

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO. LTD.,
Petitioner,

v.

WILUS INSTITUTE OF STANDARDS AND TECHNOLOGY INC,
Patent Owner.

Case IPR2025-00934
Patent 11,159,210

DECLARATION OF TODOR V. COOKLEV, PH.D.

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I. INTRODUCTION

1. My name is Todor V. Cooklev. I have been retained as an expert witness to provide my independent opinion in regard to the matters at issue in *inter partes* review of U.S. Patent No. 11,159,210 (“the ’210 patent”) in IPR2025-00934. I have been retained by Wilus Institute of Standards and Technology, Inc., the Patent Owner in the above proceedings. Petitioner is Samsung Electronics Co. Ltd. (“Petitioner”).

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

II. QUALIFICATIONS

3. I am currently professor of electrical and computer engineering at Purdue University in Fort Wayne, Indiana. I teach several courses related to the hardware and software architectures of wireless systems and wireless devices. My research interests include most aspects of modern wireless systems, including hardware/software architectures.

4. I have received research funding from the National Science Foundation (NSF), the Defense Advanced Research Projects Agency (DARPA), the U.S. Air Force Research Laboratory, the Office of Naval Research, and a number of private companies, including major technology companies.

5. I received a Doctor of Philosophy (Ph.D.) degree in Electrical Engineering from Tokyo Institute of Technology in Tokyo, Japan in 1995.

6. I have authored and co-authored more than 100 peer-reviewed articles. I am also a named inventor on 32 U.S. patents, most of which relate to the hardware or software aspects of communication systems. For part of this work in 2019, I was inducted into the Purdue Inventors Hall of Fame. A list of my publications and patents appears in my *curriculum vitae* attached as Appendix 1. Among my publications is the textbook “Modern Communications Systems: A First Course”, published by the University of Michigan at the beginning of 2024.

7. I have also experience in private industry. My work has been in the areas of communication protocols, software, digital signal processing, and integrated circuit design for communication systems.

8. I have contributed to the development of several major standards for communication systems and numerous amendments. I have participated in many meetings of standards committees. I have prepared, submitted, and presented documents relating to technical matters considered by these committees.

9. Between 2000-2002 and 2005-2008 I was a Voting Member of the IEEE 802.11 Working Group. Around 2005-2007 I was Chair or a Study Group within IEEE 802.11. For part of my work, I received an award from IEEE

Standards Association in 2012. I have reviewed and voted on most IEEE 802.11 standards and amendments published since 2000.

10. During this period, I have also reviewed and voted on other standards on wireless networking or on the implementation of wireless devices. Around 2007-2011 I participated in the Software-Defined Radio Forum (later the Wireless Innovation Forum). Around 2011-2012 I participated in the work of the 3GPP.

11. In 2020, I was elected to serve on the Board of Governors of the IEEE Standards Association as a Member-at-Large. The Board of Governors provides overall leadership of the IEEE Standards Association.

12. Between 2017 and 2025 I was Series Editor for Wireless and Radio Communications of the IEEE Communications Standards Magazine (which is the premier journal in the field of communication standards). As a member of the Editorial Board, I coordinated the review of scholarly manuscripts submitted to the wireless and radio communications series.

13. I am qualified by education and experience to testify as an expert with respect to subject matter in the fields of wireless communications, wireless communications protocols, hardware and software architectures for wireless devices, signal processing algorithms, and related areas.

14. I have attached a current copy of my curriculum *vitae* as Appendix 1, which includes a list of my publications. My CV also includes a list of cases

during at least the last five years in which I have testified as an expert either at a trial or deposition.

III. COMPENSATION

15. I am compensated at my standard hourly rate of \$700 for my time spent working in connection with this case. My compensation does not depend on my opinions or on the outcome of this litigation. If called as a witness, I would testify as to the statements and opinions contained in this report.

IV. MATERIALS CONSIDERED

16. In the course of conducting my analysis and forming my opinions, I have reviewed materials including those listed below:

- i. U.S. Patent No. 11,1592,210 (Ex. 1001) (“the ’210 patent”);
- ii. The prosecution history of the ’210 patent (Ex. 1002);
- iii. The Declaration signed by Dr. Christopher J. Hansen in IPR2025-00934 (Ex. 1003) (the “Hansen Declaration”);
- iv. 802.11ax Draft Specifications D1.0, D0.5, D0.4, D0.3, D0.2, and D0.1 (Exs. 1004–1009)
- v. Baradjwaj (Ex. 1013)
- vi. Sun (Ex. 1015)
- vii. The exhibits and other documents cited herein.

V. APPLICABLE LEGAL STANDARDS

A. Level Of Ordinary Skill In The Art

17. My opinions in this declaration are based on the understandings of a person of ordinary skill in the art, which I understand is sometimes referred to as an “ordinary artisan” or by the acronyms “POSITA” or “PHOSITA,” as of the time of the invention, which I understand is here assumed to be the priority date (which I understand to be January 9, 2017). I understand that the person of ordinary skill in the art is a hypothetical person who is presumed to have known the relevant art at the time of the invention. By “relevant,” I mean relevant to the challenged claims of the '210 patent.

18. I understand that factual indicators of the level of ordinary skill in the art include the various prior art approaches employed, the types of problems encountered in the art, the rapidity with which innovations are made, the sophistication of the technology involved, and the educational background of those actively working in the field. I understand that, in assessing the level of skill of a person of ordinary skill in the art, one should consider the type of problems encountered in the art, the prior solutions to those problems found in the prior art references, the rapidity with which innovations are made, the sophistication of the technology, the level of education of active workers in the field, and my own experience working with those of skill in the art at the time of the invention.

19. In this case, Dr. Hansen has asserted in his declaration that a person of ordinary skill in the art as of the time of the '210 patent would have had:

a Bachelor's degree in electrical engineering, computer engineering, computer science, or a related field, and at least 3 years of experience in the research, design or development of wireless communication devices, systems, and/or networks, or the equivalent, as of the Critical Date. Increased educational experience can make up for less work experience, and vice versa. Ex. 1003 [Hansen-Decl.] ¶ 29.

20. For the purposes of this declaration, I accept Dr. Hansen's proposed qualifications of a POSITA (setting aside the question of *when* that experience must have been achieved, which I take no position on).

21. Although my qualifications exceed those of a POSITA (and exceeded this level since before the priority date of the '210 patent), my analysis and opinions are from the perspective of a POSITA, as set forth above.

22. My opinions as stated in this declaration would remain valid even if the Board adopts a slightly different level of ordinary skill in the art.

B. My Understanding Of Legal Standards

23. When considering the '210 patent and stating my opinions, I rely on the following legal standards as described to me by the attorneys for Wilus Institute of Standards and Technology, Inc.

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

25. I understand that an obviousness analysis involves comparing a claim to the prior art to determine whether the claimed invention would have been obvious to a person of ordinary skill in the art at the time of the invention in view of the prior art and in light of the general knowledge in the art as a whole. I also understand that obviousness is ultimately a legal conclusion based on underlying facts of four general types, all of which must be considered: (1) the scope and content of the prior art; (2) the level of ordinary skill in the art; (3) the differences between the claimed invention and the prior art; and (4) any objective indicia of non-obviousness, including any praise of the invention.

26. I also understand that obviousness may be established under certain circumstances by combining or modifying the teachings of the prior art. Specific teachings, suggestions, or motivations to combine any first prior art reference with a second prior art reference can be explicit or implicit, but must have existed before the date of purported invention. I understand that prior art references themselves may be one source of a specific teaching or suggestion to combine features of the prior art, but that such suggestions or motivations to combine art

may come from the knowledge that a person of ordinary skill in the art would have had.

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

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

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

30. I understand that claims are to be construed from the perspective of a POSITA, and should be given their plain meaning to a POSITA in light of the intrinsic record absent lexicography (e.g., a clear definition) or disclaimer (e.g., a clear narrowing of claim scope in the specification or prosecution history).

31. I am not offering any legal opinions in this declaration, nor am I qualified to do so. I only consider such legal standards in framing my opinions and

conclusions as well as placing assertions made by Petitioner in the Petition into the proper context. Additionally, from a subject matter perspective, I understand that the petitioner always has the burden of persuasion regarding a challenge of patentability of an invention under an inter partes review.

VI. OVERVIEW OF THE '210 PATENT

32. The '210 Patent was filed on December 31, 2019, and issued on October 26, 2021. It is a continuation of U.S. Patent No. 10,567,047 filed on July 8, 2019 which is a continuation of PCT Application No. PCT/KR2018/000443, filed on January 9, 2018. Ex. 1001 at pgs. 1-2. The PCT Application further claims priority to Korean Application Nos. 10-2017-0003147 on January 29, 2017, and 10-2017-08927 on January 18, 2018. Ex. 1001 at 1:9-18. The '210 patent lists Juhyung Son, Jinsam Kwak, Geonjung Ko, Woojin Ahn as inventors. Wilus Institute of Standards and Technology Inc. ("Wilus") is the sole assignee of record.

33. The '210 patent describes that there is a continued need "for providing a high-efficiency and high-performance wireless LAN communication technology in a high-density environment" and recognizes that "in a next generation wireless LAN environment, communication having high frequency efficiency needs to be provided indoors/outdoors under the presence of high-density stations and access points (AP)." Ex. 1001, at 2:35-44. The techniques provided in the '210 patent can

advantageously increase the total resource utilization rate, and improve the performance of the wireless LAN system. Ex. 1001, 4:15-23.

34. A High Efficiency Multi-User PHY Protocol Data Unit (HE MU PPDU) is used for OFDMA (Orthogonal Frequency Division Multiple Access) and/or MU-MIMO transmission methods to enable an Access Point (AP) to send data to multiple stations (STAs) simultaneously. MU-MIMO achieves multi-user access by transmitting different spatial streams to different users, while OFDMA divides the available bandwidth into smaller Resource Units (RUs) allocated to different users. The preamble of an HE MU PPDU contains the HE-SIG-A (High Efficiency Signal A) and HE-SIG-B (High Efficiency Signal B) fields. The '210 patent discloses techniques for configuring and using a combination of subfields in HE-SIG-A and HE-SIG-B to enable correct decoding of resources for full-bandwidth (BW) MU-MIMO transmissions without OFDMA. This approach prevents misinterpretation of the HE-SIG-B field and ensures proper decoding and resource allocation for both the MU-MIMO or single-user (non-MU-MIMO) transmissions.

35. An important recognition of the '210 patent was that the SIGB Compression field of the HE-SIG-A could be used to indicate full-bandwidth MU-MIMO transmission even when the relevant PPDU is only targeted to a single user, “to reduce the signaling overhead of the HE-SIG-B of the uplink transmission.”

Ex. 1001, 19:1–24. This understanding is contrary to how skilled artisans at the time interpreted the most recent draft of the 802.11ax standard, such that a single user “cannot” be indicated when SIG-B Compression field is set to 1. *See* Ex. 1035 at page 484, CID 9770; Ex. 1021 at 3 (restating CID 9970).

Representative Claim 1 of the '210 patent recites the following:

[1pre] A wireless communication terminal, the terminal comprising:

[1.1] a communication unit; and

[1.2] a processor configured to process signals transmitted and received through the communication unit, wherein the processor is configured to:

[1.3] receive, through the communication unit, a high efficiency multi-user PHY protocol data unit (HE MU PPDU), wherein a preamble of the HE MU PPDU includes high efficiency signal A field (HE-SIG-A) and high efficiency signal B field (HE-SIG-B), and

[1.4] decode the received HE MU PPDU based on information obtained from the preamble,

[1.5] wherein when a SIG-B compression field of the HE-SIG-A indicates full bandwidth multi User-Multiple Input Multiple Output(MU-MIMO) transmission, a format of user field(s) included in a user specific field of the HE-SIG-B is identified based on a number of MU-MIMO users indicated by a subfield of the HE-SIG-A,

[1.6] wherein when the number of MU-MIMO users indicates two or more users, the user specific field of the HE-SIG-B includes user fields for MU-MIMO allocation, and

[1.7] wherein when the number of MU-MIMO users indicates a single user, the user specific field of the HE-SIG-B includes one user field for non-MU-MIMO allocation.

