

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Woojin Ahn, et al. Attorney Docket No. 39843-0199IP1
U.S. Patent No.: 11,516,879
Issue Date: November 29, 2022
Appl. Serial No.: 17/383,479
Filing Date: July 23, 2021
Title: WIRELESS COMMUNICATION METHOD USING ENHANCED
DISTRIBUTED CHANNEL ACCESS, AND WIRELESS
COMMUNICATION TERMINAL USING SAME

DECLARATION OF EXPERT

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

Date: May 28, 2025

By: Matthew C. Valenti
Dr. Matthew Valenti

Table of Contents

I.	ASSIGNMENT.....	4
II.	QUALIFICATIONS AND BACKGROUND INFORMATION.....	4
III.	OVERVIEW OF CONCLUSIONS FORMED	11
IV.	LEVEL OF ORDINARY SKILL IN THE ART.....	12
V.	LEGAL STANDARDS	13
	A. Terminology.....	13
	B. “Prior Art”.....	14
	C. Anticipation.....	14
	D. Obviousness	15
VI.	MATERIALS CONSIDERED	19
VII.	Technology Background.....	20
	A. Wireless Communication Networks.....	20
	B. IEEE 802.11 and WiFi.....	20
	C. Contention-Based Transmissions and Access Categories	21
	D. Trigger-Based Transmissions and UL-MU	25
	E. Beacon Frames.....	29
	F. MPDUs and PPDU.....	29
	G. Acknowledgement (ACK) Policy.....	32
VIII.	THE ’879 PATENT	33
	A. Overview of the ’879 Patent	33
	B. Prosecution History of the ’879 Patent.....	35
IX.	OVERVIEW AND COMBINATIONS OF PRIOR ART REFERENCES ..	36
	A. Overview of Zhou (SAMSUNG-1004/SAMSUNG-1005).....	37
	B. Overview of Cherian (SAMSUNG-1006/SAMSUNG-1007).....	40
	C. Overview of Kim (SAMSUNG-1008).....	42
	D. Overview of Ho (SAMSUNG-1018).....	43
	E. Overview of Bharghavan (SAMSUNG-1010)	44
	F. Combination of Zhou-Cherian-Kim (SAMSUNG-1004-SAMSUNG-1005-SAMSUNG-1008).....	46
	G. Combination of Zhou-Cherian-Kim-Ho (SAMSUNG-1004-SAMSUNG-1005-SAMSUNG-1018).....	55
	H. Combination of Zhou-Cherian-Kim-Bharghavan (SAMSUNG-1004-SAMSUNG-1005-SAMSUNG-1008-SAMSUNG-1010)	59
X.	MANNER IN WHICH THE PRIOR ART REFERENCES RENDER THE ’879 CLAIMS UNPATENTABLE	64

A.	Ground 1: Combination of Zhou-Cherian-Kim Renders Obvious Claims	
	1-3, 8-10.....	65
	Claim 1.....	65
	Claim 2.....	116
	Claim 3.....	119
	Claim 8.....	121
	Claim 9.....	127
	Claim 10.....	127
B.	Ground 2 – Combination of Zhou-Cherian-Kim-Ho Renders Obvious	
	Claims 4-5.....	127
	Claim 4.....	127
	Claim 5.....	131
C.	Ground 3 – Combination of Zhou-Cherian-Kim- Bharghavan Renders	
	Obvious Claims 6-7	133
	Claim 6.....	133
	Claim 7.....	141
XI.	CONCLUSION.....	142

I. ASSIGNMENT

1. I have been retained on behalf of Samsung Electronics Co., Ltd. (“Samsung”) to offer technical opinions related to 11,516,879 (“the ’879 patent”) (SAMSUNG-1001). I understand that Samsung is requesting that the Patent Trial and Appeal Board (“PTAB” or “Board”) to institute an *inter partes* review (“IPR”) proceeding of the ’879 patent.

2. I have been asked to provide my independent analysis of the ’879 patent based on the prior art publications cited in this declaration.

3. I am not and never have been, an employee of Samsung. I received no compensation for this declaration beyond my normal hourly compensation based on my time actually spent analyzing the ’879 patent, the prior art publications cited below, and issues related thereto, and I will not receive any added compensation based on the outcome of any IPR or other proceeding involving the ’879 patent.

II. QUALIFICATIONS AND BACKGROUND INFORMATION

4. I am over the age of 18 and am competent to write this declaration. I have personal knowledge, or have developed knowledge of these technologies based upon education, training, or experience, of the matters set forth herein.

5. My qualifications are summarized here and explained in more detail in my curriculum vitae, which is attached as Appendix A to this report. Appendix A also includes a list of my publications and the cases in which I have testified at

deposition, hearing, or trial within the past four years.

6. I received a Bachelor of Science degree in Electrical Engineering from Virginia Polytechnic Institute & State University (Virginia Tech) in May 1992. I received a Master of Science degree in Electrical Engineering from Johns Hopkins University in May 1995 and a Ph.D. in Electrical Engineering from Virginia Tech in 1999.

7. From 1992 to 1995 I served as an Electronics Engineer at the U.S. Naval Research Laboratory in Washington DC. During this time, I worked on signal processing systems, including systems that used adaptive antenna arrays.

8. From 1995 to 1999, I was a Graduate Research Assistant and Instructor in the Bradley Department of Electrical and Computer Engineering at Virginia Tech. For my Ph.D. research while working as a research assistant, I conducted in-depth investigations into signal processing and error-control coding techniques specifically tailored for wireless communication systems including wireless and cellular networks.

9. From 1999 to present, I have been a faculty member at West Virginia University in Morgantown, West Virginia. I was initially appointed as an Assistant Professor, was promoted to Associate Professor with tenure in 2005, and then was promoted to Professor in 2010. At WVU, I regularly teach the senior undergraduate course on Wireless Networking (CPE 462), which covers key

concepts behind modern wireless networks, including orthogonal frequency division multiple access (OFDMA), channel access techniques, multiple-input multiple-output (MIMO) antenna systems, automatic repeat request, and link adaptation. I also teach graduate courses on Coding Theory (EE 567) and Communication Theory (EE 561). In addition to my teaching, I run an active funded research program focused on wireless communications and signal processing. I have advised over 50 graduate students who worked in my lab, including 10 Ph.D. students, to degree completing.

10. I have authored numerous technical papers on various aspects of mobile and wireless communication systems that have been published in well-respected, peer-reviewed journals, such as the *IEEE Transactions on Communications*, *IEEE Transactions on Wireless Communications*, and the *International Journal on Wireless Information Networks*.

11. I have extensive experience in developing software for the simulation and implementation of various aspects of wireless communication systems, including error-control coding and adaptive modulation. My software is freely available to the public in a package called the *Coded Modulation Library (CML)*¹. The software implements certain portions of several standardized systems

¹ <https://github.com/wvu-wcrl/CML>.

including WiMAX, UMTS, HSDPA, and LTE.

12. I have experience designing transmission schemes for the uplink of a wireless network. For instance, in the paper “Analysis of a frequency-hopping millimeter-wave cellular uplink,” published in the October 2016 issue of *IEEE Transactions on Wireless Communications*, I analyzed the uplink for a system that uses millimeter-wave frequencies and single-carrier frequency-division multiple access (SC-FDMA), which is a relative of OFDMA. I discuss OFDMA and uplink transmission below in the technology tutorial.

13. I have experience designing channel access schemes for wireless networks. For instance, in a paper entitled “Exclusion and guard zones in DS-CDMA ad hoc networks” published the June 2013 issue of *IEEE Transactions on Communications*, I analyzed a wireless network that uses a carrier-sense multiple access (CSMA) protocol. I discuss channel access schemes, including CSMA, below in the technology tutorial.

14. I am an active member of the *Institute for Electrical and Electronic Engineers* (IEEE), the world’s largest technical professional organization with the aims of fostering technological innovation and excellence. As an IEEE member, I have been involved in running some of the most impactful journals and conferences in the field of wireless communications. For instance, I have served in many roles for *IEEE Transactions on Wireless Communications*, including

chairing the Executive Editorial Committee and chairing the Steering Committee.

Moreover, I have served in various program committee roles including serving as Technical Program Chair, which is the top technical leadership position, for the *IEEE International Conference on Communications* (ICC), which is a flagship conference of the IEEE Communications Society that attracts thousands of papers and participants annually.

15. In 2018, my research achievements were honored with elevation to *IEEE Fellow* status. As the most prestigious level of membership within the IEEE, the Fellow grade recognizes individuals through a stringent selection process. No more than 0.1% of IEEE members are elevated annually to Fellow, underscoring the distinction and selectivity of this recognition.

16. Since 2011, I have been registered as a Professional Engineer (P.E.) in the state of West Virginia. This licensure affirmed my engineering proficiency through the successful completion of rigorous examinations and the attaining of sufficient experience. To retain this licensure, I remain committed to upholding these proficiencies by engaging in continuing education and contributing to the advancement of engineering knowledge.

17. Taken as a whole, my academic and practical experience have given me a substantial basis upon which to evaluate the technology that is in question in the claims of the '879 Patent. Based on my experience and education, and the

acceptance of my publications and professional recognition by peers in my field, I believe that I am qualified to opine as to the knowledge and level of skill of one of ordinary skill in the art at the time of the alleged invention of the '879 Patent (which I further describe below) and what such a person would have understood at that time, and the state of the art during that time.

18. A complete copy of my curriculum vitae, which includes a list of my publications and contains further details on my education, experience, publications, patents, and other qualifications to render an expert opinion, is attached as an appendix.

19. In writing this Declaration, I have considered the following: my own knowledge and experience, including my work experience in the fields of wireless communication protocols; my experience in teaching those subjects; and my experience in working with others involved in those fields. In addition, I have analyzed the following publications and materials, in addition to other materials I cite in my declaration:

20. I have reviewed the '879 patent (SAMSUNG-1001), and relevant excerpts of the prosecution history (SAMSUNG-1002) of the '879 patent. Among various textbooks, documents, and publications, I have also reviewed the following prior art references:

- U.S. Pub. No.: 2017/0202023 (“Zhou”) (SAMSUNG-1004)

- Provisional Patent Application No. 62/278,268 (“Zhou-Prov”) (SAMSUNG-1005)
- U.S. Pub. No.: 2017/0325264 (“Cherian”) (SAMSUNG-1006)
- Provisional Patent Application No. 62/333,745 (“Cherian-Prov”) (SAMSUNG-1007)
- U.S. Pub. No.: 2018/0034595 (“Kim”) (SAMSUNG-1008)
- U.S. Pub. No.: 2018/0352572 (“Cariou”) (SAMSUNG-1009)
- U.S. Patent No.: 9,197,482 (“Bharghavan”) (SAMSUNG-1010)
- IEEE-802.11-16/1180r0 (SAMSUNG-1012)
- Excerpts from the Prosecution History of U.S. Patent 11,116,035 (SAMSUNG-1013)
- CWAP: Certified Wireless Analysis Professional, Official Study Guide, McGraw Hill, 2004 (SAMSUNG-1016)
- 802.11: Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Standard, IEEE Computer Society, 2012 (SAMSUNG-1017)
- U.S. Pub. No.: 2010/0195664 (“Ho”) (SAMSUNG-1018)
- IEEE 802.11-16/0024r1 (SAMSUNG-1022)

21. Counsel (Fish & Richardson) has informed me that I should consider these materials through the lens of one of ordinary skill in the art related to the

'879 patent at the time of the earliest possible priority date of the '879 patent, and I have done so during my review of these materials. I have been informed by Counsel to use the date of September 7, 2016 as the Priority Date.

22. I have no financial interest in the outcome of this proceeding. I am being compensated for my work as an expert on an hourly basis. My compensation is not dependent on the outcome of these proceedings or the content of my opinions.

23. My opinions, as explained below, are based on my education, experience, and expertise in the fields relating to the '879 Patent. Unless otherwise stated, my testimony below refers to the knowledge of one of ordinary skill in the art as of the earliest possible priority date. Any figures that appear within this document have been prepared with the assistance of Counsel and reflect my understanding of the '879 Patent and the prior art discussed below.

III. OVERVIEW OF CONCLUSIONS FORMED

24. This declaration explains the conclusions that I have formed based on my analysis of all of the considered materials and my personal experience. To summarize those conclusions, based upon my knowledge and experience and my review of the prior art references listed above, I believe that:

- Ground 1: Claims 1-3, 8-10 are obvious in view of Zhou, Cherian, Kim

- Ground 2: Claims 4-5 are obvious in view of Zhou, Cherian, Kim, Ho
- Ground 3: Claims 6-7 are obvious in view of Zhou, Cherian, Kim, Bharghavan

25. In support of these conclusions, I provide an overview of the references in Section IX and more detailed comments regarding the obviousness of claims 1-10 (“the Challenged Claims”) of the ’879 patent in Section X.

IV. LEVEL OF ORDINARY SKILL IN THE ART

26. In my opinion, a person of ordinary skill in the art (“POSITA”) relating to, and at the time of, the Priority Date would have been someone with 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 (“POSITA”). Increased educational experience can make up for less work experience, and vice versa.

27. Further, all positions in this declaration are from the vantage point of a POSITA as of September 7, 2016.

28. Based on my experiences, I have a good understanding of the capabilities of a POSITA. Indeed, I have taught, participated in organizations, and worked closely with many such persons over the course of my career. Based on

my knowledge, skill, and experience, I have an understanding of the capabilities of a POSITA. For example, from my industry experience, I am familiar with what a POSITA would have known and found predictable in the art. From teaching and supervising my post-graduate students, I also have an understanding of the knowledge that a person with this academic experience possesses. Furthermore, I possess those capabilities myself and would have satisfied the criteria to be a POSITA at the time of the invention.

V. LEGAL STANDARDS

A. Terminology

29. I have been informed by Counsel and understand that the best indicator of claim meaning is its usage in the context of the patent specification as understood by one of ordinary skill. I further understand that the words of the claims should be given their plain meaning unless that meaning is inconsistent with the patent specification or the patent's history of examination before the Patent Office. Counsel has also informed me, and I understand that, the words of the claims should be interpreted as they would have been interpreted by one of ordinary skill at the time of the invention was made (not today). The '879 patent was filed July 23, 2021, and claims priority to a Korean application filed September 7, 2016, which I refer to as the "Critical Date" in this proceeding. Because I do not know at what date the invention as claimed was made, if ever, I

have used the Critical Date of the '879 patent as the point in time for claim

interpretation purposes. My opinion does not change if the invention date is earlier.

B. “Prior Art”

30. I have been informed by Counsel and understand that documents and materials that qualify as prior art can render a patent claim unpatentable as being anticipated or obvious.

31. I am informed by Counsel and understand that all prior art references are to be looked at from the viewpoint of a person of ordinary skill in the art at the time of the invention, and that this viewpoint prevents one from using his or her own insight or hindsight in deciding whether a claim is anticipated or rendered obvious.

C. Anticipation

32. I understand that patents or printed publications that qualify as prior art can be used to invalidate a patent claim as anticipated or as obvious.

33. I understand that, once the claims of a patent have been properly construed, the second step in determining anticipation of a patent claim requires a comparison of the properly construed claim language to the prior art on a limitation-by-limitation basis.

34. I understand that a prior art reference “anticipates” an asserted claim, and thus renders the claim invalid, if all limitations of the claim are disclosed in

that prior art reference, either explicitly or inherently (i.e., necessarily present).

D. Obviousness

35. I understand that even if a patent is not anticipated, it is still invalid if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a POSITA.

36. I have been informed by Counsel and understand that a claim is unpatentable for obviousness and that obviousness may be based upon a combination of references. I am informed by Counsel and understand that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. However, I am informed by Counsel and understand that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art.

37. I am informed by Counsel and understand that when a patented invention is a combination of known elements, a court determines whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue by considering the teachings of prior art references, the effects of demands known to people working in the field or present in the marketplace, and the background knowledge possessed by a person having ordinary skill in the

art.

38. I am informed by Counsel and understand that a patent claim composed of several limitations is not proved obvious merely by demonstrating that each of its limitations was independently known in the prior art. I am informed by Counsel and understand that identifying a reason those elements would have been combined can be important because inventions in many instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be combinations of what, in some sense, is already known. I am informed by Counsel and understand that it is improper to use hindsight in an obviousness analysis, and that a patent's claims should not be used as a "roadmap."

39. I am informed by Counsel and understand that an obviousness inquiry requires consideration of the following factors: (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called "secondary considerations" of non-obviousness, which include: (i) "long felt need" for the claimed invention, (ii) commercial success attributable to the claimed invention, (iii) unexpected results of the claimed invention, and (iv) "copying" of the claimed invention by others.

40. I have been informed by Counsel and understand that an obviousness evaluation can be based on a single reference or a combination of multiple prior art references. I understand that the prior art references themselves may provide a

suggestion, motivation, or reason to combine, but that the nexus linking two or more prior art references is sometimes simple common sense. I have been informed by Counsel and understand that obviousness analysis recognizes that market demand, rather than scientific literature, often drives innovation, and that a motivation to combine references may be supplied by the direction of the marketplace.

41. I have been informed by Counsel and understand that if a technique has been used to improve one device, and a person of ordinary skill at the time of invention would have recognized that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill.

42. I have been informed by Counsel and understand that practical and common-sense considerations should guide a proper obviousness analysis, because familiar items may have obvious uses beyond their primary purposes. I have been informed by Counsel and understand that a person of ordinary skill looking to overcome a problem will often be able to fit together the teachings of multiple prior art references. I have been informed by Counsel and understand that obviousness analysis therefore takes into account the inferences and creative steps that a person of ordinary skill would have employed at the time of invention.

43. I have been informed by Counsel and understand that a proper

obviousness analysis focuses on what was known or obvious to a person of ordinary skill at the time of invention, not just the patentee. Accordingly, I understand that any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed.

44. I have been informed by Counsel and understand that a claim can be obvious in light of a single reference, without the need to combine references, if the elements of the claim that are not found explicitly or inherently in the reference can be supplied by the common sense of one of skill in the art.

45. In sum, my understanding is that prior art teachings are properly combined where one of ordinary skill having the understanding and knowledge reflected in the prior art and motivated by the general problem facing the inventor, would have been led to make the combination of elements recited in the claims. Under this analysis, the prior art references themselves, or any need or problem known in the field of endeavor at the time of the invention, can provide a reason for combining the elements of multiple prior art references in the claimed manner.

46. I have been informed by Counsel and understand that in an *inter partes* review, “the petitioner shall have the burden of proving a proposition of unpatentability,” including a proposition of obviousness, “by a preponderance of the evidence.” 35 U.S.C. §316(e).

VI. MATERIALS CONSIDERED

47. My analysis and conclusions set forth in this declaration are based on my educational background and experiences in the field (*see* Section II). Based on my knowledge and experience, I believe that I am considered to be an expert in the field. Also, based on my knowledge and experience, I understand and know of the capabilities of persons of ordinary skill in the field around the Critical Date, and I taught, participated in organizations, and worked closely with many such persons in the field during that time frame.

48. As part of my independent analysis for this declaration, I have considered the following: the background knowledge/technologies that were commonly known to persons of ordinary skill in this art during the time before the Critical Date; my own knowledge and experiences gained from my work experience in the field of the '879 patent and related disciplines; and my experience in working with others involved in this field and related disciplines.

