. *See, e.g.*, INTEL-1027 at 166 ("For indoor applications beyond 20 feet, propagation losses increase at about 30 dB per 100 feet."); INTEL-1015 at 114-17 (describing path loss coefficient as different for free space and indoor environment); AXW-2015 at 445-46 (describing that free space loss is "an 'ideal' number" that neglects factors relevant to 802.11 networks).

57. Additionally, the larger the carrier frequency is, the smaller is the operating range, as the path loss increases with increasing carrier frequency. This fundamental property would have been known to a POSA. Indeed, this has been studied in connection with 802.11, showing range improvements with systems operating at 700 MHz rather than 2.4 GHz. *See* AXW-2014 (ITU News) at 5 ("It was observed that the range of 802.11b/g WLAN operating at 700 MHz can double in non line-of-sight conditions and quadruple in line-of-sight, as compared to 2.4

GHz."). Additionally, the IEEE authorized amendments to the 802.11 standards for OFDM operation below 1 GHz, in part, because of improved range. *See* AXW-2025 (802.11af Project Authorization); AXW-2026 (802.11ah Project Authorization).

58. Regardless, it is generally true that the signal degrades the further the receiver is from the transmitter. Consider the figure below depicting an access point (at distance = 0) and two receiving laptops. The ability of a receiver to properly receive a signal is limited by its noise floor. The ratio of the received signal to the noise floor is referred to as the signal-to-noise ratio, or SNR. As described above, in general, higher order modulations pack more bits into a given time interval and require higher SNR for a particular bit error rate. AXW-2015 at 235. In the figure below, the receiving laptop closer to the access point will receive a stronger signal corresponding to larger SNR than the receiving laptop further away from the access point. Or put another way, if the laptop moves from the position closer to the access point to the position further from the access point, the SNR of the signals it can receive will degrade. *See, e.g.*, AXW-2015 at 235 ("Over distance, the degradation of the signal will limit the signal-to-noise ratio at the receiver. As a station strays farther from an access point, the signal level drops; with a constant noise floor, the degraded signal will result in a degraded signal to noise ratio."), 445 ("Unlike wired networks, the speed at which wireless networks

operate depends on the distance from the nearest network uplink. As stations move farther from the serving access point, signals become weaker and the operational speed falls. Throughput depends on distance from the access point and the position of the device in a way that is unfamiliar to users of wired networks."); INTEL-1027 at 166 ("As the receiver moves away from the transmitter, the receiver's signal power decays until it reaches the receiver's noise floor, at which time the bit error rate becomes unacceptable."). Thus, in general, the closer laptop will be able to communicate with the access point using higher rate modulation than the farther-away laptop. Or, the laptop will be able to communicate at a higher data rate when it is closer to the access point. *See, e.g.*, INTEL-1015 at 114-117.

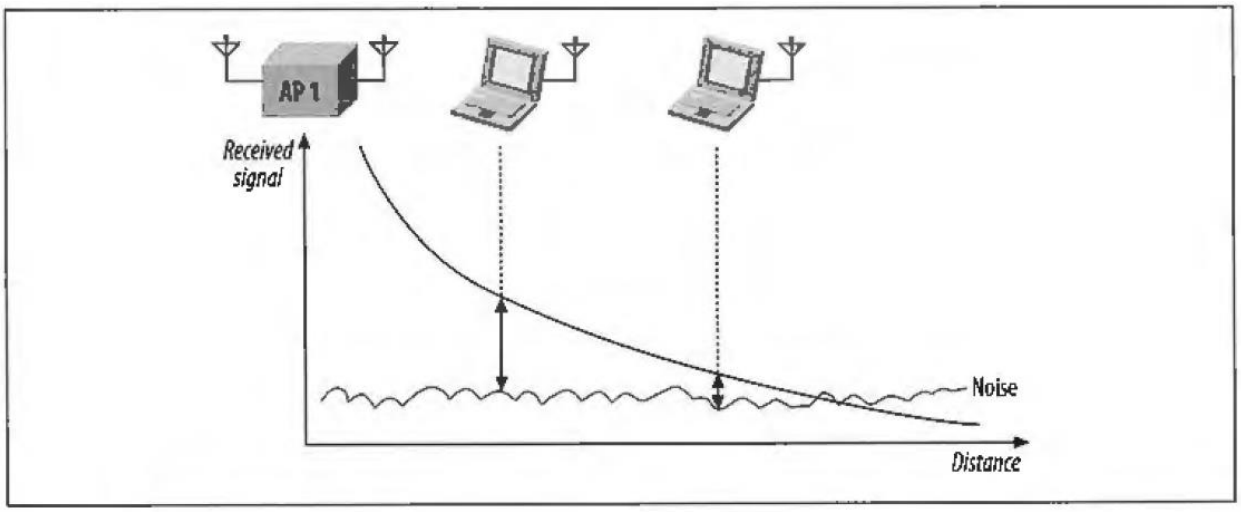


Figure 10-4. Throughput versus distance

AXW-2015 at 235; *see also* INTEL-1027 at 167. The below figure shows a rough qualitative depiction of how the data rate of a network changes with distance, but

with the access point in the middle and showing radial regions of data rate. *See* AXW-2015 at 445-46.

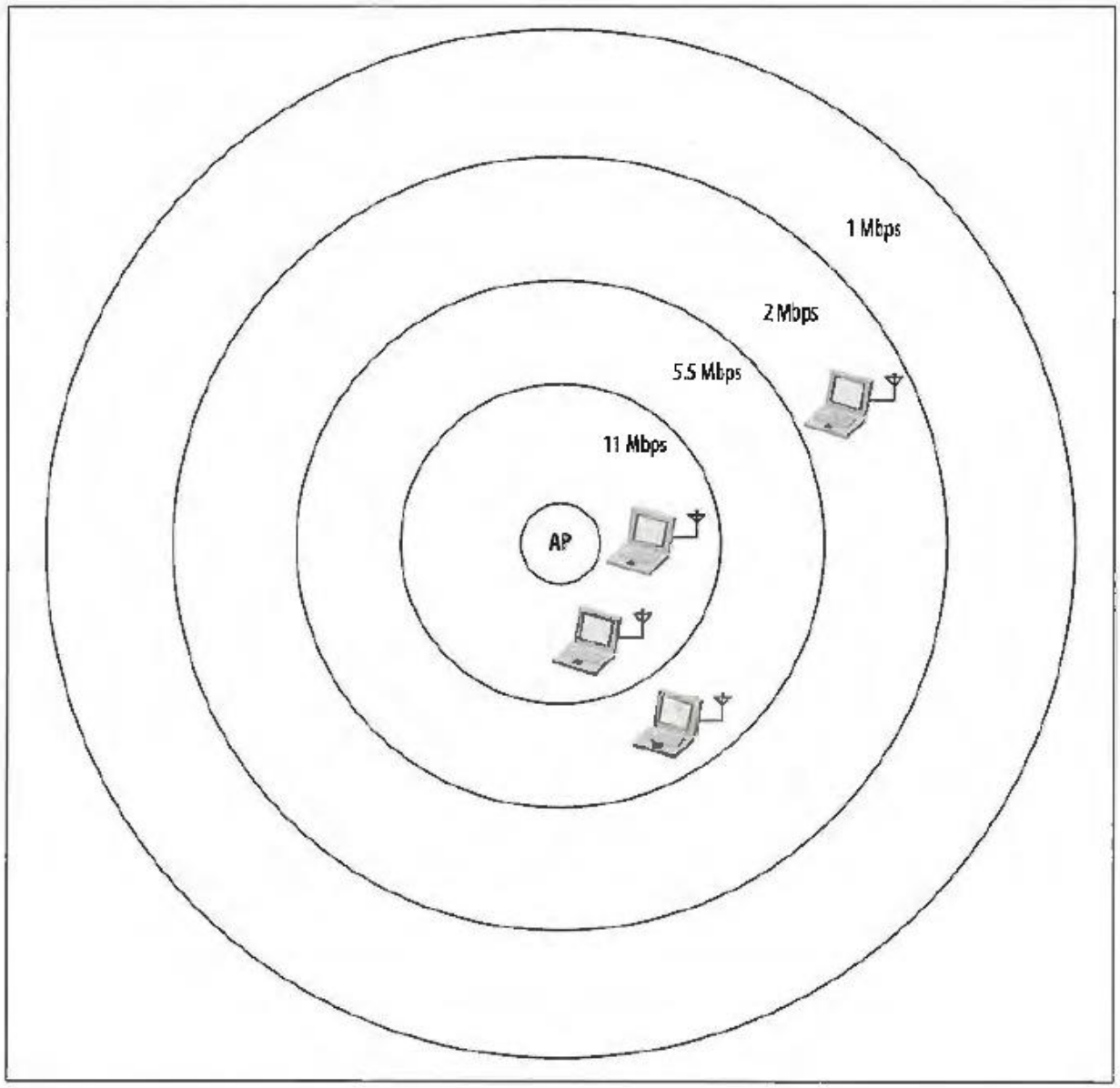


Figure 21-1. Dependence of performance on range

AXW-2015 at 446.

59. The wireless channel is dynamic, meaning that wireless signals can experience different channel effects that vary over time and depend on the wireless

frequency that is used. "Radio waves bounce off objects, penetrate through walls, and can often behave somewhat unpredictably. Radio waves can suffer from a number of propagation problems that may interrupt the radio link, such as multipath interference and shadows." AXW-2015 at 6, 445-46. "[E]verything in the environment is either a reflector or an attenuator of the signal carrying the LAN data. This can cause significant changes in the strength of a signal received by a WLAN station, sometimes severing the station from the LAN entirely. At the wavelengths used in the IEEE 802.11 WLAN, small changes in position can cause large changes in the received signal strength. This is due to the signal traveling many paths of differing length to arrive at the receiver." INTEL-1027 at 2-3, 164; *see also, e.g.*, INTEL-1016 at 10.

60. The phenomenon of the transmitted signal taking different paths to arrive at a receiver is referred to as multipath. A simplified example is depicted below.

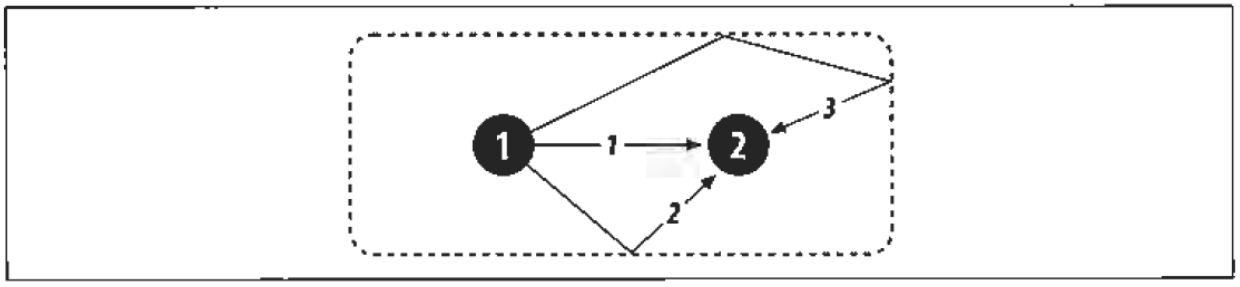


Figure 10-6. Multiple paths

AXW-2015 at 237; *see also* INTEL-1027 at 162. If the signal is the same along each path, the reflected radio waves may arrive either completely in-phase as in (b)

below, completely out-of-phase as in (c) below, or somewhere in between as in (a) below. The destructive interference of the waves combining at the receiver is often referred to as multipath fading or multipath interference. *See, e.g.*, AXW-2015 at 237; INTEL-1027 at 168.

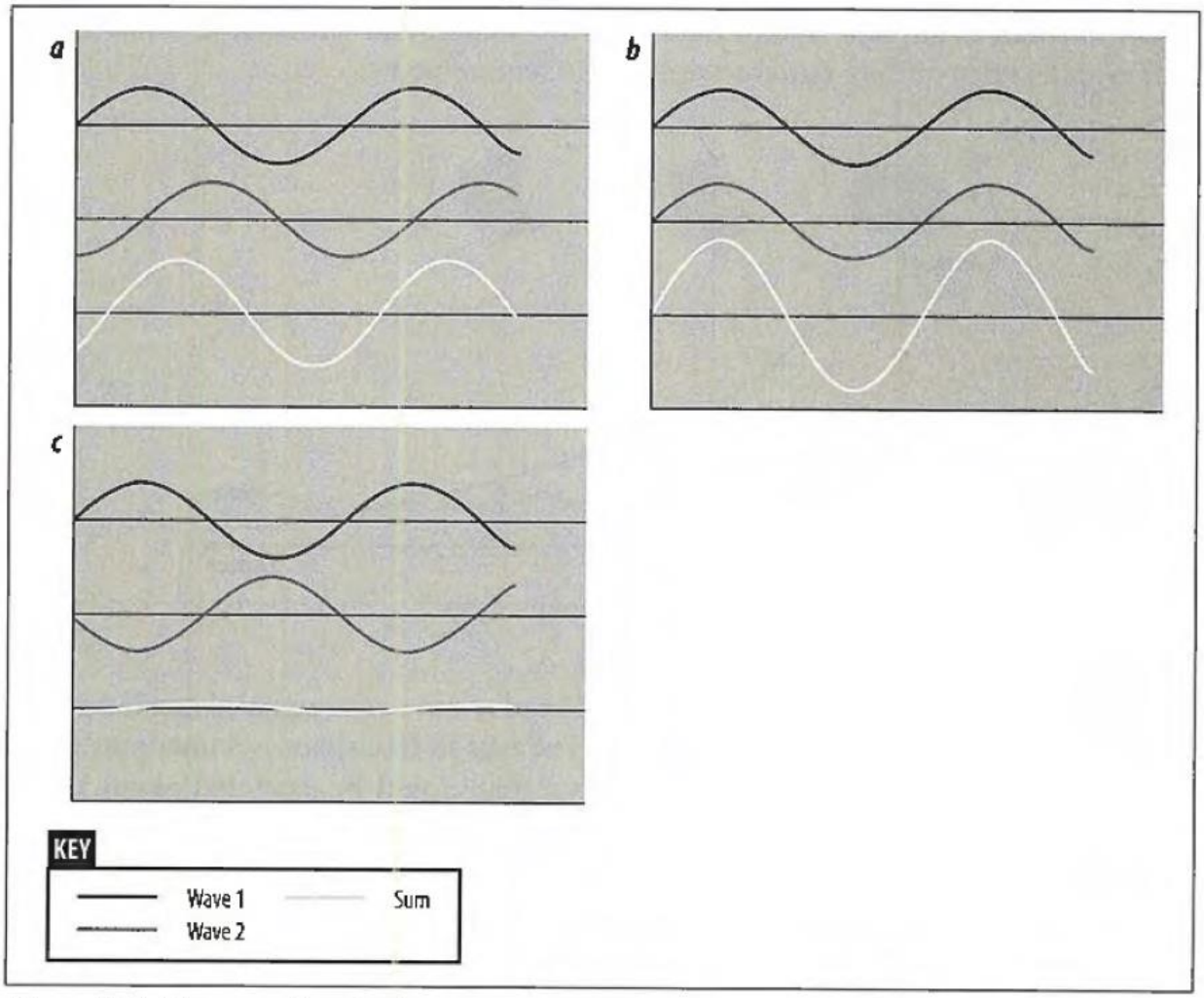


Figure 10-5. Wave combination by superposition

AXW-2015 at 236. Moreover, the effects of the wireless channel and the environment in which the signals propagate affect the error rates of the modulated

signals. As discussed in the next section, path diversity can also be used to enhance wireless performance.

E. Diversity and MIMO

61. As discussed in the previous section, the multipath nature of wireless communication creates a fading environment. In addition to coding and interleaving, discussed above in Section V.B and which also can be considered a form of diversity, other diversity techniques can help cope with a fading environment. *See, e.g.*, INTEL-1016 at 59-60. The general idea with diversity is to provide the receiver with options that can enhance reception. Diversity can be provided in frequency, time, space, or polarization to provide separate channels. *See, e.g.*, INTEL-1016 at 59-60.

62. It is known that space diversity is one of the more efficient diversity techniques, in particular as compared to time or frequency. Space diversity refers to multiple slightly separated antennas in space that are used to create independent paths to achieve uncorrelated channels. Use of multiple antennas is a form of space diversity, also referred to as antenna diversity. *See, e.g.*, INTEL-1016 at 59, 71; INTEL-1027 at 172-73; INTEL-1015 at 124. "[A]ntenna diversity can be used to either improve the link performance of a signal or increase data throughput." INTEL-1015 at 124. In a simple form, antennas are spaced apart from each other to minimize the effects of the uncorrelated multipath at the receiver, allowing the

receiver to pick and demodulate the signal with better SNR. INTEL-1027 at 172; *see also, e.g.*, AXW-2015 at 312 (describing interfaces with "two antennas in a diversity configuration, but the basis of diversity is that the 'best' antenna is selected" and "only a single antenna is used at any point"); INTEL-1015 at 131-33 (describing "selection diversity" as "choosing the receive antenna with the largest SNR in each symbol interval").

63. A more advanced form of diversity at the receiver is Maximal Ratio Combining (MRC), which requires multiple antennas and a receive chain processing connected to each of those antennas. *See, e.g.*, INTEL-1015 at 133-34; AXW-2027 (Ouyang). Rather than picking one received signal or another for reception, a weighted sum of the received signals can be used. *See, e.g.*, INTEL-1015 at 133-35.