36. Independent Claim 6 (reproduced below) also recites similar elements as Claim 1.

[6pre] A wireless communication method of a wireless communication terminal, the method comprising:

[6.1] receiving a high efficiency multi-user PHY protocol data unit (HE MU PPDU), wherein a preamble of the HE MU PPDU includes high efficiency signal A field (HE-SIG-A) and high efficiency signal B field (HE-SIG-B); and

[6.2] decode the received HE MU PPDU based on information obtained from the preamble,

[6.3] wherein when a SIG-B compression field of the HE-SIG-A indicates full bandwidth multi User-Multiple Input Multiple Output (MUMIMO) transmission, a format of user field(s) included in a user specific field of the HE-SIG-B is identified based on a number of MU-MIMO users indicated by a subfield of the HE-SIG-A,

[6.4] wherein when the number of MU-MIMO users indicates two or more users, the user specific field of the HE-SIG-B includes user fields for MU-MIMO allocation, and

[6.5] wherein when the number of MU-MIMO users indicates a single user, the user specific field of the HE-SIG-B includes one user field for non-MU-MIMO allocation.

37. As shown above, limitations 6.3 and 6.5 are substantively identical to limitations 1.5 and 1.7.

VII. CLAIM CONSTRUCTION

38. As noted above, I understand that claim terms are to be given their plain and ordinary meaning in light of the intrinsic record absent a clear definition (lexicography) or disavowal of claim scope in the intrinsic record. I have applied this understanding to the claim language but specifically emphasize a particular claim requirement that is relevant to my analysis herein.

39. Specifically, as explained below, in order for the processor to be configured according to the claim requirements, it must be configured to receive a HE MU PPDU such that “the number of MU-MIMO users indicates a single user” *and* “a SIG-B compression field of the HE-SIG-A indicates full bandwidth MU-MIMO transmission” simultaneously.

40. Claim 1 recites a “processor” that “is configured to... receive a [HE MU PPDU], wherein a preamble of the HE MU PPDU includes [HE-SIG-A] and [HE-SIG-B] field... [1.5] wherein when a SIG-B compression field of the HE-SIG-A indicates full bandwidth [MU-MIMO] transmission, a format of user field(s) included in a user specific field of the HE-SIG-B is identified based on a

number of MU-MIMO users indicated by a subfield of the HE-SIG-A,... [1.7]
wherein the number of MU-MIMO users indicates a single user, the user specific
field of the HE-SIG-B includes one user field for non-MU-MIMO allocation.

41. As shown above, limitation [1.7] recites that “*when the number of MU-MIMO users indicates a single user*, the user specific field of the HE-SIG-B includes one user field for non-MU-MIMO allocation.” A POSITA would understand that “the number of MU-MIMO users” derives antecedent basis from limitation [1.5]’s recitation of “a number of MU-MIMO users indicated by a subfield of the HE-SIG-A.” And limitation [1.5] specifies that this number of users is indicated “*when* a SIG-B compression field of the HE-SIG-A indicates full bandwidth [MU-MIMO] transmission.”

42. Accordingly, “the number of MU-MIMO users” that “indicates a single user” (in limitation [1.7] must be the *same* “number of MU-MIMO users indicated by a subfield of the HE-SIG-A” that is identified “*when a SIG-B compression field of the HE-SIG-A indicates full bandwidth [MU-MIMO] transmission*” (in limitation [1.5]). In other words, the “number of MU-MIMO users” must be indicated by a subfield of the HE-SIG-A simultaneously with (“when”) a SIG-B compression field of the HE-SIG-A indicates full bandwidth MU-MIMO transmission.

43. As noted above, both claims 1 and 6 have a similar structure. My analysis is therefore likewise applicable to claim 6, such that in order to practice limitation [1.7], in the decoding process, the number of MU-MIMO users must indicate a single user (as recited in limitation [6.5]) *simultaneously with* the SIG-B compression field of the HE-SIG-A indicating full bandwidth MU-MIMO transmission (as recited in limitation [6.3]).

44. As explained in further detail below, although Dr. Hansen's theories provide examples of ways in the prior art may indicate a single user, he fails to show that this would ever occur such that the *claimed* "number of MU-MIMO users" (i.e., the same "number of MU-MIMO users" that is indicated by a subfield of the HE-SIG-A "*when* a SIG-B compression field of the HE-SIG-A indicates full bandwidth [MU-MIMO] transmission") would "indicate[]" a single user" as the claims require. Instead, as explained in more detail below, it is my opinion that a POSITA would have understood that in the context of the prior art relied upon, when a SIG-B compression field of the HE-SIG-A indicates full bandwidth MU-MIMO transmission, the "[n]umber of MU-MIMO users *cannot* be 1," such that the hexadecimal value of 0x0 that would correspond to the number of users being set to 1 should be "reserved." See Ex. 2021 at 3; Ex. 1035 at page 484, CID 9770.

VIII. OPINIONS REGARDING DR. HANSEN'S INVALIDITY THEORIES

A. Ground 1A (802.11ax_D1.0)

45. 802.11ax_D1.0 (or “D1.0,” for short) is a draft specification of the 802.11ax standard. Dr. Hansen contends that D1.0 was publicly accessible as of December 1, 2016. Exhibit 1003 at ¶ 65. I offer no opinion on the public accessibility of D1.0 as of that date, and for purposes of this declaration only I assume for the sake of argument that D1.0 was in fact publicly accessible

46. Dr. Hansen relies on B22 of the HE-SIG-A field of a PPDU as being the claimed “SIG-B compression field of the HE-SIG-A” as recited in limitation [6.3] (and the similar limitation [1.5]. Ex. 1003, ¶107; *id.*, ¶144 (Dr. Hansen’s analysis for [1.5] merely incorporating the [6.3] analysis by reference). This field is shown in Table 28-17 of D1.0, reproduced below.

Table 28-17—HE-SIG-A field of an HE MU PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
HE-SIG-A1	B0	UL/DL	1	<p>Indicates whether the PPDU is sent UL or DL: Set to 0 for DL Set to 1 for UL</p> <p>This field indicates DL for TDLS, mesh and IBSS.</p> <p>NOTE—The TDLS peer can identify the TDLS frame by To DS and From DS fields in the MAC header of the MPDU.</p>
	B1-B3	SIGB MCS	3	<p>Indicates the MCS of the HE-SIG-B field: Set to 0 for MCS 0 Set to 1 for MCS 1 Set to 2 for MCS 2 Set to 3 for MCS 3 Set to 4 for MCS 4 Set to 5 for MCS 5 The values 6 and 7 are reserved</p>
	B4	SIGB DCM	1	<p>Set to 1 indicates that the HE-SIG-B is modulated with dual sub-carrier modulation for the MCS. Set to 0 indicates that the HE-SIB-B is not modulated with dual sub-carrier modulation for the MCS. DCM is only applicable to MCS0, MCS1, MCS3, and MCS4.</p>
	B5-B10	BSS Color	6	<p>The BSS Color field is an identifier of the BSS</p>
	B11-B14	Spatial Reuse	4	<p>Set to SR Disallowed to disallow SRP-based spatial reuse (see 27.9 (Spatial reuse operation) and 27.11.6 (SPATIAL_REUSE)).</p> <p>NOTE—This part needs further development.</p> <p>Set to SR_Restricted to restrict the spatial reuse transmission (see 27.9.2.1 (General) and 27.11a (TXVECTOR parameters SPATIAL_REUSE for an HE PPDU)).</p>

Table 28-17—HE-SIG-A field of an HE MU PPDU (continued)

B15-B17	Bandwidth	3	Set to 0 for full 20 MHz Set to 1 for full 40 MHz Set to 2 for full 80 MHz Set to 3 for full 160 MHz and 80+80 MHz Set to 4 for preamble puncturing in 80 MHz, where in the preamble only the secondary 20 MHz is punctured Set to 5 for preamble puncturing in 80 MHz, where in the preamble only one of the two 20 MHz sub-channels in secondary 40 MHz is punctured Set to 6 for preamble puncturing in 160 MHz or 80+80 MHz, where in the primary 80 MHz of the preamble only the secondary 20 MHz is punctured Set to 7 for preamble puncturing in 160 MHz or 80+80 MHz, where in the primary 80 MHz of the preamble the primary 40 MHz is present.
B18-B21	Number Of HE-SIG-B Symbols Or MU-MIMO Users	4	If the SIGB Compression field is 0, indicates the number of OFDM symbols in the HE-SIG-B field minus 1. If the SIGB Compression field is 1, indicates the number of MU-MIMO users minus 1.
B22	SIGB Compression	1	Set to 1 for full BW MU-MIMO. Set to 0 otherwise.
B23-B24	GI+LTF Size	2	Indicates the GI duration and HE-LTF size: Set to 0 to indicate a 4x HE-LTF and 0.8 μs GI Set to 1 to indicate a 2x HE-LTF and 0.8 μs GI Set to 2 to indicate a 2x HE-LTF and 1.6 μs GI Set to 3 to indicate a 4x HE-LTF and 3.2 μs GI
B25	Doppler	1	Set to 0 if Doppler mode is not used Set to 1 if Doppler mode is used

47. Ex. 1004, 302–303. Dr. Hansen additionally relies on bits 18–21 of the HE-SIG-A field as indicating “a number of MU-MIMO users” as claimed. *See* Ex. 1003, ¶107 (noting that “the number of STAs in the MU-MIMO group is indicated in the SIGB Number of Symbols/Number of MU-MIMO Users field in the HE-SIG-A field”). As explained below, I disagree that D1.0 discloses or renders obvious that this “number of MU-MIMO users” could “indicate[] a single user” simultaneously with “a SIG-B compression field of the HE-SIG-A indicat[ing] full

bandwidth [MU-MIMO] transmission,” as the claim would require under Dr. Hansen’s claim mapping.

1. D1.0 does not disclose that the number of users would indicate a single user while the SIG-B compression field is set to 1.

48. Dr. Hansen’s theory is that “the number of user block fields... varies depending on the number of indicated users” in the HE-SIG-A field, such that “only a single (i.e., one) user block would be provided for the case where a single user is indicated for non-MU-MIMO allocation.” *Id.*, ¶119. Dr. Hansen further opines that this “one user block field would have included a single (i.e., one) user field” in this alleged scenario of “transmissions to single users.” *Id.* ¶120.

49. Dr. Hansen’s theory is based on the premise that “the number of users indicated in the SIG-A field” *would* be set to a single user (value 0x0) in the context of D1.0. I disagree with Dr. Hansen in this regard for several reasons.

50. For example, in the context of “an MU-MIMO allocation” (i.e., an allocation where the “SIG-B compression field” is set to 1 to indicate full bandwidth MU-MIMO transmission), D1.0 teaches that the “Spatial Configuration subfield encoding” of Table 28-24 applies. *See* Ex. 1004 at 322 (internal page 296). And Table 28-24 makes clear that the number of users (i.e., “ N_{user} ”) in this context is a number ranging from a minimum of “2” to a maximum of “8.” *Id.* at 323–324 (internal pages 297–298).

Table 28-24—Spatial Configuration subfield encoding

N_{user}	B3...B0	Nsts [1]	Nsts [2]	Nsts [3]	Nsts [4]	Nsts [5]	Nsts [6]	Nsts [7]	Nsts [8]	Total Nsts	Number of entries
2	0000-0011	1-4	1							2-5	10
	0100-0110	2-4	2							4-6	
	0111-1000	3-4	3							6-7	
	1001	4	4							8	
3	0000-0011	1-4	1	1						3-6	13
	0100-0110	2-4	2	1						5-7	
	0111-1000	3-4	3	1						7-8	
	1001-1011	2-4	2	2						6-8	
	1100	3	3	2						8	
4	0000-0011	1-4	1	1	1					4-7	11
	0100-0110	2-4	2	1	1					6-8	
	0111	3	3	1	1					8	
	1000-1001	2-3	2	2	1					7-8	
	1010	2	2	2	2					8	

Table 28-24—Spatial Configuration subfield encoding (continued)

5	0000-0011	1-4	1	1	1	1				5-8	6
	0100-0101	2-3	2	1	1	1				7-8	
6	0000-0010	1-3	1	1	1	1	1			6-8	4
	0011	2	2	1	1	1	1			8	
7	0000-0001	1-2	1	1	1	1	1	1		7-8	2
8	0000	1	1	1	1	1	1	1	1	8	1

51. Furthermore, Dr. Hansen identifies no statement in D1.0 (and I am aware of no such statement) that a full-bandwidth *multi-user* MIMO allocation could ever be directed to only a *single* user. Thus, in light of these teachings of D1.0 discussed above, a POSITA reviewing D1.0 would understand that when B22 (i.e., the SIG-B compression field) of the HE-SIG-A is set to 1 (thus indicating multi-user MIMO transmission), the number of users indicated by B18-21 (i.e., the field specifying the “number of MU-MIMO users minus 1”) cannot have a value of 0x0 and thus cannot indicate that the number of MU-MIMO users is 1.