49. In addition, I have analyzed the publications and materials listed above (*see* Section II).

50. My analysis and conclusions set forth in this declaration are based on the perspective of a POSITA.

VII. Technology Background²

A. Wireless Communication Networks

51. A *wireless network* is a communication system that enables devices to exchange data without physical cables, using radio waves instead. In a typical *wireless local area network* (WLAN), such as a *Wi-Fi* network, the network consists of one or more *access points* (APs) that serve as central hubs.

SAMSUNG-1016, pp.21-24³. These APs manage and coordinate communications for a group of connected devices known as *stations* (STAs). Common examples of STAs include laptop computers, smartphones, and IoT devices. SAMSUNG-1016, pp.39-41, 58-59. The AP provides connectivity to these mobile devices, often acting as a bridge to a broader network infrastructure, such as the internet.

SAMSUNG-1016, pp.314-316. In a WLAN, each transmission is over either an *uplink* or a *downlink*. The *uplink* refers to communications from the STA to the AP, while the *downlink* refers to communications from the AP to the STA.

SAMSUNG-1017, pp.10, 24.

B. IEEE 802.11 and WiFi

52. *IEEE 802.11* is a family of standards developed by the *Institute of*

² An acronym table is provided as Appendix B to this Declaration.

³ Page numbers refer to the PDF pagination unless otherwise noted.

Electrical and Electronics Engineers (IEEE) defining technical specifications for WLANs. These standards form the foundation for *Wi-Fi*. SAMSUNG-1016, pp.24-30. The 802.11 standard specifies how wireless devices communicate over the air at the MAC (Media Access Control) and PHY (Physical Layer) levels, including details such as modulation, timing, access protocols, and data rates. SAMSUNG-1016, Chapter 5 and 8. Following the original IEEE 802.11 standard, each subsequent revision within the family has been numbered with a one or two-letter suffix, such as 802.11g, 802.11e, and 802.11n. SAMSUNG-1017, p. ix.

C. Contention-Based Transmissions and Access Categories

53. In Wi-Fi (IEEE 802.11) networks, most uplink transmissions are contention-based, meaning devices must compete for access to transmit on the uplink, which is a shared wireless channel. SAMSUNG-1016, pp.77-81. To manage sharing of the uplink, 802.11 uses a protocol called *CSMA/CA* (Carrier Sense Multiple Access with Collision Avoidance). SAMSUNG-1017, pp.11, 35, 818-819. When a STA has data to transmit, it first monitors the channel. If the channel is idle, the STA waits for a fixed amount of time called the *Arbitration Inter-Frame Space* (AIFS) and then initiates a backoff procedure to reduce the risk of collisions. SAMSUNG-1017, pp.567-569, 834-844. The backoff timer is assigned a value that is randomly selected from a range between 0 and the *Contention Window* (CW) value, which is initially a minimum value denoted by

CW_{min}. SAMSUNG-1017, pp.567-569, 836-837. If the channel is idle, the backoff timer decrements, and when the backoff timer reaches zero, the STA attempts to transmit. SAMSUNG-1017, *Id.*; 818-819. If the STA senses that the channel is busy during the countdown, the timer is paused and resumes once the channel is idle again for a new AIFS period. SAMSUNG-1017, pp.876-879. If the channel is busy when the backoff timer reaches zero, the CW value is increased (up to a maximum value of *CW_{max}*), another random value is selected from the range between 0 and the new CW value, and the process starts over with the backoff timer reset to the newly selected random value. SAMSUNG-1017, 567-568, 834-837, 876-879.

54. To support *Quality of Service* (QoS), IEEE 802.11e introduced *EDCA* (Enhanced Distributed Channel Access). EDCA extends the basic CSMA/CA mechanism by defining four *Access Categories* (ACs), each with its own independent queue and contention parameters. SAMSUNG-1017, pp.663-664. These categories allow the network to prioritize different types of traffic. SAMSUNG-1017, 389-419, 663-664.

55. Each access category uses its own values for the contention parameters including *CW_{min}*, *CW_{max}*, and AIFS, which are collectively known as the *EDCA Parameter Set* as seen in example Table 8-106. SAMSUNG-1017, pp.820-822, Table 8-106.

Table 8-106—Default EDCA parameter set for STA operation if dot11OCBAActivated is true

AC	CWmin	CWmax	AIFSN	TXOP Limit OFDM/CCK- OFDM PHY
AC_BK	aCWmin	aCWmax	9	0
AC_BE	aCWmin	aCWmax	6	0
AC_VI	$(aCWmin+1)/2-1$	aCWmin	3	0
AC_VO	$(aCWmin+1)/4-1$	$(aCWmin+1)/2-1$	2	0

SAMSUNG-1017, Table 8-106.

56. This parameter set is typically broadcast by the AP in *beacon frames*, which instruct STAs how to prioritize traffic based on access category.

SAMSUNG-1017, pp.820-821. For example, voice traffic (AC VO) might have a smaller CWmin and shorter AIFS, allowing it to access the channel more quickly than background traffic (AC BK), which would use larger CW values and a longer AIFS. SAMSUNG-1017, 567-568. By differentiating access in this way, EDCA helps ensure that high-priority traffic gets timely access to the wireless medium, improving overall performance and user experience in QoS-sensitive applications. The 2012 revision of the IEEE 802.11 standard shows how User Priorities (UPs) are mapped to ACs, the contents of an EDCA parameter set element, and example associations of ACs to CW parameters. SANSUNG-1017, Table 9-1, Figure 8-192, Table 8-106.

Table 9-1—UP-to-AC mappings

Priority	UP (Same as 802.1D user priority)	802.1D designation	AC	Designation (informative)
Lowest  Highest	1	BK	AC_BK	Background
	2	—	AC_BK	Background
	0	BE	AC_BE	Best Effort
	3	EE	AC_BE	Best Effort
	4	CL	AC_VI	Video
	5	VI	AC_VI	Video
	6	VO	AC_VO	Voice
	7	NC	AC_VO	Voice

SAMSUNG-1017, Table 9-1.

Element ID	Length (18)	QoS Info	Reserve d	AC_BE Parameter Record	AC_BK Parameter Record	AC_VI Parameter Record	AC_VO Parameter Record
Octets:	1	1	1	4	4	4	4

Figure 8-192—EDCA Parameter Set element

SAMSUNG-1017, Figure 8-192.

Table 8-106—Default EDCA parameter set for STA operation if dot11OCBAActivated is true

AC	CW _{min}	CW _{max}	AIFSN	TXOP Limit OFDM/CCK- OFDM PHY
AC_BK	aCW _{min}	aCW _{max}	9	0
AC_BE	aCW _{min}	aCW _{max}	6	0
AC_VI	(aCW _{min} +1)/2-1	aCW _{min}	3	0
AC_VO	(aCW _{min} +1)/4-1	(aCW _{min} +1)/2-1	2	0

SAMSUNG-1017, Table 8-106.

D. Trigger-Based Transmissions and UL-MU

57. In addition to contention-based uplink transmissions—where each device independently contends for access to the channel by sensing the medium and using a random backoff timer—the wireless network can also employ trigger-based uplink transmissions. In this scheduled approach, the AP coordinates and initiates uplink transmissions by sending a Trigger Frame that assigns specific transmission parameters to one or more devices. SAMSUNG-1022, pp. 43-45, 43. With trigger-based transmission, the AP explicitly coordinates when and how the STAs transmit on the uplink through a process of *scheduling*. SAMSUNG-1022, pp. 43-45, 43 (“The UL MU operation allows an AP to solicit immediate simultaneous response frames from one or more non-AP STAs. Non-AP STAs transmit their response frames in HE trigger-based PPDU format”). This scheduling is accomplished through a special control message, the *Trigger Frame*,

sent by the AP to the STAs on the downlink. SAMSUNG-1022, pp.17 (“The Trigger frame is used to allocate resource for UL MU transmission and to solicit an UL MU transmission at [TBD IFS] after the PPDU that carries the Trigger frame.”), 43-45. Trigger-based transmission may be used to induce the simultaneous transmission of multiple STAs through a process referred to as *Uplink Multi-User* (UL-MU) communication. SAMSUNG-1022, pp.29-32, 43, 67, 124 (“UL MU-MIMO is a technique to allow multiple STAs to transmit simultaneously over the same frequency resource to the receiver.”). In UL-MU, multiple stations transmit to the AP at the same time, each using a portion of the available spectrum as defined by the Trigger Frame. SAMSUNG-1022, *Id.* This method eliminates contention among stations, allowing multiple devices to transmit simultaneously in a controlled and efficient manner. SAMSUNG-1022, pp.29-32, 43, 67, 124. Figures 2 and 10-5 below demonstrate examples of using a trigger frame to elicit a multi-STA response. SAMSUNG-1022, FIG. 2.

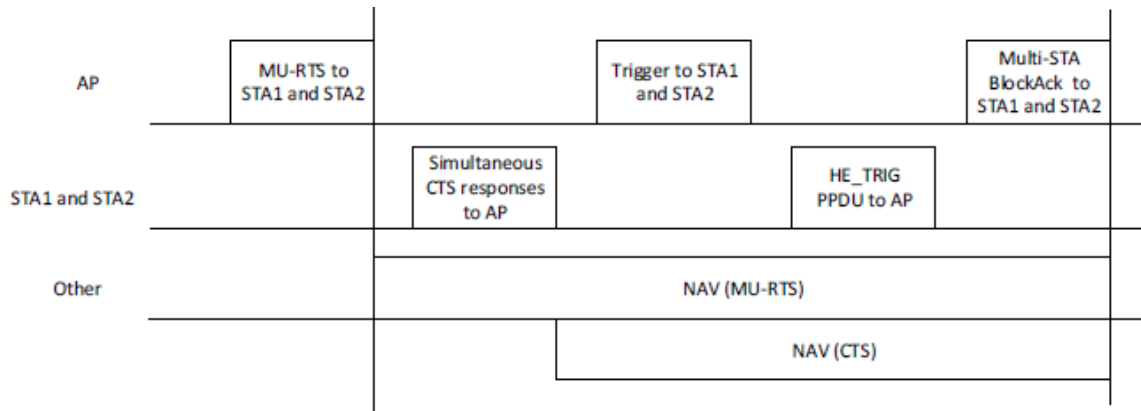


Figure 2 – Example of MU-RTS/CTS/Trigger/HE_TRIG PPDU/Multi-STA BlockAck and NAV setting

SAMSUNG-1022, Figure 2.

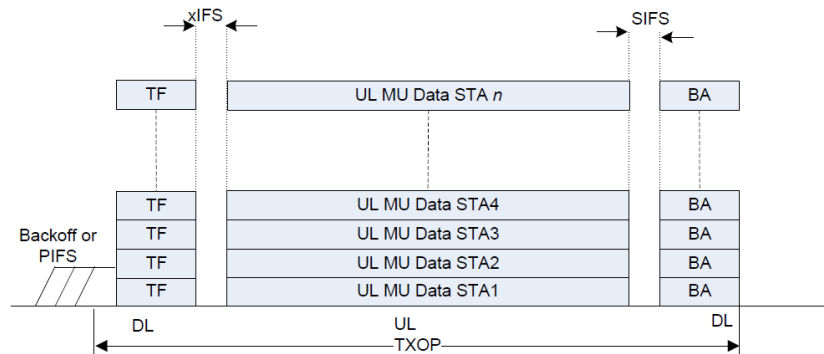


Figure 10-5 - An example of a TXOP containing an UL MU transmission with an immediate DL MU transmission containing unicast BlockAck frames acknowledging the frames received from the respective STAs

SAMSUNG-1022, Figure 10-5.

58. The Trigger Frame provides instructions to STAs, specifying the timing, transmission parameters, and channel resources to use for the uplink transmissions. SAMSUNG-1022, pp.17-18, 17 (“The Trigger frame also carries other information required by the responding STA to send UL MU.”). More specifically, it tells each STA exactly when to transmit, which portion of the

channel to use, and what modulation and coding scheme to apply. SAMSUNG-1022, pp.12-13. Once the Trigger Frame is received, the selected stations transmit in a tightly synchronized fashion, eliminating the need for contention. SAMSUNG-1022, FIGs. 10-5 through 10-8.

59. A key technology enabling UL-MU is *Orthogonal Frequency Division Multiple Access* (OFDMA). OFDMA divides the channel bandwidth into smaller subchannels called *Resource Units* (RUs). SAMSUNG-1022, p.124; SAMSUNG-1016, pp.262-263. These RUs can be independently assigned to different stations, allowing each station to use a subset of subcarriers for its transmission. For example, in a 20 MHz channel, the AP might divide the spectrum into several RUs and assign each to a different station, allowing them all to transmit concurrently. SAMSUNG-1022, pp.45-46, 67, 88. Another way to implement UL-MU is to use *Multiple Input Multiple Output* (MIMO) communications, wherein multiple antennas are used at each STA and AP. SAMSUNG-1022, pp.42-47, FIGs. 10-6 through 10-8; SAMSUNG-1017, p.56. More generally, UL-MU could be implemented using a combination of OFDMA and MIMO allowing resources to be carved up both in frequency and space. SAMSUNG-1022, p.43 (“The UL MU operation allows an AP to solicit immediate simultaneous response frames from one or more non-AP STAs. Non-AP STAs transmit their response frames in HE trigger-based PPDU format, in either UL MU

OFDMA UL MU-MIMO, or both.”); SAMSUNG-1012, pp.5-7.

E. Beacon Frames

60. A *beacon frame* is a type of management frame used in wireless networks to announce the presence and characteristics of a network. SAMSUNG-1017, pp.419-423. It is broadcast periodically by the access point to inform nearby STAs that the network is available and to provide the information needed to join and operate within it. SAMSUNG-1017, pp.847-848.

61. Beacon frames contain a variety of important information, including the network name, supported communication parameters, security capabilities, and timing details. SAMSUNG-1017, pp.419-423. One key purpose of the beacon frame is to allow mobile devices to discover available networks by scanning. SAMSUNG-1017, pp. 847-848, 869, 899. In addition to network identification, the beacon frame also provides synchronization services by including a timestamp that helps devices align their internal clocks with the network’s timing. SAMSUNG-1017, pp.419-423. For networks that support power-saving features, beacon frames may include scheduling information such as traffic indication maps, which let devices know if the network has buffered data available. SAMSUNG-1017, pp.974-977.

F. MPDUs and PPDU

62. Wireless networks such as IEEE 802.11, organize the network into

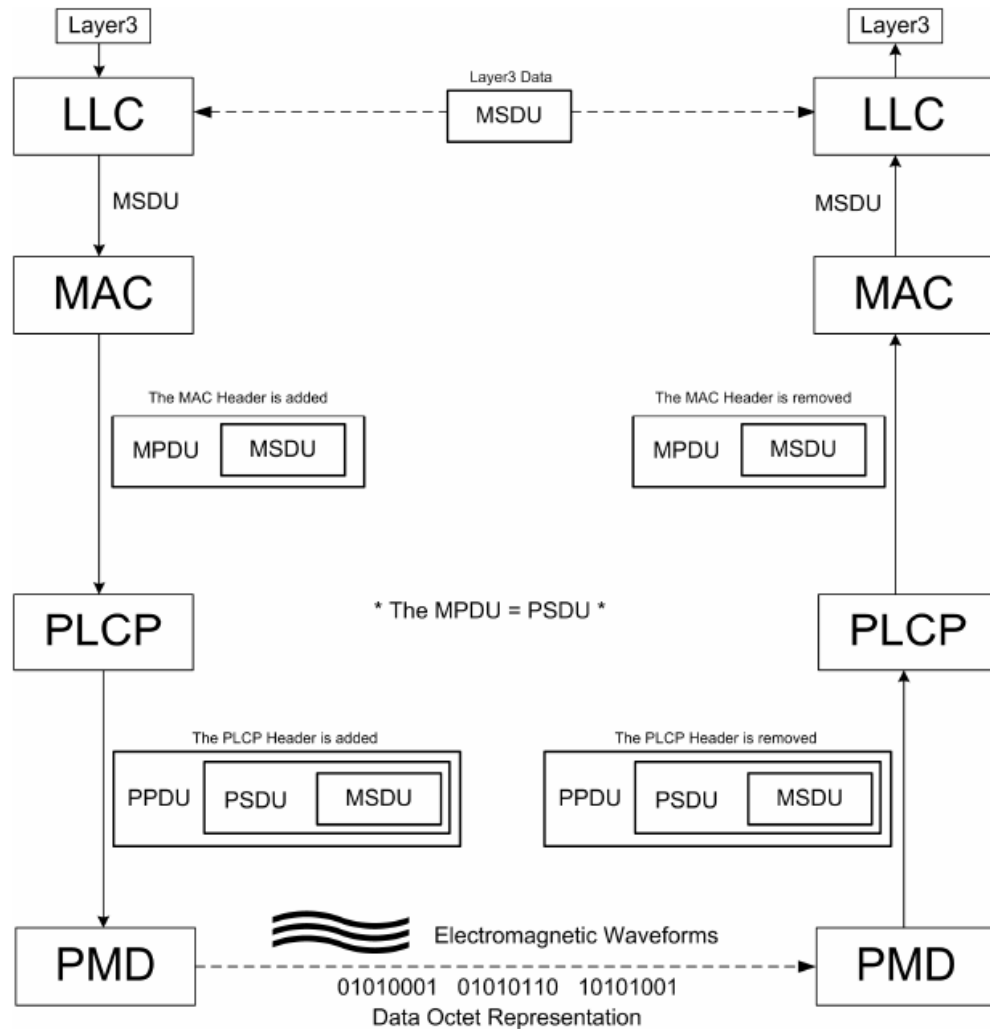
layers, with higher layers passing data down to lower layers until the lowest layer – called PHY (for physical layer) – is reached, which physically transmits the data to the receiver. Each layer adds its own headers and control information to ensure reliable and efficient communication. Two important data units in this layered architecture are the *MAC Protocol Data Unit* (MPDU) and the *Physical Protocol Data Unit* (PPDU). These units play central roles at the MAC layer and physical layer, respectively. SAMSUNG-1016, pp.166-169.

63. The MPDU is the data frame created by the MAC layer. It includes the MAC header, the data payload, and a frame check sequence (FCS) used for error detection. The MAC header contains information such as source and destination addresses, sequence numbers, and QoS (quality of service) information if applicable. SAMSUNG-1017, pp.380-382. The payload can be anything from a small control message to a large chunk of application data, depending on the transmission context. In later versions of IEEE 802.11, multiple MPDUs may be aggregated into a single transmission to reduce overhead and improve throughput. This is known as *A-MPDU* (Aggregated MPDU). SAMSUNG-1017, pp.95-97.

64. Once the MAC layer constructs the MPDU, the MPDU is passed down to the PHY layer, which packages it into a PPDU for transmission over the air. The PPDU includes the MPDUs, as well as a preamble and a PHY header. SAMSUNG-1016, pp.166-169. The preamble is used by the receiving device to

detect the presence of a transmission, synchronize timing, and perform channel estimation. The PHY header contains instructions for decoding the MPDU(s), such as the modulation and coding scheme used, the length of the transmission, and other relevant physical layer parameters. SAMSUNG-1016, pp.255-262. The PPDU is the final over-the-air frame—it's what the transmitter actually sends, and what the receiver picks up, decodes, and hands off to higher layers. SAMSUNG-1016, pp.166-169.

FIGURE 5.1 Frame Nomenclature



SAMSUNG-1016, Figure 5.1.