64. While the above relates to improving reception, the general concept can be extended to transmission as well. A multiple input-multiple-output (MIMO) system has transmit- and receive-chains connected to each transmitting or receiving antenna. *See* AXW-2015 at 312. "Each RF chain is capable of simultaneous reception or transmission, which can dramatically improve throughput. Furthermore, simultaneous receiver processing has benefits in resolving multipath interference, and may improve the quality of the received signal far beyond simple diversity. Each RF chain and its corresponding antenna

are responsible for transmitting a *spatial stream*." AXW-2015 at 312. This is also referred to as spatial multiplexing, where "independent data streams are multiplexed in space." INTEL-1016 at 79. This approach takes advantage of the multipath in the environment to send independent data streams at the same time, increasing the throughput of the system.

65. As I have explained in this and previous sections, there are numerous ways to improve the range for two communicating devices. These include changing the modulation mode, decreasing the data rate, using a larger code rate, using antenna diversity techniques such as selection diversity, MRC, or MIMO, increasing the transmit power, improving receiver sensitivity, changing RF components, changing the transmission frequency, MIMO-based transformations like beamforming, and repeating the information. However, the Petition does not justify the choice of repetition; indeed, there is not even discussion of these options as alternatives. Wireless engineering is a series of tradeoffs, and there are a number of ways to arrive at a solution, but a POSA must consider both the advantages and disadvantages of the different approaches.

F. The Hidden Terminal Problem

66. In a wireless communication environment, it cannot be assumed that every device can communicate with or even hear transmissions of every other device in the area. This is illustrated below. Laptop 1 can communicate with

Laptop 2, but not Laptop 3. Similarly, Laptop 3 can communicate with Laptop 2, but not Laptop 1. Thus, Laptop 3 is "hidden" from Laptop 1, and similarly Laptop 1 is "hidden" from Laptop 3.

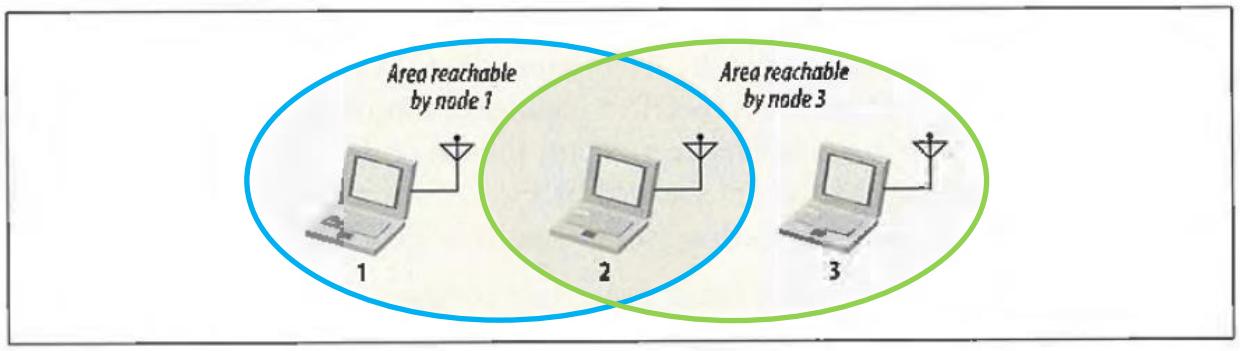


Figure 3-2. Nodes 1 and 3 are "hidden"

AXW-2015 at 35 (annotated)[1]; *see also* INTEL-1027 at 21-22. Absent mechanisms to deal with the hidden terminal problem, it can lead to collisions. For example, "[i]f a simple transmit-and-pray protocol was used, it would be easy for node 1 and node 3 to transmit simultaneously, thus rendering node 2 unable to make sense of anything. Furthermore, nodes 1 and 3 would not have any indication of the error because the collision was local to node 2." AXW-2015 at 35. Failed transmissions lead to retransmissions and backoffs, meaning decreased throughput for the system. *See* AXW-2015 at 34-44.

[1] The copy from the book does not clearly show the zones in which node 1 and node 3 can communicate, so I have annotated those zones in blue and green respectively. They overlap where node 2 is located.

67. The 802.11 standards, and specifically the MAC, exchange control frames to deal with the hidden node problem. Request to Send (RTS) and Clear to Send (CTS) exchanges before sending the actual data are used to reduce the likelihood of collisions in data transmissions due to a hidden-terminal problem. *See* AXW-2015 at 35-36; INTEL-1027 at 21-24.

G. TGn and 802.11n

68. The IEEE 802.11n task group (TGn) had a goal to achieve 100 Mbps net throughput. AXW-2015 at 311. While a number of proposals were initially made, proposals from TGn Sync and WWiSE (short for "World-Wide Spectrum Efficiency") emerged as leading candidates. *See* AXW-2015 at 311. "At a very high level, both proposals are similar, though they differ in the emphasis on increasing peak data rates versus improving efficiency. Each of them makes use of multiple-input/multiple-output (MIMO) technology in several configurations and provides for backwards compatibility with installed systems in the same frequency band. Both support operation in the current 20 MHz channels, with provisions to use double-width 40 MHz channels for extra throughput." AXW-2015 at 311. There were, of course, numerous differences between them as well. *See, e.g.*, AXW-2015 at 314-42.

69. While there were a number of TGn Sync and WWiSE proposals that evolved over time, I will focus on the TGn Sync proposal from the January 2005

timeframe and the July 2005 WWiSE proposal because they are most addressed in the Petition. *See* INTEL-1011; INTEL-1005. I note from review of the IEEE mentor website (also identified in the Lansford Declaration (INTEL-1007 ¶20)[2]), under the TGn Group, there are proposals and presentations of proposals (including revisions) both before and after the above two proposals.

70. I was able to find these files because I knew exactly what I was looking for. My experience with the IEEE mentor website is that it provides very limited searching capabilities and does not appear to search within the contents of the files posted. The search appears to only allow searching in the document control number, the title, the author, or the author's affiliation. For example, a search for "range" does not return any WWiSE proposal. Thus, when using the

[2] The Lansford Declaration purports to explain the availability of IEEE working group materials. It refers to an FTP (file transfer protocol) site where such materials may have been available. *See* INTEL-1007 ¶19. I note that FTP sites pre-date, and are not, websites like people are familiar with today. FTP sites generally allow a user to see and navigate a directory structure, as well as upload or download files, depending on permissions. They are not used like websites where information is posted in a form immediately loaded by a web browser.

IEEE mentor website, one would have to open files individually to see if it has anything relevant or useful to their search.

1. TGn Sync Proposals

71. As the January 2005 TGn Sync proposal explains, it is intended to achieve 243 Mbps rate using two antennas, with options for rates beyond 600 Mbps. *See* INTEL-1011 at 3. "The PHY techniques used to achieve the higher data rates involve a MIMO evolution of 802.11 OFDM PHY with spatial division multiplexing of spatial streams, wider bandwidth options (either 20MHz or 40MHz, but not required in regulatory domains where prohibited) and an optimized interleaver for both the 20 MHz and 40MHz channelizations. Additionally, optional enhancements include advanced FEC coding techniques (LDPC), transmit beamforming with negligible additional cost in the receiving client device and/or additional RF chains. These options provide scalability if additional robustness and/or throughput is required." INTEL-1011 at 3; *see also* INTEL-1011 at 20, 110-11. Additional improvements over legacy 802.11 are also described. *See* INTEL-1011 at 3-4, 19-20.

72. As with the legacy 802.11a/g OFDM PHY implementation, the January 2005 TGn Sync proposal uses 48 data subcarriers with 4 pilot subcarriers in the 20 MHz mode. INTEL-1011 at 111, 118-19.

73. The PPDU format for two antennas is depicted below. The red boxes indicate that when those symbols are transmitted from the second antenna, cyclical delay diversity should be applied to avoid unintentional beamforming. INTEL-1011 at 113. The L-STF, L-LTF, and L-SIG are "identical" to the legacy preamble and SIGNAL fields discussed above for 802.11a/g. INTEL-1011 at 113-14.

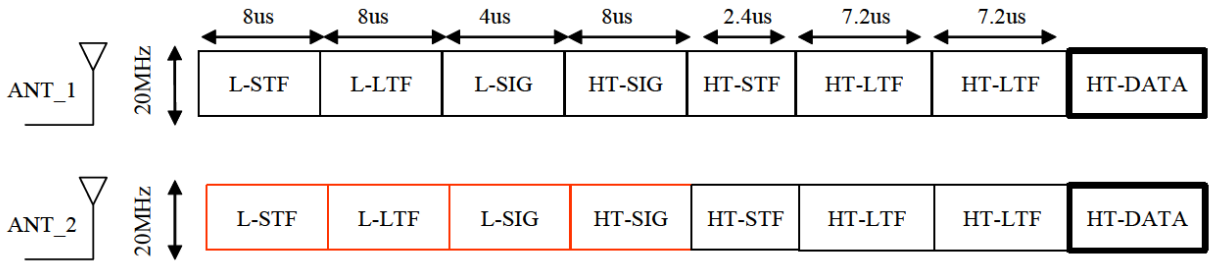


Figure 47: PPDU Format for 2x20 Mandatory Basic MIMO Transmission

INTEL-1011 at 112. "The HT-SIG contains information needed to correctly de-map and decode the HT data field (i.e. the MIMO-OFDM symbols). It also contains fields for supporting advanced techniques . . . ." INTEL-1011 at 115. The HT-STF and HT-LTF are additional training symbols for "accurate power measurement for MIMO AGC" and "channel estimation and fine frequency offset estimation." INTEL-1011 at 115.

74. The HT-SIG "consists of two OFDM symbols: HTSIG1 and HTSIG2." INTEL-1011 at 133. The bit maps for the two symbols are depicted below and described in the proposal. *See* INTEL-1011 at 133-37.

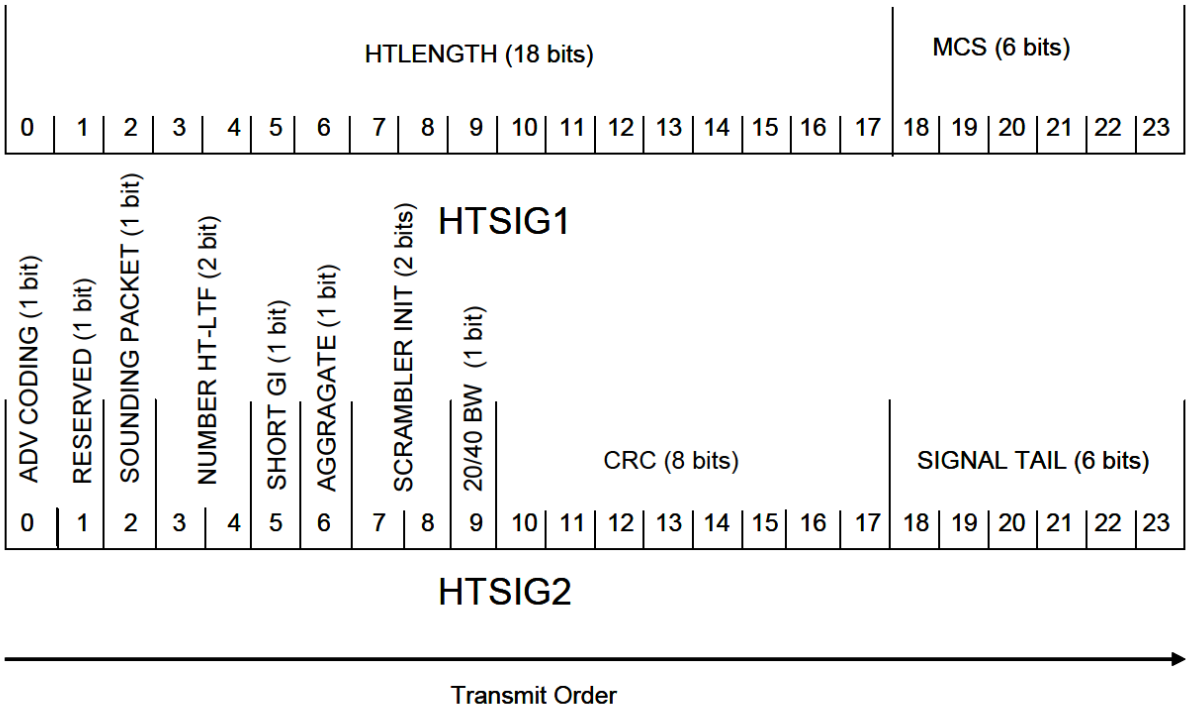


Figure 62: HT SIGNAL FIELD (HTSIG1 and HTSIG2) bit assignment

INTEL-1011 at 134. In the TGn Sync proposal, "BPSK modulation is used for the L-SIG and HT-SIG, with code rate ½ resulting in 6 Mbit/s." INTEL-1011 at 131. Thus, the 24 bits of HTSIG1 are coded into 48 bits and sent in one OFDM symbol, and the 24 bits of HTSIG2 are coded into 48 bits and sent in another OFDM symbol, both BPSK modulated.

75. The proposal notes that "a HT receiver will not a-priori know whether a legacy packet is being received or a HT packet." INTEL-1011 at 121. The proposal builds in "two mechanisms for signaling a HT transmission: (a) send the HT-SIG as a BPSK signal on the quadrature axis, instead of on the in-phase axis, and (b) invert the polarity of the pilots in the HT-SIG with respect to the pilots in

the L-SIG. These two mechanisms allow an auto-detect of a HT transmission." INTEL-1011 at 121.

76. The January 2005 TGn Sync proposal explains that, "[d]ue to the susceptibility of a wireless link to multipath fading, especially in a MIMO channel, our proposal introduces two optional techniques for improving the robustness of the link between the transmitter and the receiver, with the aim to keep the client (station) configuration low-cost and low-power[.]" INTEL-1011 at 110. The two techniques are "Transmitter beamforming" and "Advanced channel coding." INTEL-1011 at 110. "Beamforming-MIMO can achieve higher throughput than basic MIMO at same SNR, or conversely, higher range at the same data rate." INTEL-1011 at 147-48.

77. Beamforming requires channel state information. *See* INTEL-1011 at 147-48. The channel state information is gathered by the transmitter first requesting that the receiver send a "sounding packet." INTEL-1011 at 147; *see also* INTEL-1011 at 118. The channel state information is extracted from the sounding packet and used to calculate the required beamforming matrix for the transmitter. INTEL-1011 at 147-48. The transmitter data path with beamforming capability included is depicted below.

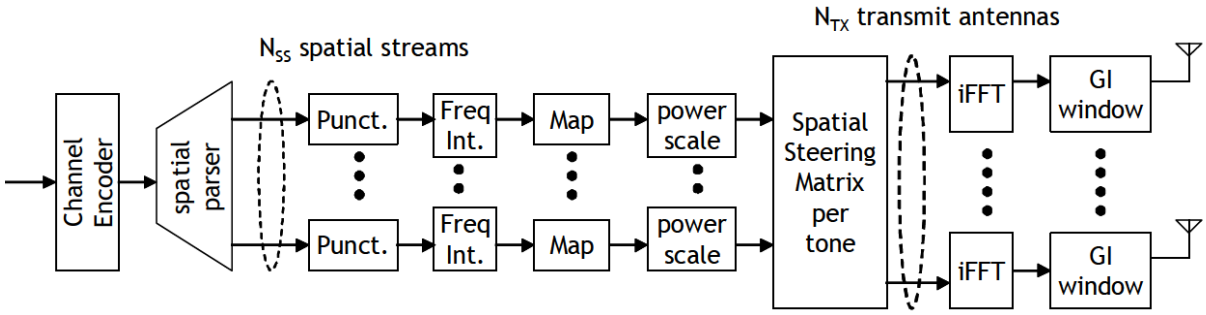


Figure 53: Transmitter Datapath with option to perform spatial shaping

INTEL-1011 at 117.

78. Another description summarizing TGn Sync beamforming is provided by Gast: "Two optional modes take advantage of information learned about the radio channel, which is referred to as 'closed-loop' operation. TgnSync devices send 'sounding' frames to each other to measure the performance of the link. Based on the information gleaned from sounding and calibration, *beamforming* can be used to boost signal quality. Higher signal quality means that a given data rate can be used at a longer range. For a given signal-to-noise ratio, a beamformed transmission can carry more data." AXW-2015 at 334.

2. WWiSE Proposals and July 2005 WWiSE (INTEL-1005)

79. The July 2005 WWiSE proposal was also based on a MIMO OFDM PHY and provided for mandatory data payload communication up to 135 Mbps, with optional support up to 540 Mbps. INTEL-1005 at 55. This was achieved with two mandatory transmit antennas, with optional support for three or four transmit antennas. *See* INTEL-1005 at 55. 20 MHz channel operation was mandatory,

while 40 MHz channel operation was optional. *See* INTEL-1005 at 55. July 2005 WWiSE provided for a PLCP frame format that could be used in a network with legacy devices, called mixed-mode, but also one that could be used when all devices implemented the new standard, called greenfield mode. *See* INTEL-1005 at 58-60. In greenfield mode, fewer preamble sequences are transmitted and there is no SIGNAL-MM field, which conveys the legacy 802.11a SIGNAL information and is not needed if all devices implement the new standard. *See* INTEL-1005 at 58-60, 71. The proposal also could use LDPC coding. *See* INTEL-1005 at 74. A number of other improvements to legacy 802.11 are described throughout. *See generally* INTEL-1005.