52. I reached this opinion based on my own review of the D1.0 reference, but my opinion that a POSITA would have interpreted D1.0 in this way is confirmed by contemporaneous evidence of what individuals having at least the skill level of a POSITA would have understood D1.0 to disclose.

53. For instance, a January 9, 2017 comment on D1.0 by Youhan Kim¹ noted that in light of D1.0’s teachings, the “[n]umber of MU-MIMO users *cannot be* 1 (value 0x0).” Ex. 1035 at page 484, CID 9770. Mr. Kim drew this conclusion based on the D1.0 draft that did not explicitly teach that the number of MU-MIMO users *could* be 1, “because the Spatial Config subfield in HE-SIG-B has *Nuser*

¹ Youhan Kim, according to his LinkedIn Profile, has a Ph.D. in Electronic and Electrical Engineering, and has been working on relevant wireless networking technology since September 2006, and worked at Qualcomm and predecessor companies since 2009. Ex. 2022.

>=2.” *Id.* Mr. Kim thus believed that the logical conclusion from the teachings of D1.0 was that the value 0x0 (i.e., setting the number of MU-MIMO users to be 1) simply could not be used, and thus should be “reserved” when MU-MIMO transmission was indicated. Accordingly, there is contemporaneous evidence that a skilled artisan, when reviewing D1.0, would have understood that the “[n]umber of MU-MIMO users *cannot* be 1” such that the input corresponding to that invalid number of users should never be placed into the “Number of ... MU-MIMO Users field of HE-SIG-A.”

54. This was not some fringe or unreasonable opinion but was rather confirmed by another highly skilled individual, John (Ju-Hyung) Son, the lead inventor of the 210 patent.² Specifically, in response to that comment, Dr. Son “[a]gree[d] in principle with the comment,” but recognized a potential “use case for setting the value [0x0] for the “Number of Users Symbols or MU-MIMO Users field of HE-SIG-A in HE MU PPDU is the” specific use case of “UL HE MU

² John Son received a Ph.D. in Electronics from Seoul National University in 2007, and has been working in standardization and development for networking technology since 2008. *See* Ex. 2023. Although John Son is listed as the lead author of Ex. 2021, I note that Lochan Verma is also named in Exhibit 2021. As of December 2013, Mr. Verma had “a decade of industry experience in wireless communications” and “authored more than 20 patents and international publications.” *See* Ex. 2024 at 6. Mr. Verma additionally holds a master’s degree in Electrical Engineering and Computer Science from Seoul National University. *See* Ex. 2025 at 9.

PPDU,” in which a “non-AP STA transmitter” could “reduce HE-SIG-B overhead by setting SIGB compression field to 1 while the number of MU-MIMO Users field is set to 0. Therefore, the value 0x0 should not be reserved.” Ex. 2021 at 3. In other words, the inventor of the ’210 patent recognized something that other skilled artisans such as Youhan Kim failed to recognize—that there is a valuable use case for setting the Number of MU-MIMO Users field to 0x0 even when the SIG-B Compression field is 1.

55. After recognizing this advantage of setting the SIG-B Compression field to 1 while the Number of MU-MIMO Users is set to 0x0 (indicating a single user), Mr. Son proposed that D1.0 be *modified* to allow for the “SIGB Compression field” to be “set to 1 (indicating full bandwidth MU-MIMO transmission) *and* the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in the HE-SIG-A field of an HE MU PPDU” to be “set to 0 (indicating 1 MU-MIMO user)” simultaneously. In my opinion, this was a substantive modification to D1.0 at least because, as discussed above, a POSITA would have believed that this implementation was inconsistent with the disclosure of D1.0.³

³ I note that other skilled individuals were unsure even of whether the HE MU PPDU could *ever* be targeted to a single user. For example, CID 5264, cited by the Petition (*see* Pet. 46 n.6), expressed confusion as to whether a multi-user PPDU could *ever* be used “for a single user.” *See* Ex. 1035, 142 (CID 5264: “[I]s it allowed to use the HE MU PPDU for a single user?”); Ex. 1036, 3 (same). The commentor Dorothy Stanley noted that such a usage would be inconsistent with the

56. My opinion in this regard is confirmed by the testimony of Dr. Hansen, who was unable to identify any similar teaching in D1.0 itself. *See* Hansen Dep. Tr. at 31:13–21 (“Q. So specifically, this bottom paragraph on page 3 of Exhibit 1036 states that the MU-MIMO Users field can indicate one MU-MIMO user. I didn’t see anything like that in the 802.11ax D1.0 draft. Did I miss something? A. Yeah. I really don’t—don’t know the answer to that.”).

57. I also note that I disagree with Dr. Hansen’s declaration opinion that “[t]he number of users indicated in the HE-SIG-A field starts from zero, which indicates one user,” (*see* Exhibit 1003 ¶ 118)—as noted above, a 0x0 value in the number of users field of HE-SIG-A is inconsistent with both the express teachings of D1.0 and the understanding of highly skilled professionals at the time. Likewise, I disagree with Dr. Hansen’s assertion that “when the number of MU-MIMO users indicated is one (the value of the HE-SIG-A field is zero), then the receiver identifies the format of the HE-SIG-B user field for a single-user (SU) allocation, the subfields of which are shown in Table 28-22. *See* Ex. 1003, ¶108

teachings of D1.0 itself. *See id.* (noting that if it *is* “allowed to use the HE MU PPDU for a single user,” a “statement [in D1.0] is incorrect”). And Dr. Hansen acknowledged that Ms. Stanley has “probably more than” the level of skill of a POSITA. Hansen Dep. Tr. 13:22–14:4. The fact a skilled individual was unsure whether a HE MU PPDU could *ever* be targeted to a single user further reinforces my opinion that a person of ordinary skill in the art would not have believed a single user would be possible in the specific scenario where full-bandwidth MU-MIMO is indicated.

(characterizing Ex. 1004, 320). D1.0 itself does not disclose this, because the teaching of D1.0 that Dr. Hansen is characterizing does not relate to a scenario where the SIGB Compression bit would be set to 1. *See* Ex. 1004, 320 (not providing any discussion of SIGB Compression bit being set to 1 or full BW MU-MIMO transmission being indicated, in the context of the discussion of a field “address[ing] a single STA in an RU or a STA in an MU-MIMO allocation in an RU”).

2. Dr. Hansen fails to show that it would have been obvious for the number of users to indicate a single user while the SIG-B compression field is set to 1.

58. I note that Dr. Hansen provides several opinions regarding why it would supposedly have been obvious to include a single User field in the HE-SIG-B “when a single user is indicated in the HE-SIG-A field.” *See, e.g.*, Ex. 1003, ¶114; *id.* ¶117 (addressing the obviousness of what would happen “when a single user is indicated”); *id.* ¶126 (alleging what would be obvious “when a single user (SU) was indicated by the HE-SIG-A”). However, none of this analysis sets forth any rationale whatsoever as to why it would have been obvious for a single user to be indicated in the HE-SIG-A field while the SIG-B compression field is set to 1 in the first place.

59. The lack of rationale provided by Dr. Hansen to modify D1.0 to allow the number of MU-MIMO users to be a single user while the SIG-B compression

field is set to 1 confirms my understanding, supported by the understanding of contemporaneous professionals, that D1.0 prohibited such a setting. Therefore, it was not obvious. As noted above, highly skilled⁴ professionals in the relevant timeframe believed that D1.0 was inconsistent with setting the number of MU-MIMO Users to 1 (value 0x0) while the SIGB Compression bit was set to 1. In fact, a highly skilled professional believed that “the value 0x0 [should be] *reserved* [in other words, currently disallowed] for the Number of HE-SIG-B Symbol or MU-MIMO Users field of the HE-SIG-A for HE-MU PPDU if the SIGB Compression field is 1.” Ex. 1035, at page 484, CID 9770 (reaching this conclusion because he believed that the “Number of MU-MIMO users *cannot* be 1 (value 0x0)”).

B. Ground 1B (802.11ax_D1.0 in combination with Bharadwaj)

60. For Ground 1B, Dr. Hansen merely incorporates by reference his analysis of Ground 1A for limitations [6.3] and [6.5] (which are equivalent to limitations [1.5] and [1.7] respectively, and require simultaneously indicating full bandwidth MU-MIMO transmission “when the number of MU-MIMO users indicates a single user.” And like with Ground 1A, Dr. Hansen fails to provide any motivation to modify D1.0’s disclosure such to allow the Number of MU-MIMO

⁴I use the term highly skilled professional or individual to refer to someone who has qualifications significantly exceeding those of a POSITA.

users to be set to 1 (value 0x0) when the SIGB Compression bit is set to 1 (indicating full-bandwidth MU-MIMO transmission).

C. Ground 2 (Bharadwaj in combination with Sun)

1. A POSITA would not have understood Bharadwaj to be compatible with Dr. Hansen’s proposed combination.

61. Bharadwaj, like D1.0, relates to 802.11, including 802.11ax. *E.g.*, Ex. 1013, [0064], [00143] (indicating that IEEE 801.11ax or “some future version of IEEE 802.11” is used). Bharadwaj was filed on December 21, 2016, and Dr. Hansen acknowledges that under his theory that D1.0 was publicly accessible as of December 1, 2016, a POSITA reviewing Bharadwaj would have had access to D1.0. *See* Hansen Dep. Tr. at 24:25–25:7.

62. In my opinion, Dr. Hansen’s opinions with respect to Bharadwaj fail at least for similar reasons as to D1.0; a POSITA would have understood that, based on heavily overlapping teachings between the two references, that the nearly identical disclosures in relevant respect between D1.0 and Bharadwaj should be interpreted the same way. I note that Dr. Hansen himself was unable to identify how the bits 18-21 of the HE-SIG-A (i.e., the Number of MU-MIMO Users field of the HE-SIG-A) should be interpreted differently between D1.0 and Bharadwaj other than to vaguely note that “there could be differences between them” (Hansen Dep. Tr. at 10:8–11:2), and for the reasons I provide above, in my opinion a

POSITA would not have understood there to be a reason for the Number of MU-MIMO users to indicate a single user while the SIGB Compression bit is set to 1.

63. As explained above regarding Ground 1, D1.0 teaches a spatial configuration table corresponding to full-bandwidth MU-MIMO transmission that only accounts for MU-MIMO users being greater than or equal to two users. *See* Ex. 1004, 323–24 (Table 28-24). On this basis, a POSITA would have understood that the number of MU-MIMO users “*cannot be*” a single user. Ex. 1035 at page 484, CID 9770. Table 28-24 of Ex. 1004 is reproduced below:

Table 28-24—Spatial Configuration subfield encoding

N_{user}	B3...B0	Nsts [1]	Nsts [2]	Nsts [3]	Nsts [4]	Nsts [5]	Nsts [6]	Nsts [7]	Nsts [8]	Total Nsts	Number of entries
2	0000-0011	1-4	1							2-5	10
	0100-0110	2-4	2							4-6	
	0111-1000	3-4	3							6-7	
	1001	4	4							8	
3	0000-0011	1-4	1	1						3-6	13
	0100-0110	2-4	2	1						5-7	
	0111-1000	3-4	3	1						7-8	
	1001-1011	2-4	2	2						6-8	
	1100	3	3	2						8	
4	0000-0011	1-4	1	1	1					4-7	11
	0100-0110	2-4	2	1	1					6-8	
	0111	3	3	1	1					8	
	1000-1001	2-3	2	2	1					7-8	
	1010	2	2	2	2					8	

Table 28-24—Spatial Configuration subfield encoding (continued)

5	0000-0011	1-4	1	1	1	1				5-8	6
	0100-0101	2-3	2	1	1	1				7-8	
6	0000-0010	1-3	1	1	1	1	1			6-8	4
	0011	2	2	1	1	1	1			8	
7	0000-0001	1-2	1	1	1	1	1	1		7-8	2
8	0000	1	1	1	1	1	1	1	1	8	1

64. Bharadwaj has a table that is *identical* in terms of substance to D1.0's spatial configuration table, reproduced below. Ex. 1013 at [0036] & FIG. 7.