G. Acknowledgement (ACK) Policy

65. In wireless networks, particularly those using IEEE 802.11, *acknowledgments* – often referred to as *ACKs* – play a key role in ensuring data reliability. When a STA transmits a frame – whether part of a single-user or multi-user transmission – it typically expects a response from the AP confirming

successful reception. This response could be a simple ACK, a Block ACK (for aggregated data), or a Multi-STA Block ACK (in multi-user uplink scenarios). SAMSUNG-1022, pp.31-33, 34-36 The sender's expectations are governed by the *ACK policy*, which is indicated in the QoS Control field of the MAC header. SAMSUNG-1017, pp.391-392; SAMSUNG-1022, Tables 9-426a, 9-426b.

66. In trigger-based uplink transmissions, the access point (AP) schedules a single station or multiple stations to transmit simultaneously. SAMSUNG-1022, pp. 43-45, 43 (“The UL MU operation allows an AP to solicit immediate simultaneous response frames from one or more non-AP STAs. Non-AP STAs transmit their response frames in HE trigger-based PPDU format”). After receiving the data, the AP typically sends a *Multi-STA Block ACK*, which includes acknowledgment information for all participating stations. SAMSUNG-1017, pp.834, 904-917; SAMSUNG-1022, pp.34-36. However, if a station uses the *No ACK* policy, the AP may skip this response, reducing overhead when reliability isn't critical. Thus, the AP can determine whether or not to send a response to the triggered uplink transmission by appropriately checking the ACK policy. SAMSUNG-1017, pp.904-917; SAMSUNG-1022, Tables 9-426a, 9-426b.

VIII. THE '879 PATENT

A. Overview of the '879 Patent

67. The '879 Patent is directed to “a wireless communication terminal that

communicates wirelessly” with a base communication terminal. SAMSUNG-1001, Abstract. The disclosure focuses on improving the efficiency of wireless communication, particularly in scenarios involving contention-based channel access and multi-user uplink (UL-MU) transmissions. SAMSUNG-1001, 11:20-32.

68. The problem purportedly addressed by this patent is disclosed as arising particularly when multi-user uplink (UL-MU) transmissions are scheduled. SAMSUNG-1001, 10:24-31. In UL-MU transmission, a base station (e.g., a Wi-Fi access point) can allocate resources allowing multiple wireless terminals to transmit data to it simultaneously, often using technologies like Orthogonal Frequency-Division Multiple Access (OFDMA). SAMSUNG-1001, 11:3-32. A UL-MU transmission is useful when a large number of stations (STAs) need to transmit at the same time. *Id.* When a terminal is scheduled for such a transmission, its normal contention-based behavior might compromise the efficiency of the scheduled transmission or interfere with other terminals also participating in it. SAMSUNG-1001, 11:33-52.

69. The proposed solution involves a wireless communication terminal dynamically adapting its channel access behavior based on whether it is scheduled to participate in a multi-user uplink transmission. SAMSUNG-1001, 36:57-37:9. This involves establishing two sets of channel access parameters, a set of “legacy” parameters, which are suitable for conditions without UL-MU transmissions and a

set of MU parameters for use when the STA is scheduled for UL-MU transmissions. SAMSUNG-1001, 12:38-43, 30:27-28. A stated goal is to make a terminal that is scheduled for UL-MU transmission use the MU parameters which cause a STA to be less aggressive in its contention for the channel to prevent collisions. SAMSUNG-1001, 12:35-62.

70. To ensure the less aggressive MU EDCA parameters are not used indefinitely, which if allowed would result in delayed contention-based transmissions, the patent describes the use of MU EDCA timers. SAMSUNG-1001, 19:43-61, 22:49-64. These timers can be utilized based on events like receiving a trigger frame. *Id.* When the timer expires, the terminal may revert to its “legacy” EDCA parameters, thereby reverting to “legacy” contention-based timing. SAMSUNG-1001, 21:62-22:48, 24:59-25:31. Consequently, the system configured in such a manner is disclosed as providing the advantage(s) of reducing the number of contention-based collisions when stations receive indication (via a trigger frame) of a multi-STA uplink (UL-MU transmission). SAMSUNG-1001, 19:46-20:16.

B. Prosecution History of the '879 Patent

71. Counsel has informed me and I have reviewed that during prosecution of the '879 Patent, no claim rejections were made. SAMSUNG-1002. Rather, the application was allowed following an examiner interview discussing some

formalities, and the cancellation of two dependent claims by examiner's amendment. SAMSUNG-1002, 40, 1590.

72. During prosecution of the '879 Patent's parent application⁴, a non-final rejection issued rejecting certain claims as being obvious over various combinations of Cherian, IEEE (SAMSUNG-1012), Zhou, Liu, and Baron. SAMSUNG-1013, 732-737.

73. In response, Applicant amended claims to include two "when" clauses, which correspond to elements [1.5] and [1.6] in the Petition. These two "when" clauses will be explained in more detail in the analysis of the prior art, but each describe conditions for actions taken based on two separate conditions.

IX. OVERVIEW AND COMBINATIONS OF PRIOR ART REFERENCES

74. I understand that the Zhou and Cherian references may rely upon provisional application filings to qualify as prior art to the '879 patent by the dates discussed below. I have reviewed the relevant provisional applications for these references.

Reference	Priority Documents
Zhou (SAMSUNG-1004)	Zhou Provisional (SAMSUNG-1005)
Cherian (SAMSUNG-1006)	Cherina Provisional (SAMSUNG-1007)

⁴ Application No. 16/294,883, which issued as Patent No. 11,160,035.

75. Where I rely on those references for the prior art grounds, I have included parallel citations to these priority documents and/or explain how these priority documents support the reference by the Critical Date.

76. I also note that Zhou and Cherian explicitly incorporate the disclosures of the above provisional applications by reference. *See* SAMSUNG-1004, 0001; SAMSUNG-1006, 0001.

A. Overview of Zhou (SAMSUNG-1004/SAMSUNG-1005)

77. Zhou describes methods and apparatus for selecting enhanced distributed channel access (EDCA) parameters for different stations in a wireless communication system and is analogous to the '879 Patent. SAMSUNG-1004, Title; SAMSUNG-1005, Title, 0001, 0010. Zhou acknowledges that wireless networks often rely on the carrier sense multiple access (CSMA) mechanism for channel access, where devices sense the medium for idleness before transmitting. SAMSUNG-1004, 0026; SAMSUNG-1005, 0032. However, in dense network environments, relying on idleness sensing can lead to inefficiencies, increased latency, and reduced throughput. SAMSUNG-1004, 0027; SAMSUNG-1005, 0033. The increasing demand for bandwidth and the growing number of active wireless devices exacerbate these issues. SAMSUNG-1004, 0027; SAMSUNG-1005, 0033.

78. To overcome these challenges, especially with the advent of technologies allowing multiple stations (STA) to communicate simultaneously with a single access point (AP) via multi-user (MU) transmissions (such as MU-MIMO and UL-OFDMA for uplink (UL) communications), Zhou proposes a system for selecting and signaling enhanced distributed channel access (EDCA) parameters to different STAs. SAMSUNG-1004, 0045; SAMSUNG-1005, 0051. Zhou teaches the use of UL-MU transmissions (often associated with newer standards like 802.11ax) in combination with the EDCA parameters. SAMSUNG-1004, 0078; SAMSUNG-1005, 0011.

79. Zhou suggests that an AP could select different EDCA parameters, such as shorter transmission opportunity (TXOP) limits and/or larger minimum contention windows (CW_{min}) for STAs operating in different modes (UL-MU or UL-SU). SAMSUNG-1004, 0078, 0037, FIG. 5; SAMSUNG-1005, 0010-0011, 0043, FIG. 5. This adjustment aims to allow UL-MU enabled STAs to organize UL-MU transmissions in a more fair and efficient manner than legacy EDCA parameters used in legacy transmissions. *Id.*

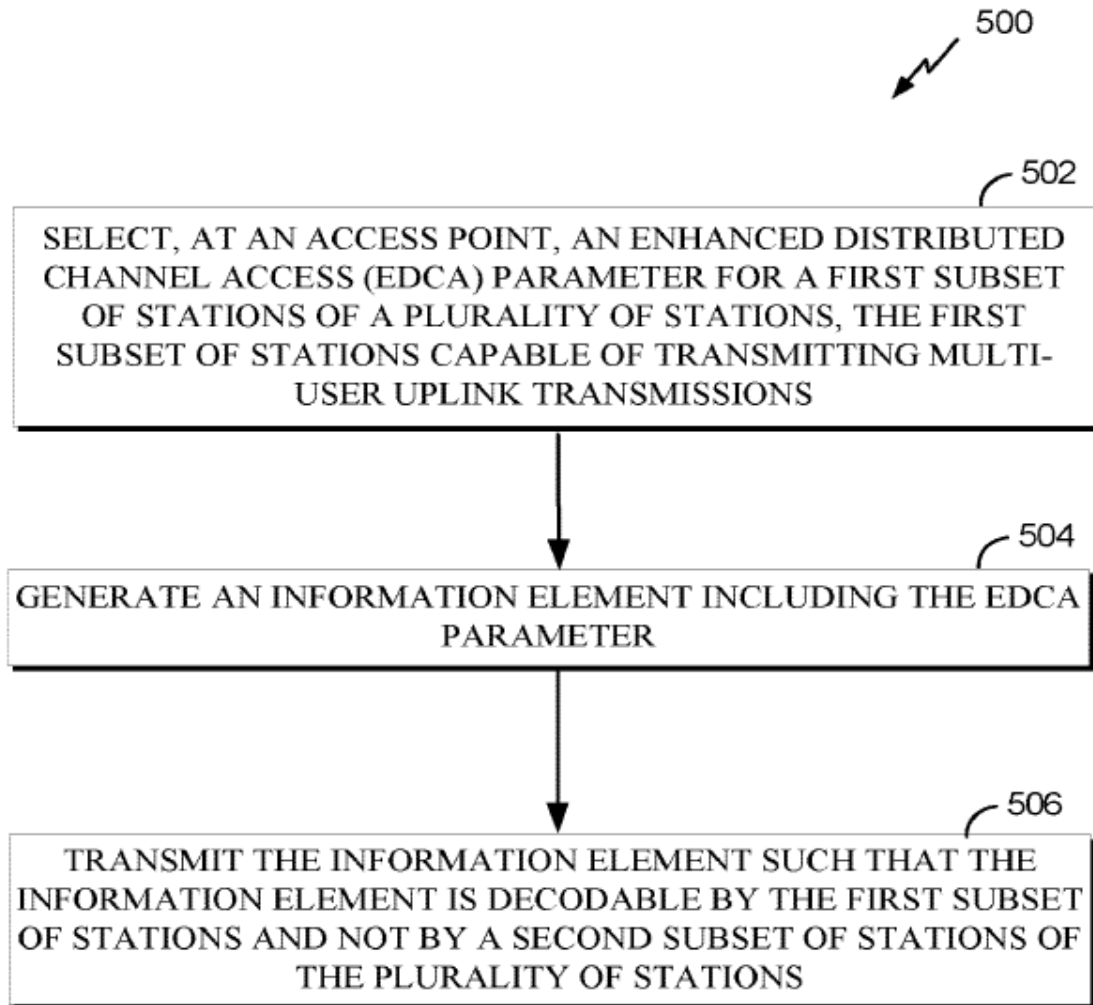


FIG. 5

SAMSUNG-1004, FIG. 5.

B. Overview of Cherian (SAMSUNG-1006/SAMSUNG-1007)

80. Analogous to the '879 Patent, Cherian addresses challenges in wireless communication systems exacerbated by increased demand for bandwidth and the deployment of next-generation standards like IEEE 802.11ax. SAMSUNG-1006, 0003, 0019; SAMSUNG-1007, 0002, 0014. Cherian's advancements aim to allow multiple user terminals to communicate with a single access point by sharing channel resources, often utilizing technologies like Multiple-Input Multiple-Output (MIMO). *Id.* While these multi-user (MU) modes promise higher throughput, Cherian focuses on the intricacies of devices transitioning between traditional single-user (SU) operation and the more efficient MU modes. SAMSUNG-1006, Title, 0006, 0021-0022, 0032; SAMSUNG-1007, Title, 0005, 0016-0017, 0026. Cherian recognizes that, in dense network environments, the conventional Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) mechanism used for channel access in single user (SU) mode can become inefficient, leading to increased delays and reduced per-user throughput. SAMSUNG-1006, 0048-0052; SAMSUNG-1007, 0041-0045.

81. To improve performance, especially in scenarios supporting both SU and MU operations, Cherian's disclosure centers around managing the backoff procedures of a station (STA) as it switches EDCA parameters between these modes. SAMSUNG-1006, 0006, 0022, 0032, 0048-0049, 0059; SAMSUNG-1007,

0005, 0017, 0026, 0041-0042, 0052. A backoff procedure, effectively an enforced random delay before transmission, is used in a WLAN to manage multiple transmissions by sensing when the channel is free. SAMSUNG-1006, 0006, 0020; SAMSUNG-1007, 0005, 0015. Cherian highlights that STAs might operate in SU mode by default and then transition to MU mode upon receiving a trigger frame from an access point (AP). SAMSUNG-1006, 0054, 0060-0061, 0067, 0079, 0081; SAMSUNG-1007, 0047, 0052-0053, 0058, 0066, 0068. However, Cherian recognizes that a STA in MU mode might need to revert to SU mode if it fails to receive subsequent trigger frames from the AP within a certain timeframe. SAMSUNG-1006, 0056, 0063, 0067, FIG. 4; SAMSUNG-1007, 0049, 0055, 0058, FIG. 4.

82. Furthermore, Cherian discloses a MU EDCA Parameter Set element, which is used by the AP to provide quality of service (QoS) related parameters (e.g., EDCA parameters) for MU operation. SAMSUNG-1006, 0049, 0073-0077, FIG. 6; SAMSUNG-1007, 0042, 0060-0064, FIG. 5. Cherian also describes how STAs may update their EDCA parameters based on the received MU EDCA Parameter Set elements and the expiration of timers related to MU operation. SAMSUNG-1006, 0078-0079; SAMSUNG-1007, 0065-0066. Ultimately, Cherian aims to optimize transmissions by intelligently managing backoff procedures, thereby improving overall wireless network efficiency and throughput, especially

in dense deployment scenarios utilizing advanced 802.11 standards. SAMSUNG-1006, 0048-0049; SAMSUNG-1007, 0041-0042.

C. Overview of Kim (SAMSUNG-1008)

83. Kim teaches a method for transmitting and receiving acknowledgement (ACK) or negative-acknowledgement (NACK) signals in a Wireless LAN (WLAN) system based on an ACK policy and is analogous to the '879 Patent. This is particularly relevant in scenarios involving Uplink (UL) Multi-User (MU) transmission schemes, where an Access Point (AP) receives data from multiple stations (STAs) simultaneously because collisions may occur and each STA can ensure their respective transmissions were received through acknowledgments. SAMSUNG-1008, 0004-0006.

84. Kim discusses using different ACK policies in a STA to control how an AP responds to data received from the STAs. SAMSUNG-1008, 0007-0015. Notably, Kim details an ACK policy field within the Quality of Service (QoS) control field of a UL-MU frame, which uses 2 bits to indicate four different ACK policy values (Normal ACK, no ACK, PSMP ACK, or Block ACK). SAMSUNG-1008, 0094, Tables 6-9.

85. Kim includes discussion of trigger frames transmitted by the AP that initiate the UL-MU transmission, and the subsequent ACK/NACK procedures are governed by the ACK policy set by the transmitting STAs. SAMSUNG-1008,

0096, 0102.

D. Overview of Ho (SAMSUNG-1018)

86. Ho describes specific procedures governing the selection and adjustment of the contention window (CW) value within a Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) framework for obtaining contended allocations and is analogous to the '879 Patent. SAMSUNG-1018, Abstract, 0002-0003. Central to this mechanism is a backoff counter, utilized by a wireless communications device (STA) to determine the transmission start time for a contended allocation. SAMSUNG-1018, 0004. When a node possesses traffic designated for transmission, particularly when the backoff counter is at a zero value, the counter is initialized by selecting an integer value at random. SAMSUNG-1018, 0008. More specifically, the value is selected at random from the interval (1, CW), where the upper bound, CW, is a contention window value chosen based upon the priority of the traffic designated for transmission. SAMSUNG-1018, 0021, 0024. Initially, or subsequent to a successful transmission wherein additional transmissions requiring contended allocations remain, the CW is set to a minimum value (CW_{min}) corresponding to the user priority. SAMSUNG-1018, 0025-0031. The backoff counter, once set, is decremented for each idle contention slot detected, contingent upon the counter being in an unlocked state. SAMSUNG-1018, 0021.

87. When the backoff counter reaches zero, the device attempts transmission in the ensuing contention slot. SAMSUNG-1018, 0040, 0045. Should this transmission endeavor prove unsuccessful, defined by the absence or incorrect reception of an acknowledgment, the CW value is subject to recalibration. SAMSUNG-1018, 0028-0030. The method prescribes an alternating doubling mechanism for adjusting the CW value subsequent to a failed transmission. SAMSUNG-1018, 0010. Specifically, the CW is adjusted by alternately doubling its value. SAMSUNG-1018, 0010, 0025-0031. This doubling process is subject to an explicit upper bound: the CW value is not permitted to exceed CW_{max} for the relevant user priority. *Id.*

E. Overview of Bharghavan (SAMSUNG-1010)

88. Bharghavan focuses on optimizing Quality of Service (QoS) in wireless networks and is analogous to the '879 Patent. SAMSUNG-1010, Title, Abstract. A key aspect of managing QoS in shared wireless mediums is handling contention for various levels of QoS between devices trying to transmit. SAMSUNG-1010, 2:3-11. Bharghavan describes a mechanism using backoff timers and a contention window to address that aspect. SAMSUNG-1010, 4:65-5:53.

89. Specifically, when the communication medium is considered open or idle after an AIFS (automatic inter-frame spacing) time, each node seeking to

transmit enters a contention time. SAMSUNG-1010, 4:65-5:53. During the contention time, each node selects a random amount of time to wait (the backoff time) before attempting to access the medium. SAMSUNG-1010, 4:65-5:53. The size of the contention window influences a node's chances of accessing the medium, with smaller ranges potentially granting higher priority. SAMSUNG-1010, 4:65-5:53. Importantly, if a backoff timer expires while the medium is busy, the timer pauses and resumes its countdown once the medium becomes idle again after the AIFS period, giving an advantage to nodes that have already begun their backoff. SAMSUNG-1010, 4:65-5:53.

90. Figure 3 in Bharghavan's patent conceptually illustrates a method where an AP determines QoS (e.g., an access category), queues data flows in each access category, and then sets channel access parameters, including the Contention Window Time (318, 324) and Back-Off Parameter (322, 328), based on whether there is traffic for a particular queue (316). SAMSUNG-1010, 8:1-63. This dynamic adjustment of backoff-related parameters based on QoS is central to Bharghavan's approach to optimize the wireless network.