80. Unlike legacy 802.11a/g, the July 2005 WWiSE proposal used 54 data subcarriers with only 2 pilot subcarriers in the 20 MHz mode. INTEL-1005 at 64.

81. The greenfield PPDU format for two antennas is depicted below for two transmit antennas in 20 MHz channelization (as well as one or two transmit antennas in 40 MHz channelization).

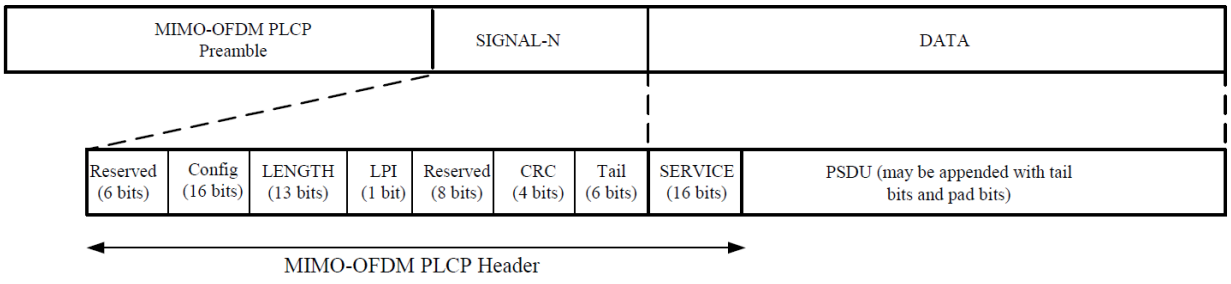


Figure 001 – PPDU frame format: Greenfield access in the 1TX (40 MHz) and 2TX (20 and 40 MHz) modes

INTEL-1005 at 58. The corresponding mixed-mode PPDU is depicted below. It adds another MIMO-OFDM PLCP preamble, followed by the SIGNAL-MM field, to the front of the greenfield PPDU.

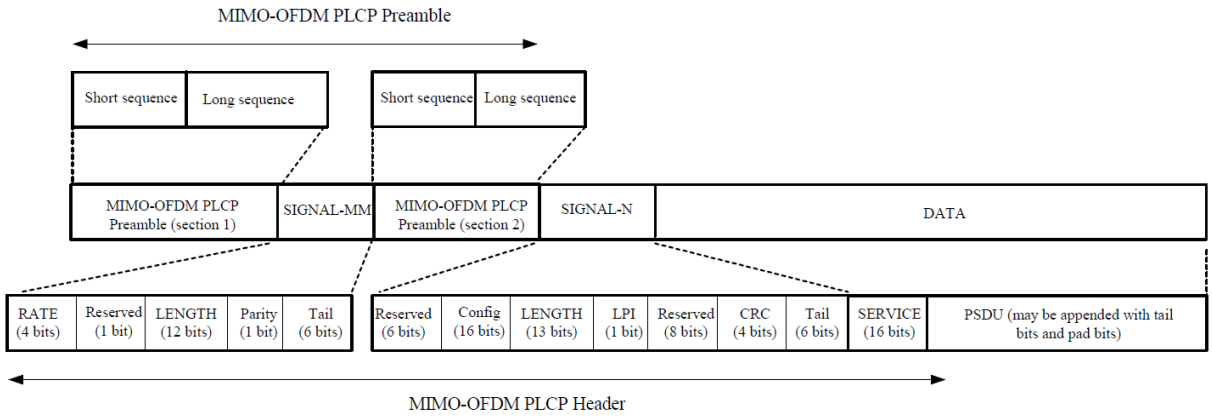


Figure 003 – PPDU frame format: Mixed-mode access in the 1TX (40 MHz) and 2TX (20 and 40 MHz) modes

INTEL-1005 at 59. The MIMO-OFDM PLCP preamble(s), SIGNAL-MM, and SIGNAL-N fields are transmitted from both antennas with a cyclical shift. *See* INTEL-1005 at 65-71. SIGNAL-MM is the same as the 802.11a/g legacy SIGNAL field, while the SIGNAL-N field specifies all configuration and length-related parameters associated with the PPDU transmission. *See* INTEL-1005 at 58. The MIMO-OFDP PLCP preamble consists of short and long training sequences for synchronization and channel estimation accuracy. *See* INTEL-1005 at 65-66.

82. The SIGNAL-N (or SIG-N) "is composed of a single MIMO-OFDM symbol." INTEL-1005 at 69. The bit map for the single symbol is depicted below and described in the proposal. *See* INTEL-1005 at 69-70.

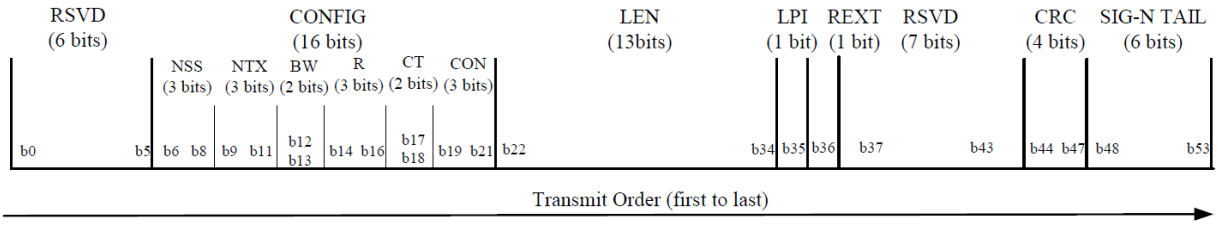


Figure 017 – SIG-N field bit assignment

INTEL-1005 at 70. In the July 2005 WWiSE proposal for the mandatory 20 MHz modes, "the encoding of the single SIG-N MIMO-OFDM symbol shall be performed with QPSK modulation of the subcarriers of the first antenna and shall use convolutional coding at R = ½." INTEL-1005 at 70. Because QPSK is used (2 bits per symbol), and there are 54 data subcarriers, even when the 54 bits are coded into 108 bits, they still can be sent in a single OFDM symbol.

83. The Petition states that "[July 2005] WWiSE also added specifications for 'Extended Range (ER) capable devices," and "[t]o support ER capability, the SIG-N field includes a REXT bit field indicating whether standard or extended range communication is being used for transmission." Pet. 12. The Petition argues that the WWiSE discussion in the Hansen reference is based on the January 2005 WWiSE proposal. Pet. 10. To the extent the Petition is saying its stated additions are the only differences between the January and July 2005 WWiSE proposals, a review of the table of contents of each shows that there are other differences. INTEL-1005 at 5-12; INTEL-1012 at 4-10. To the extent the

Petition is saying that July 2005 WWiSE is the first WWiSE proposal that discusses extended range and a REXT bit, that is incorrect.

84. Reference to an extended range mode and the REXT bit appear to be first added in the March 2005 WWiSE proposal. *See, e.g.*, AXW-2028 (March 2005 WWiSE Proposal)[3] at 52-57. Notably, the cover of July 2005 WWiSE states that it adds "ER protection." INTEL-1005 at 1. I discuss why this was needed, and a necessary part of the July 2005 WWiSE extended range mode, below.

85. In July 2005 WWiSE, "Extended Range (ER) capable devices are devices which support the optional Extended Range MCS, in addition to the Normal Range (NR) MCS, and the long SIG-N field format, as defined in section 20.3.4." INTEL-1005 at 50. The optional ER mode must be used with NTX-STBC modes and only using the BPSK rate ½ modulation mode. INTEL-1005 at 69 ("The extended communication range configuration is only used with the optional NTX-STBC modes (described in subclause 20.3.5.10) and only with rate-1/2 encoding using BPSK modulation."). Additionally, in order to allow for there to be both ER and NR capable devices, an "ER beacon" and "a new set of protection

[3] This document is on the IEEE Mentor website as DCN 05/0149r0 despite the information in the header of the file. As the file shows at least some tracked changes, it seems the authors had not yet updated the header information.

rules" must also be added to the protocol. INTEL-1005 at 50. I address the above requirements of the ER mode separately below.

86. Aside from Clause 9.15 on page 50, "ER MCS" does not appear in July 2005 WWiSE. Given the abbreviations, it is clear it means Extended Range Modulation and Coding Scheme. *See* INTEL-1005 at 15. This appears to be a reference to the modulation and coding provided on page 79 of July 2005 WWiSE, as this is the clause referenced above regarding NTX-STBC modes with which the ER mode must be used. Thus, only the 6.75 Mbps BPSK row from the table of page 79 can be used in ER mode. As explained above in Section V.B, BPSK is the most robust modulation mode of those available in 802.11 and July 2005 WWiSE. This modulation mode is used for encoding the data portion of the frame when the number of transmit antennas is greater than the number of transmitted spatial streams and is not applied to the header. *See* INTEL-1005 at 78. It uses Space-Time Block Coding, which is a technique that requires transmission of two symbols that have specific relationships between them. *See* INTEL-1005 at 78-82. The net effect is a diversity gain, which accounts for the extended range referred to in the proposal.

87. Again, aside from Clause 9.15 on page 50, the term "long SIG-N" does not appear in July 2005 WWiSE, but Clause 9.15 points to Clause 20.3.4. There, July 2005 WWiSE states that "[i]n the extended communication range

configuration (ER), SIG-N is composed of two consecutive MIMO-OFDM symbols: The SIG-N MIMO-OFDM symbol is followed by a second MIMO-OFDM symbol,denoted [sic] as ER-SIG-N." INTEL-1005 at 69. An example of the frame in the two transmit antenna, 20 MHz, greenfield mode is depicted below.

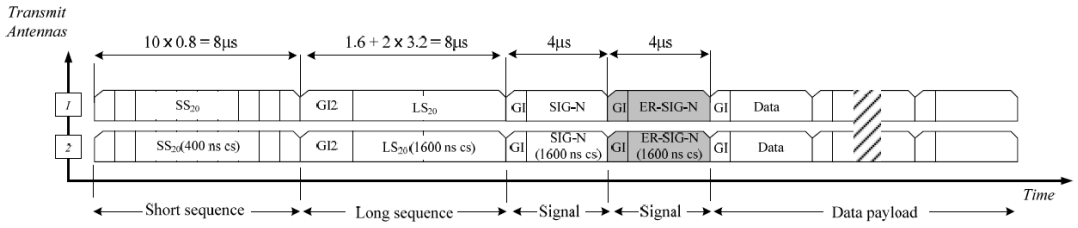


Figure 007 – MIMO-OFDM Training structure for N_{TX} = 2, 20 MHz, greenfield operation. The shaded field indicates the optional duplicate SIG-N for extended range communication.

INTEL-1005 at 67. As the figure states, "[t]he shaded field indicates the optional duplicate SIG-N for extended range communication." The entire SIG-N field is duplicated as the ER-SIG-N field, though a permutation is applied to the ER-SIG-N relative to the SIG-N. *See* INTEL-1005 at 69. Additionally, the REXT bit is set in SIG-N and ER-SIG-N. *See* INTEL-1005 at 69. In the mandatory 20 MHz mode depicted above, the ER-SIG-N would also be modulated with QPSK rate ½ code like the SIG-N field, as described above. *See* INTEL-1005 at 70. As noted above, the ER-SIG-N is not used on its own. Instead, it is only used when using the NTX-STBC BPSK rate ½ mode.

88. To enable the ER mode, July 2005 WWiSE defines "mandatory" rules for beacon generation "for ER-capable" access points. INTEL-1005 at 52. Generally, in 802.11, beacons are used to announce the existence of an 802.11

network at regular intervals and provide information about how to communicate on that particular network. *See, e.g.*, AXW-2015 at 106. In particular, "[t]he area in which Beacon frames appear defines the basic service area." AXW-2015 at 106. In July 2005 WWiSE, the ER beacon is to be transmitted "using an ER MCS," meaning that the data portion of that frame containing the beacon is sent using the NTX-STBC BPSK rate ½ mode. INTEL-1005 at 50. Because the point of the mode and the ER MCS is that it can be understood at extended range, the ER beacon can also be received at a greater distance by an ER device that can understand the NTX-STBC BPSK rate ½ mode.

89. What this means is, there are nodes in the wireless network that can send and receive ER frames that may not be able to receive NR frames. According to July 2005 WWiSE, this creates a new "hidden node problem" with its attendant problems such as costly retransmissions. INTEL-1005 at 46; *see supra* Section V.F. Thus, July 2005 WWiSE defines "protection mechanisms" that are "mandatory for NR and ER-capable" devices. INTEL-1005 at 46. The protection mechanisms involve a series of CTS and/or RTS messages to ensure NR devices know to be silent during ER transmissions and vice versa. *See* INTEL-1005 at 46-48. Similar to protection mechanisms added for 802.11g, "[t]hroughput may suffer a significant hit as a result of this exchange." AXW-2015 at 300. This is because

valuable air time needs to be spent on making sure the medium is clear to avoid collisions. *See supra* Section V.F.

90. Thus, the repeated header field is just one part of what July 2005 WWiSE defines as necessary for its extended range mode to work.

3. IEEE 802.11n

91. The completed 802.11n standard was published by the IEEE in October 2009. *See* AXW-2024 (802.11n) at Cover. While the 802.11n standard does contain aspects from the various TGn Sync and WWiSE proposals from TGn, it notably does not include something like the ER mode, along with its mandatory protection, beacon, long SIG-N, and REXT bit, as described in July 2005 WWiSE. While not identical, the 802.11n standard follows the HT-SIG1/HT-SIG2 approach from TGn Sync proposals rather than that of July 2005 WWiSE. *See* AXW-2024 at 275-77. *See, e.g.*, AXW-2024 at 275-78. It does, however, include beamforming like in the TGn Sync proposals. *See, e.g.*, AXW-2024 at 303-13.

VI. Ground 1: The Petition's Hansen and Jul 2005 WWiSE Combination

A. Overview of the Art and Asserted Combinations

1. Hansen (INTEL-1006)

92. Hansen is titled "Method and System for Compromise Greenfield Preambles for 802.11n." Hansen places the context of its disclosure into the TGn working group that I have discussed above in Section V.G, explaining that the working group was "chartered to develop a standard to enable WLAN devices to

achieve throughput rates beyond 100 Mbits/s." INTEL-1006 at [0008]-[0009]. Hansen explains that a number of proposals had emerged, including "proposals from TGn Sync, which is a multi-industry group working to define proposals for next generation wireless networks that are to be submitted for inclusion in IEEE 802.11n," as well as from WWiSE. INTEL-1006 at [0009], [0033]. I have discussed aspects of proposals from these groups above in Section V.G. Hansen states that "[c]urrent proposals from TGn Sync may not provide a mechanism to support greenfield access. As such, mixed mode access communications based on current TGn Sync may be required to comprise information that may not be required in greenfield access communications." INTEL-1006 at [0033]. I have generally described mixed mode and greenfield access in Sections V.G.1 to V.G.2 above. To briefly recap, mixed mode assumes both 802.11n devices and "legacy" 802.11 devices on the same wireless network, while greenfield mode assumes that all devices are 802.11n devices. INTEL-1006 at [0032]. Hansen's primary goal is to define greenfield modes for the TGn Sync proposals. *See, e.g.*, INTEL-1006 at Title, Abstract, [0007]-[0008], [0027], [0032]-[0033], [0087], [0096]-[0097], [0117].

93. Hansen describes its reasoning for adding greenfield mode to the TGn Sync proposals, including through examples. Hansen first explains that "[t]he utilization of greenfield access may reduce the portion of time required to transmit

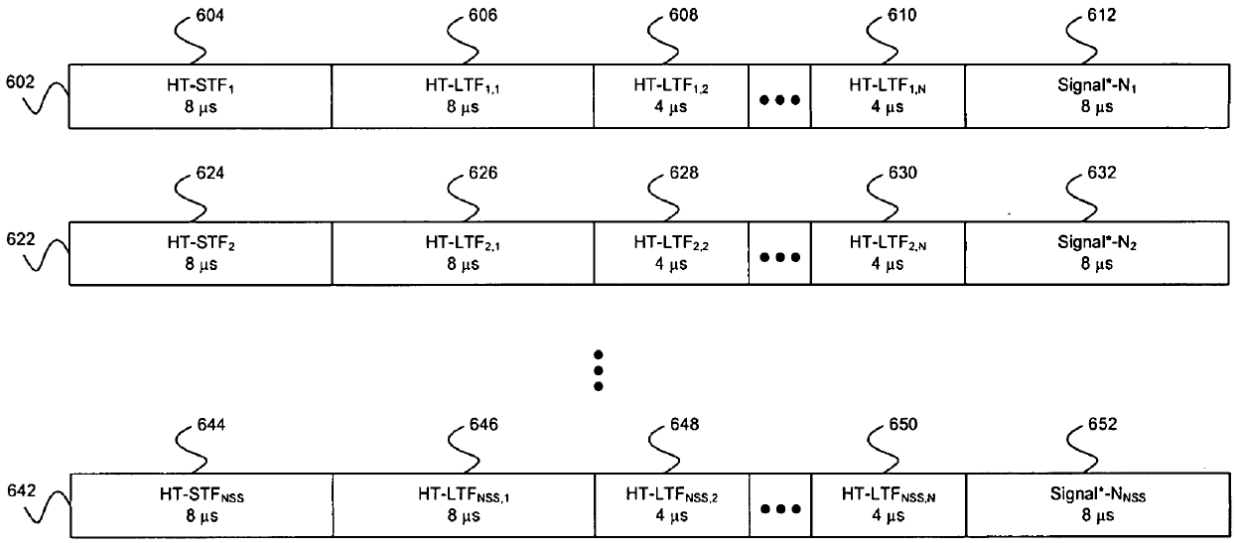
data due to overhead comprising preamble fields and header fields. This may enable higher data throughput rates to be achieved. This may further enable more robust transmission of data by enabling comparable data rates to be maintained while reducing the coding rate of encoded transmitted data. The reduction of the coding rate may enable comparable data rates to be maintained for transmission via RF channels characterized by lower SNR while still achieving desired target levels of packet error rates." INTEL-1006 at [0027]. The 100 Mbps throughput that TGn was trying to obtain was after removing protocol overhead, including preambles and headers. While necessary, these elements use air time but do not send any user data. The idea of the greenfield mode was to eliminate preambles and headers that only legacy devices required, as to reduce the overhead and improve overall throughput.