Nuser	B3 ... B0	Nsts [1]	Nsts [2]	Nsts [3]	Nsts [4]	Nsts [5]	Nsts [6]	Nsts [7]	Nsts [8]	Number of Entries
2	0000~0011	1~4	1							10
	0100~0110	2~4	2							
	0111~1000	3~4	3							
	1001	4	4							
3	0000~0011	1~4	1	1						13
	0100~0110	2~4	2	1						
	0111~1000	3~4	3	1	705					
	1001~1011	2~4	2	2						
	1100	3	3	2						
4	0000~0011	1~4	1	1	1					11
	0100~0110	2~4	2	1	1					
	0111	3	3	1	1					
	1000~1001	2~3	2	2	1					
	1010	2	2	2	2					
5	0000~0011	1~4	1	1	1	1				6
	0100~0101	2~3	2	1	1	1				
6	0000~0010	1~3	1	1	1	1	1			4
	0011	2	2	1	1	1	1			
7	0000~0001	1~2	1	1	1	1	1	1		2
8	0000	1	1	1	1	1	1	1	1	1

65. Ex. 1013, FIG. 7. And as noted above, a POSITA reading this table in the context of D1.0 would have understood that the number of MU-MIMO users field “cannot” indicate a single MU-MIMO user, because “Nuser” must be a value

from 2 to 8. The same understanding would have applied to Bharadwaj, given its identical teachings in relevant respect. And neither D1.0 nor Bharadwaj teaches what the inventors of the '210 patent recognized, which was that “setting the value 9 for the Number of... MU-MIMO Users field of the HE-SIG-A in HE MU PPDU is the UL HE MU PPDU case,” in order to “reduce HE-SIG-B overhead by setting SIGB Compression field to 1 while the number of MU-MIMO Users field is set to 0.” Ex. 2021 at 3; *id.* (proposing a change indicating that “the SIGB Compression field... is set to 1 (indicating full bandwidth MU-MIMO transmission) and the Number Of... MU-MIMO Users field... is set to 0 (indicating 1 MU-MIMO user)” simultaneously); Ex. 1001, 19:1–24 (noting that “the SIG-B compression field may be set according to different rules between when the UL/DL field indicates downlink transmission and when it indicates uplink transmission,” such that “when the UL/DL field indicates uplink transmission, the value of the SIG-B compression field may *always* be set to 1” even though only a single user is indicated (because in uplink transmission, only a single AP will be receiving the PPDU), in order “to reduce the signaling overhead of the HE-SIG-B of the uplink transmission”).

66. Accordingly, because Bharadwaj has an identical teaching to D1.0 that conveys to a POSITA that Nuser must be ≥ 2 such that Nuser *cannot* be 1 when SIGB Compression is set to 1 (and no teaching similar to that of the '210 patent that the SIGB Compression bit can operate differently depending on

context, e.g., to reduce overhead in uplink transmissions), a POSITA would have interpreted Bharadwaj the same as D1.0, such that a POSITA would have understood that the Number of MU-MIMO users *cannot* be a single user when SIGB Compression is set to 1. Consequently, Baradwaj does not cure the deficiencies of D1.0.

67. I further note that Bharadwaj makes clear that its invention is intended to be consistent with 802.11 specifications, including 802.11ax. *See* Ex. 1013, [0064] (“The STAs 110 and APS 105 shown in FIG. 1 communicate according to the WLAN radio and baseband protocol including physical (PHY) and medium access control (MAC) layers from IEEE 802.11 and its various versions including, but not limited to, 802.11b, 802.11g, 802.11a, 802.11n, 802.11ac, 802.11ad, 802.11ah, 802.11z, 802.11ax, etc.”). And 802.11ax is the most recent of the listed 802.11 standards. Accordingly, a POSITA would have looked to D1.0 itself to understand the teachings of Bharadwaj and would have had the same understanding of Bharadwaj’s “number of MU-MIMO users” field as D1.0’s same field of the HE-SIG-A.

68. I note that Dr. Hansen briefly cites to a teaching in Bharadwaj that a certain setting is “applicable for full BW MU-MIMO or MU PPDU targeted to a single user.” *See, e.g.,* Ex. 1013, FIGS. 15C, 21B (cited by Ex. 1003, ¶154). Dr.

Hansen on this basis alleges that “the HE MU PDU would have also supported the single-user scenario.” Ex. 1003, ¶154.

69. Notably, Dr. Hansen does *not* allege that a POSITA would have understood the HE MU PDU as supporting the single-user scenario *when full-bandwidth MU-MIMO transmission is indicated*, as the claims require. *See id.* In my opinion, this concept is not disclosed or rendered obvious by Bharadwaj. Bharadwaj’s teachings regarding “single user” is limited to “MU PDU targeted to single user.” Specifically, Bharadwaj teaches that “1x + 0.8 us CP+LTF Type only applicable for full BW MU-MIMO or *MU PDU targeted to single user.*” Ex. 1013, FIGS. 15C, 21B. In other words, this setting is applicable for full BW MU-MIMO (directed to multiple users, as a POSITA would have understood full BW MU-MIMO requiring for the reasons noted above), or an MU PDU (i.e., a specific PDU type) that is targeted to a single user (which a POSITA would understand can be targeted to a single user when SIGB compression does *not* indicate full BW MU-MIMO).

70. For additional context, a HE MU PDU can be transmitted in one of two modes, determined by the SIG-B compression field of the HE-SIG-A of the PDU: (1) full-bandwidth MU-MIMO transmission (SIGB Compression field = 1), or (2) OFDMA with MU-MIMO transmission (SIGB Compression field = 0). *See, e.g.,* Ex. 1004 at pp. 238-239, 286, 298. In mode (1), a POSITA would not have

understood that a single user could be indicated, as the user-specific field of the HE-SIG-B is structured solely for MU-MIMO allocations and the allocation is incompatible with a single-user configuration, as a POSITA would have understood (and as noted above, highly skilled artisans *did* recognize this incompatibility in the context of D1.0 which provides nearly identical teachings). In OFDMA mode (2), however, a single user is conceivable, because the user-specific field in that mode includes a *non*-MU-MIMO allocation capable of describing one user. For instance, this mode is shown in FIG. 5 of Bharadwaj, where an RU allocation can be provided for a single user. (Notably, in this context, the Number of MU-MIMO Users is *not* indicated in the HE-SIG-A because when SIGB Compression is set to 0, bits 18–21 of HE-SIG-A “indicates the number of HE-SIG-B symbols” rather than “the number of MU-MIMO users minus 1.” See Ex. 1013, FIG. 21A.) Accordingly, a POSITA would *not* have understood Bharadwaj’s reference to “single user” in this context to modify the “full BW MU-MIMO” mode, which (unlike the OFDMA, non-full bandwidth mode) would have only allowed for *multiple* users. In other words, Bhardwaj discloses that this CP+LTF Type was available for *either* (1) “full BW MU-MIMO” (i.e., targeted to multiple users) *or* (2) “MU PPDU targeted to single user.”

71. My opinion in this regard is supported not only by the teachings of Bharadwaj itself (although those teachings are sufficient for my opinions), but also

by the recognition of skilled professionals who understood that full-bandwidth MU-MIMO transmission could not be indicated simultaneously with a single user being specified. It is also supported by Bharadwaj’s failure to explain the context behind why a full-bandwidth MU-MIMO transmission would (or could) be indicated simultaneously with indication of only a single user. This is in stark contrast to the invention of Dr. Son as articulated in the ’210 Patent, that the SIG-B Compression field could be used in this unique way (indicating full-bandwidth MU-MIMO transmission while only a single user is indicated) in order to “to reduce the signaling overhead of the HE-SIG-B of the uplink transmission.” Ex. 2001, 19:1–24; *see also* Ex. 2021 at 3 (discussing a proposal to “reduce HE-SIG-B overhead by setting SIGB Compression field to 1 while the number of MU-MIMO Users field is set to 0”).

2. Dr. Hansen’s combination fails for additional reasons.

72. Dr. Hansen alleges that a POSITA would have combined Bharadwaj with Sun, such that Sun’s HE-SIG-B formatting would be used “[w]hen a single user is indicated” in the HE-SIG-A. Ex. 1003, ¶172. As noted above, Bharadwaj does not disclose that a single user *would* be indicated simultaneously with the SIGB Compression field being set to 1 and indicating full-bandwidth MU-MIMO transmission, as the claims require. But in any event, even if a POSITA would

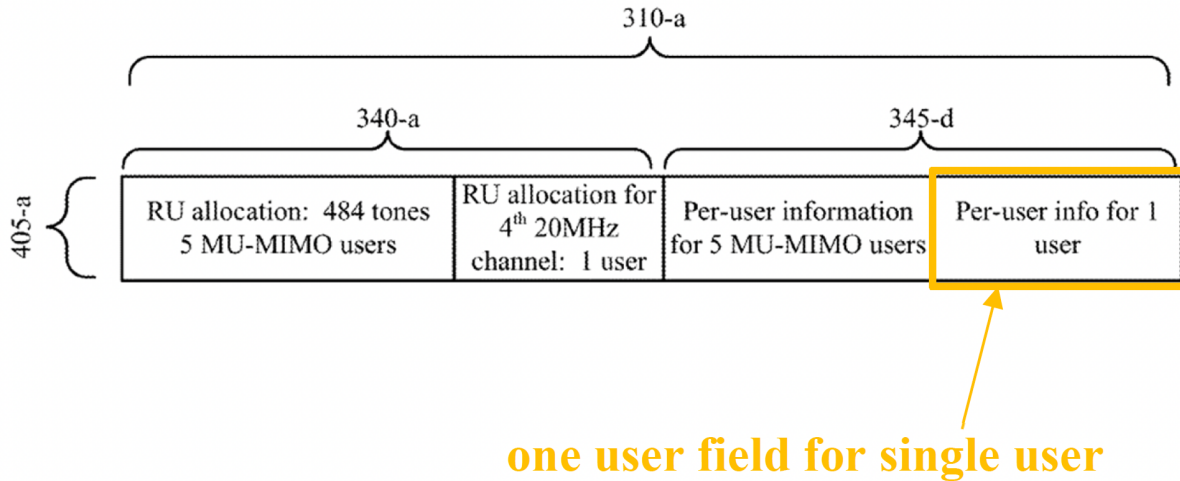
have combined Bharadwaj with Sun, the combination would not satisfy the claim requirements.

73. First, Dr. Hansen fails to show that Sun cures any deficiency of Bharadwaj in disclosing or rendering obvious that the number of MU-MIMO users would be indicated as a single user in the HE-SIG-A while the SIGB Compression field indicated full-bandwidth transmission. For example, he does not point to any teaching in Sun that allegedly discloses or even relates to simultaneous indication of (1) a single user and (2) SIGB Compression field indicating full-bandwidth MU-MIMO transmission.

74. Second, in Dr. Hansen's analysis of limitation [1.7], Dr. Hansen does not even allege that the *claimed* "number of MU-MIMO users" (i.e., the number of MU-MIMO users indicated simultaneously with the SIGB Compression field indicating full-bandwidth MU-MIMO transmission) would indicate a single user. Dr. Hansen's analysis of limitation [1.7] does not substantively address how his opinions are even allegedly compatible with the SIGB Compression field indicating full-bandwidth MU-MIMO transmission mode.

75. Third, the fact that Dr. Hansen's analysis fails to account for the requirement that the SIGB Compression field indicate full-bandwidth MU-MIMO transmission simultaneously with the number of MU-MIMO users indicating a single user is confirmed by the fact that Dr. Hansen relies on HE-SIG-B formats

from both Bharadwaj and Sun that include a common block. *See* Ex. 1003, ¶¶171–172 (relying on FIG. 5 of Bharadwaj and FIGS. 13A–B of Sun, Dr. Hansen’s annotations of which are reproduced below).