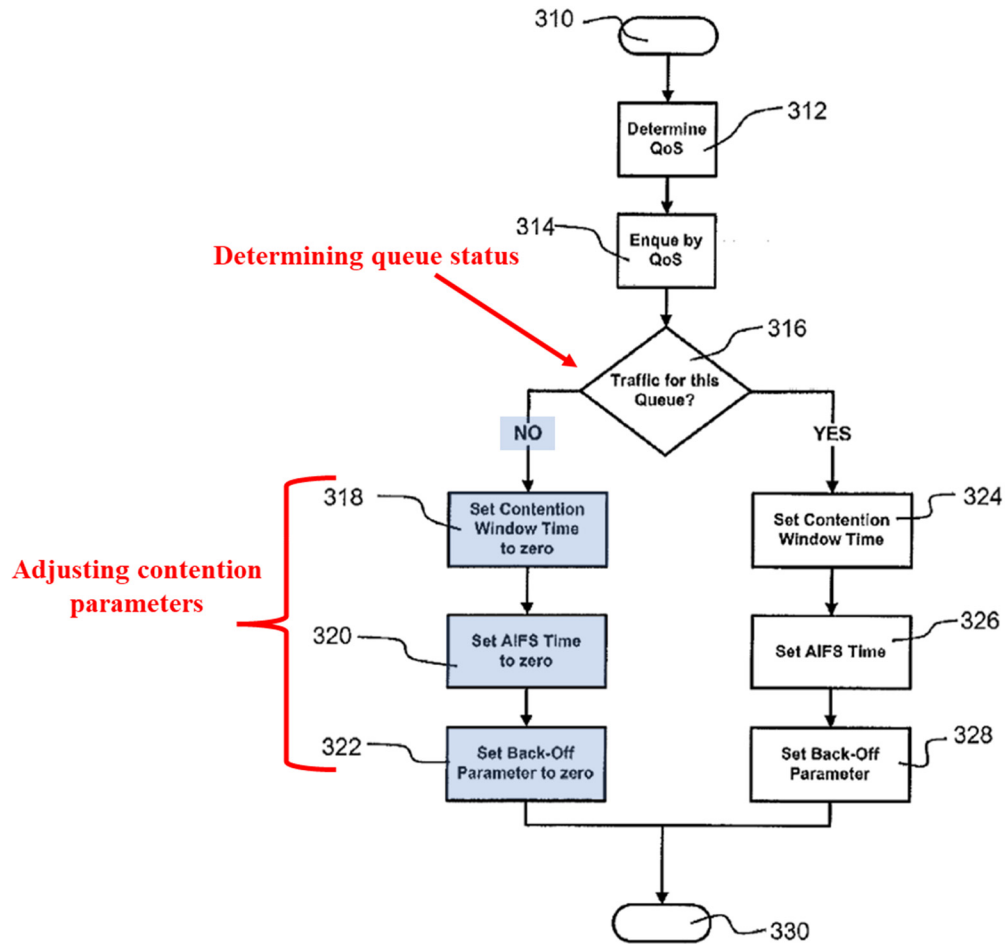


Figure 3

SAMSUNG-1010, FIG. 3.

F. Combination of Zhou-Cherian-Kim (SAMSUNG-1004-SAMSUNG-1005-SAMSUNG-1008)

91. Zhou, Cherian, and Kim disclose wireless communication protocols and techniques, compliant with IEEE 802.11ax, that demonstrate the recognized need, by the Critical Date, to optimize resource sharing among multiple STAs communicating with a single AP. SAMSUNG-1004, 0005, 0012; SAMSUNG-1005, 0004-0005; SAMSUNG-1006, 0003-0004, 0019; SAMSUNG-1007, 0002-

0004, 0014. Traditional single-user channel access mechanisms, such as Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), can become inefficient in dense network environments and when dealing with devices having varying capabilities. SAMSUNG-1004, 0026-0027; SAMSUNG-1005, 0032-0034; SAMSUNG-1006, 0020, 0048-0051; SAMSUNG-1007, 0015, 0041-0044. This is because with various devices all contending for access, more collisions will occur which will increase the waiting times for each STA (e.g., increasing the time backoff timers run for each AC at each STA). Recognizing this, a POSITA would have been aware of ongoing efforts to enhance network performance by managing both channel access parameters and transitions between different operational modes (e.g., schedule or unscheduled transmissions), either of which can exacerbate the above-noted inefficiencies. SAMSUNG-1004, 0002-0005; SAMSUNG-1005, 0001-0004; SAMSUNG-1006, 0003-0004, 0019; SAMSUNG-1007, 0002-0004, 0014. In view of the disclosures of Zhou, Cherian, and Kim, a POSITA would have understood the relevance of needed improvements to both channel access mechanisms and the management of transitions between single-user (SU) and multi-user (MU) operation. SAMSUNG-1004, 0004, 0012; SAMSUNG-1005, 0004-0005; SAMSUNG-1006, 0003, 0052-0053; SAMSUNG-1007, 0002, 0045-0046. Specifically, these references address the scheduling and coordination of multiple STAs to change between SU and MU operations and a corresponding

change in EDCA parameters. *Id.*

92. Consequently, a POSITA would have found it logical to consider the teachings of both the Zhou and Cherian references in combination, because they deal with various aspects of SU and MU transmissions. Zhou discloses methods and apparatuses for selecting channel access parameters (specifically, EDCA parameters) for stations having differing device capabilities, and, in doing so, differentiating between those stations capable of multi-user uplink (UL-MU) transmissions and those that are not (sometimes referred to as “legacy” STAs). SAMSUNG-1004, 0055-0058; SAMSUNG-1005, 0061, 0064; SAMSUNG-1006, 0067, 0073-0077; SAMSUNG-1007, 0058, 0060-0064. Similarly, Cherian focuses on the transitions between SU and MU modes (e.g., for UL-SU and UL-MU transmissions), highlighting the need to manage backoff procedures for efficient operation in both scenarios. SAMSUNG-1006, 0006, 0078-0079; SAMSUNG-1007, 0005, 0065-0066.

93. A POSITA seeking to optimize wireless network performance in environments supporting both SU and MU operations would naturally have sought ways to integrate the concepts of (i) tailoring channel access parameters based on device capabilities (Zhou), (ii) ensuring smooth and efficient transitions between operating modes through intelligent backoff management (Cherian), and (iii) ensuring transmissions were effectively communicated between APs and STAs

with acknowledgement policies (Kim). This combined approach would aim to create a more holistic solution for improving throughput and reducing delays in modern wireless networks.

94. Specifically, a POSITA would have been motivated by at least the following factors:

95. First, a POSITA would have been motivated to optimize transitions between SU and MU Modes. Zhou discusses the use of different EDCA parameters to manage contention-based communications during the operations of different transmission modes (e.g., SU or MU) in a wireless network. SAMSUNG-1004, 0040-0042; SAMSUNG-1005, 0046-0048. Cherian focuses on transitions between EDCA parameters used during SU and MU modes. SAMSUNG-1006, 0058-0061; SAMSUNG-1007, 0050-0053. Specifically, Cherian discloses using EDCA parameter sets and EDCA parameter timers to control (i) the EDCA parameters used in each mode (e.g., SU or MU), and (ii) the duration of time in which the parameters are used. SAMSUNG-1006, 0058-0061, 0076, FIG. 4; SAMSUNG-1007, 0050-0053, 0063, FIG. 4. Kim similarly illustrates using trigger frames to initiate a transition between UL-SU and UL-MU transmissions. SAMSUNG-1008, 0080-0081, 0096, Table 3. A POSITA recognizing the need for efficient mode transitions as highlighted by Cherian, would have been motivated to combine Zhou's architecture with Cherian's parameter sets and timer, and Kim's

acknowledgement of the various transmissions. The combination provides elements capable of managing the initiation of a UL-MU transmissions (e.g., the transition from UL-SU mode to UL-MU mode), the parameters used while in each mode, and the transition back to UL-SU mode. Such a combination would have provided predictable solutions for devices moving between transmission modes, thereby ensuring efficient channel utilization while preventing performance degradation during transitions between modes, a problem known in the field. It also provides the benefit of defining how STAs will transition in and out of UL-MU mode.

96. Second, a POSITA would have been motivated to implement the transitions between UL-SU and UL-MU modes in an efficient manner by reducing wasted overhead and controlling the period of time a station uses particular EDCA parameters. Zhou describes this need for improved efficiency and decreased overhead. SAMSUNG-1004, 0004; SAMSUNG-1005, 0005. Cherian provides similarly motivated disclosure by teaching the exacting use of EDCA parameters and an EDCA parameter timer to precisely control the transition between transmission modes. SAMSUNG-1006, 0006, 0022, 0032, 0048-0049, 0059; SAMSUNG-1007, 0005, 0017, 0026, 0041-0042, 0052. Kim describes specifics for controlling particular transmission modes based on whether acknowledgements are requested. SAMSUNG-1008, 0094, Tables 6-9. A POSITA looking to reduce

the communications overhead of stations transitioning across various modes would have employed Cherian's directed EDCA parameters and EDCA parameter timer to efficiently switch the station back to SU mode after a period of time.

Additionally, a POSITA would have been motivated to employ Kim's acknowledgement policies with said timer in a logical manner based on whether a STA is waiting for an acknowledgement. In fact, it was well known and understood that such acknowledgement policies would have been used to determine whether the transmissions were successful. SAMSUNG-1018, 0009 ("A successful transmission occurs when the node either receives an expected acknowledgment correctly, or transmits a frame that does not require an acknowledgment.").

97. Third, the combination would have addressed a known design need for robust, efficient wireless networks operating within the 802.11 standards. The need for reliable and efficient data transfer in wireless LANs was a well-established design need by the time of the Critical Date. SAMSUNG-1004, 0002-0005; SAMSUNG-1006, 0019-0022. A POSITA would have recognized that optimizing channel access (Zhou) and managing mode transitions (Cherian) are crucial for efficiency. *Id.* However, without a mechanism to more clearly define the periods of time in which the mode transmission occurs (Cherian and Kim), the benefits of these optimizations could be undermined by inefficient practices. Therefore, incorporating an acknowledgement mechanism (e.g., acknowledgment

policies) as disclosed by Kim was a logical and necessary step to address the known need for robust communication in wireless LAN systems. In other words, given the limited number of choices as to when to set Cherian's EDCA parameter set timer, it would have been obvious for a POSITA to try Kim's method of *when* to set or otherwise use a timer. Specifically, Kim provides the acknowledgement policies that would allow the transmitting station to know whether the transmission was successful and, if successful, to set Cherian's timer. I have been advised by counsel that market pressures can motivate a POSITA to use known or available techniques to explore a finite number of potential solutions to a given problem. I agree that, in the combination of Zhou, Cherian, and Kim, a POSITA would have been motivated to solve the problem using the limited solutions available within the 802.11 architecture.

98. Fourth, acknowledgement protocols (like those in Kim) were a well-known and widely used technique in various communication systems, including wireless networks, to ensure reliable data delivery. For example, Ho describes one well-known reason for such acknowledgement policies when stating: "[a] successful transmission occurs when the node either receives an expected acknowledgment correctly, or transmits a frame that does not require an acknowledgement." SAMSUNG-1018, 0009. Because Zhou and Cherian disclose methods for enhancing channel access and managing mode transitions in a WLAN,

it would have been an obvious adaptation of a standard technique to incorporate an acknowledgement policy mechanism, such as the contention-based acknowledgement policies described by Kim, to improve the overall reliability and quality of service of the proposed wireless communication methods.

99. Fifth, the combination of Zhou, Cherian, and Kim offers a potential for enhanced performance across multiple dimensions of a wireless LAN system—a well-recognized goal at the time. Not only would a POSITA be motivated by these market factors, but the growth rate of wireless devices at the time of the Critical Date demonstrated a need for methods of communicating in wireless networks with numerous STAs. The contention-based methods used up to this point can struggle to support a plurality of STAs communicating through an AP because as the number stations increase, the number of potential collisions also increases. The use of UL-MU techniques would have allowed a number of stations to simultaneously transmit, thus alleviating the more sequential transmission backlog that would have occurred in traditional contention-based transmissions. Zhou focuses on optimizing channel access through UL-MU and UL-SU transmission coordination, Cherian addresses efficient transitions between UL-MU and UL-SU modes, and Kim provides a means for using acknowledgement signals in such transmissions. Combining these would have predictably led to a system that is not only more efficient in utilizing the wireless medium but also more

reliable in delivering data, representing a natural and obvious optimization strategy for a POSITA seeking to improve overall WLAN performance. I am informed by counsel that the determination of obviousness considers the level of ordinary skill in the pertinent art, and that a POSITA should not be treated as an automaton. Instead, a POSITA—possessing skills in the relevant art—would have been capable of and motivated to pursue optimizations in both efficiency and reliability. These capabilities rely not only on the disclosure of the references, but the learned knowledge and experience of a POSITA.

100. Thus, a POSITA would have possessed the common sense understanding that these aspects taught in Zhou, Cherian, and Kim are interrelated and contribute to the overall performance of a WLAN. For instance, while Zhou addresses efficient channel access and Cherian focuses on smooth mode transitions, the success of these mechanisms is linked to the reliable delivery of data—the same reliability sought through Kim’s disclosure of acknowledging transmissions. A POSITA, faced with the goal of improving WLAN performance, would logically consider integrating techniques that enhance efficiency (Zhou and Cherian) with those that ensure reliability (Kim). As discussed with counsel, a POSITA would have had available to them more than simply the disclosure of the references and would in fact possess the fundamental knowledge behind the references enabling a POSITA to understand the disclosure. Based on this

understanding and informed by counsel of the relevant case law regarding a POSITA's ability to piece together references, it is my opinion that a POSITA, at the time of the Critical Date, would have been able to fit the teachings of multiple patents together like pieces of a puzzle. This is especially true in light of the teachings of each reference address different facets of a common technological goal within the same field of wireless networks. The motivation to combine would stem from the known design need for robust and efficient wireless communication, and a POSITA would have readily recognized the predictable benefit of ensuring reliable data transfer in a system optimized for channel access and mode transitions.

G. Combination of Zhou-Cherian-Kim-Ho (SAMSUNG-1004-SAMSUNG-1005-SAMSUNG-1018)

101. A POSITA would have been motivated to combine Zhou-Cherian-Kim with Ho because of the potential for improved stability in wireless communication through Ho's description of a standardized and bounded contention backoff mechanism following transmission failures (e.g., limiting backoff timers to $CW_{\max}$). SAMSUNG-1018, 0010, 0025-0031. Zhou provides methodologies for selecting EDCA parameters tailored to different stations, Cherian describes procedures for transitioning between UL-SU and UL-MU modes, and Kim outlines the acknowledgement policies for transmissions in these modes. The incorporation of Ho's teachings offers a specific and well-defined approach to managing

retransmissions via the doubling of the contention window with an upper bound at $CW_{\max}$. *See* Section IX.F (Zhou-Cherian-Kim combination); SAMSUNG-1018, 0031 (“the node doubles CW . . . but if doubling the CW would exceed $CW_{\max}[UP]$, the node shall set the CW to $CW_{\max}[UP]$.”). Specifically, Ho teaches the use of the very EDCA parameters disclosed in Zhou and Cherian within contention-based transmission techniques such as backoff timers.

102. Furthermore, the explicit mention in Ho of the contention window doubling, but not exceeding $CW_{\max}$, is a technically sound and inherently obvious design constraint rooted in the fundamental principles of the Distributed Coordination Function (DCF) and EDCA. SAMSUNG-1017, pp.837, 879. Indeed, such techniques were employed in contention-based methods prior to the Critical Date and known to a POSITA. *Id.* The maximum contention window ($CW_{\max}$) (taught by Ho and defined within the 802.11 standards) is a defined parameter that prevents excessively long backoff periods, which could lead to significant delays that would reduce throughput in the network. The mathematical outcome of repeatedly doubling a value until it reaches a predefined maximum is a well-understood and basic computational process, and its application in limiting the exponential backoff is a common practice in the art. SAMSUNG-1017, FIG. 9-10. A POSITA implementing the dynamic EDCA parameter selection of Zhou and the mode transition mechanisms of Cherian would naturally have understood the

common practice of bounding the contention window during backoff procedures to maintain acceptable network performance. Demonstrated in the annotated figure below, the principle of a bounded exponential backoff is a widely used technique in wireless communication to handle contention, and its integration here is a logical application of known techniques to enhance the reliability of the combined Zhou-Cherian-Kim combination. SAMSUNG-1018, 0010; SAMSUNG-1017, pp.937, 879, FIG. 9-10. Counsel informs me that a POSITA can use common sense and the skills available to them—and known in the art—to piece together separate teachings like a “puzzle.” Thus, a POSITA would have been capable of combining Zhou, Cherian, Kim, and Ho because of the disclosed compatibility within the 802.11 architecture, the employment of known methods used within said architecture, and the common teachings regarding UL-SU and UL-MU transmissions among the references.

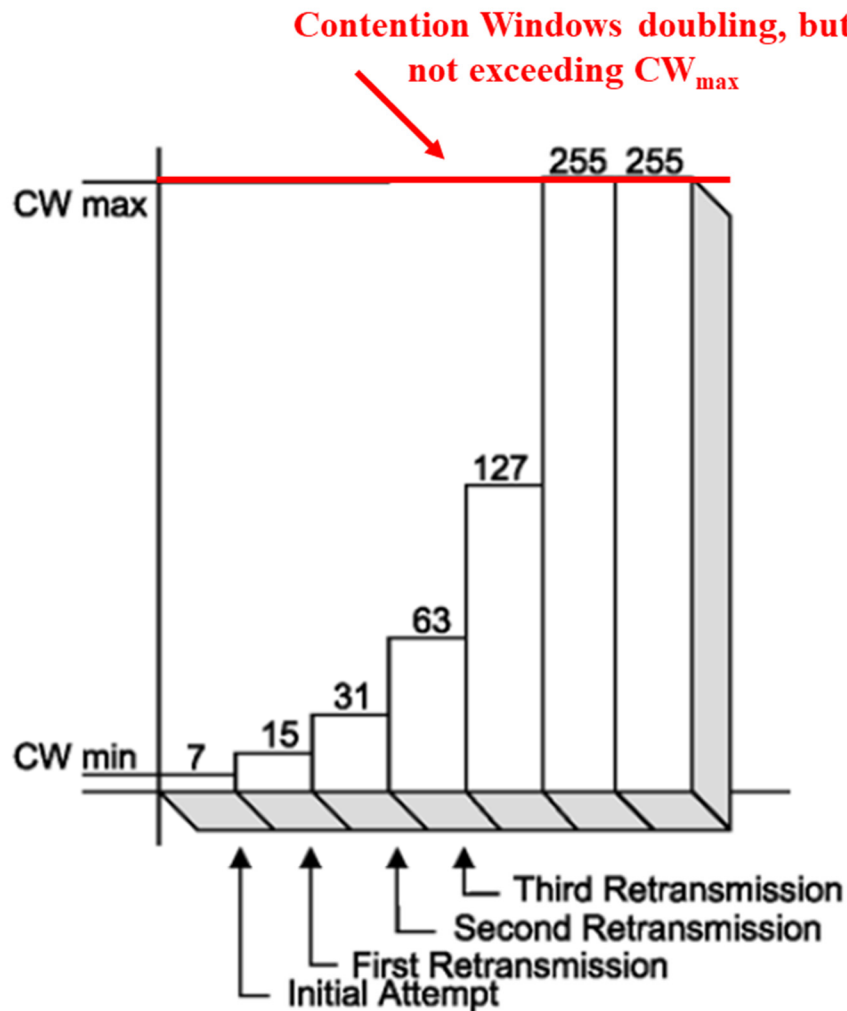


Figure 9-10—Example of exponential increase of CW

SAMSUNG-1017, FIG. 9-10.