94. Hansen Figure 4a "shows exemplary training fields and header fields for mixed mode access in accordance with a TGn Sync proposal." INTEL-1006 at [0061]. Relatedly, Figure 4b "shows an exemplary L-SIG header field for mixed mode access in accordance with a TGn Sync proposal." INTEL-1006 at [0066]. The L-SIG header field is "a legacy signal field." INTEL-1006 at [0061]. And Figure 4c "shows an exemplary HT-SIG header field for mixed mode access in accordance with a TGn Sync proposal." INTEL-1006 at [0067]. Hansen uses a duration of 4 μs as the OFDM symbol time, consistent with legacy 802.11

standards and the 802.11n proposals. *See* INTEL-1006 at [0062]. Hansen explains that each of the "legacy short training field (L-STF)" is the "equivalent in time duration to 2 IEEE 802.11n OFDM symbols and corresponding guard interval times" and each of the "legacy long training field (L-LTF)" is also the "equivalent in time duration to 2 IEEE 802.11n OFDM symbols and corresponding guard intervals." INTEL-1006 at [0061]-[0062]. The L-SIG is "equivalent in time duration to 1 IEEE 802.11n OFDM symbol and corresponding guard interval," and the HT-SIG is the "equivalent in time duration to 2 IEEE 802.11n OFDM symbols and corresponding guard intervals." INTEL-1006 at [0062]. There are also high throughput short training fields and high throughput long training fields (HT-STF and HT-LTF respectively) with durations of 2.4 μs and 7.2 μs respectively. INTEL-1005 at [0062]. Thus, the legacy portion of the preamble (L-STF, L-LTF, and L-SIG) occupies 5 OFDM symbol times. *See* INTEL-1006 at [0070]. In an exemplary PPDU with 1,500 binary octets, Hansen explains that the legacy portion accounts for 21% of the air time. INTEL-1006 at [0071]. Eliminating this portion allows the effective data rate to go up because the same data can be sent in less air time. *See* INTEL-1006 at [0071]-[0072] (158 Mbps vs. 125 Mbps). Alternatively, after eliminating the legacy portion, the coding rate could be reduced, making the signal more robust, while still obtaining a data rate similar to that achieved when the legacy portion is included. *See* INTEL-1006 at [0071], [0073] (decreasing code

rate from ¾ to 2/3 but achieving 150 Mbps vs. 125 Mbps), [0074] (decreasing code rate from ¾ to ½ but achieving 120 Mbps vs. 125 Mbps), [0075].

95. Hansen's Figure 6a, relied upon in the Petition, essentially implements the above description by eliminating the legacy portion from Figure 4a. Hansen states that in Figure 6a, the "Signal*-N fields 612, 632, and 652 may be represented as shown in FIG. 4c." INTEL-1006 at [0089]. As noted above, Figure 4c "shows an exemplary HT-SIG header field for mixed mode access in accordance with a TGn Sync proposal." INTEL-1006 at [0067]. As explained above in Section V.D, preambles need to be sent before information-bearing portions of a packet in order to prepare the receiver to demodulate the signal. A POSA would have understood that that is why Hansen does not simply remove the legacy portion from Figure 4a, as that would make the HT-SIG, which carries information bits, the first part of the signal. Instead, the preamble is moved ahead of HT-SIG in Figure 6a, as depicted below, showing packets sent from different transmit antennas. Notably, as shown in Figure 6a, the Signal*-N/HT-SIG field is sent from each transmitting antenna. *See* INTEL-1006 at [0087], Fig. 6a. So long as there is a sufficient amount of training ahead of the Signal*-N field, it may be placed ahead of some training symbols, as it is done in Figure 6b. The training symbols can mimic those from the legacy 802.11 standards. *See* INTEL-1006 at [0097].



96. In this way, Hansen Figure 6a does not incorporate anything substantive from Hansen Figures 5a, 5b, and 5c. Hansen Figure 5b is not used at all because Hansen Figure 4c is used instead. And the ordering of the training symbol fields in the figure above is different from Hansen Figure 5a and Hansen Figure 5c. With respect to the PPDU format, Hansen does not try to mix and match aspects of the various TGn Sync and WWiSE proposals, aside from including a greenfield mode.

97. Hansen describes an exemplary MIMO transceiver with which its greenfield preamble may be used, depicted below. *See* INTEL-1006 at [0041], Fig. 2b. A transmit chain is generally depicted toward the top (200) and a receiver chain is generally depicted toward the bottom (201). There is also a processor (240) and a baseband processor (242). The processor is described as performing tasks at the lower layers of the network stack such as the PLCP and Physical

Medium Dependent (PMD) functions, described above in connection with the 802.11 standards discussion. *See* INTEL-1006 at [0043]. The baseband processor analyzes received data and performs MAC related functions like those mentioned above in connection with the 802.11 standards discussion. *See* INTEL-1006 at [0043].

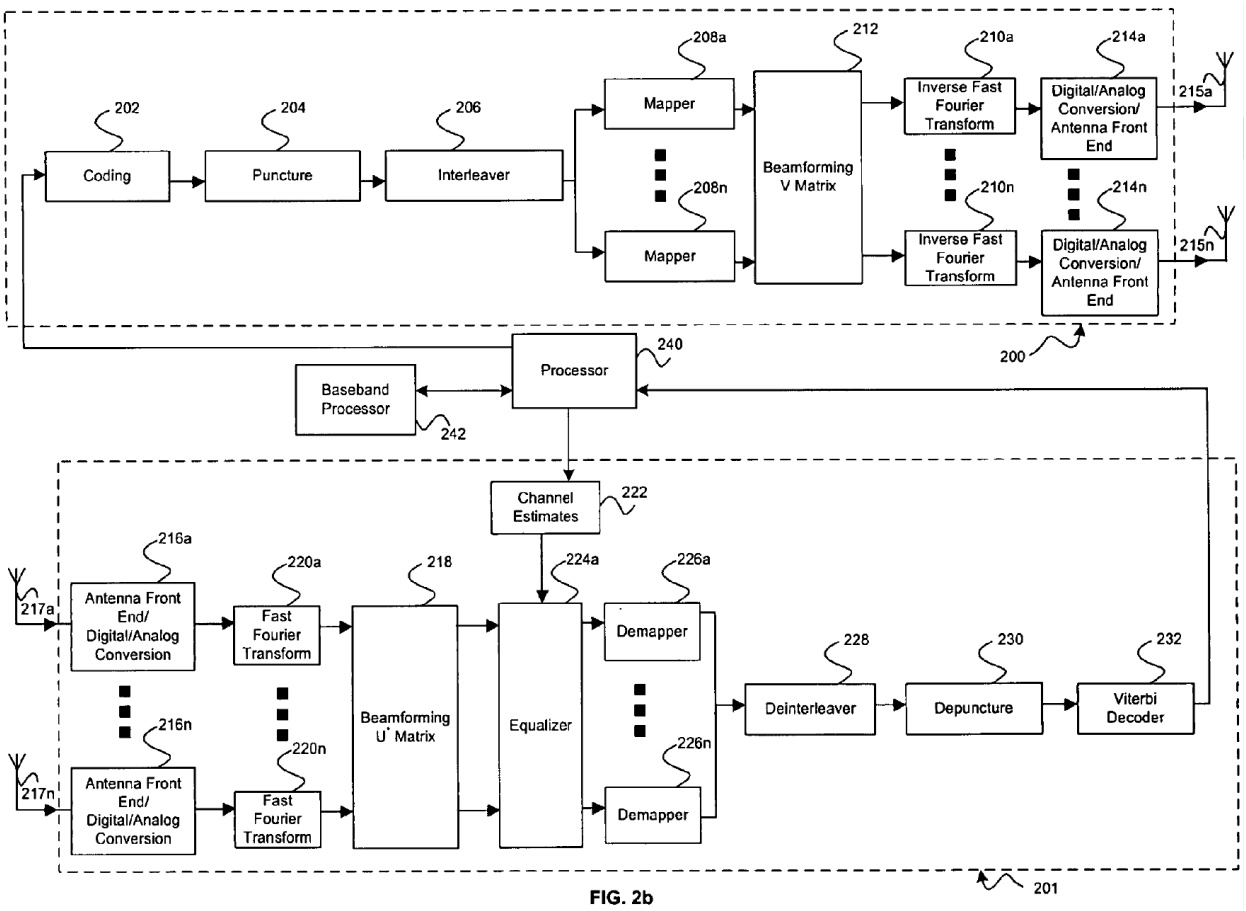


FIG. 2b

98. The transmitter includes "a coding block 202, a puncture block 204, an interleaver block 206, a plurality of mapper blocks 208a, . . . , 208n, a plurality of inverse fast Fourier transform (IFFT) blocks 210a, . . . , 210n, a beamforming V matrix block 212, and a plurality of digital to analog (D/A) conversion and antenna

front end blocks 214a, . . . , 214n." INTEL-1006 at [0041]. The coding block applies a forward error correction such as binary convolutional coding. INTEL-1006 at [0044]. As described above in Section V.B, this adds redundant bits to allow for potential recovery from errors created in the channel. The puncture block can remove some of those redundant bits by changing, for example, a rate ½ code into a rate 2/3 code. INTEL-1006 at [0045]. The interleaver rearranges bits, which combats against burst errors by spreading out consecutive bits. INTEL-1006 at [0045]. The bits from the interleaver are split to separate streams with each stream having a mapper block. INTEL-1006 at [0045]-[0046]. The mapper takes bits and creates modulation symbols (e.g., QPSK). INTEL-1006 at [0046].

99. The mapped symbols from the streams are fed to a beamforming V matrix block that generates output signals that, when emitted from the plurality of antennas, combine together to create an optimized beam pattern with directivity or gain in a particular direction (i.e., toward the receiver). I discussed beamforming above in Section V.G.1 in connection with the TGn Sync proposals. The Hansen Provisional also explains this: "Smart antenna systems combine multiple antenna elements with a signal processing capability to optimize the pattern of transmitted signal radiation and/or reception in response to the communications medium environment. The process of optimizing the pattern of radiation is sometimes referred to as 'beamforming,' which may utilize linear array mathematical

operations to increase the average signal to noise ratio (SNR) by focusing energy in desired directions." INTEL-1010 at [05].[4] As a POSA would have understood (*see* discussion of beamforming above in Section V.G.1 and in Section V.D regarding SNR and range), beamforming enhances the range of a transmitted signal.

100. The signal outputs from the beamforming block are fed to the IFFT blocks that place the mapped and beamformed symbols onto subcarriers of OFDM symbols. INTEL-1006 at [0048]. The signals are then converted from digital to analog and ultimately transmitted by the plurality of antennas. INTEL-1006 at [0049].

101. The receive chain effectively works in reverse by receiving the signals over the air at the plurality of antennas, down-converting the signals to baseband, and converting the analog signals to digital. INTEL-1006 at [0050]. FFT blocks convert the received OFDM signals to the frequency domain and the various subcarriers. INTEL-1006 at [0051]. The modulated subcarriers are demodulated to extract symbols. INTEL-1006 at [0051]. The beamforming block U* effectively removes the transform applied by the beamforming V block in the

[4] The Hansen Provisional is incorporated by reference into Hansen. INTEL-1006 at [0001], [0006].

transmitter, and then feeds the output to an equalizer that uses the channel estimate to reverse some of the channel effects. INTEL-1006 at [0052]-[0053]. Demapper blocks then convert the equalized symbols to bit streams. INTEL-1006 at [0054]. The bits streams are then combined and fed to the deinterleaver to reverse the rearranging performed by the interleaver. INTEL-1006 at [0055]. The depuncture block adds null bits to the stream prior to feeding the stream to a Viterbi decoder that can decode to the original uncoded bit stream, which is fed to the baseband processor. INTEL-1006 at [0055]-[0056].

102. As noted and described above, the exemplary transceiver is a MIMO transceiver. As described above in Section V.E, MIMO provides for a number of diversity benefits. The Hansen Provisional explains this as well. First, the Hansen Provisional describes a MIMO transmission scheme that includes beamforming, like the one described above in connection with Hansen Figure 2b: "Current transmission schemes in MIMO systems typically fall into two categories: data rate maximization, and diversity maximization. Data rate maximization focuses on increasing the aggregate data transfer rate between a transmitting mobile terminal and a receiving mobile terminal by transmitting different spatial streams from different antenna. One method for increasing the data rate from a transmitting mobile terminal would be to decompose a high bit rate data stream into a plurality of lower bit rate data streams such that the aggregate bit rates among the plurality

of lower bit rate data streams is equal to that of the high bit rate data stream. Next, each of the lower bit rate data streams may be mapped to at least one of the transmitting antennas for transmission. In addition, each signal comprising one of the lower bit rate data streams is multiplicatively scaled by a weighting factor prior to transmission. The plurality of multiplicative scale factors applied to the plurality of signals comprising the lower bit rate data streams may be utilized to form the transmitted 'beam' in the beamforming technique. An example of a data rate maximization scheme is orthogonal frequency division multiplexing (OFDM), in which each of the plurality of signals is modulated by a different frequency carrier signal prior to mapping and multiplicative scaling. OFDM transmission may be resistant to multipath fading in that a portion, but most likely not all, of the data transmitted may be lost at any instant in time due to multipath fading." INTEL-1010 at [10]. Notably, Figure 1 of the Hansen Provisional is nearly the same as Hansen Figure 2b.

103. The Hansen Provisional also explains "diversity maximization" with MIMO systems: "Diversity maximization focuses on increasing the probability that a signal transmitted by a transmitting mobile terminal will be received at a receiving mobile terminal, and on increasing SNR of received signals. In diversity maximization, multiple versions of the same signal may be transmitted by a plurality of antenna. The case in which a transmitting mobile terminal is

transmitting the same signal via all of its transmitting antenna may be the pure spatial diversity case in which the aggregate data transfer rate may be equal to that of a single antenna mobile terminal. There is a plurality of hybrid adaptations of the data rate and spatial diversity maximization schemes which achieve varying data rates and spatial diversities." INTEL-1010 at [11]. Hansen's transceiver may be classified as a hybrid one, because it is set up for data rate maximization using beamforming and potentially different spatial streams, as described above. But it also uses the "pure spatial diversity case" in, for example Figure 6a, which the same Signal*-N is transmitted on the different streams. This provides a diversity gain for the Signal*-N field, which can also be considered a range extension for that field.

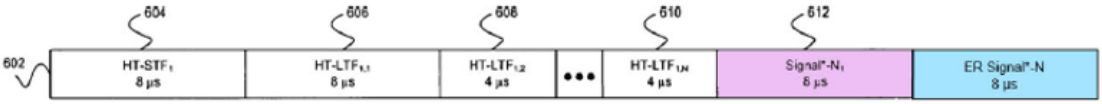
2. July 2005 WWiSE (INTEL-1005)

104. I have already described the July 2005 WWiSE reference above in Section V.G.2 and I incorporate that discussion herein.

3. The Combination of Hansen and July 2005 WWiSE

105. To guide my discussion below, I provide a brief overview of the relevant parts of the Petition's combination of Hansen and July 2005 WWiSE. I first note, however, that the Petition appears to propose two different combinations. The first appears in the "motivation to combine" section of the Petition. Pet. 13-

14. There, Intel proposes modifying Hansen's packets to repeat its Signal*-N field to add an ER Signal*-N field, reproduced below:



Hansen's "Compromise" PPDU with WWiSE's duplicate SIG-N field for ER communication

Pet. 13-14. Confirming that its proposed combination is to modify Hansen's packets, Intel states that a POSA "would have been motivated to include support fields (or subfields) necessary to support ER in Hansen's transceiver." Pet. 14; *see also* Pet. 14 (describing adding July 2005 WWiSE's REXT bit to Hansen's Signal*-N header field), 17 ("[T]he combination adds a repeated data field … to the PPDU frame … and adds a one-bit sub-field … to the header field."), 18 ("[T]he combination adds fields/sub-fields to an existing packet structure."). For the reasons discussed below, a POSA would not have been motivated to combine Hansen and July 2005 WWiSE to reach this oversimplified combination.