Bharadwaj, FIG. 5 (annotated)

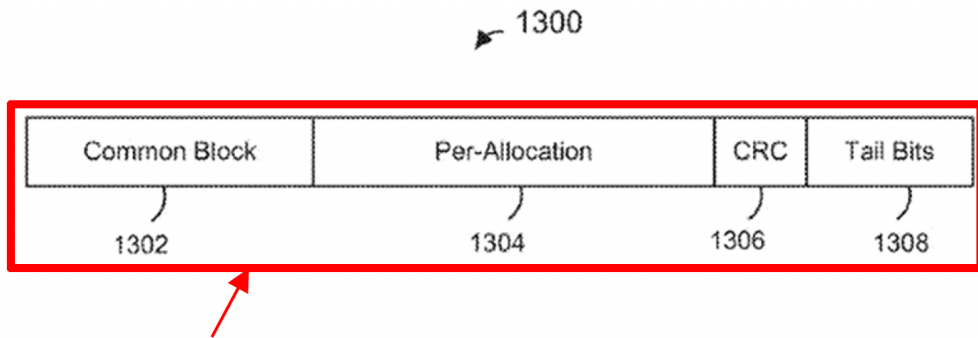
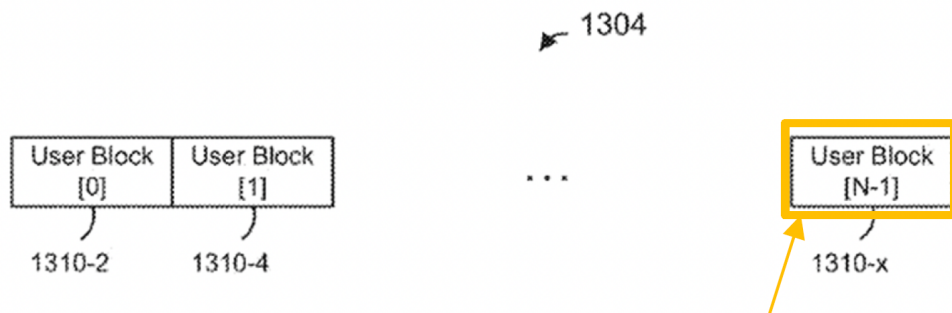


Fig. 13A HE-SIG-B



user block with one user field for one user

Fig. 13B

Sun, FIGS. 13A-B (annotated)

Ex. 1003, ¶¶171–172 (Dr. Hansen’s annotations). As can be seen above, both the format of Bharadwaj and Sun’s HE-SIG-B signal fields include common blocks (340-a and 340-b in Bharadwaj—see Ex. 1013, [0085]—Common Block 1302 in Sun).

76. However, a POSITA would have recognized that these HE-SIG-B formats are *inapplicable* to the scenario where full BW MU-MIMO transmission is indicated, because it was well known that in the context of 802.11 systems such as

Bharadwaj and Sun, that the common block is not present in the setting of full bandwidth MU-MIMO transmission. *See, e.g.*, Ex. 1004, 312 (“*When the SIGB Compression field in the HE-SIG-A field of an HE MU PPDU is set to 1 (indicating full bandwidth MU-MIMO transmission), the Common Block field is not present* and the [HE-SIG-B] content channel consists of only the User Specific field.”); Ex. 1005 at 254 (same); Ex. 1006 at 194 (same); Ex. 1007 at 177 (same). Thus, a POSITA seeking to implement Bharadwaj’s teachings would have been well aware that a common block should *not* be present when the HE-SIG-A field indicates full bandwidth MU-MIMO transmission, and would not have attempted to incorporate Sun’s HE-SIG-B format (which includes a common block) in such a scenario.

77. In sum, it is my opinion that Bharadwaj does not disclose or render obvious that the SIGB Compression field could ever indicate full BW MU-MIMO transmission while the number of MU-MIMO users indicated would be a single user. But even if Bharadwaj counterfactually *did* disclose or render obvious such a scenario, Dr. Hansen fails to establish that a POSITA would have looked to and combined Sun with Bharadwaj in the manner Dr. Hansen suggests, at least not in a way that would satisfy the requirements of claims 1 and 6.

IX. CONCLUSIONS

78. Although my complete opinions are set forth above, for convenience I summarize several points of my opinions in conclusion. For the foregoing reasons, based on my expertise and experience and the record of this case that I have reviewed, it is my opinion that the claims of the '210 patent are not obvious over the identified prior art and the theories articulated by Dr. Hansen.

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

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

Respectfully submitted,

Dated: February 27, 2026



Todor V. Cooklev, Ph.D.

APPENDIX 1A

Todor Cooklev, PhD.

Curriculum Vitae

Personal

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Contact e-mail: tcooklev@gmail.com
Cell: 925-984-5283

Citizenship: United States (by naturalization)

Professional experience

2016 –

Professor of Electrical and Computer Engineering
2101 E Coliseum Blvd., ETCS 349
Purdue University Fort Wayne, Indiana 46805

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

2013 – 2017

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

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

2018 – 2019

Chief Technology Officer, Stryke Industries LLC

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

2010 – 2016

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

2008 – 2022

Director, Wireless Technology Center
Purdue University Fort Wayne

2005 – 2008

Consultant, Hitachi America Ltd., San Jose, California

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

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

Grants Awarded

1. Office of Naval Research Summer Fellow 2020, Naval Surface Warfare Center Crane
2. National Science Foundation S²ERC I/UCRC, “FPGA implementation of shared-memory middleware”, 2017-2019, PI
3. National Science Foundation S²ERC I/UCRC, “Shared-memory middleware”, 2016-2017, PI
4. City of Fort Wayne, Economic Development Fund, 2013-15, co-PI.
5. Allen County Capital Improvement Board (CIB), 2013-15, co-PI
6. U.S. Defense Advanced Research Projects Agency (DARPA) Small Business Technology Transfer (STTR) Phase I “A flexible and extensible solution to incorporating new RF devices and capabilities into EW/ISR networks, co-PI, August 2013 – February 2014.
7. National Science Foundation S²ERC I/UCRC, “The performance of middleware solutions for SDR”, 2013-2014, PI
8. National Science Foundation S²ERC I/UCRC, “Cognitive decision applications for embedded use,” 2011-2012, PI
9. Visiting Fellowship, National Institute of Communication Technology (Japan), 2011
10. National Science Foundation S²ERC I/UCRC, “Signal processing techniques for multicarrier modulation,” 2009-2011, PI
11. NMDG, Belgium, laboratory grant 2010, PI
12. National Science Foundation, Professional Science Master’s Program, MS in engineering, with concentration in wireless and systems engineering, 2010-2013, Co-PI.
13. Emona Instruments, Sydney, Australia, Laboratory exercises in communications, Principal Investigator, 2008.
14. Lilly Endowment, wireless laboratory grant, 2010, PI.
15. ITT (now Harris) Communications Systems, 2007-2011, PI.
16. State of Indiana, workforce development, 2008-2010, PI
17. National Science Foundation DUE-0442313, “Standards in Education for Product, Process, and Service Design and Development: A Proof-of-Concept Project,” 2005-2008, PI.

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

Honors and Awards

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

Education

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

Professional Activities

Board Membership:

Board of Governors, IEEE Standards Association, 2021-2022

Committee/Editorial Board Membership:

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

Committee Membership:

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

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

Program Committee Membership:

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

Tutorials at International Conferences

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

Short Courses and Invited Talks excluding conferences:

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

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

Publications

Books and Monographs

- 1) T. Cooklev and A. Yagle, *Modern Communication Systems: A first course*, Michigan Publishing, 2023. (Available at <https://services.publishing.umich.edu/Books/M/Modern-Communications-Systems>)
- 2) T. Cooklev, *Wireless communications standards: A Study of IEEE 802.11, 802.15, 802.16*, IEEE Press, New York, NY. 2004.

Chapters in Books

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

Journal Papers

- 1) V. Kolev, T. Cooklev, F. Keinert, “Bauer’s spectral factorization method for low order multiwavelet filter design”, *Journal of Computational and Applied Mathematics*, vol. 441, May 2024.
- 2) Kolev, T. Cooklev, F. Keinert, “Design of a Simple Orthogonal Multiwavelet Filter by Matrix Spectral Factorization,” *Circuits, Systems, and Signal Processing*, 2019.
- 3) Y. Acar and T. Cooklev, “High performance OFDM with index modulation”, *Physical Communication*, vol. 32, pp. 192-199, 2019.
- 4) M. Sherman and T. Cooklev, “Abstract descriptions of spectrum: VITA 49 and IEEE 1900.5.2”, *IEEE Communications Standards Magazine*, vol. 2, no. 4, pp. 43-48, December 2018.
- 5) T. Cooklev, V. Poulkov, D. Bennett, K. Tonchev, “Enabling RF data analytics services and applications via cloudification,” *IEEE Aerospace Electronic Systems Magazine*, vol. 33, no. 5-6, pp. 44-55, May-June 2018.

- 6) V. Kolev, T. Cooklev, F. Keinert, "Matrix spectral factorization for the SA4 multiwavelet," *Journal of Multidimensional Systems and Signal Processing*, vol.29, Issue 4, pp 1613–1641, 2018.
- 7) H. Dogan, T. Cooklev, and J. Darabi, "Improved low-complexity zero-padded OFDM receivers", *Digital Signal Processing*, vol. 51, pp. 92–100, April 2016.
- 8) P. Baltiiski, I. Iliev, B. Kehaiov, V. Poulkov, and T. Cooklev, "Long-Term Spectrum Monitoring with Big Data Analysis and Machine Learning for Cloud-Based Radio Access Networks," *Wireless Personal Communications*, vol. 87, issue 3, pp. 815-835, April 2016.
- 9) T. Cooklev, J. Darabi, C. McIntosh, and M. Mosaheb, "Cloud-based approach for spectrum monitoring," *IEEE Instrumentation and Measurement Magazine*, vol. 18, no. 2, pp. 33-37, April 2015.
- 10) Sven Bilén, A. Wyglinski, C. Anderson, T. Cooklev, C. Dietrich, B. Farhang-Boroujeny, "On Software-Defined Radio as an integrative educational resource," *IEEE Communications Magazine*, vol. 52, no. 5, pp. 184-193, May 2014.
- 11) Hakan Yıldız, Yusuf Acar, Todor Cooklev, Hakan Dogan, "Generalized Prefix for Space-Time Block Coded OFDM Wireless Systems over Correlated MIMO Channels," *IET Communications*, vol. 8, no. 9, pp. 1589-1598, June 2014.
- 12) T. Cooklev, A. Nishihara, "An Open RF-Digital interface for software-defined radios," *IEEE Micro*, vol. 33, no. 6, pp. 47-55, Dec. 2013.
- 13) T. Cooklev, R. Normoyle, and D. Clendenen, "The VITA 49 RF-digital interface," *IEEE Circuits Systems Magazine*, vol. 12, no. 4, pp. 21-32, Dec. 2012.
- 14) T. Cooklev, "An improved prefix for OFDM-based cognitive radios", *Electron. Lett.*, vol. 48, No. 4, Feb. 2012.
- 15) Y. Alqudah and T. Cooklev, "Hands-on open access broadband wireless technology lab", *Int. J. Interactive Mobile Tech.*, Vol. 6, No 4, 2012, pp. 13-18.
- 16) T. Cooklev, H. Dogan, R. Cintra, H. Yildiz, "Generalized prefix for OFDM wireless systems over quasi-static channels," *IEEE Transactions on Vehicular Technology*, vol. 60, No. 8, pp. 3684 – 3693, Nov. 2011.
- 17) F. Ramirez-Mireles, T. Cooklev, and G. A. Paredes-Orozco, "UWB-FSK: Performance tradeoffs for high-complexity receivers," *IEEE Transactions on Consumer Electronics*, vol. 56, no. 4, pp. 2123-2131, 2010.
- 18) S. Hossain, D. Batovski, and T. Cooklev, "Eight-channel transmultiplexer with binary matrix sequences," *Assumption Univ. Journal of Technology (Thailand)*, vol. 13, No. 4, pp. 193-202, 2010.