103. Counsel informs me that a motivation to combine is not merely the independent existence of features within a reference. Instead—as is the case here, the technical motivation lies in the recognized need for efficient and reliable data

transmission in wireless networks. Incorporating Ho's specified backoff mechanism provides a clear and effective way to address potential collisions that might occur within the more complex channel access schemes enabled by the combined Zhou-Cherian-Kim framework. This integration leverages known and reliable techniques to enhance the robustness of the overall system. Thus, a POSITA would have had a reasonable expectation of success in the combination of these references (e.g., a Zhou-Cherian-Kim-Ho combination).

H. Combination of Zhou-Cherian-Kim-Bharghavan (SAMSUNG-1004-SAMSUNG-1005-SAMSUNG-1008-SAMSUNG-1010)

104. A POSITA would have been motivated to combine Zhou-Cherian-Kim with Bharghavan because of the potential for enhanced Quality of Service (QoS) management and more efficient medium access control in wireless networks by dynamically adapting channel access parameters based on real-time traffic conditions (access category queue status). SAMSUNG-1010, 8:5-56. With Zhou's methods for selecting EDCA parameters for diverse STAs, Cherian's disclosure of mechanisms for transitions between UL-SU and UL-MU communication modes, and Kim's acknowledgement policies, the incorporation of Bharghavan's teachings offers an efficient mechanism to dynamically adjust these parameters and behaviors in response to queue status and contention levels associated with different QoS requirements. *See* Section IX.F; SAMSUNG-1010, 8:34-52. Specifically, Bharghavan adds details to the performance of individual access

category queues that would have utilized the EDCA parameters of Zhou and Cherian.

105. Specifically, a POSITA seeking to improve the performance of a wireless system in line with the motivations described in Section IX.F would have sought to refine STA behavior based on the presence or absence of traffic within QoS-queues (e.g., Access Category queues), as contemplated by Bharghavan. Indeed, the very same QoS-queues are referenced in Zhou and Cherian through the use of EDCA parameter sets where parameters within each set would apply to each of the Access Category contention window values (e.g., ‘VO’(voice), ‘VI’ (video), ‘BE’ (best efforts) or ‘BG’ (background).”). Integrating Bharghavan’s queue management into Zhou-Cherian-Kim’s selection process would allow for a more context-aware adjustment of STA transmission behavior. For instance, if Bharghavan detects an empty queue for a particular QoS level, the system, informed by Zhou and Cherian’s methods, could dynamically adjust the backoff timer (that uses EDCA parameters) for that QoS level. SAMSUNG-1010, 8:19-52

106. For example, setting the contention window parameters for an empty queue to zero serves to effectively remove that QoS level from the current contention process, thus favoring the QoS levels having actual traffic. This is useful when a particular data type, for example, “voice” currently has no data queued to transmit. In such an example, it would not be beneficial to operate a

backoff timer for an access category that has no data to transmit. This dynamic adaptation addresses a design need for efficient resource utilization by preventing unnecessary contention for channels when certain traffic types are inactive (e.g., there is no data queued for transmission). As informed by counsel, market demand, rather than scientific literature, can drive design trends, and the demand for efficient QoS management in wireless networks provides a clear impetus for such an integration. Additionally, as discussed before, a POSITA would have also employed common-sense to such a problem realizing that when an access category queue is empty, there is no need to establish a backoff timer in order to contend for channel access. Instead, employing methods described in Bharghavan—shown in the annotated figure below—would have been an obvious and common-sense implementation to a POSITA.

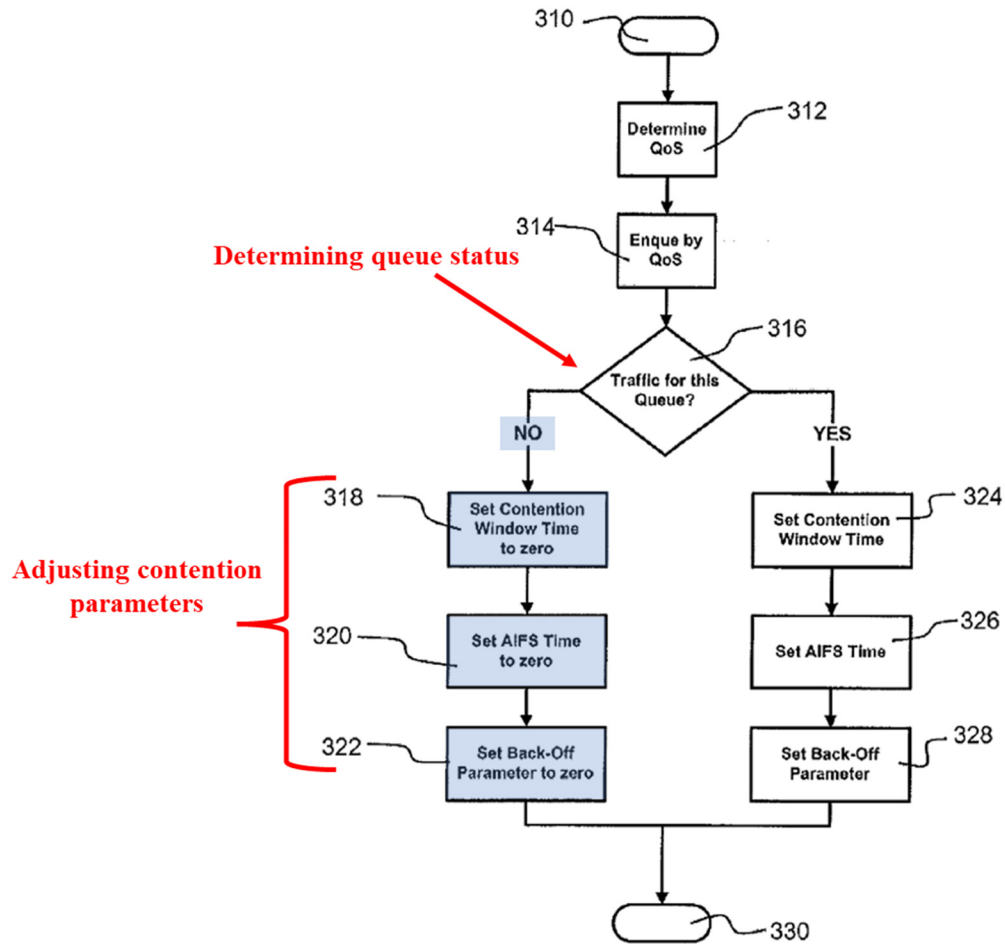


Figure 3

Bharghavan's FIG. 3 (SAMSUNG-1010).

107. When integrated with Cherian's UL-SU/UL-MU mode transitions, Bharghavan's contention-aware parameter adjustments could be particularly beneficial. For example, after a period of MU transmissions orchestrated by a trigger frame (as per Cherian and Kim), if Bharghavan's mechanisms detect low or empty queues for certain QoS levels (e.g., Access Category queues), the system could influence the backoff procedures potentially allowing stations with higher

priority traffic (that had data queued) to contend for the channel or medium more quickly. SAMSUNG-1010, 8:34-52. This proactive adjustment, based on queue status, provides a common-sense technical advantage in maintaining QoS across different operational modes and aligns with techniques that would have been known by a POSITA. A POSITA would recognize that such common-sense techniques demonstrated in Bharghavan would improve similar processes in the same way, and that using such a technique is obvious—requiring simple integration of known methods. Here, the concept of adjusting channel access parameters based on contention (e.g., setting a contention window to zero when a queue is empty), as suggested by Bharghavan, could be logically applied to enhance the mode transition mechanisms described by Zhou, Cherian, and Kim.

108. The implementation of such a combined system would rely on the hardware and software capabilities outlined by Zhou-Cherian-Kim ([1.1]), where processors and memory would have been used to execute the algorithms for EDCA parameter selection (Zhou), mode transition management (Cherian), and the dynamic adjustments based on queue status and contention (Bharghavan). SAMSUNG-1010, 8:34-52. This integration leverages known building blocks—like pieces of a puzzle—to achieve a predictable improvement in network performance and QoS.

109. I am informed by counsel that the motivation to combine must be

more than just the independent existence of these technologies with references. In this combination, the technical motivation stems from the recognized need for improved QoS and efficient resource management in wireless networks, where dynamically adapting channel access parameters based on real-time traffic conditions and differentiated priorities (as suggested by the integration of Bharghavan with Zhou-Cherian-Kim) provides a logical and obvious solution for a POSITA. This is particularly true given the fact that at some point a given Access Category queue may be empty and, in such circumstances, neither contention-based channel access for such a queue nor the backoff procedures supporting such channel access are necessary. Thus, when a queue is empty (e.g., there is not data to transmit), there exists an obvious need to augment the backoff procedure accordingly. Bharghavan provides methods to implement such an augmentation by adjusting the backoff procedures when an Access Category queue is empty. The focus on queue status and the implied impact of inactivity from Bharghavan would have addressed these recognized needs.

X. MANNER IN WHICH THE PRIOR ART REFERENCES RENDER THE '879 CLAIMS UNPATENTABLE

110. In my opinion, a person of ordinary skill in the art would have found claims 1-10 of the '879 Patent to have been obvious based on the Zhou-Cherian-Kim combination, Zhou-Cherian-Kim-Ho combination, and Zhou-Cherian-Kim-Bharghavan combination.

A. Ground 1: Combination of Zhou-Cherian-Kim Renders Obvious Claims 1-3, 8-10

Claim 1

[1.0] A wireless communication terminal that wirelessly communicates with a base wireless communication terminal, the wireless communication terminal comprising:

111. Zhou-Cherian-Kim renders obvious [1.0]. For example, Zhou discloses “wireless communication systems” that “allow multiple user terminals (UTs) [(*a wireless communication terminal*)] to communicate with a single access point [(*that wirelessly communicates with a base wireless communication terminal*)] by sharing the channel resources.” SAMSUNG-1004, 0001-0005; SAMSUNG-1005, 0001-0004. Zhou discloses through Figures 1-2 and related description, the composition of the “terminal” (*the wireless communication terminal comprising*), e.g., (STAs) employing various devices “configured to communicate via a wireless medium.” SAMSUNG-1004, 0017-0018, 0025; SAMSUNG-1005, 0023-0024, 0031. Some example UT STAs include laptops, cellphones, and TVs. SAMSUNG-1004, FIG. 1; SAMSUNG-1005, FIG. 1.

112. More specifically, Zhou discloses the transmission of wireless signals “according to a high-efficiency 802.11 protocol using orthogonal frequency-division multiplexing (OFDM).” SAMSUNG-1004, 0014-0018; SAMSUNG-1005, 0020-0024.

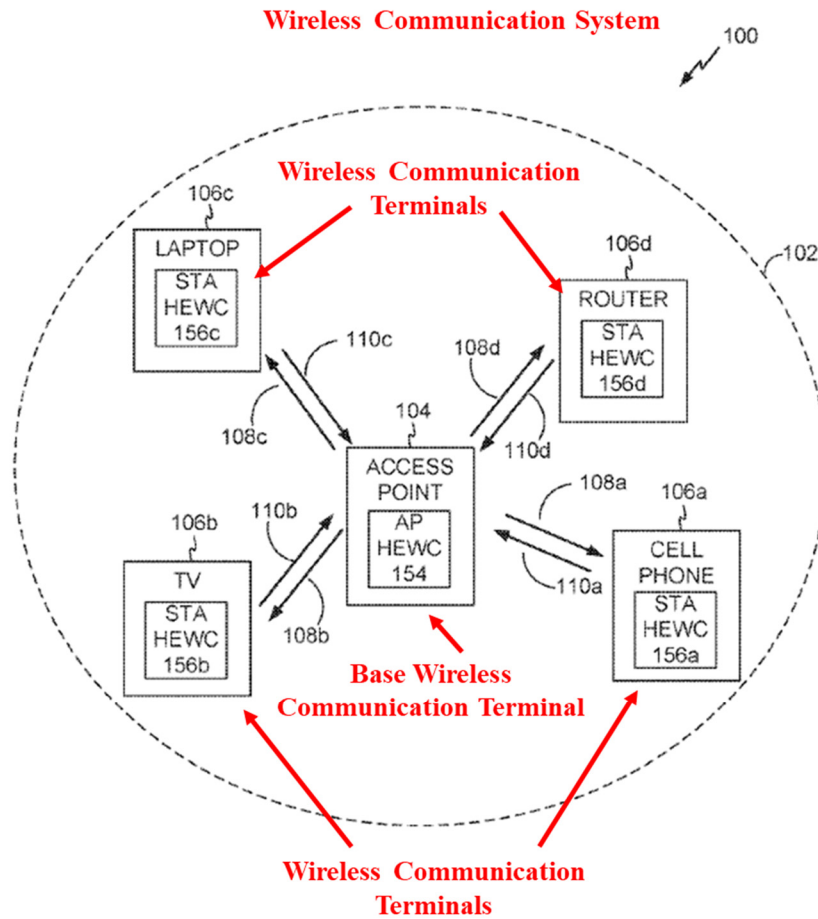


FIG. 1

SAMSUNG-1005, FIG. 1⁵.

113. Similarly, Cherian discloses a User Terminal (UT) (*[a] wireless communication terminal*) that wirelessly communicates with and Access Point (AP) (*a base wireless communication terminal*). SAMSUNG-1006, FIG. 1-2,

⁵ All figures are annotated in color unless otherwise noted.

0031; SAMSUNG-1007, FIG. 1-2, 0025 (“FIG. 1 illustrates a multiple-access multiple-input multiple-output (MIMO) system 100 with access points and user terminals.”). Thus, in light of their respective disclosure, a POSITA would have understood and found obvious that these references each teach wireless communication systems in which *a wireless communication terminal wirelessly communicates with a base wireless communication terminal*.

[1.1] a transceiver; and a processor, wherein the processor is configured to:

114. Zhou-Cherian-Kim renders obvious [1.1]. For example, Zhou teaches through disclosure of a “wireless device 202” an example user terminal (wireless device 202) including “*a processor 204*” and “*a transceiver 214*.” SAMSUNG-1004, 0031-0032, 0034-0039, FIG. 2; SAMSUNG-1005, 0037-0038, 0040, 0045, FIG. 2.

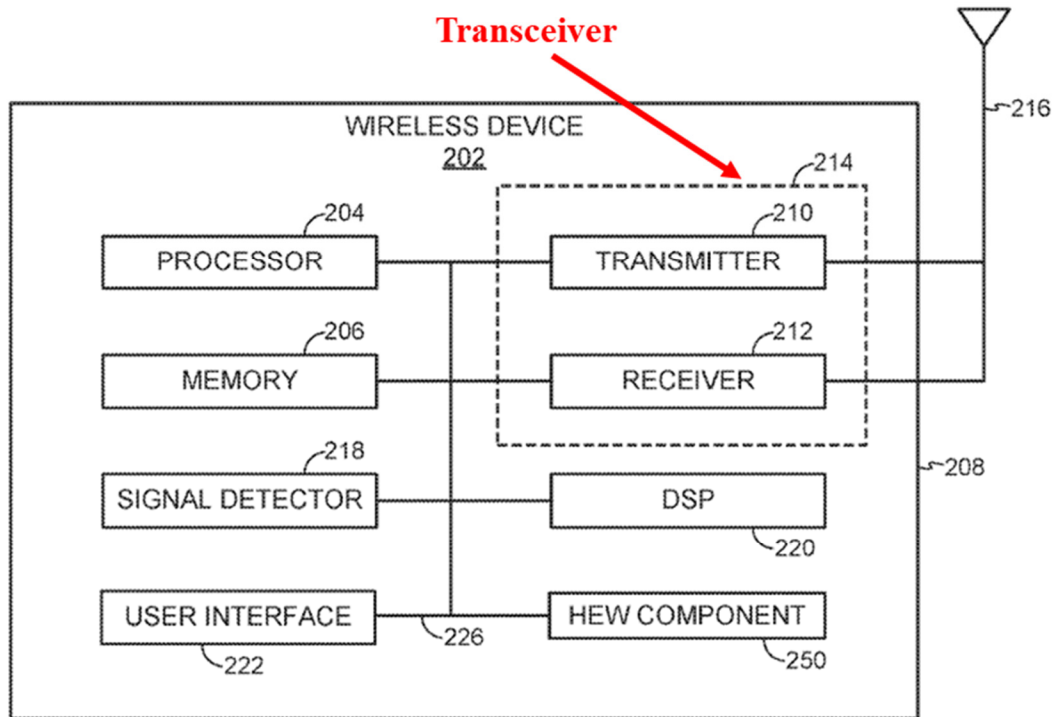
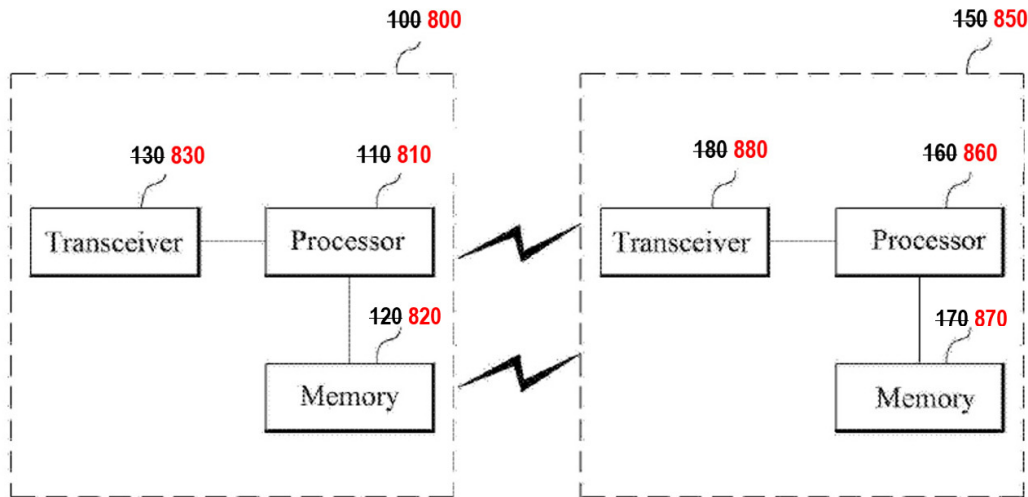


FIG. 2

SAMSUNG-1005, FIG. 2.

115. Cherian teaches that wireless communication terminals (Cherian's UTs) include *a transceiver and a processor*. SAMSUNG-1006, FIG. 2, 0038, 0042, 0088-0090; SAMSUNG-1007, FIG. 2, 0031, 0035, 0070-0072.

116. Kim similarly describes a wireless communication terminal (STA or station 800) comprising at least processors and transceivers. SAMSUNG-1008, 0131-0134. "The *processors* 810 and 860 and/or the *transceivers* 830 and 880 may include an Application-Specific Integrated Circuit (ASIC), a chipset, a logical circuit, and/or a data processor." SAMSUNG-1008, 0131-0134.



SAMSUNG-1008, FIG. 27⁶.

117. Zhou teaches that *the processor is configured to* “implement not only the functionality described above with respect to the processor 204, but also to implement the functionality described above with respect to the signal detector 218 and/or the DSP [digital signal processor] 220.” SAMSUNG-1004, 0039; SAMSUNG-1005, 0041. Zhou describes several various processes that the processor is “*configured to*” perform. SAMSUNG-1004, 0033; SAMSUNG-1005,

⁶ As issued, Kim Fig. 27 has incorrect reference numerals. In the annotated version above, the original, incorrect reference numerals (**black**) are struck-through, and the correct reference numerals (**red**) substituted in their place to match the corresponding prose description.