106. The Petition, however, in its walkthrough of the limitations of the independent claims of the '262 patent, applies a different combination, proposing to use Hansen's transceiver architecture to implement July 2005 WWiSE's mixed-mode PPDU formats. *See* Pet. 20-21. For example, claim 1 of the '262 patent

recites a "first packet," which the Petition maps onto the following July 2005 WWiSE PPDU, which includes SIG-MM, SIG-N, and ER-SIG-N fields:

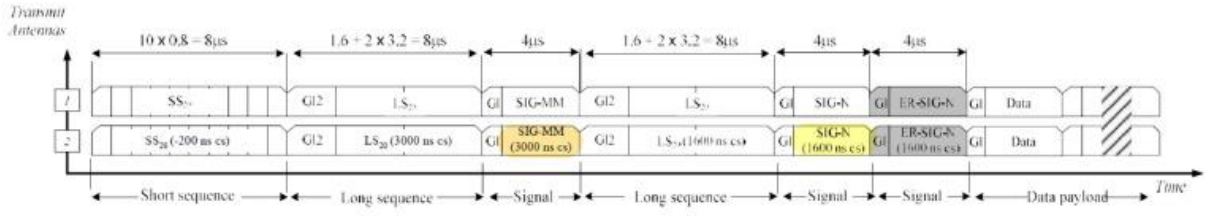


Figure 008 – MIMO-OFDM Training structure for N_{TX} = 2, 20 MHz, mixed-mode operation. The shaded field indicates the optional duplicate SIG-N for extended range communication.

Pet. 25. Claim 1 further recites a "second packet," which the Petition identifies as the July 2005 WWiSE NR mixed mode PPDU:

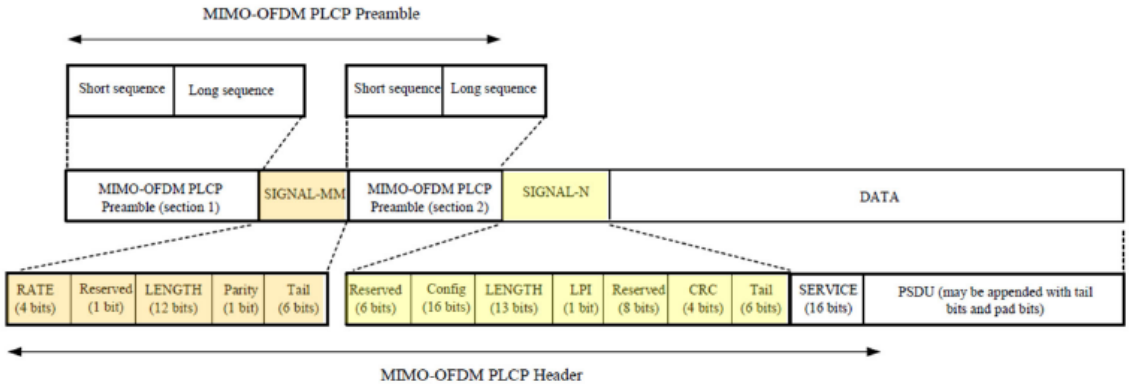


Figure 003 – PPDU frame format: Mixed-mode access in the 1TX (40 MHz) and 2TX (20 and 40 MHz) modes

Pet. 33. Only in the claim-by-claim analysis, does the Petition address this second proposed combination, arguing that "[a] POSITA would … have had a reasonable expectation of success in implementing WWiSE's PPDUs using Hansen's transceiver," because Hansen's transceiver "compromis[es] a transmitter and a receiver in a MIMO system." Pet. 21; *see also* Pet. 19. But neither the Petition,

nor Intel's Expert, provide any reasoning or basis on how Hansen's transceiver could or would be modified to receive July 2005 WWiSE's PPDU formats as shown in Figures 008 and 003. *See* INTEL-1003 ¶99. Regardless, the below explains why a POSA would not have combined Hansen and July 2005 WWiSE to reach the Petition's over-simplified combination as proposed by the Petition.

B. A POSA Would Have Not Combined Hansen and July 2005 WWiSE as Proposed in the Petition

107. The premise of the Petition's combination is that a POSA would have taken repeated header bits from July 2005 WWiSE and add them to Hansen's greenfield preamble. From my review of the materials presented, I disagree. The Petition's approach ignores numerous details about Hansen and July 2005 WWiSE, as well as fundamental engineering associated with wireless and 802.11 networks, to arrive at the proposed combination. Below, I explain a number of reasons why a POSA would have had no motivation to make the combination as proposed in the Petition.

1. Hansen and July 2005 WWiSE Have Different Range Capabilities

108. The Petition proposes adding repeated header bits to Hansen, but never explains why a POSA would have done that. Nor does the Petition consider why and how July 2005 WWiSE uses a repeated header. And the Petition also does not consider the differences in implementation between Hansen and July 2005

WWiSE. These details are critical to understanding whether a POSA would have been motivated to make the proposed combination. And, for the reasons explained below, a POSA would have not been motivated to make the proposed combination.

109. As explained above in Section VI.C describing the combination, the Petition relies on Hansen Figure 6a, with Signal*-N filled in with Hansen Figure 4c. This results in two OFDM symbols with 24 information bits each. Given that a POSA would have been extremely familiar with the legacy 802.11 standards, a POSA would have recognized this kind of arrangement as the same as used in the legacy 802.11 standards. As explained above in Section V.C, the header for 802.11a/g likewise had 24 information bits. In the legacy 802.11 standards, the header is always rate ½ coded and transmitted using BPSK modulation "to ensure reliable reception." INTEL-1015 at 35; *supra* Section V.C. Hansen's reference to the legacy 802.11 standards' use of "48 data-bearing subcarriers," INTEL-1006 at [0034], and use of 24 information bits to be translated into a single OFDM symbol would have confirmed for a POSA that Hansen's Signal*-N is coded and modulated the same. Hansen does not state otherwise.

110. Moreover, Hansen Figure 4c, which is used in Figure 6a, is the "HT-SIG header field" "in accordance with a TGn Sync proposal." INTEL-1006 at [0087]. The January 2005 TGn Sync proposal (INTEL-1011) confirms that the HT-SIG header field is transmitted consistent with the legacy 802.11 standards,

using rate 1/2 coding and BPSK modulation for the two OFDM symbols. *See supra* Section V.G.1. Consistent with Gast, a POSA would have recognized that "[t]he HT-SIG field is modulated conservatively," meaning rate 1/2 coding and BPSK modulation are used to ensure robustness. AXW-2015 at 337.[5]

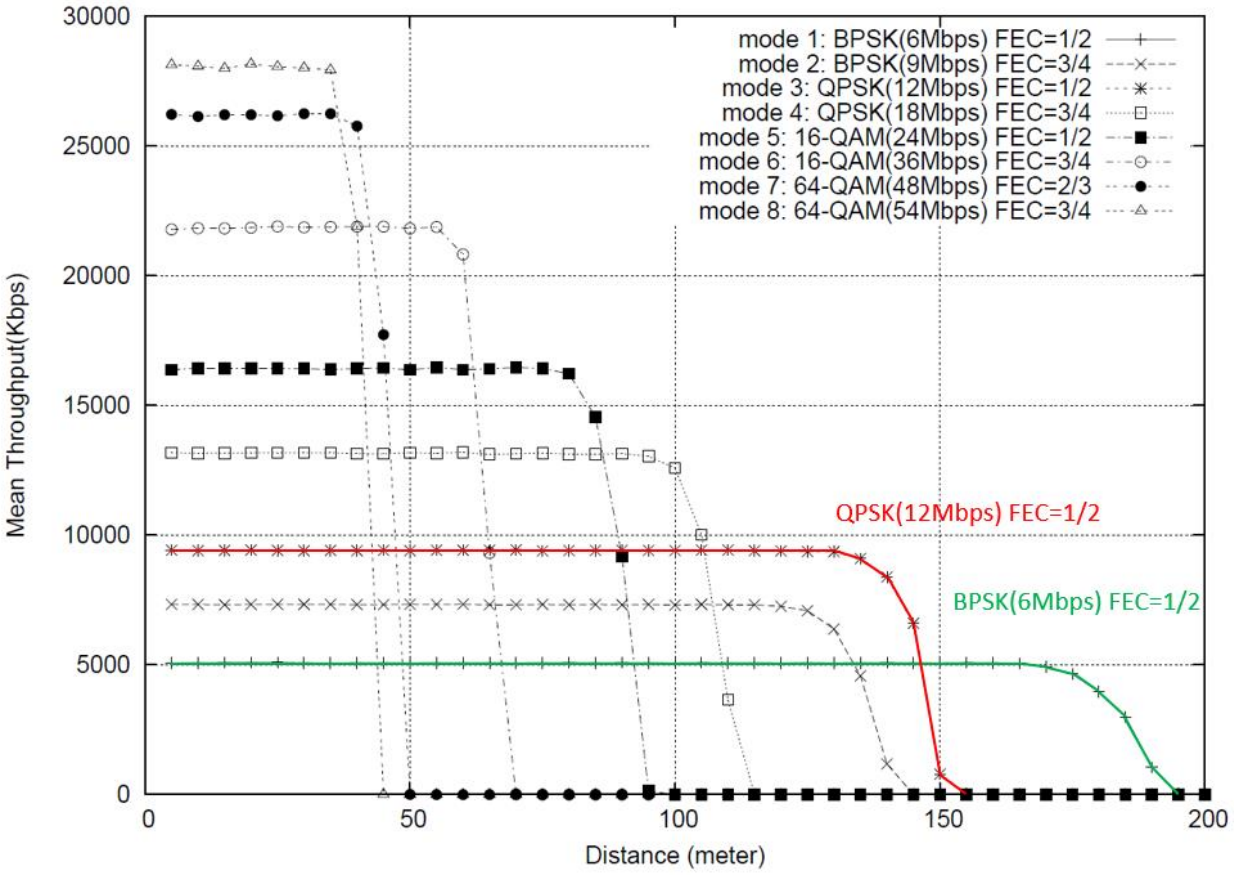
111. At the mandatory 20 MHz mode of July 2005 WWiSE, its comparable header is modulated and coded differently from Hansen and TGn Sync. Rather than using the most robust modulation used in 802.11 (i.e., BPSK), July 2005 WWiSE uses QPSK, as explained above. *See supra* Section V.G.2. July 2005 WWiSE uses a different number of data-bearing subcarriers and a different number of pilot signals than the legacy 802.11 standards or TGn Sync (INTEL-1011). Those changes, coupled with using QPSK modulation, allowed July 2005 WWiSE to put all 54 bits of its SIGNAL-N header field into one symbol using rate 1/2 code, rather than two like Hansen and TGn Sync. *See supra* Section V.G.2; AXW-2015 at 321 (explaining that the WWiSE SIGNAL-N field "is always sent using QPSK, R=1/2, and is not scrambled"). As I explained above in Sections V.B to V.D, that

[5] Gast refers here to "Q-BPSK" because TGn Sync rotates the BPSK constellation to use the Q rather than I constellation axis. *See* INTEL-1011 at 131. That rotation does not change the characteristics of BPSK that I have described in this declaration.

change in modulation mode to pack more bits into a single OFDM symbol comes at the cost of robustness, or equivalently range at which the header field can be properly received.

112. This difference in the WWiSE and TGn Sync proposals was apparently discussed during the TGn meetings. The WWiSE camp appeared to criticize TGn Sync for having "such a long HT-SIG field" and use of BPSK modulation. AXW-2016 (March 2005 TGn Sync Submission) at 35. The TGn Sync group's response was that the QPSK and rate 1/2 coding used in July 2005 WWiSE had an insufficient error performance and was not robust enough for the header field. AXW-2016 at 35.

113. As explained above in Section V.B, in an AWGN channel, there is a theoretical 3dB difference in SNR between BPSK and QPSK, though it may often be larger in practice, such as in fading channels as discussed above in Section V.D. As I explained above in Section V.D, this 3dB (or more) translates to a difference in range capabilities between BPSK and QPSK. The below chart, annotated to identify the relevant modulation modes in red (QPSK) and green (BPSK), provides a level of quantification for the range difference between the QPSK used by July 2005 WWiSE and the BPSK used by Hansen.



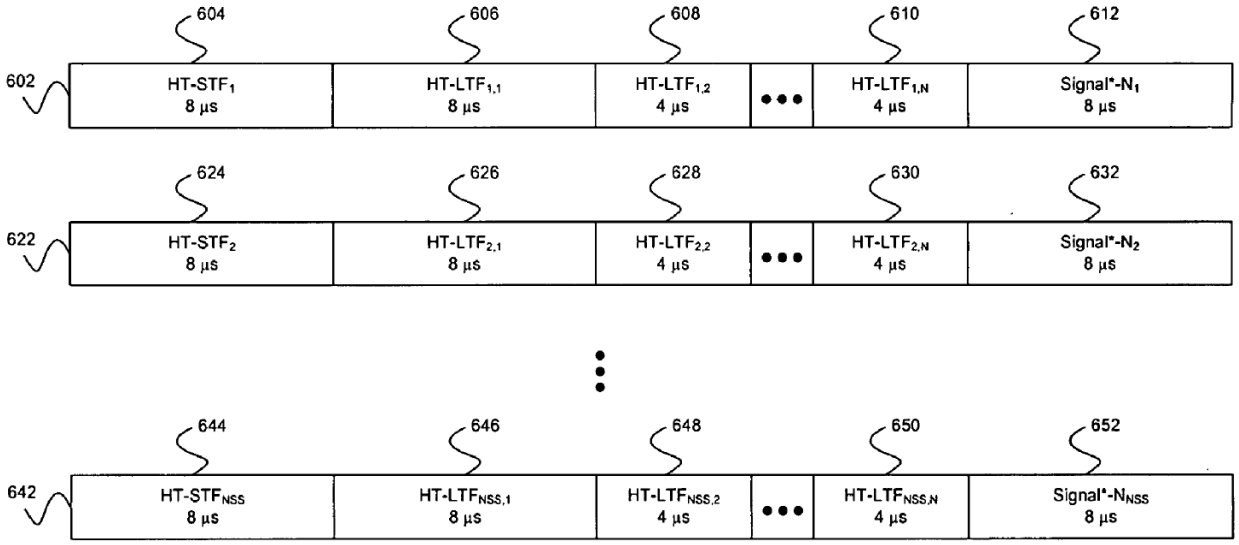
AXW-2029 (Manshaei) at 759. The chart shows mean throughput versus distance for various modulation and coding schemes in 802.11a. Consistent with expectation, it shows that BPSK provides reliable throughput at a longer range than QPSK.

114. This 3dB difference between BPSK and QPSK also explains why July 2005 WWiSE resorts to repeated header bits. Assuming perfect combining, a repeated symbol leads to a 3dB (i.e., doubling) SNR performance improvement. `In essence, the repeated QPSK header symbol in July 2005 WWiSE simply tries to put the header back on par with BPSK modulation. Thus, July 2005 WWiSE repeats the SIGNAL-N field because it chose to start from a less robust modulation

mode in QPSK. A POSA would have recognized that and understood that Hansen already uses more robust BPSK for its header field.

115. Beyond already having a more robust header than July 2005 WWiSE, Hansen's transceiver also builds in the beamforming feature. As explained above in Sections V.G.1 and VI.A, beamforming can boost the signal quality and therefore improve range. July 2005 WWiSE, however, did not include a specific way to do beamforming. While some articles regarding WWiSE proposals reference beamforming, they state only that provisions are included. *See*, *e.g.*, INTEL-1037. The proposals themselves, or at least July 2005 WWiSE, do not include a specific implementation. That Hansen already had beamforming for extending range is another reason why a POSA would have not adopted the approach of July 2005 WWiSE into Hansen.

116. Additionally, Hansen uses MIMO with Figure 6a, as depicted below, which shows transmission of the preamble and header from N antennas of Hansen's MIMO transceiver. *See* INTEL-1006 at [0087]. As explained above in Section VI.A, these repeated header fields on the different transmit chains can be combined at the receiver to improve reception of the underlying information bits of the header.



117. The lower bound in the MIMO scenario is the 3dB improvement from using two antennas. *See, e.g.*, INTEL-1016 at 72 ("doubling *L* yields a 3-dB power gain"), 77-78. More antennas would lead to further improvement and additional range performance. This is yet another reason why Hansen has already ample range extension features, and a POSA would have not simply added repeated header bits.

118. Adding repeated header bits, especially when there is no showing that they are needed or beneficial, is also contrary to the teachings and goals of Hansen itself. As explained in Section VI.A above, the purpose of the greenfield mode is to eliminate unnecessary portions of the PPDU, so as to improve overall throughput. Moreover, according to Hansen, greenfield preambles "may further enable more robust transmission of data by enabling comparable data rates to be maintained while reducing the coding rate of encoded transmitted data. The

reduction of the coding rate may enable comparable data rates to be maintained for transmission via RF channels characterized by lower SNR while still achieving desired target levels of packet error rates." INTEL-1006 at [0027]. In other words, greenfield mode would allow a reduction in code rate (meaning more robust and therefore longer range) while achieving similar or only slightly lower data rates. The addition of redundant header bits—which July 2005 WWiSE was using because its header was sent using QPSK—would be contrary to Hansen's teachings, because it would needlessly reduce the overall throughput.