- 19) T. Cooklev, "Engineering standards and engineering education," *Journal of IT Standardization Research*, vol. 8, 2010, pp. 1-10.
- 20) R. Cintra and T. Cooklev, "Robust image watermarking using non-regular wavelets," *Journal of Signal, Image, and Video Processing*, 2008.
- 21) T. Cooklev, A. Pakdaman, J. Eidson, "IEEE 1588 over IEEE 802.11 for synchronization of wireless local area nodes," *IEEE Trans. Instrumentation and Measurement*, vol. 56, No. 5, pp. 1632-1639, Oct. 2007.
- 22) T. Cooklev and A. Nishihara, "Analytic constructions of complementary sequences," *IEICE Trans. Fundamentals*, November 2006.
- 23) T. Cooklev, "An efficient architecture for orthogonal wavelet transforms," *IEEE Signal Processing Letters*, Feb. 2006.
- 24) T. Cooklev, "Standards for the wireless Internet," *Annual review of communications*, vol. 57, Dec. 2004.
- 25) T. Cooklev, G. Berbecel and A. N. Venetsanopoulos, "Wavelets and differential-dilation equations," *IEEE Trans. Signal Processing*, vol. 48, pp. 2258-2268, 2000.
- 26) T. Cooklev and A. Nishihara, "Biorthogonal coiflets," *IEEE Trans. Signal Processing*, vol. 47, pp. 2582-2588, 1999.
- 27) T. Cooklev, A. Nishihara, T. Yoshida, and M. Sablatash, "Multidimensional two-channel linear phase FIR filter banks and wavelet bases with vanishing moments," *Journal of Multidimensional Systems and Signal Processing*, vol. 9, pp. 39-76, January 1998.
- 28) T. Cooklev, A. Nishihara and M. Sablatash "Regular orthonormal and biorthogonal wavelet filters," *Signal Processing*, vol. 57, pp. 121-137, Feb. 1997.
- 29) T. Yoshida, T. Cooklev, A. Nishihara, and N. Fujii, "Design of non-separable 3-D QMF banks using McClellan transformations," *IEICE Trans. Fundamentals*, vol. E79-A, No. 5, May 1996, pp. 716-720.
- 30) M. Sablatash and T. Cooklev "Coding of high-quality audio signals by wavelets and wavelet packets," *Digital Signal Processing: A Review Journal*, vol. 6, No. 2, pp. 96-107, April 1996.
- 31) V. Dimitrov, T. Cooklev, and B. Donevsky "Number-theoretic transforms over the golden-section quadratic field," *IEEE Trans. Signal Processing*, No. 8, pp. 1790-1797, August 1995.
- 32) V. Dimitrov and T. Cooklev, "Hybrid algorithm for computing the matrix polynomial," *IEEE Trans. Circuits Syst.*, No. 7, pp. 377-380, July 1995.

- 33) V. Dimitrov and T. Cooklev ``Two algorithms for modular exponentiation based on nonstandard arithmetics,`` Special issue on cryptography and information security, *IEICE Transactions on Fundamentals*, Jan. 1995.
- 34) M. Sablatash , Todor Cooklev and Takuro Kida, ``The coding of image sequences by wavelets, wavelet packets and adaptive wavelet packets,`` *IEEE Trans. Broadcasting*, Dec. 1994.
- 35) T. Cooklev and A. Nishihara, ``Partial and generalized FFT,`` *IEICE Trans. on Fundamentals*, Sept. 1994.
- 36) V. Dimitrov, T. Cooklev and B. Donevsky, "Generalized Fermat-Mersenne number theoretic transforms," *IEEE Trans. Circuits Syst.*, vol. 41, pp. 133-139, Feb. 1994.
- 37) T. Cooklev, T. Yoshida and A. Nishihara, ``Maximally flat half-band diamond-shaped FIR filters using the Bernstein polynomial,`` *IEEE Trans. Circuits Syst.*, vol. 40, pp. 749-751, Nov. 1993.
- 38) T. Cooklev and A. Nishihara, ``Maximally flat FIR Hilbert transformers,`` *Int. Journal Circuit Theory and Applications*, vol. 21, pp. 563-570, 1993.
- 39) T. Cooklev, S. Samadi, A. Nishihara and N. Fujii, Efficient implementation of all maximally flat FIR filters of a given order,`` *Electronics Lett.*, vol. 29, No. 7, pp. 598-599, 1993.
- 40) S. Samadi, T. Cooklev, A. Nishihara and N. Fujii, ``Multiplierless structure for maximally flat linear phase FIR filters,`` *Electronics Lett.*, vol. 29, No. 2, pp. 184-185, 1993.
- 41) V. Dimitrov, T. Cooklev and B. Donevsky, "Generalized Fermat number transforms,`` *ASME Journal on Numerical Modeling*, 1992, N. 4 pp. 11-22.
- 42) T. Cooklev, V. Dimitrov and B. Donevsky, "Systolic implementation of the complex Chebyshev structure,`` *Int. J. Electronics*, vol. 73, pp. 1247-1252, Dec. 1992.
- 43) T. Cooklev and A. Nishihara, "Efficient design of N--D hyperspherically symmetric FIR filters,`` *IEICE Transactions on Fundamentals of Electronics, Inform. and Comput. Sci.*, vol. E75-A, pp. 1739-1742. Dec. 1992.
- 44) T. Cooklev, V. Dimitrov and B. Donevsky, "An improved systolic implementation of complex digital filters,`` *Archiv fuer Elektronik und Uebertragungstechnik (Germany)*, vol. 46, pp. 434-436, Nov.-Dec. 1992.
- 45) V. Dimitrov, T. Cooklev and B. Donevsky, "On the multiplication of reduced biquaternions and applications,`` *Information Processing Letters*, vol. 43, pp. 161-164, Sept. 1992.

Conference Papers

- 1) T. Cooklev, "The analog RF-digital interface: the VITA 49 standard and evolution roadmap" First IEEE Next G Summit, Johns Hopkins University, June 2022.
- 2) Plamen Semov, Pavlina Koleva, Vladimir Poulkov, and Todor Cooklev, "Evolution of Mobile Networks and C-RAN on the Road Beyond 5G," 43rd Int. Conf. on Telecommunications and Signal Processing, Milan, Italy, July 2020.
- 3) Y. Acar, S. Colak, T. Cooklev, "Dual-Mode Index Modulation Aided OFDM with Generalized Prefix", *Int. Symp. Networks, Computers, and Communications*, June 2019, Istanbul, Turkey.
- 4) T. Cooklev, "Making Software Defined Networks Semantic," *Proc. WINSYS*, July 2015, Colmar, France.
- 5) T. Cooklev, L. Stanchev, "A comprehensive and hierarchical ontology for wireless systems," *Wireless World Research Forum*, Marrakech, Morocco, May 2014.
- 6) Yusuf Acar, H. Yildiz, H. Dogan, and H. Dogan, "Generalized Prefix Approach for Alamouti Coded OFDM Systems over Gaussian Channels Correlated in Space," IEEE 2014 World Congress on Computer Applications and Information Systems (WCCAIS), Hammamet, Tunisia, January 17-19, 2014.
- 7) Yusuf Acar, H. Yildiz, H. Dogan, and H. Dogan, "Performance Improvement for Correlated 4x4 MIMO-OFDM Systems by Generalized Prefix Approach," 2013 Int. Conference on Signal Processing and Communications, Dec. 12-14, Noida, Uttar Pradesh, India.
- 8) T. Cooklev, L. Stanchev, C. Chen, "Wireless cloud architecture based on thin clients and ontologies," *Proc. IEEE Midwest Symp. Circuits and Systems*, Columbus, OH, Aug. 2013
- 9) Acar, Y.; Yildiz, H.; Cooklev, T.; Dogan, H., "High-performance MIMO OFDM wireless systems with generalized prefix," *21st Signal Processing and Communications Applications Conference (SIU)*, 2013, 24-26 April 2013, North Cyprus.
- 10) Dogan, H. Yildiz, T. Cooklev, Y. Acar, "Coded OFDM wireless systems with generalized prefix", Int. Conf. on Application of Information and Communication Technologies, Tbilisi, Georgia, Oct. 2012.
- 11) A. Madanayake, C. Wijenayake, Nghi Tran, T. Cooklev, Sean V Hum, L. T. Bruton, "Directional Spectrum Sensing using Tunable Multi-D Space-Time Discrete Filters," First IEEE International Workshop on Emerging COgnitive Radio Applications and aLgorithms (IEEE CORAL), San Francisco, CA June 2012.
- 12) Yazan A. Alqudah and T. Cooklev, Hands-On Open Access Broadband Wireless Technology Lab, *Proc. IEEE Global Engineering Education Conference (IEEE EDUCON)*, Marrakech, Morocco, April 2012.
- 13) Yazan A. Alqudah and T. Cooklev, Hands-On Open Access Broadband Wireless Technology Lab, ASEE Illinois/Indiana Section Conference, Valparaiso, IN, March 2012.

- 14) D. Mueller, T. Cooklev, H. Oloomi, C. Pomalaza-Ráez, and S. Walter, "A Graduate Program In Wireless Technology And Systems Engineering: Overview And Initial Experiences", ASEE Illinois/Indiana Section Conference, Valparaiso, IN, March 2012.
- 15) L. Stanchev and T. Cooklev, "Describing Radio Hardware and Software Using OWL for Over-The-Air Software Download," SDR Forum Tech. Conference, Washington, DC, Dec. 2010.
- 16) A. Marcum, T. Cooklev, and Carlos Pomalaza-Raez, "Simple OFDM," Virginia Tech Wireless Summer School, June 2010.
- 17) C. Chen, Z. Chen, T. Cooklev, and C. Pomalaza-Raez, "On spectrum probing in cognitive radio networks: does randomization matter," IEEE Int. Conf. Communications, May 2010.
- 18) Z. Chen, T. Cooklev, C. Chen, and Carlos Pomalaza-Raez, "Modeling primary user emulation attacks and defenses in cognitive radio networks," Int. Performance Computing and Communications Conference, Dec. 2009, Phoenix, AZ
- 19) T. Cooklev and M. Cummings, "Changing metalanguage landscape," SDR Forum Technical Conference, Washington, DC, Dec. 2009.
- 20) F. Ramirez-Mireles, T. Cooklev, and M. Sablatash, "Analysis of filter-based non-coherent detection of UWB FSK with antenna and multipath effects," IEEE MILCOM 2008.
- 21) T. Cooklev and M. Cummings, "Networking description language for ubiquitous cognitive networking," SDR Forum Technical Conference, Washington, DC, Nov. 2008.
- 22) M. Cummings, T. Cooklev, B. Lyles, P. A. Subrahmanyam, "Commercial wireless metalanguage scenario," Software Defined Radio Technical Conference, Denver, CO, November 2007.
- 23) T. Cooklev and A. Abedi, "Teaching the IEEE wireless communication standards dynamically," 2007 Frontiers in Education Conference, Milwaukee, WI, Oct. 10-13, 2007.
- 24) S. Gaur and T. Cooklev, "Using Finer AIFSN granularity to Accurately Tune the Flow Ratios in IEEE 802.11e," The 18th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), Sept. 2007, Athens, Greece.
- 25) S. Gaur and T. Cooklev, "'Performance Enhancement of IEEE 802.11e EDCA by Random AIFSN", 2007 3rd International Conference on Testbeds and Research Infrastructures for the Development of Networks & Communities (TridentCom), Grosvenor Resort, Orlando, FL, May 21-23, 2007.
- 26) F. Ramirez-Mireles, and T. Cooklev, "Effects of Antenna and Multipath Frequency Selectivity on UWB Using Non-coherent FSK," World Wireless Forum, Stanford, CA, May 18-20 2007.
- 27) F. Ramirez-Mireles, and T. Cooklev, "An Investigation of Antenna and Multipath Effects on Pulse-Based UWB Using FSK," IEEE Globecom, San Francisco 2006.