0039 (“The instructions, when executed by the one or more processors, cause the processing system to perform the various functions described herein.”).

SAMSUNG-1006, FIG. 2, 0038, 0088-0090; SAMSUNG-1007, FIG. 2, 0031, 0070-0072. Moreover, a POSITA would have understood and found obvious that such implementations of 802.11 compliant network protocols could be enabled through software programing—a skill well within the capabilities of a POSITA. Such software programming would have been carried out by a processor “configured to” perform the operations of the software.

118. Thus, Zhou-Cherian-Kim renders obvious that the wireless communication terminal comprises *a transceiver; and a processor, wherein the processor is configured to* perform the recited functions following “configured to:”.

[1.2] receive, from the base wireless communication terminal, a trigger frame using the transceiver, wherein the trigger frame triggers a orthogonal frequency division multiple access (OFDMA) uplink transmission of the wireless communication terminal,

119. Zhou-Cherian-Kim renders obvious [1.2]. For example, Zhou discloses wireless communication between the access point (AP) and mobile stations (STA). SAMSUNG-1004, 0042-0044; SAMSUNG-1005, 0048-0050. Specifically, Zhou teaches that “a UL-MU trigger frame [is] sent by the AP 104 [i.e., the claimed ‘*base wireless communication terminal*’] to the STAs [i.e., the claimed ‘*wireless communication terminal*’] 106c and 106d.” SAMSUNG-1004,

0042; SAMSUNG-1005, 0048. Thus, the STAs *receive, from the base wireless communication terminal* (Zhou's AP), *a trigger frame using the transceiver* (Zhou component 214). A POSITA would have understood and found obvious that, given Zhou's context and disclosure of (i) the APs and STAs communicating wirelessly, and (ii) the transceivers within both components, that signals, including the trigger frame, would have been received *using* Zhou's *transceiver* 214. *See* [1.1]; SAMSUNG-1004, 0035, FIG. 1; SAMSUNG-1005, 0041, FIG. 1; SAMSUNG-1006, FIG. 2; SAMSUNG-1007, FIG. 2. Indeed, the use of transceivers within a wireless network is not only disclosed in the references used here, but it would have been common-sense that transceivers were used within devices employing the 802.11 standards. SAMSUNG-1017, 44 (mentioning STAs with "conformant PHY transceivers"). The reception of signals using the transceiver of a STA (*receive, from the base wireless communication terminal, a trigger frame using the transceiver*) would have been understood and obvious to a POSITA.

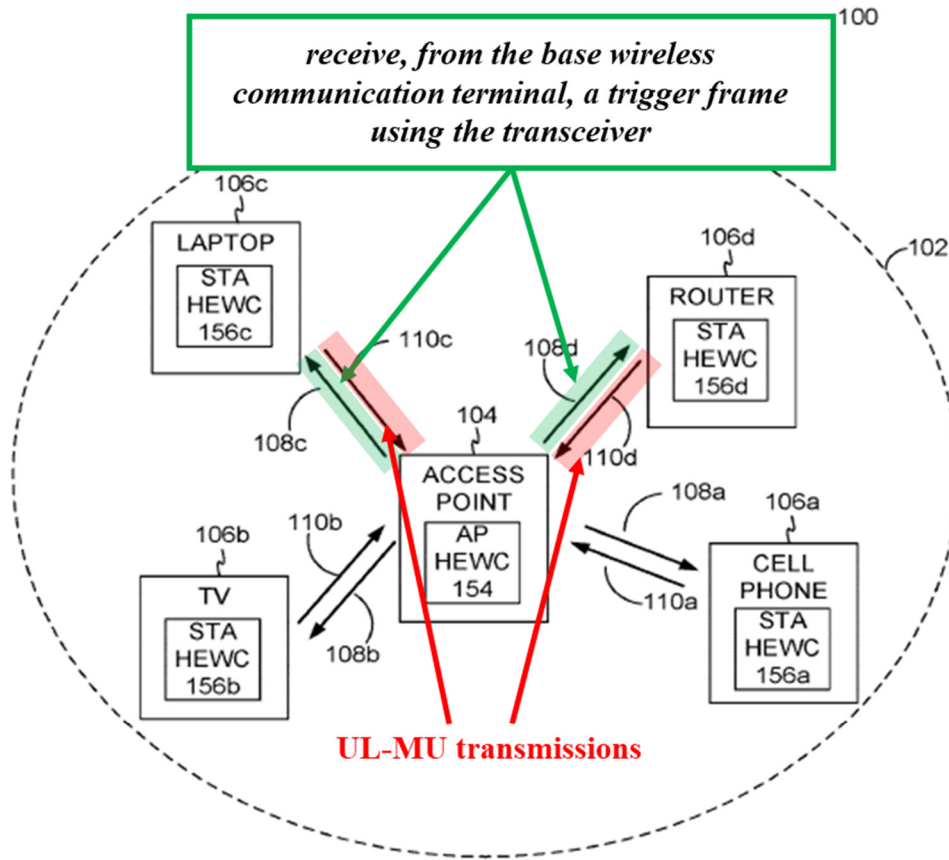


FIG. 1

SAMSUNG-1004, FIG. 1.

120. In Figure 1, Zhou teaches the STA's responsive transmission of "the UL-MU signals 110c and 110d (e.g., UL-MU-MIMO or UL-OFDMA transmissions) may be based on a UL-MU trigger frame sent by the AP 104 to the STAs 106c and 106d." SAMSUNG-1004, 0042; SAMSUNG-1005, 0048. Thus, the UL-OFDMA signals or **OFDMA uplink transmissions** can be responsive to "a

UL-MU trigger frame sent by the AP 104 to the STAs.” In other words, the UL-MU *trigger frame* sent from Zhou’s AP to the STA can *trigger[] a orthogonal frequency division multiple access (OFDMA) uplink transmission*. SAMSUNG-1004, 0044; SAMSUNG-1005, 0050 (OFDMA “UL frames can be [] triggered by the AP 104 (e.g., via MU-MIMO, UL OFDMA or other UL-MU transmission).”). A POSITA would have understood and found obvious that Zhou’s disclosure of “an STA 106 whose UL frames can be ... triggered by the AP 104” teaches that the AP sends to the STA a *trigger frame* that *triggers a . . . (OFDMA) uplink transmission*. SAMSUNG-1004, 0044; SAMSUNG-1005, 0050. As discussed in my Technology Background section, these trigger frames are sent from APs to STAs and employed to “trigger” STAs for coordinated, simultaneous transmission of data. *See* Section VII.D. Both MIMO and OFDMA were known types of transmissions that could be triggered with these trigger frames—each type (MIMO and OFDMA) employing different physical transmission characteristics to achieve the same goal of UL-MU transmissions. Thus, a POSITA would have understood and found obvious the use of trigger frames for *trigger[ing] a orthogonal frequency division multiple access (OFDMA) uplink transmission of the wireless communication terminal*.

121. Finally, Zhou teaches that the “STAs . . . may transmit UL-MU signals 110c and 110d.” and that “the UL-MU signals 110c and 110d (e.g., UL-

MU-MIMO or UL-OFDMA transmissions) may be based on a UL-MU trigger frame sent by the AP 104 to the STAs 106c and 106d.” SAMSUNG-1004, 0042; SAMSUNG-1005, 0048. Thus, Zhou teaches that the *uplink transmission* is transmitted from *the wireless communication terminal* (e.g., “transmitted by” Zhou’s STA).

122. Similarly, Cherian teaches that STAs receive, from the base wireless communication terminal, a trigger frame using the transceiver, wherein the trigger frame triggers a orthogonal frequency division multiple access (OFDMA) uplink transmission of the wireless communication terminal. SAMSUNG-1006, FIG. 4; SAMSUNG-1007, FIG. 4. A POSITA would have understood and found obvious that the receipt of signals at Cherian’s STAs would have been performed through a wireless interface such as a transceiver. Specifically, Cherian states that a “serving AP generally performs the function of the coordinator by broadcasting a trigger frame scheduling resources (e.g., time and frequency resources) for multiple STAs for simultaneous UL transmissions.” SAMSUNG-1006, 0053-0054, 0056; SAMSUNG-1007, 0046-0047, 0049. These simultaneous transmissions would utilize OFDMA—one of the known and available methods for UL-MU transmissions in the 802.11 standard. SAMSUNG-1022, p.43 (“The UL MU operation allows an AP to solicit immediate simultaneous response frames from one or more non-AP STAs. Non-AP STAs transmit their response frames in HE

trigger-based PPDU format, in either UL MU OFDMA UL MU-MIMO, or both.”); SAMSUNG-1006, 0027, 0052; SAMSUNG-1007, 0021, 0045 (“In OFDMA, however, multiple users are allowed to access channels at the same time.”).

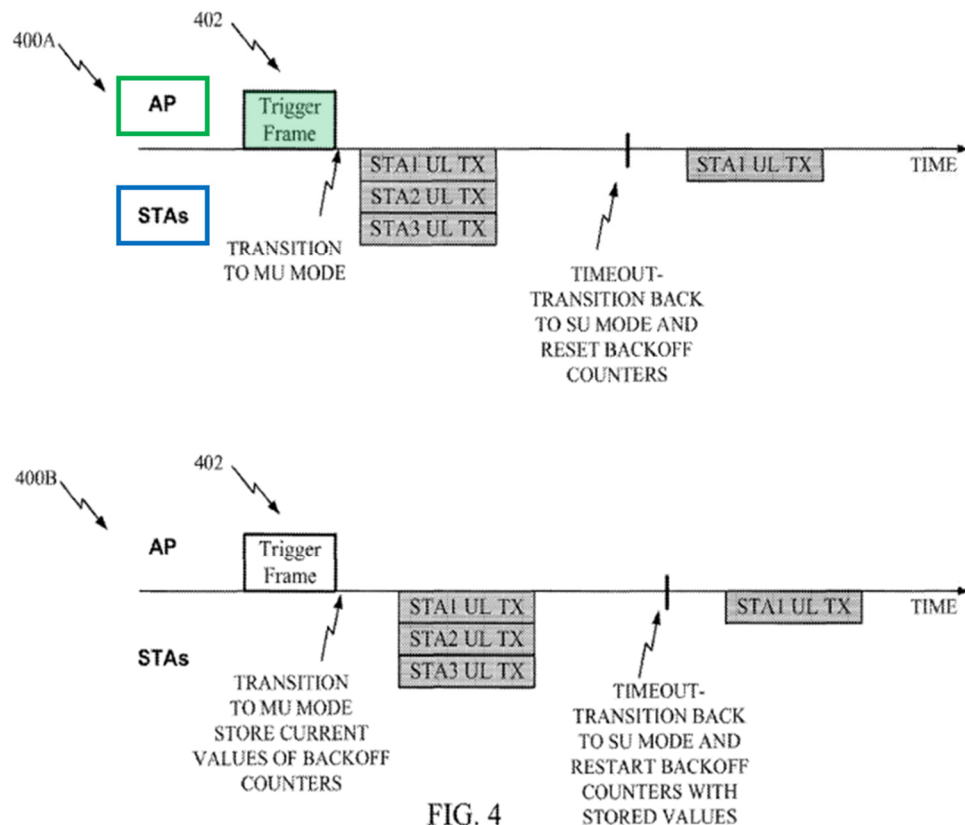


FIG. 4

SAMSUNG-1006, FIG. 4.

123. Kim also teaches the use of trigger frames used to initiate UL-MU OFDMA transmissions. Kim’s disclosure below provides an example in which UL-MU transmission of an OFDMA “type” “may be initialized when an AP transmits a trigger frame to a plurality of STAs”. SAMSUNG-1008, 0080.

A UL MU transmission scheme may be used in an 802.11ax

system as described above and may be initialized when an AP transmits a trigger frame to a plurality of STAs (e.g., STA 1 to STA 4) as illustrated in FIG. 12. The trigger frame may include UL MU allocation information (e.g. resource location and size, STA IDs, an MCS, and an MU type (MIMO, OFDMA, etc.)).
SAMSUNG-1008, 0080.

124. Kim further teaches a method where a STA “receiv[es] a trigger frame from the AP” corresponding to the claimed *receiv[ing], from the base wireless communication terminal* (AP), *a trigger frame*. A POSITA would have understood and found obvious that receipt of the wireless signals by Kim’s STA is accomplished *using the transceiver* of Kim—indeed, Kim discloses this very concept when teaching “a transceiver [that is] configured to receive a trigger frame transmitted to a plurality of STAs”). SAMSUNG-1008, 0018-0019, cl. 13, FIG. 27. The STA then proceeds to “transmitting data to the AP through a multi-user frame in response to the trigger frame” or a scheduled UL-MU transmission.

SAMSUNG-1008, cl. 13. Kim describes the UL-MU transmission can be of an OFDMA type, thus disclosing that *the trigger frame triggers a orthogonal frequency division multiple access (OFDMA) uplink transmission of* (or by) *the wireless communication terminal*. SAMSUNG-1008, 0080. A POSITA would have understood and found obvious that Kim’s “multi-user frame” would consist of one of Kim’s disclosed multi-user (MU) types “(MIMO, OFDMA, etc.).”

SAMSUNG-1008, 0080.

125. Thus, a POSITA would have understood and found obvious in light of Zhou, Cherian, and Kim, that the STAs *receive, from the base wireless communication terminal, a trigger frame using the transceiver, wherein the trigger frame triggers a orthogonal frequency division multiple access (OFDMA) uplink transmission of the wireless communication terminal* because the use of trigger frames for the purpose of UL-MU transmissions (MIMO or OFDMA) was known prior to the Critical Date.

[1.3] transmit, to the base wireless communication terminal, a trigger-based physical layer protocol data unit (PPDU) in response to the trigger frame using the transceiver,

126. Zhou-Cherian-Kim renders obvious [1.3]. Specifically, Zhou discloses the transmission of UL-MU transmissions between the STA and the AP in response to receiving trigger frames. SAMSUNG-1004, 0021, 0042, 0075; SAMSUNG-1005, 0027, 0048 (“the UL-MU signals 110c and 110d (e.g., UL-MU-MIMO or UL-OFDMA transmissions) may be based on a UL-MU trigger frame sent by the AP 104 to the STAs”), 0081 (“The trigger frame could be a trigger frame that triggers UL OFDMA random access.”). Specifically, the disclosure from Zhou demonstrates the use of trigger frames to elicit UL-MU or simultaneous uplink transmissions from a number of STAs through coordinated scheduling. *Id.* A POSITA would have understood and found obvious transmissions from a STA

in response to Zhou's trigger frame can use physical layer protocol data units (PPDU) or "packets" in accordance with the 802.11 standards. SAMSUNG-1004, 0035, 0041; SAMSUNG-1005, 0041("In some aspects, the data unit may comprise a physical layer convergence procedure (PLCP) protocol data unit (PPDU). In some aspects, the PPDU is referred to as a packet."), 0047. Indeed, Zhou teaches that data is transmitted using PPDU. SAMSUNG-1004, 0035; SAMSUNG-1005, 0041. A POSITA have recognized and found obvious the use of PPDU not only for "responsive" transmissions but for nearly all transmissions within an 802.11-like network for various reasons—one of which is that PPDU are a fundamental PHY layer data packet routinely used to transmit data in these networks.

127. A POSITA would have understood and found obvious that transmissions in an 802.11 architecture such as Zhou's utilized physical layer convergence protocol (PLCP) protocol data units (PPDU). SAMSUNG-1016, pp.166-169, 248-252. In fact, prior to the Critical Date, 802.11 textbooks explains that a PPDU is a fundamental unit used for transmission. SAMSUNG-1016, p. 166 ("The PPDU is . . . to be transmitted onto the RF medium as symbols representing the 0s and 1s of the PPDU"). Thus, communication from one station to another (e.g., between a STA and an AP) is achieved using PPDU.

128. The annotated figure below illustrates the flow of data through various layers of the IEEE 802.11 wireless communication protocol stack, specifically

showing how data is encapsulated and transmitted from a sender to a receiver. The figure shows the three lowest layers of the 802.11 protocol stack starting with layer 3 at the top, then working down to layer 2 in the middle, which is divided into two sublayers: the Logical Link Control (LLC) sublayer and the Medium Access Control (MAC) sublayer, and then finally to layer 1 at the bottom, which is divided into two sublayers: the Physical Layer Convergence Protocol (PLCP) sublayer and the Physical Medium Dependent (PMD) sublayer. Starting from the top, Layer 3 data is passed from the LLC sublayer down to the MAC sublayer as a MAC Service Data Unit (MSDU), where it is encapsulated with a MAC header to form a MAC Protocol Data Unit (MPDU). This MPDU is then passed down to the PLCP sublayer.

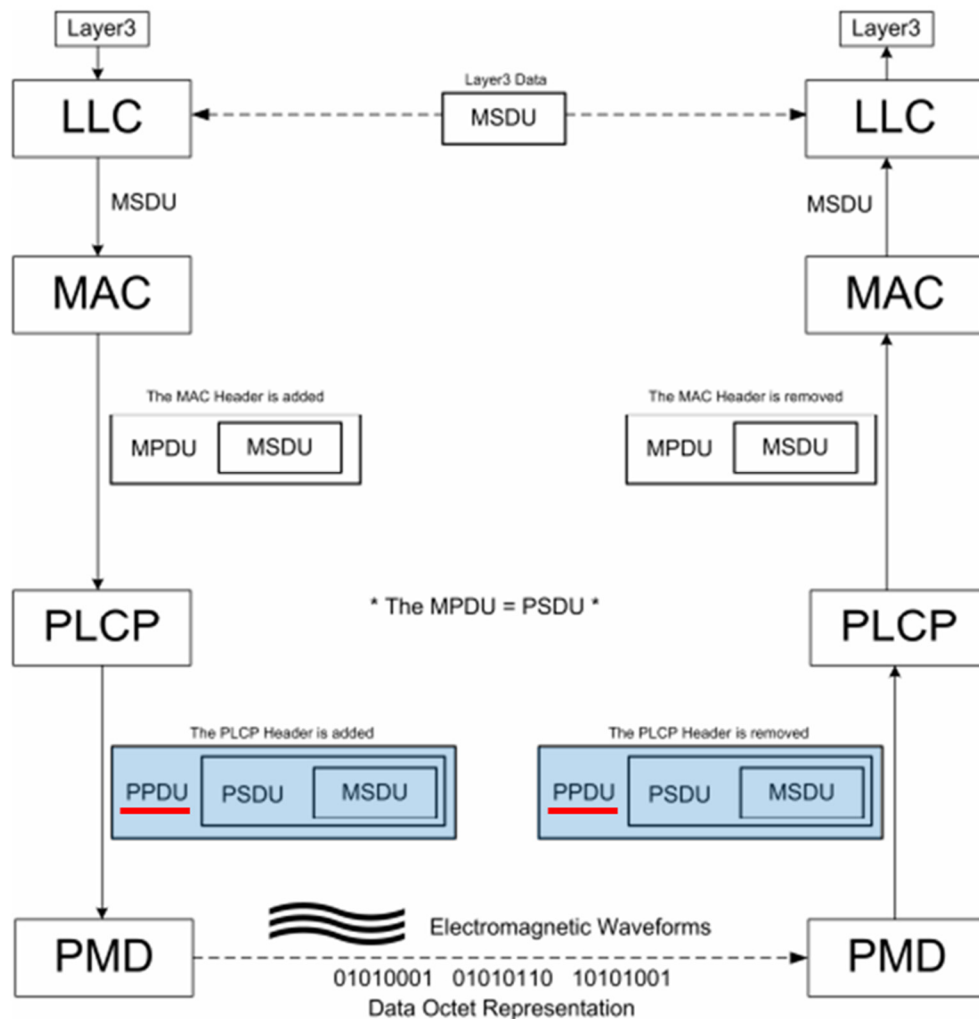
129. At the PLCP level, the MPDU—now referred to as a Physical Layer Service Data Unit (PSDU)—is further encapsulated with a PLCP header to form a Physical Layer Protocol Data Unit (PPDU). The PPDU represents the complete physical layer transmission unit. It is then passed down to the PMD sublayer, which converts it into electromagnetic waveforms for transmission over the air. Thus, the PPDU is a fundamental part of these networks.