2. Repeated Header Bits Alone Is An Incomplete Version of July 2005 WWiSE's Extended Range Mode

119. As explained above in Section V.G.2, repeated header bits were one of at least four different requirements in July 2005 WWiSE to make Extended Range mode functional. And as it is clear from the context of those different requirements in July 2005 WWiSE, Extended Range mode was not about robustly sending header bits. Instead, it was to have devices that could communicate useful data (rather than only the header) at extended range. While there can be reasons in certain environments or certain systems to repeat a header frame alone, in most cases, something will be done to the data/payload to ensure it can be robustly communicated as well. *See, e.g.*, INTEL-1028 at 47-51 (describing repetition in payload and header). That is the case with July 2005 WWiSE as well, which states that "[t]he extended communication range configuration is only used with the

optional NTX-STBC modes (described in subclause 20.3.5.10) and only with rate-1/2 encoding using BPSK modulation." INTEL-1005 at 69.

120. To recap, the four requirements from July 2005 WWiSE are appropriate PHY modes, a special beacon, coexistence/protection mechanisms, and robust signaling. *See supra* Section V.G.2.

121. As explained above in Section V.G.2, repeated header bits were necessary because July 2005 WWiSE chose to use QPSK modulation for its header. Thus, the robust signaling required for July 2005 WWiSE was on the order of what Hansen already provided for its header.

122. The appropriate PHY modes are the ones that July 2005 WWiSE explicitly says the Extended Range configuration is only used with: NTX-STBC modes with rate-1/2 encoding using BPSK modulation. INTEL-1005 at 69. These modes are described in clause 20.3.5.10 of July 2005 WWiSE. As noted there, these modes are Space-Time Block Coding modes that "are applicable when N_{TX}, the number of TX antennas, is greater than N_{ss}, the number of transmitted spatial streams." INTEL-1005 at 78. While various NTX-STBC modes are defined in July 2005 WWiSE, it makes clear that only the rate-1/2 BPSK mode is used with Extended Range mode. *See* INTEL-1005 at 69, 79. As described in the document, the NTX-STBC modes require specific relationships between subcarriers of OFDM symbols across two symbol times and is also dependent on the number of

antennas and number of spatial streams used. *See* INTEL-1005 at 79-82. Hansen does not mention NTX-STBC modes, nor explain or state that its transceiver is capable of using them. And the Petition never describes incorporating NTX-STBC modes into Hansen, let alone explains how a POSA would have done so, or why a POSA would have done so in light of the range enhancing features already present in Hansen, as described in Section VI.A above. Moreover, adding NTX-STBC modes would also require changing Hansen's HT-SIG to account for additional modulation modes, as the 6 MCS bits were essentially all accounted for already in TGn Sync, and HT-SIG in Hansen has nowhere to put additional bits signaling NTX-STBC configuration. *See* INTEL-1011 at 134-35, 156.

123. The special beacon is transmitted using the NTX-STBC BPSK rate 1/2 mode, meaning that it can be received at a greater distance by an ER device. *See supra* Section V.G.2. This means that ER devices can associate with an access point and join the wireless network at a longer range than NR devices. As explained above in Section V.G.2, this also means that the ER mode creates a new hidden node problem. Because of that, July 2005 WWiSE builds in protection mechanisms to ensure that NR and ER devices do not cause collisions over the air because they cannot hear the transmissions of the other mode. *See supra* Section V.G.2. As noted, during TGn, this involved significant MAC modifications. These are akin to those in 802.11g, in which throughput was decreased because of

the extra protection mechanisms required. *See supra* Section V.G.2. But this is all necessary for July 2005 WWiSE's extended range mode. But again, Hansen's goal with its greenfield preambles was to eliminate unnecessary overhead and increase overall throughput.

124. The Petition and Dr. La Porta consider none of these factors when they took the repeated header bits out of July 2005 WWiSE to purportedly combine them with Hansen. These are considerable changes to the protocol and transceiver of Hansen, and neither the Petition nor Dr. La Porta attempt to incorporate them into the combination nor explain how or why a POSA would have done so, despite July 2005 WWiSE itself, and related documentation, noting that these other aspects of the July 2005 WWiSE proposal are requirements for its Extended Range mode. Moreover, the Petition fails to demonstrate that the resulting combination has any meaningful change to its range performance. While a POSA could repeat header bits in Hansen, there is no reason to do so, and certainly not for the reasons headers are repeated in July 2005 WWiSE, as I have explained. And by ignoring the NTX-STBC modes, the Petition never demonstrates that there is any change to the range performance for the data payload portion of the proposed PPDUs. The Petition nowhere explains why a POSA would have wanted only the header bits to be received at a greater distance. Said another way, changes to the MAC packet format need to be considered in light of the PHY layer and cannot be done in a vacuum.

3. The Petition's REXT Bit Implementation Is Flawed

125. July 2005 WWiSE deals with a single OFDM symbol that contains the entire SIGNAL-N header field and repeats that symbol in its entirety. As explained above in Section V.G.2, SIGNAL-N is the July 2005 WWiSE counterpart to the HT-SIG field in Hansen and TGn Sync, which is made up of HT-SIG1 and HT-SIG2. The Petition's proposed combination includes a "REXT bit," taken from the SIG-N field of July 2005 WWiSE, which the Petition asserts is used for "indicating whether a device is operating in NR or ER configuration," and inserts it into a reserve bit in Hansen's Signal*-N header field. Pet. 14.[6] The Petition does not explain which reserve bit is being occupied by the REXT bit in its combination, or how its proposed combination would facilitate moving back and forth between NR mode and ER mode based on current channel conditions. For example, if a device starts communication in NR mode, but recognizes that

[6] As explained above in Section VI.C, the Petition does not explain how Hansen's transceiver could simply accept the PPDUs of July 2005 WWiSE without any modifications as advanced in the Petition's claim-by-claim analysis. This section, however, is directed to evaluating the Petition's proposed combination in the "motivation to combine" section of the Petition, which proposes modifications to Hansen's packet structure. *See* Pet. 13-18.

conditions have changed and NR communication is not successful, it is to switch to ER mode and set the REXT bit to so indicate. But because a transmitter wants to achieve the highest rate possible, it would also try to move from ER mode back to NR mode at some point in time. The Petition proposes no explanation as to how Hansen's receiver would know when to switch range modes.

126. Moreover, in a wireless environment with different PPDUs, like in the Petition's combination, mechanisms must exist so that the receiver knows which PPDU is being received. For example, in the TGn Sync proposal (INTEL-1011), it notes that, "[s]ince our proposal supports interoperability between HT devices and legacy OFDM devices at the PHY layer, a HT receiver will not a-priori know whether a legacy packet is being received or a HT packet. That determination can only be made after the L-SIG. Our proposal supports two mechanisms for signaling a HT transmission: (a) send the HT-SIG as a BPSK signal on the quadrature axis, instead of on the in-phase axis, and (b) invert the polarity of the pilots in the HT-SIG with respect to the pilots in the L-SIG. These two mechanisms allow an auto-detect of a HT transmission." INTEL-1011 at 121. Thus, as Hansen adopts the TGn Snyc proposal for its Figure 6a, before even considering what the bits being received are and what to do with them, Hansen's receiver would see these changes to the RF signal between the L-SIG symbol and the subsequent HT-

SIG symbol, and know that the PPDU is not a legacy PPDU, regardless of the REXT bit.

127. As such, Hansen's receiver must have a way to know which PPDU it is currently receiving so that it knows which symbols are repetitions of which, and which are to be combined together. As noted above, the only thing that could be used to identify these PPDUs in the Petition's proposed combination is the REXT bit. *See* Pet. 14, 17. But the problem with the combination is the Petition does not identify where this REXT bit is placed, for example whether it is placed in the HT-SIG1 or HT-SIG2 symbol, which could result in different outcomes. *See, e.g.*, Pet. 14 ("[A] POSA would have been motivated to use one of the reserved bits in Hansen's Signal*-N header field to extend Hansen's Signal*N-header field to incorporate WWiSE's REXT bit indicating whether a device is operating in NR or ER configurations.").

128. The consequence of whether the REXT bit is placed in the HT-SIG1 or HT-SIG2 is material as to whether a POSA would have been motivated to make the Petition's proposed combination. For example, if the REXT bit is placed in HT-SIG2, when an arbitrary PPDU of the combination arrives, the first symbol (HT-SIG1) is received, demodulated, and stored in a buffer at the receiver. At this point, the receiver has not even decoded HT-SIG1. The receiver also has no way of knowing whether the next symbol is ER-HT-SIG1 or HT-SIG2. And at this

point, the receiver still has not even seen the REXT bit. The Petition never explains how the receiver knows to combine the two symbols when the receiver conceivably could switch between NR and ER mode. Nor does the Petition say what would happen in the NR mode.

129. Thus, without further explanation, the Petition's proposal that the REXT bit could simply be added into any reserved bit of Hansen's Signal*-N is insufficient to accomplish the goals of the Petition, even if the Petition were to evaluate its modified Hansen packet format in the claim-by-claim analysis (which it does not). For example, the approach of putting the REXT bit into HT-SIG2 leads to a system that is unable to switch between NR and ER mode as needed. A POSA would have recognized these flaws and appreciated that the Petition's proposed combination in the motivation to combine section would not work.

4. In Light of the Above Issues, a POSA Would Not Be Motivated to Combine Hansen and July 2005 WWiSE

130. First, the Petition asserts that Hansen suggests combination with July 2005 WWiSE because Hansen "repeatedly suggest[s] the combination" between proposals from "WWiSE and TGN industry groups." Pet. 14-15. That is not an accurate statement. As I explained above in Section VI.A, aside from the idea of a greenfield mode, Hansen's Figure 6a, which the Petition relies on, Hansen essentially uses nothing from the WWiSE proposals and the PPDU formats shown in Hansen Figures 5a, 5b, and 5c. The Petition identifies nothing from WWiSE

proposals that Hansen incorporates, and so it is incorrect to say that Hansen "suggest[s] to bridge the gap between the WWiSE and TGn Sync industry groups." Pet. 15. There were numerous differences between the two industry groups in terms of their proposals, and adding just greenfield PPDUs could hardly be considered a compromise. *See*, *e.g.*, AXW-2015 at 314-42. The position advanced by the Petition is further undermined by that fact that by September 2005, WWiSE proposals essentially disappeared because the various groups actually did begin merging and compromising.[7] And as explained above in Section V.G.3, the 802.11n standard never incorporated the ER capability as defined in July 2005 WWiSE. The Petition ignores this and provides no reason why a POSA would have looked at July 2005 WWiSE at all when the standard had progressed much further by 2009 in a direction without repeated header bits. Of course, the industry wanted a standard to be developed. But such compromise made to get to a final standard is unrelated to repeated header bits or the ER mode from July 2005

[7] *See, e.g.*, AXW-2030 (IEEE 802.11n Report). After nearly being eliminated entirely, WWiSE and MITMO were reinstated in May 2005, but by September 2005 a "Joint Proposal group (now comprised of members from three proposal groups reinstated during the May meeting (TGn Sync, WWiSE and MITMOT)" was "developing a merged proposal." AXW-2030 at 7-8.

WWiSE. And the addition of the greenfield mode aspect to Hansen would not, on its own, have provided any motivation for a POSA to start looking to make significant changes in unrelated ways, like range, to the overall protocol.

131. Second, the Petition asserts that a POSA would have "incorporated July 2005 WWiSE's ER capability into Hansen's greenfield PPDU to introduce "diversity" and "improve robustness of communication" to counter fading and/or noise. Pet. 17 ("The addition of support for WWiSE's ER capability to Hansen's transceiver would extend the range of reliable communication between devices by providing diversity when environmental conditions (fading and/or noise) adversely affect communication."). But as explained above in Sections VII.A and VII.B, the combination does not extend the range of successful communication between devices. And the Petition does not adequately address how use of the REXT bit to signal the ER mode would work for the reasons I explained in Section VII.C. And by ignoring all the requirements of July 2005 WWiSE's ER mode and not attempting to incorporate them into Hansen, the combination, at best, extends the range of the header field, but not successful communication between devices of useful data/payload. *See supra* Section VII.B. Moreover, and fundamental to the Petition's proposed use of Hansen's transceiver with July 2005 WWiSE's PPDU formats in the claim-by-claim analysis, the Petition did not even incorporate the ER MCS into the combination, as doing so would require rearchitecting Hansen's

transceiver and header to include NTX-STBC modes. *See supra* Section VII.B. The Petition provides no rationale for why a POSA would be motivated to extend the range of only the header field.

132. And for the reasons discussed, the Petition's generic assertion that "ER capability … would extend the range of reliable communications," does not change that. Even if I assumed that the Petition offered a combination that actually extended the range for more than just the header, a POSA would have understood that wireless is a series of tradeoffs, and there are numerous approaches to improving range such as repetition, beamforming, antenna diversity, MIMO, changing code rates, changing modulation modes, changing carrier frequency, changing transmit power, changing RF hardware, etc. A POSA would have not added repeated headers to Hansen without considering other approaches, some of which Hansen already has, as already explained. Indeed, since basic repetition was known, a POSA would have expected that if the repeated header function was desirable enough, Hansen would have at minimum discussed it. That Hansen never suggests or proposes the use of repeated headers would indicate to a POSA that the repeated headers should not be used in the compromise greenfield preambles. For that reason, it is important to note that the ER mode of July 2005 WWiSE provides longer range relative to the NR mode of July 2005 WWiSE only. Absent analysis, which is not provided in the Petition or in the Petition's expert declaration, a POSA

would have not assumed that range extension as defined in July 2005 WWiSE would be beneficial if added to Hansen. For the reasons I have explained, it would not be. *See supra* Section VII.A.

133. Furthermore, as explained in Section VII.A, Hansen already has improved range compared to July 2005 WWiSE. The proposals were discussed numerous times during TGn working group meetings, including comparing beamforming, like in Hansen, with NTX-STBC in July 2005 WWiSE. *See, e.g.*, AXW-2016 at 41-42. Responding to the WWiSE group, the TGn Sync group explained that the "[a]dditional complexity of 2-symbol processing, overhead ofextra [sic] dead symbol etc." were all reasons why such modes were not included in TGn Sync proposals, which favored beamforming, which "outperforms" NTX-STBC and is "superior" to it. AXW-2016 at 41-42.

134. Third, I also note that the Petition asserts that a POSA would have combined Hansen and July 2005 WWiSE "for use in the 802.11 standard being developed." Pet. 18. Yet the addition of the REXT bit to Hansen Figure 6a and the combination's PPDUs eliminates the only reserved bit in the header field. A POSA motivated to define PPDUs for a standard would have understood that standards are typically defined in a way to allow some flexibility for future extensibility and/or customization. For example, the 802.11a SIGNAL header field contained a reserved bit, INTEL-1013 at 7; the January 2005 TGn Sync

proposal HT-SIG header field contained a reserved bit, INTEL-1011 at 133-34; the July 2005 WWiSE proposal SIGNAL-N header field contained 13 reserved bits, INTEL-1005 at 69-70; the G.9960 PHY-frame header field contained 6 reserved bits, INTEL-1028 at 32-33; and the eventual 802.11n standard HT-SIG header contained a reserved bit, AXW-2016 at 275-76. In my view, there is a benefit in maintaining one or more reserved bits for flexibility or future extension, such as in the standards cited above. While a POSA could have used the REXT bit of July 2005 with Hansen to arrive at the 802.11n standard, it is more likely that a POSA would not want to use this reserve bit, if such a use could be avoided, because it would sacrifice flexibility, especially as the proposed use of the bit is flawed.

135. Fourth, the Petition asserts "the combination is merely of prior art elements according to known methods to yield predictable results," and involves only "the combination of a repeated data field (known method) to the PPDU frame (prior art element) and adds a one-bit sub-field (or reassign existing reserve bit if available) to the header field." Pet. 17. For the reasons discussed in Sections VII.A, VII.B, and VII.C, I disagree. The statement conflates "July 2005 WWiSE's ER capability" with just repeated header bits. As I have explained, the ER capability of July 2005 WWiSE had four requirements, all of which were necessary to ensure devices operated without significant issues. *See supra* Sections VI.B and VII.B. Further, because Hansen already has range extending features and uses

BPSK modulation for its header field, July 2005 WWiSE's extended range approach and use of repeated header bits is not applicable to Hansen in the same way as it is used in July 2005 WWiSE and Hansen has no need for improvement in this way and therefore is not ready for improvement using this technique as asserted by the Petition. *See supra* Section VII.A.

136. And stating that "Hansen's transceiver is compatible with the packets of WWiSE," amounts to an argument that Hansen's PPDUs are the same as those in WWiSE and treats all headers similarly. Pet. 20. But the Hansen and July 2005 WWiSE packet are very different. They do not even have the same number of bits nor the same number of OFDM symbols. Hansen's header field has 48 information bits split over two OFDM symbols with 24 information bits each. July 2005 WWiSE has 54 information bits in a single OFDM symbol. And they were transmitted using different modulation as I have explained. The two figures below show the Hansen's PPDU header field (Fig. 4c) and the July 2005 WWiSE SIGNAL-N field (from Figure 001 on page 70 of July 2005 WWiSE).