- 28) T. Cooklev and P. Siohan "Vector-transform-based OFDM", Asilomar Conf. On Computers and Comm., Pacific Grove, Nov. 2006.
- 29) S. Gaur and Cooklev, T. "Performance enhancement of IEEE 802.11e EDCA by random AIFSN," IEEE Wireless multimedia communication conf., Vancouver, BC, Canada, July 2006.
- 30) T. Cooklev, Keh-Gang Lu "A wavelet transform approach to the design of complementary sequences for communications, 39th Asilomar Conference on Systems, Signals, and Computers, Pacific Grove, CA Nov. 2005.
- 31) M. Goins, T. Cooklev, and J. W. Hines, "System-on-a-chip design for lab-on-a-chip in space-flight systems," Proc. Information Systems: New Generations, Las Vegas, NV, April 2005.
- 32) Y. Bai and T. Cooklev, "An improved method for lossless data compression" IEEE Data Compression Conference, Snowbird, Utah, March 2005.
- 33) A. Pakdaman, J. Eidson, T. Cooklev, "Synchronization of wireless LAN over IEEE 1588," Int. Conference on IEEE 1588, Baltimore MD, Sept. 2004.
- 34) T. Cooklev, "Dynamic bandwidth allocation and channel coding for providing QoS in wireless networks," Int. Conference on Telecommunications, Feb. 2003, Papeete, Tahiti.
- 35) T. Cooklev and M. Sablatash "A wavelet transform approach to the design of sequences for communications," Wireless Communications'97, Calgary, July 1997.
- 36) M. Sablatash, John Lodge, and T. Cooklev "Transmitter and receiver filter bank designs for bandwidth-on-demand multiple access communications combining wavelet packet filter bank trees and DFT polyphase filter banks" IEEE Int. Conference on Communications, Montreal, 1997.
- 37) G. Berbecel, T. Cooklev and A. N. Venetsanopoulos, "A practical wavelet-based approaches to watermarking digital images," IEEE Conf. on Consumer Electronics, Chicago, IL, 1997.
- 38) T. Cooklev, G. Berbecel, A. N. Venetsanopoulos, "Wavelets and differential-dilation equations" Canadian Workshop on Information Theory, Toronto, June 1997.
- 39) T. Cooklev, G. Berbecel, and A. N. Venetsanopoulos, "Construction of an infinitely differentiable continuous-time wavelet and differential dilations equations," Int. Workshop on Signal and Image Processing, Manchester, UK, Nov. 1996.
- 40) T. Cooklev, A. Nishihara, M. Kato, and M. Sablatash "Lattice structures for two-channel paraunitary filter banks that yield symmetric wavelet bases," EUSIPCO'96, Trieste, Italy, Sept. 1996
- 41) D. Androustos, T. Cooklev, A. N. Venetsanopoulos, "Multifilter banks and multiwavelets for multispectral image compression," World Congress of Nonlinear Analysts, Athens, July 1996.

- 42) T. Cooklev, "On the design of orthogonal filter banks and wavelets with complex coefficients," Queen's Biennial Symposium on Communications, Kingston, June 1996.
- 43) T. Cooklev, "Filter banks and wavelet transforms over finite fields," Queen's Biennial Symposium on Communications, Kingston, June 1996.
- 44) T. Cooklev, "1-D and 2-D biorthogonal filter banks with vanishing moments and biorthogonal wavelet packets" Queen's Biennial Symposium on Communications, Kingston, June 1996.
- 45) T. Cooklev, "Multichannel filter banks, vector transforms, and multiwavelets with applications in color image compression," Queen's Biennial Symposium on Communications, Kingston, June 1996.
- 46) T. Cooklev, A. Nishihara, M. Kato, and M. Sablatash "Two-channel multifilter banks and multiwavelets," IEEE ICASSP'96, Atlanta, GA, pp. 2769-2773, May 1996.
- 47) T. Cooklev, et. al., "Multifilters and multiwavelets," Wavelets in signal and image processing, Centre de recherche mathematique, Universite de Montreal, Montreal, Quebec, Canada, March 1996.
- 48) T. Cooklev, et al "Regular biorthogonal filter banks and wavelet bases: new design and implementation," Int. Conf. Digital Signal Processing., Limmasol, Cyprus, 1995.
- 49) T. Cooklev, A. Nishihara, T. Yoshida, and M. Sablatash "Regular multidimensional linear phase FIR perfect-reconstruction filter banks and wavelet bases," IEEE ICASSP'95, Detroit, MI, May 1995.
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- 53) Mike Sablatash , Todor Cooklev, "Compression of high quality audio signals by wavelet packets and other methods," Kingston Biennial Symp. Communications, Kingston, Ontario, Canada, June 1994.
- 54) M. Sablatash , Todor Cooklev and Takuro Kida, "The coding of image sequences by wavelets, wavelet packets, adaptive wavelet packets and other subband coding schemes," Kingston Biennial Symp. Communications, Kingston, Ontario, Canada, June 1994.
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- 58) T. Cooklev and A. Nishihara, "Multidimensional perfect-reconstruction linear-phase digital filter bank," Karuizawa Workshop on Circuits Systems, Karuizawa, Japan, April 1994.
- 59) T. Cooklev and A. Nishihara, "Partial FFT," Proc. 8th Digital Signal Processing Workshop, Sendai, Japan, pp. 37-42, Oct. 1993.
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- 61) T. Cooklev and A. Nishihara, "Maximally flat FIR filters," IEEE ISCAS, Chicago, IL, pp. 96-99, May, 1993.
- 62) T. Cooklev and A. Nishihara, "Maximally flat FIR Hilbert transformers," Karuizawa Workshop on Circuits and Systems, Karuizawa, Japan, pp. 37-42, April 1993.
- 63) T. Cooklev and A. Nishihara, "Systolic structures for linear-phase FIR filters," 1st IEEE Asia Pacific Conference on Circuits and Systems, pp. 304-306, Sydney, Australia, Dec. 1992.
- 64) T. Cooklev and A. Nishihara, "A new class of 2--D FIR maximally-flat digital filters," 7th Digital Signal Processing Symposium, Fuji Res. Inst., Japan, pp. 115-120. Nov. 1992.
- 65) T. Cooklev and A. Nishihara, "Design of N-D hyper spherically symmetric FIR filters," IEICE Fall Conference, pp. A-82, Tokyo, Sept. 1992.
- 66) V. Dimitrov, T. Cooklev, B. Donevsky, "Fibonacci-based complex number theoretic transform," IASTED Int. Symposium Circuits Systems, Zurich, Switzerland, pp. 69-72, July 1991.

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- 1) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 9,949,148, April 17, 2018.
- 2) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 9,936,401, April 3, 2018.
- 3) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 9,461,857, October 4, 2016.

- 4) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 9,450,794, September 20, 2016.
- 5) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 9,148,806, September 29, 2015.
- 6) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, Multicarrier packet communication system, U.S. Patent 9,148,801, September 29, 2015.
- 7) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 8,958,350, February 17, 2015.
- 8) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 8,842,570, September 23, 2014.
- 9) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 8,755,264, June 17, 2014.
- 10) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, "Systems and methods for high rate OFDM communications" U.S. Patent 8,553,579, Oct. 8, 2013.
- 11) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, Multicarrier packet communication system, U.S. Patent 8,537,703, September 17, 2013.
- 12) M. Tzannes, D. Lee, T. Cooklev, and C. Lanzl, Systems and methods for high rate OFDM communications using first and second cyclic prefix lengths and first and second pilot tones, U.S. Patent 8,416,677, April 9, 2013.
- 13) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, OFDM communications using bit allocation tables, U.S. Patent 8,284,800, October 9, 2012.
- 14) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, Systems and methods for high rate OFDM communications using first and second cyclic prefix lengths, U.S. Patent 8,159,969, April 17, 2012.
- 15) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, High rate OFDM communications using bit allocation tables, 7,924,841, May 17, 2011
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- 21) M. Tzannes, D. Lee, T. Cooklev, C. Lanzl, Systems and methods for high rate OFDM communications, 7,522,514, April 21, 2009
- 22) Kenneth Morley; Todor Cooklev, Mark Gray; Darrin Gibbs; Video signal processing method and apparatus for internet appliances or embedded systems, US Patent 6,795,869, September 2004.
- 23) Todor Cooklev, Darrin Gibbs; Mark Gray; Ken Morley; Method and system for performing speech recognition for an internet appliance using a remotely located speech recognition application, US Patent 6,772,123, August 2004.
- 24) T. Cooklev, Device and method for compensating or creating doppler effect using digital signal processing, US Patent, 6,633,617, Oct. 2003.
- 25) S. Messerly, T. Cooklev, "Adaptive filter size for the efficient computation of wavelet packet trees," US Patent 6,581,081, June 2003.

- 26) T. Cooklev, "Method and system for spatially-disjoint joint source and channel coding for high-quality real-time multimedia streaming over connection-less networks via circuit-switched interface links," US Patent 6,574,218, June 2003.
- 27) T. Cooklev, M. Gray, "System and method for precise DTMF detection," US Patent 6,560,331, May 2003.
- 28) T. Cooklev, K. Smart, "High-speed modem operating over two or more telephone lines," US Patent 6,490,295, Dec. 2002.
- 29) T. Cooklev, M. Gray, D. Gibbs, K. Morley, "Method and apparatus for continuously variable slope delta modulation coding of signals," US Patent 6,486,810, Dec. 2002.
- 30) S. Messerly, T. Cooklev, "Reduced computation system for wavelet transforms," US Patent 6,466,957, Oct. 2002.
- 31) T. Cooklev, "Method and apparatus for wavelet-based digital watermarking of signals", US Patent, March 2002.
- 32) T. Cooklev, "Method for real-time lossless data compression of computer data, US Patent 6,289,130, Sept. 11, 2001.

Selected non-refereed publications

Contributions to 3GPP

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

Contributions to IEEE 802.11

- 8) G. Venkatesan, A. Ashley, Ed Reuss, and T. Cooklev, "IEEE 802 Tutorial: Video over 802.11," March 2007. (on behalf of Hitachi America Ltd)
- 9) T. Cooklev, "Video over WLAN", doc. 11-07-0105r0, 2007. (on behalf of Hitachi America Ltd)
- 10) S. Gaur, T. Cooklev, "MAC improvement using random AIFSN," doc. 802.11-06/0657, July 2006. (on behalf of Hitachi America Ltd)
- 11) C. Tavares, T. Cooklev, S. Gaur, "On video over 802.11," doc. 802.11-06/0039, Jan. 2006. (on behalf of Hitachi America Ltd)

- 12) C. Tavares, T. Cooklev, "MAC extensions for HDTV," doc. 802.11-05/0632, July 2005. (on behalf of Hitachi America Ltd)
- 13) M. Tzannes, T. Cooklev, D. Lee, C. Lanzl, "Extended data rate 802.11a", doc. 802.11-02/232, March 2002. (on behalf of Aware, Inc.)
- 14) S. Prestwich, D. Ostermiller, K. Dobson, T. Cooklev, "Dynamic frequency hopping," IEEE 802.15, Tel Aviv, Israel, January 2000. (on behalf of Aware, Inc.)

Contributions to ITU-T SG15 Q4 on DSL technology

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

Other non-referred publications and technical reports

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

APPENDIX 1B

Expert Witness Engagements

- 2025 – Expert for Pantech
- Law firm: Mayer Brown LLP
 - ITC Investigation: No. 337-TA-1456
- 2025 – Expert for Vasu Holdings, LLC
- Law firm: Herbert Smith Freehills Kramer LLP, Redwood City, CA
 - Case names: *Vasu Holdings, LLC v. Samsung Electronics Co. Ltd., and Samsung Electronics America, Inc.*
 - Civil Action No. 2:24-cv-00034-JRG-RSP (*E. D. Tex.*)
 - Submitted infringement report
 - Technology at issue: switching between Wi-Fi and cellular communications
- 2024 – Expert for XR Communications LLC
- Law firm: Russ August Kabat, Los Angeles, CA
 - Case names: *XR Communications LLC v. AT&T Services Inc., AT&T Mobility LLC, and AT&T Corp.*
 - Civil Action No. 2:23-cv-00202-JRG-RSP (*E. D. Tex.*)
 - Submitted infringement and validity reports
 - Testified at deposition
 - PTAB Case IPR2024-00868, submitted declaration
 - Technology at issue: beamforming in cellular communications
- 2025 – Expert for D-Link
- Law firm: Pillsbury Winthrop Shaw Pittman LLP
 - ITC Investigation: No. 337-TA-1454
- 2025 – Expert for Intellectual Ventures II LLC
- Law firm: Volpe Koenig, Philadelphia, PA
 - Case name: *Tesla, Inc., v. Intellectual Ventures II LLC*
 - Case Nos. IPR2025-00220
 - Submitted declaration
 - Technology at issue: cellular communication
- 2025 – Expert for Ford Motor Company
- Law firm: Brooks Kushman P.C.
 - Case name: Ford Motor Company v. Autoconnect Holdings LLC
 - Case Nos. IPR2026-00171
 - Technology at issue: vehicle communication systems, sensors, and infotainment systems
- 2025 – Expert for TOT Power Control, S.L.
- Law firm: DiNovo Price, Austin, TX

- Case name: *TOT Power Control, S.L. v. AT&T Mobility, Inc.*,
- Case name: *TOT Power Control, S.L. v. AT&T USA Inc.*,
- Case name: *TOT Power Control, S.L. v. T-Mobile USA Inc.*,
- Civil action No. 2:21-CV-00107-ADA, No. 2:21-CV-00109-ADA (*W.D. Tex.*)
- Technology at issue: cellular communication

2025 – 2025

Expert for Netflix, Inc.