130. On the receiving end, the process is reversed: the PMD captures the electromagnetic signals, converts them back into binary data, and passes the PPDU up to the PLCP sublayer, where the PLCP header is stripped to recover the PSDU.

The MAC sublayer then extracts the original MSDU by removing the MAC header from the MPDU, and finally the data is delivered to Layer 3 through the LLC sublayer.

131. This encapsulation hierarchy ensures that data is properly prepared, transmitted, and reassembled across the wireless medium in a reliable and standardized way.

FIGURE 5.1 Frame Nomenclature



SAMSUNG-1016, FIG. 5.1.

132. Zhou describes that the STAs *transmit, to the base wireless communication terminal*, UL-MU signals *in response to the trigger frame using the transceiver* as seen in Zhou's annotated Figure 1 below. SAMSUNG-1004, 0042-0043, 0044; SAMSUNG-1005, 0048-0049, 0050. Because Zhou's transmissions are based on receipt of a trigger (trigger-based) and 802.11

transmissions utilize PPDU, a POSITA would have understood and found obvious that Zhou's UL-MU transmissions, which are disclosed as including PPDU transmissions, satisfy the “*a trigger-based physical layer protocol data unit (PPDU)*” limitation, making it an obvious implementation.

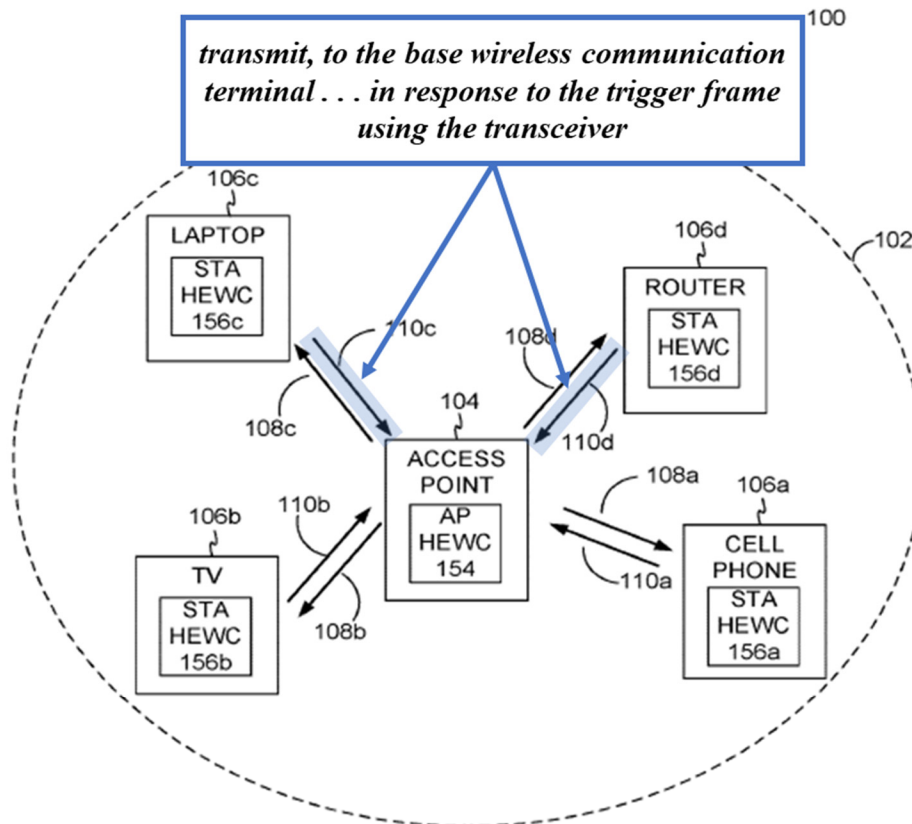


FIG. 1

SAMSUNG-1004, FIG. 1.

133. Trigger-based PPDU's are used in UL-MU transmissions to enable simultaneous and coordinated transmissions from multiple STAs under the

direction of the AP. This method allows the AP to schedule uplink transmissions using a trigger frame, which specifies when and how each STA should transmit. This scheduled approach contrasts with contention-based transmissions, such as those using CSMA/CA, where STAs independently contend for access to the medium without prior coordination. Contention-based methods are inherently unpredictable and can result in collisions or inefficient use of spectrum. In contrast, trigger-based PPDU allow for deterministic and collision-free uplink communication, improving spectral efficiency, reducing latency, and enabling reliable support for latency-sensitive or high-throughput applications. A POSITA would have understood and found obvious that the “trigger-based” responsive communications are scheduled UL-MU transmissions because 1) they are responsive to a trigger frame prompt (e.g., not contention based) and 2) the prompt schedules an UL-MU transmission responsive to the information within the trigger frame (e.g., not a contention-based transmission). Thus, when Zhou’s STA responds to the UL-MU transmission request received from the AP, the resulting transmission, which includes PPDU, is *in response to the trigger frame*.

134. More specifically, Zhou teaches that “the UL-MU signals 110c and 110d (e.g., UL-MU-MIMO or UL-OFDMA transmissions) may be based on a UL-MU trigger frame sent by the AP 104 to the STAs 106c and 106d.” SAMSUNG-1004, 0042-0043, 0044; SAMSUNG-1005, 0048-0049, 0050; *see* [1.1]. The

responsive ***trigger-based PPDU*** “uplink (UL) signal or packet 110 [is transmitted] from multiple STAs 106 to the AP 104.” SAMSUNG-1004, 0043-0044; SAMSUNG-1005, 0047-0048. Thus, Zhou’s STAs ***transmit, to the base wireless communication terminal*** UL-MU signals, communications, or transmissions ***in response to the trigger frame***. These responsive signals, communications, or transmissions would utilize the 802.11 defined PPDU for transmission and thus be ***trigger-based PPDU***s. A POSITA would have understood and found obvious that the wireless 802.11 transmissions described in Zhou between the STAs and APs is accomplished ***using the transceiver***. Thus, when participating in UL-MU transmissions, STAs ***transmit, to the base wireless communication terminal, a trigger-based physical layer protocol data unit (PPDU) in response to the trigger frame using the transceiver***.

[1.4] switch a parameter set, which is a set of parameters used for the channel access, from a first parameter set to a second parameter set based on whether the base wireless communication terminal triggers a multi-user uplink transmission participation of the wireless communication terminal,

135. Zhou-Cherian-Kim renders obvious [1.4]. Zhou teaches using EDCA parameters for different STAs in communication with the AP. SAMSUNG-1004, 0002-0003, 0041; SAMSUNG-1005, 0002, 0047. Zhou further describes the distinct application of particular EDCA parameter sets to particular stations. SAMSUNG-1004, cl 1.; SAMSUNG-1005, 0010 (“The method includes selecting, at an access point, an enhanced distributed channel access (EDCA) parameter for

communication with a station. The method further includes transmitting an indication of the selection to the station.”), 0011. The selection in Zhou can be based on whether the STA is capable of, and is called upon to participate in, UL-MU transmissions. SAMSUNG-1004, 0037, 0041, 0044; SAMSUNG-1005, 0043, 0047 (“the AP 104 may define EDCA parameters to facilitate UL-MU transmissions.”), 0050 (“adjusting EDCA parameters for STAs capable of and willing for transmitting UL MU transmissions”).

136. Cherian teaches switching between using different EDCA parameter set selections. SAMSUNG-1006, 0067, 0078; SAMSUNG-1007, 0058, 0065. Specifically, Cherian describes switching between single user (SU) and multiuser (MU) modes, each mode using different EDCA parameters. SAMSUNG-1006, 0067, 0078; SAMSUNG-1007, 0058, 0065. More specifically, Cherian discloses “transitioning from a Single-User (SU) mode . . . to a Multi-User (MU) mode” which corresponds to the claimed *switch[ing] a parameter set*. SAMSUNG-1006, 0006, 0067, 0073, 0078; SAMSUNG-1007, 0005, 0058, 0060 (“EDCA Parameter Set element provides information needed by STAs for proper operation of the QoS facility during the CP”), 0065, FIG. 3. In Cherian’s configuration, each mode (SU or MU) would utilize a distinct EDCA parameter set.

137. Cherian states that the parameters associated with different modes

include “backoff counters”⁷ [that] are used to attempt to access a medium” or *a*

parameter set, which is a set of parameters used for the channel access.

SAMSUNG-1006, cl. 1-3; SAMSUNG-1007, cl. 1-2. A POSITA would have understood and found obvious that the backoff timers and EDCA parameters relate to the backoff procedures used for contention-based transmissions. As I discussed in the Technology Background, contention-based transmissions typically use backoff procedures when accessing the channel and a backoff procedure employs a backoff timer that uses the EDCA parameter set. Given the teachings of Zhou and Cherian, a POSITA would have understood and found obvious, that access to the *medium* using access categories encompasses accessing the *channel* because, in the context of CSMA/CA, once the *medium* is accessed, the user has obtained (i.e., accessed) a *channel* for communication. SAMSUNG-1004, 0040; SAMSUNG-1005, 046 (“A transmission medium can also be termed a transmission channel.”); SAMSUNG-1006, cl. 2-3; SAMSUNG-1007, cl. 2.

138. Furthermore, Cherian explains that its “modes” are related to *sets* of

⁷ Cherian and Zhou use a combination of the terms “timer” and “counter.” A POSITA would have understood and found obvious that in the context of contention-based transmissions, “timer” and “counter” both refer to the same backoff procedures describe in the 802.11 standard.

EDCA parameters. SAMSUNG-1006, 0008, 0061, FIG. 3; SAMSUNG-1007, 0005 (“transitioning from a Single-User (SU) mode, in which a first set of one or more backoff counters are used to attempt to access a medium, to a Multi-User (MU) mode, in which a second set of one or more backoff counters are used to attempt to access the medium,”), 0053, FIG. 3. Cherian acknowledges that a POSITA would have understood and found obvious that EDCA parameters are used in controlling backoff timers used for channel access. SAMSUNG-1006, 0052, 0062-0063; SAMSUNG-1007, 0045 (“WLAN employs contention based distributed channel access”) 0054-0055, 0054 (“EDCA parameters including the values of the backoff counters”). Thus, Cherian teaches that a STA can *switch a parameter set, which is a set of parameters used for the channel access* via a backoff procedure, *from a first parameter set to a second parameter set* (e.g., from a parameter set for SU mode to a parameter set for MU mode).

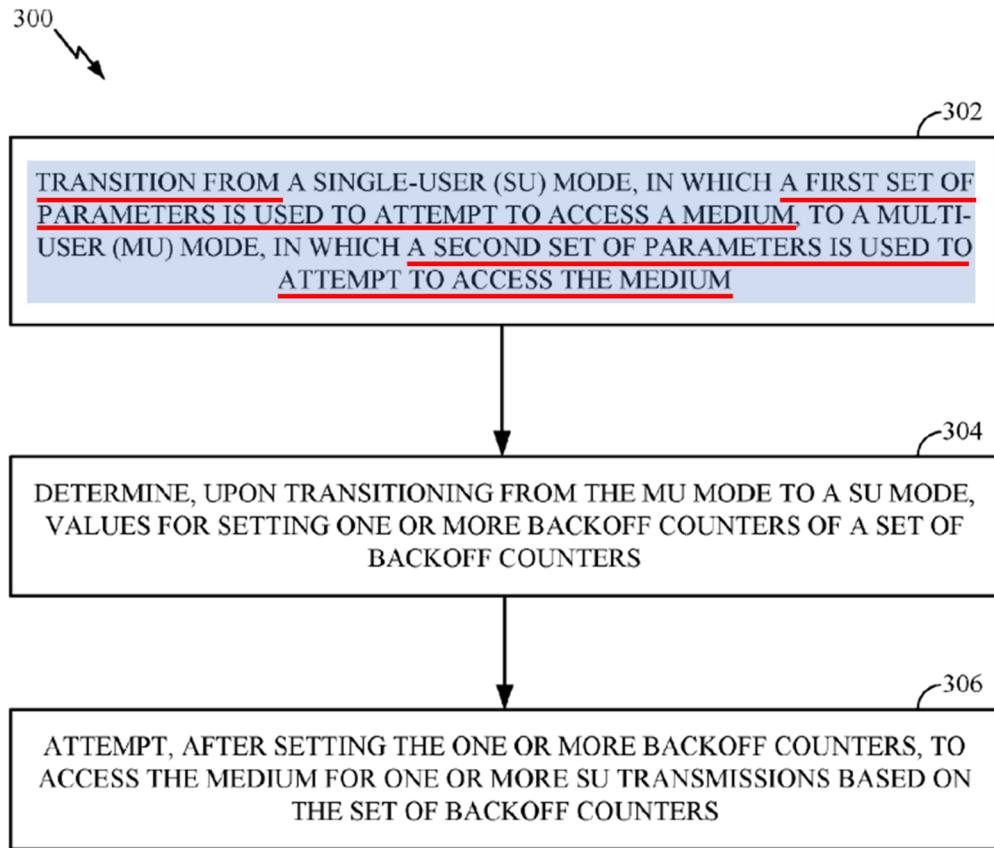


FIG. 3

SAMSUNG-1006, FIG. 3.

139. Cherian and Zhou describe the distinction between a set of EDCA parameters (a *first parameter set*) for UL-SU and a set of parameters (a *second parameter set*) for UL-MU transmission. SAMSUNG-1004, 0031, 0041, 0044; SAMSUNG-1005, 0043, 0047, 0050; SAMSUNG-1006, 0067, 0078, FIG. 3, cl. 1-3; SAMSUNG-1007, 0058, 0065, FIG. 3, cl. 1-2. Specifically, Cherian teaches “a trigger frame is transmitted by AP at 402 scheduling UL resources to stations

STA1, STA2, and STA3 for simultaneous UL transmission [(***multi-user uplink transmission participation***)].” SAMSUNG-1006, 0067; SAMSUNG-1007, 0058.

“In response to receiving the trigger frame at 402, the STAs 1-3 transition to the MU mode and, simultaneously transmit packets on the UL on resources scheduled by the trigger frame received at 402.” *Id.* Cherian describes the “transition to MU mode” as the STA “switching from SU to MU” where the “STA that receives a trigger frame. . . may update its EDCA parameters” in response to a trigger frame. SAMSUNG-1006, 0078, 0067; SAMSUNG-1007, 0065, 0058 (“In response to receiving the trigger frame at 402, the STAs 1-3 transition to the MU mode.”).

Thus, a POSITA would have understood and found obvious that when Cherian describes transmitting, to the STA, a trigger frame for “switching from SU to MU,” it refers to the EDCA parameters switch ***from a first parameter set*** (SU parameters) ***to a second parameter set*** (MU parameters) ***based on whether the base wireless communication terminal triggers a multi-user uplink transmission participation of the wireless communication terminal***. SAMSUNG-1006, 0054, 0078; SAMSUNG-1007, 0047, 0065.

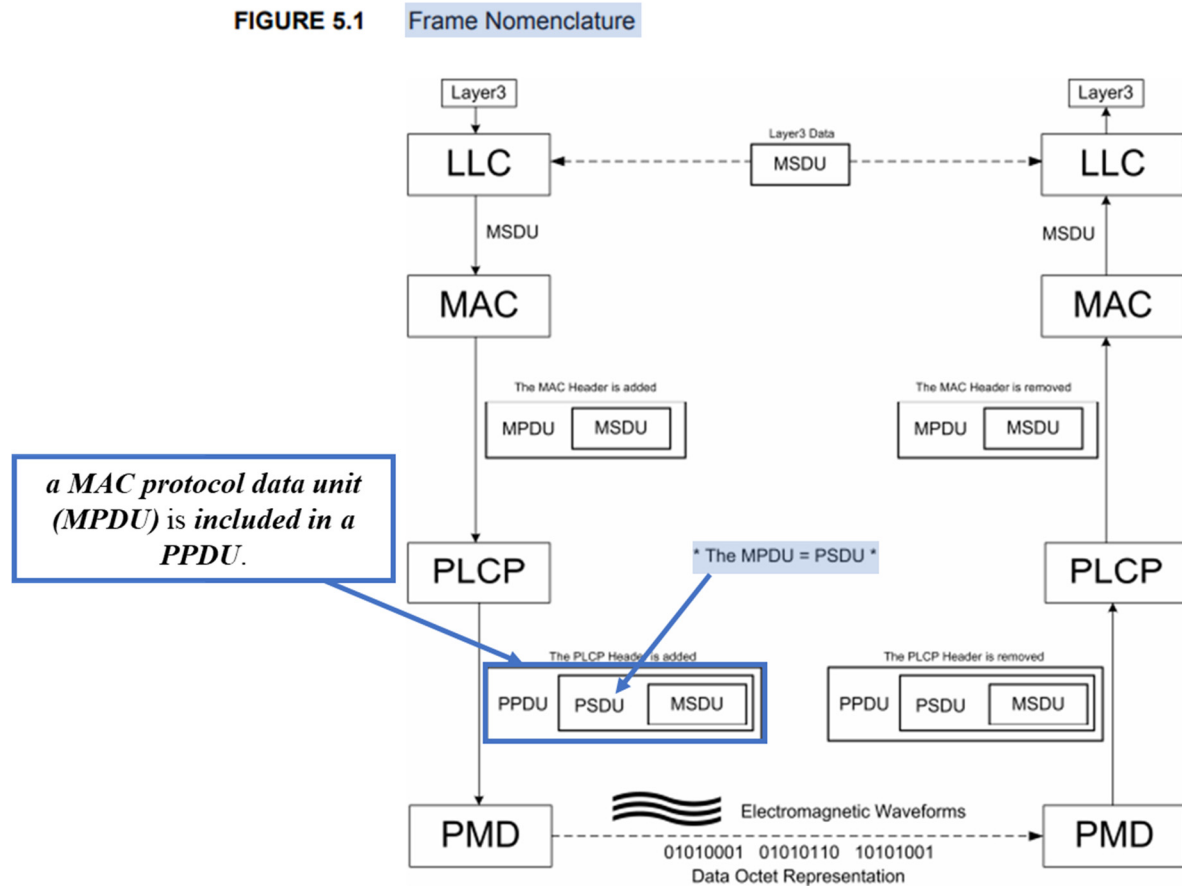
[1.5] when a MAC protocol data unit (MPDU) included in the trigger-based PPDU does not request an immediate response, set a second parameter set timer for an access category of the MPDU when the transmission of the trigger-based PPDU ends,

140. Zhou-Cherian-Kim renders obvious [1.5]-[1.6]. For example, both Zhou and Cherian disclose a STA switching between EDCA parameter sets from a

first set for use with a SU mode to a second set for use with a MU mode during which scheduled UL-MU transmissions occur. Cherian discloses the transition between modes is in response to a trigger frame being received by the STA. SAMSUNG-1006, 0067; SAMSUNG-1007, 0058. Additionally, Cherian discloses use of a timer with a value corresponding to the period of time during which UL-MU transmissions should occur. SAMSUNG-1006, 0067, 0076; SAMSUNG-1007, 0058, 0063. Elements [1.5] and [1.6] deal with whether or not the MPDU requests an immediate response (e.g., an ACK signal) from the AP, and using that condition to determine when the MU EDCA timer is set. As will be discussed below, this EDCA timer will control how long a STA will use the MU EDCA parameter set after a transmission is complete (e.g., when a transmission—that does not request an ACK—is complete or when an ACK is received after a transmission). First, if no ACK is requested [1.5] sets the timer when transmission of the trigger-based PPDU ends and, second, if an ACK is requested, [1.6] sets the timer upon receipt of the ACK signal. For at least the following reasons, Zhou-Cherian-Kim render obvious both of these configurations.