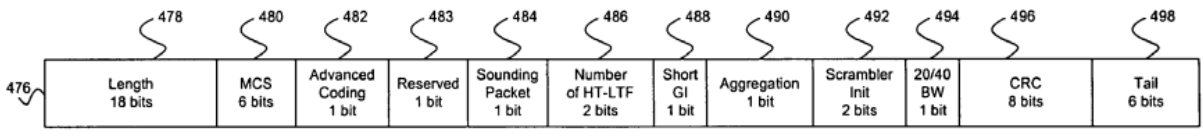
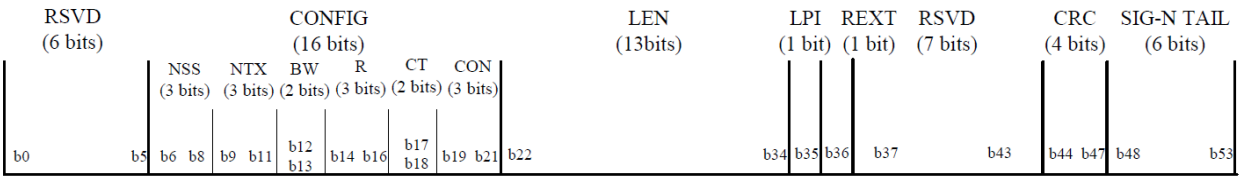


FIG. 4c

INTEL-1006 at Fig. 4c, ¶67.



July 2005 WWiSE SIGNAL-N Field (INTEL-1005 at 70 (excerpted))

137. It would have been readily apparent to a POSA that the two header fields include different bit maps that represent different information. Hansen includes a sounding packet bit, and 2 additional bits to indicate the number of training symbols used with the sounding packet (Number of HT-LTF), used *inter alia* with beamforming. *See* INTEL-1011 at 136.[8] July 2005 WWiSE does not have sounding packets or beamforming. Hansen uses 6 bits for modulation, coding rate, and number of spatial streams (MCS), while July 2005 WWiSE uses 12 bits to provide similar information (NSS, NTX, R, CON portions of CONFIG). *See* INTEL-1011 at 134-35; INTEL-1005 at 70. Hansen has 1 bit to toggle the length of the guard interval for symbols (Short GI), while July 2005 WWiSE has no such bits. INTEL-1011 at 136. While both Hansen and July 2005 WWiSE have 1 bit

[8] I refer to January 2005 TGn Sync (INTEL-1011) in this discussion because the Petition asserts this forms the basis for Hansen. *See* Pet. 14-15. Even without definition of the bit maps in Hansen, a POSA would still recognize from the names and bit assignments in Hansen Figure 4c that there are numerous differences between Hansen's header field and July 2005 WWiSE's header field.

related to aggregated PPDUs, they have different meanings. In Hansen, the Aggregation bit indicates if aggregation in the PPDU is used, which is used by the MAC to interpret the PSDU as either unaggregated or aggregated. INTEL-1011 at 136. In July 2005 WWiSE, the LPI bit indicates that the PPDU contains the last PSDU to be aggregated. INTEL-1005 at 70. Hansen includes 2 bits as an initialization value for a scrambler (Scrambler Init), while July 2005 WWiSE has no such bits. INTEL-1011 at 136. Hansen includes 1 bit for 20/40MHz selection (20/40 BW), while July 2005 WWiSE uses 2 bits for the same function (BW portion of CONFIG). INTEL-1011 at 136; INTEL-1005 at 70. Hansen has 1 bit reserved for future extensibility (Reserved), while July 2005 WWiSE has 13 such bits (RSVD listed twice). INTEL-1011 at 134; INTEL-1005 at 70. Finally, July 2005 WWiSE includes the REXT bit to indicate whether standard or extended range configuration is used, while Hansen has no such bit. INTEL-1005 at 70. The differences in the headers reflect some of the differences in the protocols. These differences point away from combination rather than suggest combination would be useful.

138. Fifth, the Petition asserts that "the combination is merely of prior art elements according to known methods," arguing that a POSA would have known how to add a repeated field and redefine a header bit. Pet. 17-18. But for the reasons that I have discussed above in this section, as well as for the reasons

discussed in Sections VII.A, VII.B, and VII.C, this statement is also incorrect. As just some examples from my analysis above, the Petition fails to account for the fact that its REXT bit implementation is flawed, and that adding a repeated header field to Hansen would not be done for the reasons set forth in the Petition. Even if one assumes that a POSA could have combined Hansen and July 2005 WWiSE as proposed in the Petition, the resulting system would have had significant technical flaws that would have made it unfit for its intended purpose and would have added unnecessary overhead that would decrease overall throughput, contrary to the teachings of Hansen. For these, and the other reasons I have explained above, a POSA would have not been motivated to combine Hansen and July 2005 WWiSE as proposed in the Petition to arrive at the challenged claims. And the Petition does not show how Hansen's transceiver could or would be modified to support the PPDUs of July 2005 WWiSE or how it would operate without any modification at all, as proposed in the claim-by-claim analysis.

VII. Ground 2: The '900PROV Does Not Disclose Claim 1 of Zhang (INTEL-1017)

139. For the purposes of these opinions, my review is limited to assessing whether a POSA would have found that claim 1 of Zhang (U.S. Patent Application Publication No. 2010/0260159 A1) (INTEL-1017) is adequately disclosed in one of its listed provisional applications, U.S. Provisional Patent Application No. 61/229,900 ("'900PROV") entitled "80 MHz OFDM for WLAN" (INTEL-1019).

I do not, for the purposes of this analysis, otherwise review the merits the Petition's proposed combination of Zhang and U.S. Patent No. 7,349,436 to Maltsev et al. (INTEL-1018), but I reserve the right to do so in any later opinions should the Board institute *inter partes* review.

140. The Petition alleges that claim 1 of Zhang is entitled to a priority date of at least July 30, 2009 based on the disclosures in the '900PROV" entitled "80 MHz OFDM for WLAN," because "claim 1 of Zhang is supported in the disclosure of the '900PROV." Pet. 48-49. For the purposes of this analysis, I thus reproduce claim 1 of Zhang in the table below:

Zhang Claim 1	
1[PRE]	A method for generating a data unit for transmission via a communication channel, the data unit conforming to a first communication protocol, the method comprising:
1[A]	generating a preamble of the data unit, wherein: the preamble includes a duration of the data unit, the first field being formatted such that the first field is decodable by a receiver device that conforms to a second communication protocol but does not conform to the first communication protocol to determine the duration of the data unit based on the first field,
1[B]	the preamble is formatted such that a portion of the preamble is decodable by a receiver device that conforms to a third communication protocol but does not conform to the first communication protocol, and
1[C]	the preamble is formatted such that a receiver device that conforms to the first communication protocol can determine that the data unit conforms to the first communication protocol; and

1[D]	generating a data portion of the data unit that conforms to the first communication protocol and does not conform to either (i) the second communication protocol or (ii) the third communication protocol.

INTEL-1017 at 13 (claim 1).

141. The '900PROV is a set of two different slide presentations of Marvell, the first entitled "Thoughts on 802.11ac Preamble," an the second entitled "80MHz OFDM for WLAN," listing five of the six named inventors in Zhang. In 2009, the 802.11ac protocol, which later went on to be referred to as Wi-Fi 5, had yet to be developed. As the '900PROV notes, it is proposing to use "OFDM with 80 MHz bandwidth to improve single-user through[p]ut in WLAN," with a hope that its proposal "will find acceptance in the next-generation WLAN." INTEL-1019 at 14.[9] Zhang, likewise, recognizes that the 802.11ac protocol did not exist at the time of its filing in April 2010, noting that "[w]ork has begun on a new standard, IEEE 802.11ac, that promises to provide even greater throughput." INTEL-1017 ¶19. Indeed, the final 802.11ac standard was not released until much later, in 2013.

[9] The Petition cites to the slide numbers in '900PROV when referring to various figures and text. However, as these numbers repeat based on the multiple slide sets shows in '900PROV, I refer to the page numbers of INTEL-1019, which correspond to the PDF page numbers.

142. The Petition relies on Figure 5 of the '900PROV as support for Zhang, which I reproduce below for reference:

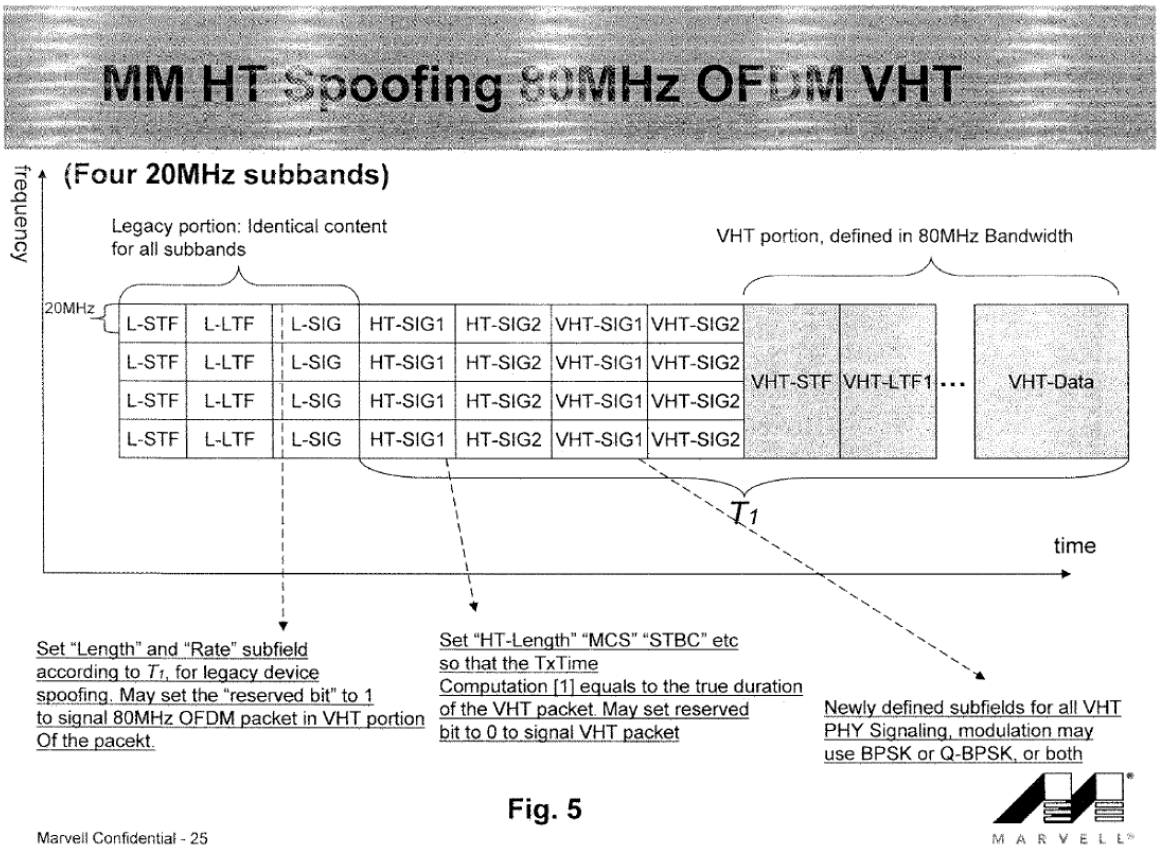


Fig. 5

INTEL-1019 at 37. Figure 5 of INTEL-1019 as shown above refers to a mixed-mode HT spoofing format that includes L-SIG, HT-SIG, and VHT-SIG fields, with "VHT-SIG" referring to a "very high throughput" packet format. *Id.* The "spoofing" feature refers to "spoofing" the "clear channel access" ("CCA") time when receiving a VHT packet. INTEL-1019 at 36.

143. The '900PROV recognizes that the VHT-SIG subfields are not defined—for example, as shown on Figure 5, there is no disclose what type of

modulation would be used for such subfields. *Id.* at 37 ("Newly defined subfields for all VHT PHY Signaling, modulation may use BPSK or Q-BPSK, or both"); *id.* at 23-24 (providing different options to potentially define VHT-SIG fields); *id.* at 40 (discussing need to newly define subfield allocation for VHT related PHY information").

A. Element 1[A]: "generating a preamble of the data unit, wherein: the preamble includes a duration of the data unit, the first field being formatted such that the first field is decodable by a receiver device that conforms to a second communication protocol but does not conform to the first communication protocol to determine the duration of the data unit based on the first field"

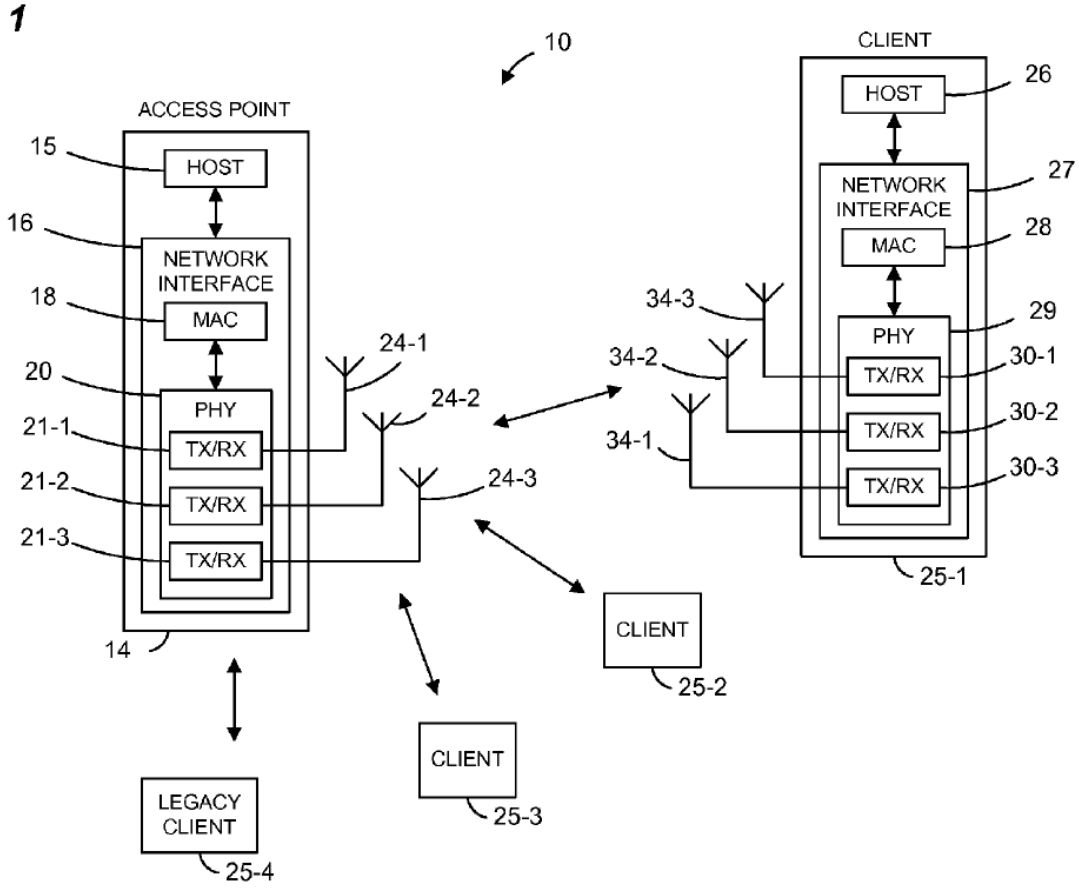
144. As noted above, the Petition's relies on Figure 5 of the '900PROV to show support for Element [1A] of Zhang. But as I explain below, a POSA would have not found that the cited portions of the '900PROV disclose the alleged invention recited in claim 1 of Zhang.

145. First, the Petition does not identify any "receiver device" in the '900PROV that "conforms to a second communication protocol but does not conform to the first communication protocol." At most the Petition and Intel's expert, Dr. La Porta, simply state as a general matter that "a legacy receiver that conforms to 802.11a … will not support subsequent version of 802.11 that came later in time … without additional software or hardware development." Pet. 53-54; INTEL-1003 ¶ 155. But neither the Petition nor Dr. La Porta cite to anything in the '900PROV that actually provides for this disclosure.

146. Second, the Petition maps the "second communication protocol" to the 802.11a standard, but there is no such disclosure that maps each claimed "communication protocol" to a specific standard in the '900PROV in the manner recited in Element [1A] of Zhang.

147. Figure 1 of Zhang, reproduced below, and its associated description is instructive, and demonstrates that Petition's mapping of the "second communication protocol" to the 802.11a standard is unsupported.

FIG. 1



INTEL-1017, Fig. 1; INTEL-1017 ¶33 ("FIG. 1 is a block diagram of an example wireless local area network (WLAN) 10, according to an embodiment."). According to Zhang, in Figure 1, "the PHY unit 20 includes a plurality of transceivers 21 and the transceivers are coupled to a plurality of antennas 24." INTEL-1017 ¶64. Zhang explains that in the Figure 1 embodiment:

> [T]he MAC unit 18 and the PHY unit 20 are configured to operate according to a ***first communication protocol (e.g., the IEEE 802.11ac Standard, now in the process of being standardized)***. In another embodiment MAC unit 18 and the PHY unit 20 are also configured to operate according to a ***second communication protocol (e.g., the IEEE 802.11n Standard)***. In yet another embodiment, the MAC unit 18 and the PHY unit 20 are additionally configured to operate according to the second communication protocol and ***a third communication protocol (e.g., the IEEE 802.11a Standard)***.

INTEL-1017 ¶64 (emphasis added). Neither the Petition, nor Dr. La Porta, provide any reasoning for swapping the second and third communication protocols in Zhang to read on Figure 5 of the '900PROV, or provide any reason why a POSA would have understood that the '900PROV provides for the claim mapping proposed in the Petition.