- Law firm: Baker Botts LLP, San Francisco, CA
- Case names: *Netflix, Inc. v. Broadcom, Inc., and VM Ware, LLC*
- Civil Action No. 3:25-cv-3738-TLT (*N. D. Cal.*)
- Submitted declaration
- Technology at issue: IEEE 1588

2024 – 2025

Expert for Headwater Research LLC

- Law firm: Russ August Kabat, Los Angeles, CA
- Case names: *Headwater Research LLC v. Cellco Partnership D/B/A Verizon Wireless and Corporate Services Group, Inc.*
- Civil Action No. 2:23-cv-00352-JRG-RSP (*E. D. Tex.*)
- Submitted infringement and validity reports
- Testified at deposition
- Technology at issue: cellular communications

2023 – 2024

Expert for Pantech Corporation

- Law firm: Mayer Brown LLP
- Case names: *Pantech Corporation and Pantech Wireless LLC v. LG Electronics Inc., and LG Electronics U.S.A., Inc. and Pantech Corporation and Pantech Wireless LLC v. OnePlus Technology (Shenzhen) Co. Ltd.*
- Civil Action Nos. 5:22-cv-00113-RWS-JBB, 5:22-cv-00069-RWS (*E. D. Tex.*)
- Submitted report in connection with claim construction, infringement and validity reports
- Testified at a deposition and at trial
- Technology at issue: cellular communications

2024 –

Expert for Skipio Technologies SI, Ltd.

- Law firm: Fish & Richardson, New York, NY
- Technology at issue: DSL communications

2024 – 2025

Expert for Scosche Industries, Inc.

- Law firm: ArentFox Schiff, LLP, Los Angeles, CA
- Case name: *Fleet Connect Solutions, LLC v. Scosche Industries, Inc.*
- Civil action No. 2:23-CV-09324 HDV (*AJRx*) (*C.D. Cal.*)
- Technology at issue: Wi-Fi and Bluetooth wireless communication

2023 – 2024

Expert for Hytera Communications Corporation,

- Law firm: Steptoe LLP, Washington, DC

- Case name: *United States of America v. Hytera Communications Corporation*
- Case No. 1:20-cr-00688 (N. D. Ill.)
- Technology at issue: software-defined radio

2024 –

Expert for Cobblestone Wireless LLC

- Law firm: Russ August Kabat, Los Angeles, CA
- Case name: *Hewlett Packard Enterprise Company and Cisco Systems, Inc., v. Cobblestone Wireless, LLC*
- Case No. IPR2024-00707
- Submitted declaration
- Technology at issue: hardware architecture of wireless devices

2024 – 2024

Expert for Broadphone LLC

- Law firm: Russ August Kabat, Los Angeles, CA
- Case name: *Samsung Electronics Co. Ltd., v. Broadphone, LLC*
- Case Nos. IPR2024-00153, IPR2024-00154, IPR2024-00155
- Submitted declaration
- Technology at issue: wireless communication systems

2020 –

Expert for Smart Mobile Technologies LLC

- Law firm: Hagens Berman Sobol Shapiro, Pasadena, CA (2020-2022); Graves and Shaw LLP, Los Angeles, CA (2022 – present).
- Case names: *Smart Mobile Technologies LLC v. Apple Inc., and Smart Mobile Technologies LLC v. Samsung Electronics Co. Ltd. and Samsung Electronics America, Inc.*
- Case Nos: 6:21-cv-00603, 6:21-cv-00701 (W.D. Tex.)
- PTAB case Nos. IPR2022-00766, IPR2022-00807, IPR2022-00808, IPR2022-01002, IPR2022-01003, IPR2022-01004, IPR2022-01005, IPR2022-00979, IPR2022-00980, IPR2022-00981, IPR2022-00982, IPR2022-01222, IPR2022-01223, IPR2022-01248, IPR2022-01249
- Submitted multiple declarations
- Testified at multiple depositions
- Technology at issue: cellular and Wi-Fi communications and networking

2022 – 2023

Expert for XR Communications, LLC d/b/a Vivato Technologies

- Law firm: Russ August Kabat, Los Angeles, CA
- Case name: *XR Communications, LLC, dba Vivato Technologies v. Asustek Computer, Inc.*
- Case No. 6:21-cv-00622-ADA (W. D. Texas)
- Reports on infringement and technical scope of license
- Testified at a deposition
- Technology at issue: beamforming in wireless communications

2023 – 2023

Expert for Metrom Rail LLC

- Law firm: McAndrews, Held & Malloy, Chicago, IL

- Case name: *Siemens Mobility, Inc., Ground Transportation Systems USA, Inc., Humatics Corp., and Piper Networks, Inc., v. Metrom Rail LLC*
- Case Nos. IPR2023-00468 & IPR2023-00470
- Submitted declaration
- Technology at issue: ultra-wideband (UWB) sensing for collision avoidance

2023 – 2024

Expert for Mitsubishi Electric Corporation

- Law firm: Xsensus LLP, Alexandria, VA
- Case name: *TCL Communication Technology Holdings Limited, TCT Mobile International Limited, TCT Mobile, Inc., TCT Mobile (US) Inc., TCT Mobile (US) Holdings Inc. v. Mitsubishi Electric Corp.*
- PTAB Case Nos. IPR2023-00957, IPR2023-00997
- Submitted declarations
- Law firm: Devlin Law Firm, LLC, Wilmington, DE
- Case name: *Mitsubishi Electric Corporation and Sisvel International S.A., vs. TCL Communication Technology Holdings Limited, TCT Mobile International Limited, TCT Mobile (US) Inc., and TCT Mobile (US) Holdings Inc.*
- Case No. 8:22-cv-01073-GW-DFM (C.D. Cal.)
- Submitted declarations
- Technology at issue: cellular communications

2023 – 2023

Expert for Lemko Corp.

- Law firm: Kramer Levin, New York, NY
- Case name: *Microsoft Corporation and Affirmed Networks, Inc. v. Lemko Corporation*
- PTAB Case Nos. IPR2023-00529, IPR2023-00530, IPR2023-00531, IPR2023-00570
- Technology at issue: implementation of cellular networks
- Submitted a declaration
- Testified at deposition

2022 – 2025

Expert for Ford Motor Company

- Law firm: Latham and Watkins (2022-2023); Brooks Kushman P.C. (2023-)
- Case name: *Neo Wireless LLC v. Ford Motor Company, General Motors, and Nissan North America, Inc.*
- PTAB Case No. IPR 2023-00763
- Submitted declarations in support of petitions for *Inter Partes* review
- Testified at depositions
- Technology at issue: wireless communications

2021 – 2024

Expert for Flexiworld Technologies

- Law firm: Nelson Bumgardner Conroy, Dallas, TX
- Case name: *Roku, Inc. v. Flexiworld Technologies*

- PTAB Case Nos. IPR2021-00713, IPR2021-00714, IPR2021-00715, PGR2021-00112, IPR2022-00775
- Submitted multiple declarations
- Testified at multiple depositions

2014 – 2023

Expert for TQ Delta, Austin, TX

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

2022 – 2024

Expert for Bell Northern Research

- Law firm: Devlin Law Firm LLC
- Case name: *Bell Northern Research, LLC v. HMD America, Inc. et al.*,
- Civil Action No. 1:22-cv-22706-RNS (S.D. Fla)
- ITC Investigation: No. 337-TA-1367
- Technology at issue: wireless communications
- Submitted declaration
- Testified at deposition

2023 – 2024

Expert for Bell Northern Research

- Law firm: Devlin Law Firm LLC
- Case Name: International Trade Commission Investigation No. 337-TA-3568, Certain Electronic Devices Having Wireless Communication Capabilities and Components Thereof
- Technology at issue: wireless local area networking
- Submitted declaration and reports
- Testified at deposition

2023 – 2023

Expert for WSOU Investments, LLC d/b/a Brazos Licensing and Development

- Law firm: Folio Law Group

- Case name: *WSOU Investments, LLC d/b/a Brazos Licensing and Development v. Google, LLC.*,
- Case No. *6:20-cv-00585-ADA (W.D. Tex.)*
- Submitted a validity report
- Testified at a deposition
- Technology at issue: determining a location of a mobile device and location-based services

2021 – 2023

Expert for TQ Delta, Austin, TX

- Law firm: Davis Law Firm, P.C., Longview TX, and McAndrews, Chicago, IL
- Case name: TQ Delta, LLC, v. Commscope Holding Company, Inc., Commscope Inc., Arris International Limited, Arris Global Ltd, Arris US Holdings, Inc., Arris Solutions, Inc., Arris Technology, Inc., and Arris Enterprises, LLC
- Civil Action No: 2:21-cv-310-JRG, 2:21-cv-309-JRG (*E.D. Tex.*)
- Submitted a declaration in connection with claim construction, infringement report, validity report, and reports on testing and simulation
- Testified at two depositions and at trial

2021 – 2023

Expert for WSOU Investments, LLC d/b/a Brazos Licensing and Development

- Law firm: Kasowitz Benson Torres LLP
- Case name: *WSOU Investments, LLC d/b/a Brazos Licensing and Development v. Canon, Inc.*,
- Case Nos. *6:20-cv-00980-ADA, 6:20-cv-00981-ADA (W.D. Tex.)*
- Submitted a declaration in connection with claim construction.
- Testified at a deposition
- Technology at issue: frequency-hopping wireless communication

2021 – 2022

Expert for NXP

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

2021 – 2022

Expert for Barkan Wireless IP Holdings, L.P.

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

- 2021 – 2022 Expert for 3G Licensing
- Law firm: Devlin Law Firm LLC
 - Case name: *Cradlepoint, Inc., Dell Inc., Honeywell International, Inc., Sierra Wireless, Inc., TCL Communication Technology Holdings Limited, TCT Mobile International Limited, TCT Mobile, Inc., TCT Mobile (US) Inc., TCT Mobile (US) Holdings Inc., Thales DIS AIS Deutschland GmbH, ZTE Corporation, and ZTE (USA) Inc. v. 3G Licensing, S.A.*
 - PTAB Case Nos. IPR2021-00640, IPR2021-01141
 - Technology at issue: cellular communications
 - Submitted declarations
 - Testified at a deposition
- 2019 – 2022 Expert for Evolved Wireless LLC, Austin, TX
- Law firm: Nelson Bumgardner Albritton P.C., Fort Worth, TX (2019–22); Bruster PLLC, Southlake, TX (2022–present)
 - Patent portfolio review
 - IPR2021-00943
 - Technology at issue: 4G cellular communications
- 2020 – 2021 Expert for General Access Solutions, Dallas, TX
- Law firm: Bartlit Beck, Denver, CO
 - Case name: *General Access Solutions, LTD. v. Virgin Mobile USA, L.P., Boost Mobile, LLC, and Sprint Spectrum L.P.*
 - Civil Action No. 2:20-cv-00007-RWS (E. D. Tex.)
 - Submitted a report on standards essentiality
 - Testified at a deposition
 - Technology at issue: protocol architecture to support beamforming in 4G and 5G cellular standards
- 2015 – 2019 Expert for Evolved Wireless, Austin, TX
- Law firm: Robins Kaplan, Minneapolis, MN
 - Civil Actions No. 15-cv-542-SLR-SRF, No. 15-cv-543-SLR-SRF, No. 15-cv-544-SLR-SRF, No. 15-cv-545-SLR-SRF, No. 15-cv-546-SLR-SRF, and No. 15-cv-547-SLR-SRF (D-Del.) brought against Apple, HTC, Lenovo, Samsung, ZTE, and Microsoft.
 - Submitted infringement and validity reports
 - Testified at deposition and trial
 - Technologies at issue: 4G cellular communications
- 2013 – 2015 Expert for Inter-Digital
- Law firm: Latham and Watkins
 - Subject matter: dual-mode 3G cellular/Wi-Fi devices in connection with Civil Actions No. 13-cv-00009-RGA and No. 13-cv-00010-RGA (D-Del.) brought against ZTE and Microsoft Mobile Oy.

- For the purpose of infringement analysis wrote a 3G mobile phone application and server software
- Produced six expert reports, deposed twice and testified at jury trial