148. Element 1[A] further recites "generating a preamble of the data unit, wherein the preamble includes a first field having information that indicates a

duration of the data unit," whereby once the "first field" is decoded, "the duration of the data unit" is determined. The Petition proposes that in Figure 5, the decoding of the L-SIG field would then indicate the "duration 'T' of the VHT data unit." Pet. 53. But Figure 5 contains no such disclosure. Rather, as shown in Figure 5, the L-SIG field contains length information regarded as "T_1" rather than "T," which does not correspond to the duration of the VHT data unit. Rather, Figure 5 shows that the "true duration" of the VHT data unit is computed based on a T_xTime equation that is set in the HT-SIG field (highlighted in green):

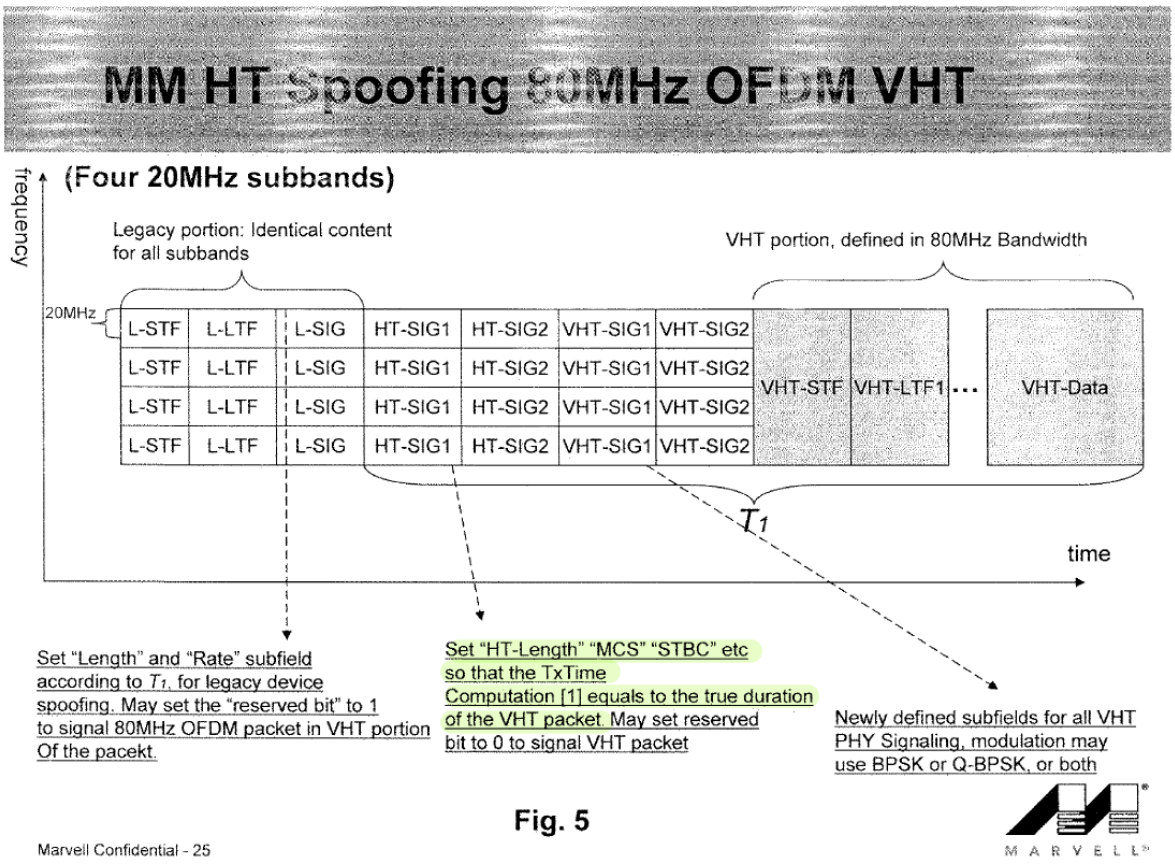


Fig. 5

INTEL-1019 at 37; *id.* at 40 ("'HT-LENGTH', 'MCS', 'STBC' subfields in HT-SIG fields should be set such that the TXTIME computation for a 11n receiver equals to the true packet duration of the VHT packet."). Indeed, the '900PROV provides that the T_xTIME must be encoded in HT-SIG2, "so according to its state machine … it will hold CCA until the end of TXTIME." *Id.* at 40. In other words, the '900PROV stresses that the true duration of the VHT packet must be encoded not in the first L-SIG field, but in the HT-SIG fields. INTEL-1019 at 37, 40.

149. The Petition and Dr. La Porta instead attempt to map the true duration of the packet "T" to the first field L-SIG, by relying on different embodiments in the '900PROV that shows a mixed-mode embodiment in Figures 1 and 2 of the '900PROV and described on slide 10 (page 22) of the '900PROV. Pet. 53 (citing to slide 10 of the '900PROV). But as discussed below, those embodiments are different than the HT-Spoofing embodiment shown in Figure 5, and do not include a third communication protocol as required by Elements 1[A] and 1[B] of Zhang:

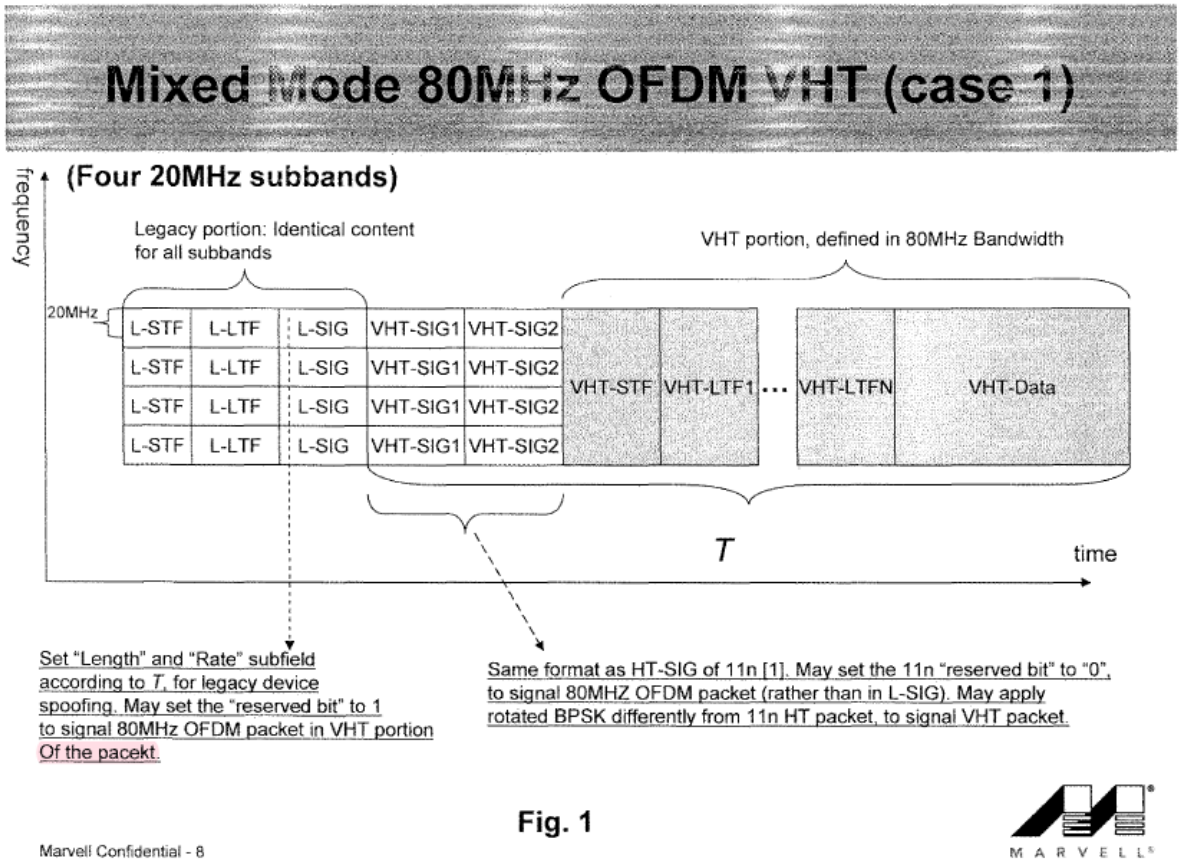


Fig. 1

INTEL-1019 at 20 (Fig. 1).

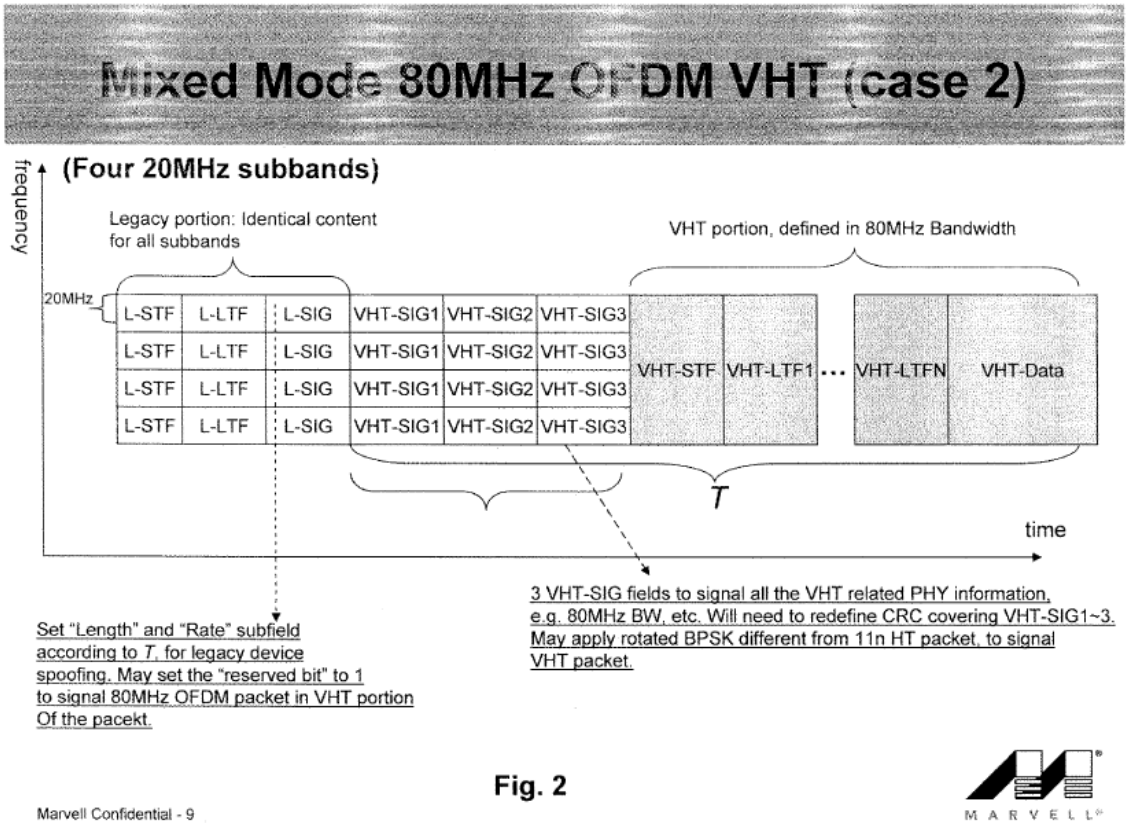


Fig. 2

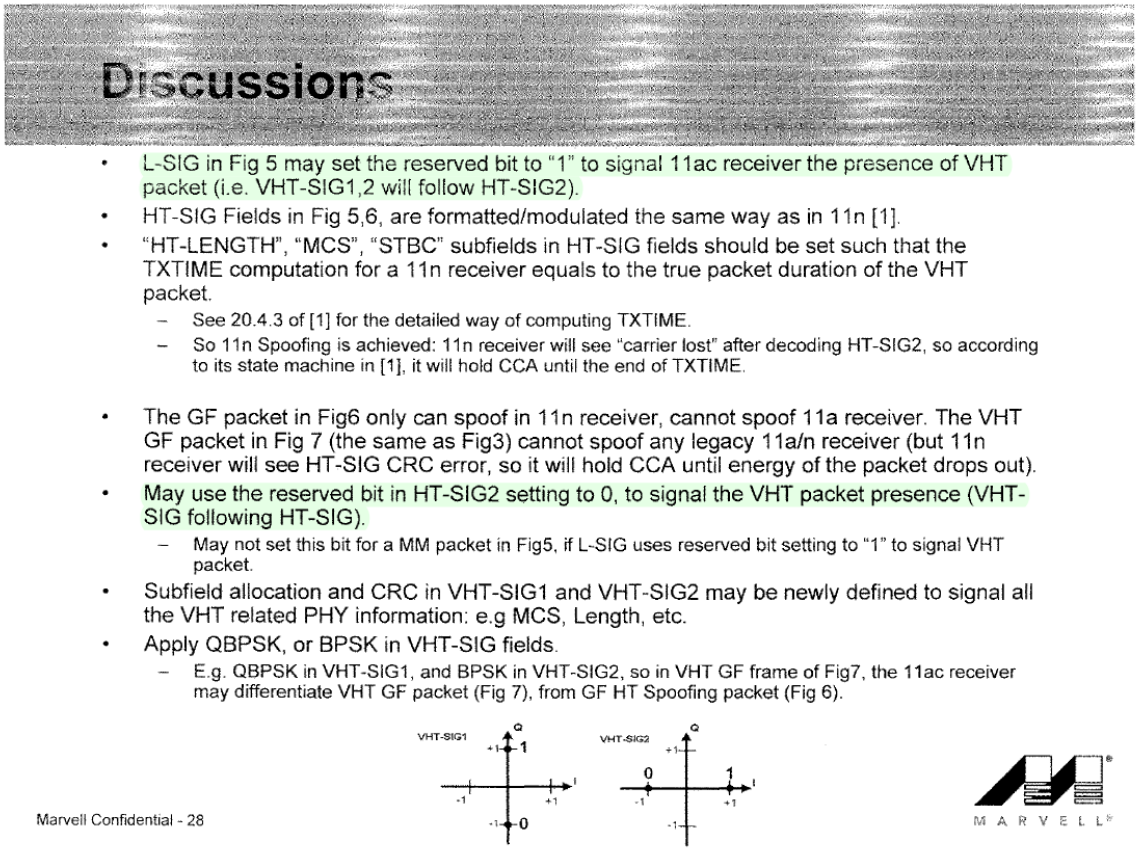
INTEL-1019 at 21 (Fig. 2). The Petition and Dr. La Porta mix and match from these different embodiments in the '900PROV in an attempt to find support for claim 1 of Zhang. But there is no such disclosure in the '900PROV whereby decoding of the first field (L-SIG) indicates the duration T (the duration of the data packet) ***and*** a disclosure that includes three different communication protocols as recited in claim 1 of Zhang.

B. Element 1[B]: "the preamble is formatted such that a portion of the preamble is decodable by a receiver device that conforms to a third communication protocol but does not conform to the first communication protocol"

150. The Petition proposes mapping the "third communication protocol" onto the IEEE 802.11n Standard. For the same reason as discussed above with respect to Figure 1 of Zhang, the Petition does not explain why it adopts this mapping or why it swapped the second and third communication protocols assigned to Figure 1 of Zhang, with those proposed in the Petition. *See* INTEL-1017 ¶64 (mapping the "second communication protocol" to the IEEE 802.11n Standard, and the "third communication protocol" to the IEEE 802.11a Standard).

C. Element 1[C]: "the preamble is formatted such that a receiver device that conforms to the first communication protocol can determine that the data unit conforms to the first communication protocol"

151. Instead of relying on the embodiment in Figure 5, the Petition and Dr. La Porta, instead point to different embodiments in the '900PROV to read on Element 1[C]. In particular, the Petition refers to the mixed-mode embodiment shown in Figures 1 and 2 of the '900PROV (which as discussed above, contain no third communication protocol as recited in claim 1 of Zhang), to point to disclosures indicating that an 802.11ac receiver device is formatted to "determine that the data unit conforms to the first communication protocol." Pet. 56. But again, that is not how the operation of the mixed-mode HT spoofing embodiment of Figure 5 operates. There, the '900PROV discloses that the preamble is formatted such that the reserved bit in the L-SIG or HT-SIG fields is used to determine that the data unit conforms to the first communication protocol:



INTEL-1019 at 40.

152. Moreover, as the Petition recognizes, the 802.11ac protocol did not yet exist, but was merely "forthcoming" as of the time of the '900PROV (and Zhang) in 2009. Accordingly, the Petition does not and cannot show that the VHT data unit that it describes would or could conform to the final, adopted 802.11ac standard.

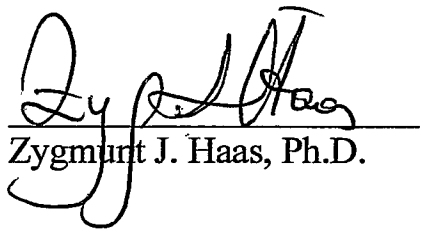
D. Element 1[D]: "generating a data portion of the data unit that conforms to the first communication protocol and does not conform to either (i) the second communication protocol or (ii) the third communication protocol"

153. For the same reasons that I opined on above with respect to Elements 1[A]-1[C], the Petition does not properly map or propose the same three communication protocols in the manner and order claimed in claim 1 of Zhang.

VIII. CONCLUSION

All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. Further, I am aware that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001. I declare under penalty of perjury that the foregoing is true and correct.

Executed on Nov. 16, 2023 (date), in Richardson, TX (city, state).



Zygmunt J. Haas, Ph.D.