141. First, Zhou-Cherian-Kim teaches *a MAC protocol data unit (MPDU) included in the trigger-based PPDU*. As discussed previously, a POSITA would have understood and found obvious that *a MAC protocol data unit (MPDU)* is *included in a PPDU*. See [1.3]. This well-known concept is displayed in the

CWAP textbook, describing how the MPDU is passed down to the physical layer where it is combined with a PLCP preamble and the PLCP header to form the PPDU. SAMSUNG-1016, p. 166. Thus, as shown in the figure below, a **MPDU** is *included in a PPDU*.



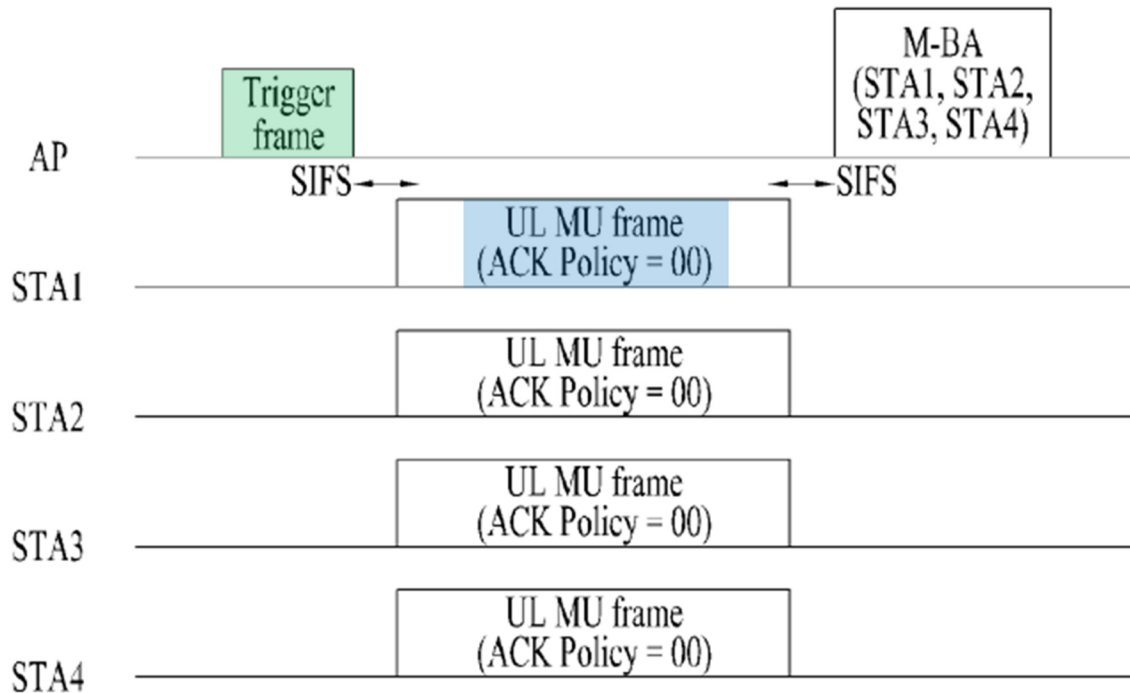
SAMSUNG-1016, FIG. 5.1.

142. As discussed previously, a **trigger-based PPDU** is a PPDU sent in response to receiving a trigger. See [1.3].

143. Second, Zhou-Cherian-Kim renders obvious configurations *when a (MPDU). . . does not request an immediate response*. For example, Kim describes

processes similar to Zhou and Cherian where “an AP may transmit a trigger frame to STA 1 to STA 4 to cause them to transmit ULMU frames.” SAMSUNG-1008, 0060, 0096-0097, 0107-0109. In figures 14-23 of Kim, various UL-MU transmissions have different acknowledgment policies. SAMSUNG-1008, FIG. 14-23. Specifically, Kim teaches, through at least Tables 1-2 and 6-9, various configurations of acknowledgements: e.g., “normal acknowledgement” and “no acknowledgement.” SAMSUNG-1008, 0064-0065, Tables 1, 6-9. As shown in Kim’s Figure 21, in response to the trigger frame, “STA 1 to STA 4 may include an ACK policy in MPDUs and transmit ULMU frames.” SAMSUNG-1008, 0096.

FIG. 21



SAMSUNG-1008, FIG. 21.

144. To account for various configurations based on each STA, Kim teaches “a method of flexibly transmitting an ACK/NACK [(acknowledgment)/(no-acknowledgement)] signal on the basis of an ACK policy value per STA.” SAMSUNG-1008, 0091. Kim goes on to describe how the “ACK policy” across different STAs can include four options “Normal ACK,” “No ACK,” “No explicit acknowledgement or PSMP ACK,” and “Block ACK.” SAMSUNG-1008, 0094-0096, Tables 6-9. Thus, Kim teaches the option of having

“an ACK policy value per STA,” e.g., a policy that includes *when a MAC protocol data unit (MPDU) . . . does not request an immediate response*. A POSITA would have understood and found obvious that whether an *MPDU* includes, or *does not* include, a *request* for *an immediate response* is a design choice contemplated by Kim. Thus, Kim teaches [1.5], *a MAC protocol data unit (MPDU) included in the trigger-based PPDU does not request an immediate response*.

TABLE 7

ACK Policy == 01
No ACK
The addressed recipient takes no action upon receipt of the frame. The ACK Policy subfield is set to this value in all individually addressed frames in which the sender does not require acknowledgment. The ACK Policy subfield is also set to this value in all group addressed frames that use the QoS frame format except with a TID for which a block ACK agreement exists. This value of the ACK Policy subfield is not used for QoS Data frames with a TID for which a block ACK agreement exists. The ACK Policy subfield for group addressed QoS Null (no data) frames is set to this value.

SAMSUNG-1008, Table 7.

145. In more detail, Kim describes transmissions from several STAs and considers available options depending on whether an acknowledgment (*an immediate response*) to those transmissions is requested. SAMSUNG-1008, 0064-0065, FIG. 10, 12. Further, these acknowledgement policies are contained within

the MPDUs. SAMSUNG-1008, 0096, Tables 6-7. At least two of the

configurations are shown below in Tables 6-7. SAMSUNG-1008, Tables 1, 6-7.

TABLE 6

ACK Policy == 00

Normal ACK or Implicit Block ACK Request.

In a frame that is a non-A-MPDU frame or VHT single MPDU:

The addressed recipient returns an ACK or QoS +CF-ACK frame after a short interframe space (SIFS) period, according to the procedures defined in ACK procedure and HCCA transfer rules. A non-DMG STA sets the ACK Policy subfield for individually addressed QoS Null (no data) frames to this value.

Otherwise:

The addressed recipient returns a Block ACK frame, either individually or as part of an A-MPDU starting an SIFS after the PPDU carrying the frame, according to the procedures defined in Block ACK procedure, Generation and transmission of Block ACK frames by an HT STA or DMG STA, Operation of HT-delayed block ACK, Rules for RD initiator, Rules for RD responder, and Explicit feedback beamforming.

SAMSUNG-1008, Table 6.

TABLE 7

ACK Policy == 01

No ACK

The addressed recipient takes no action upon receipt of the frame.

The ACK Policy subfield is set to this value in all individually addressed frames in which the sender does not require acknowledgment. The ACK Policy subfield is also set to this value in all group addressed frames that use the QoS frame format except with a TID for which a block ACK agreement exists.

This value of the ACK Policy subfield is not used for QoS Data frames with a TID for which a block ACK agreement exists.

The ACK Policy subfield for group addressed QoS Null (no data) frames is set to this value.

SAMSUNG-1008, Table 7.

146. Third, Zhou-Cherian-Kim renders obvious that the STA can *set a second parameter set timer for an access category of the MPDU when the transmission of the trigger-based PPDU ends*. Zhou and Cherian teach periods of time in which a STA would operate using MU EDCA parameters. SAMSUNG-1004, 0073, 0075, FIG. 3; SAMSUNG-1005, 0079, 0081, FIG. 3; SAMSUNG-1006, 0076, FIG. 6; SAMSUNG-1007, 0063, FIG. 5. In Cherian's Figure 6, the "MU EDCA Timer" is sent via a data frame to communicate the period of time in which the STA should operate with MU EDCA parameters. SAMSUNG-1006,

0073, 0076, FIG. 6; SAMSUNG-1007, 0060, 0063, FIG. 5.

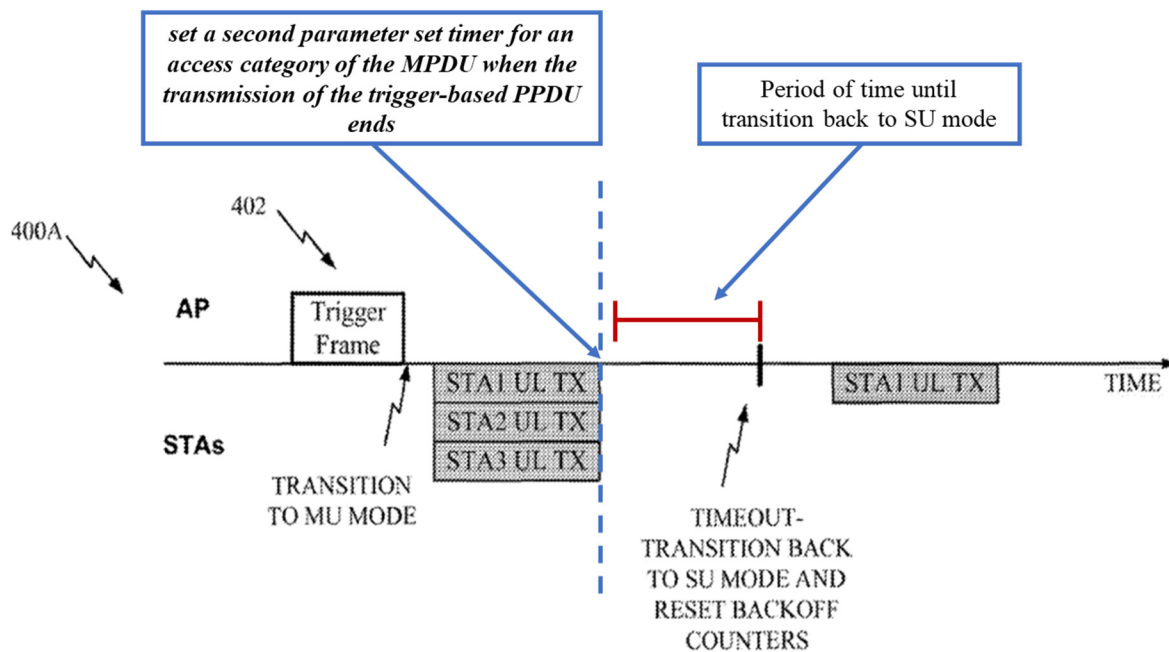
Element ID	Length	Element ID Extension	MU QoS Info	MU EDCA Timer	MU AC_BE Parameter Record	MU AC_BK Parameter Record	MU AC_VI Parameter Record	MU AC_VO Parameter Record
Octets: 1	1	1	1	2	2	2	2	2

SAMSUNG-1006, FIG. 6.

147. Specifically, Cherian teaches using a MU EDCA timer (*a second parameter set timer*) for the purpose of controlling the period of time in which UL-MU EDCA parameters are used by the STA. SAMSUNG-1006, 0076, FIG. 6; SAMSUNG-1007, 0063, FIG. 5. Cherian describes the MU EDCA timer “indicates the duration of time, in units of TUs, for which the provided MU EDCA parameters are valid after reception of a Trigger frame.” SAMSUNG-1006, 0049, 0076, 0067; SAMSUNG-1007, 0042, 0063, 0058 (“Once the timeout period expires, each STA transitions back to an SU mode.”). Recall in [1.4] that the STA switches the EDCA parameter set from SU EDCA parameters (*a first parameter set*) to MU EDCA parameters (*a second parameter set*).

148. Zhou’s disclosure of resetting the timer “after the STA 106 transmits a scheduled UL transmission, or transmits a scheduled UL transmission and gets an ACK message” or “after the STA 106 transmits a non-scheduled UL transmission, or transmits a non-scheduled UL transmission and gets an ACK message”

demonstrates various times at which the setting or resetting of a timer could have occurred. SAMSUNG-1004, 0075; SAMSUNG-1005, 0081. Here, a POSITA would have understood and found obvious in the context of Zhou, Cherian, and Kim that Zhou's "after" the STA transmits teaches the claimed "***when the transmission of the trigger-based PPDU ends.***" In combination with Cherian's defined "EDCA timer" a POSITA would have understood and found obvious that, in Zhou-Cherian-Kim when no immediate response is requested the STA *set[s] a second parameter set timer . . . when the transmission of the trigger-based PPDU ends.* SAMSUNG-1006, 0056, 0067; SAMSUNG-1007, 0049, 0058 ("Once the timeout period expires, each STA transitions back to an SU mode."), FIG. 4, FIG. 6.



SAMSUNG-1006, FIG. 4(a).

149. In more detail, determining when to set the timer is a design choice—described in Zhou—with a finite number of options available to a POSITA. SAMSUNG-1004, 0075; SAMSUNG-1005, 0081. For example, setting the timer immediately after transmission of a PPDU or after acknowledgement of that PPDU are both choices available under the 802.11 standard, described in Kim and Zhou, and understood by a POSITA. SAMSUNG-1004, 0075; SAMSUNG-1005, 0081; SAMSUNG-1008, Table 1. Moreover, it would have been obvious to a POSITA that when a station is transmitting UL-MU transmissions without a request for ACK, the waiting period dictated by the EDCA timer is set after the UL-MU transmission is complete e.g., *when the transmission of the ... PPDU ends*. Indeed, Zhou teaches various obvious times at which the “reset” of a timer could occur, the end of a transmission being one of them. SAMSUNG-1004, 0075; SAMSUNG-1005, 0081.

150. In more detail, a POSITA would have understood and found obvious that if an immediate response were requested the STA would wait for acknowledgement from the AP (to ensure the transmission did not fail) before Zhou’s timer is reset. A POSITA would have understood that the purpose of an ACK request is to verify whether the STA does not need to re-transmit the data. SAMSUNG-1018, 0009 (“A successful transmission occurs when the node either receives an expected acknowledgment correctly, or transmits a frame that does not

require an acknowledgement.”) Thus, the transmission requiring an immediate response is not complete until the immediate response is received. A POSITA would have recognized that waiting to set the timer after acknowledgment is received would ensure the transmission is complete and no re-transmission is necessary, thus allowing the MU EDCA timer to be set and wait for further instructions before switching back to SU mode. In the case where an ACK is requested, the timer would not be set until after the immediate response is received. In the case where no immediate response is received (as here in [1.5]), it is logical to not delay setting the timer. As counsel informs me, and as I discussed in the combination of Zhou, Cherian, and Kim, a POSITA is not an automaton, and would have understood the known methods (ACK polices) and how to apply them to achieve predictable results.

151. Thus, a POSITA reviewing Zhou, Cherian, and Kim would have understood and found obvious that the STA can *set a second parameter set timer for an access category of the MPDU when the transmission of the trigger-based PPDU ends* because no ACK is requested and therefore not expected.

SAMSUNG-1004, 0075; SAMSUNG-1005, 0081.

152. Finally, Zhou-Cherian-Kim teaches *a second parameter set timer for an access category*. In its background section, Zhou describes the well-known use of EDCA parameters with access categories. SAMSUNG-1004, 0003;

SAMSUNG-1005, 0002 (“EDCA defines separate data traffic access categories, which may include best effort, background, video and voice”).

153. Zhou’s disclosure teaches that, by utilizing EDCA parameters that define “separate data traffic categories,” “high-priority traffic has more opportunity of being sent than a low-priority traffic because a station with high priority data traffic waits for less time before sending such a data packet.” SAMSUNG-1004, 0003; SAMSUNG-1005, 0002. A POSITA would have understood and found obvious that Zhou’s description of EDCA parameters used for channel access with separate categories, where each category can “wait[]” for transmission, teaches the well-known EDCA parameter based backoff timers for *access categories*.

154. Similarly, Cherian describes the different *access categories* used in combination with EDCA parameters as demonstrated in Cherian’s Figure 6.

SAMSUNG-1006, 0049, FIG. 6; SAMSUNG-1007, 0042, FIG. 5.

Element ID	Length	Element ID Extension	MU QoS Info	MU EDCA Timer	MU AC_BE Parameter Record	MU AC_BK Parameter Record	MU AC_VI Parameter Record	MU AC_VO Parameter Record
Octets: 1	1	1	1	2	2	2	2	2

SAMSUNG-1006, FIG. 6.

155. A POSITA would have understood and found obvious that when setting the parameter set timer, which Cherian describes “indicates the duration of

time, in units of TUs, for which the provided MU EDCA parameters are valid,” applies to at least *an access category*. SAMSUNG-1006, 0049, 0076, 0067; SAMSUNG-1007, 0042, 0063, 0058 (“Once the timeout period expires, each STA transitions back to an SU mode.”). Specifically, Cherian teaches that “MU EDCA parameters are valid” for one or more of *an access category* until the “duration of time” expires. *Id.* Because, Cherian’s EDCA parameters are used in backoff timers for the access categories, a POSITA would have understood and found obvious that the *parameter set timer* defines a period of time in which one or more of *an access category of the MPDU* is to the current set of MU EDCA parameters. Therefore, Zhou-Cherian-Kim teaches *set a second parameter set timer for an access category of the MPDU*.

156. Additionally, a POSITA would have understood and found obvious that the “access category of the MPDU” is determined by the Traffic Identifiers (TID) field in its QoS Control field, which reflects the User Priority (UP) of the data it carries. SAMSUNG-1017, pp.664, 792, Table 9-1, Figure 8-192, Table 8-106. The transmitting STA uses this UP to indicate the access category for transmitting within an MPDU. For example, the 802.11 standard defines a QoS field in the Mac Layer frame (MPDU). SAMSUNG-1017, Chapter 8. Within the QoS field are bits identifying the type of traffic being transmitted. SAMSUNG-1017, p.389-391. The 802.11 standard states “the AP’s MAC sublayer shall derive

the access category from the priority using the mapping in Table 9-1.”

SAMSUNG-1017, p.98, 100.

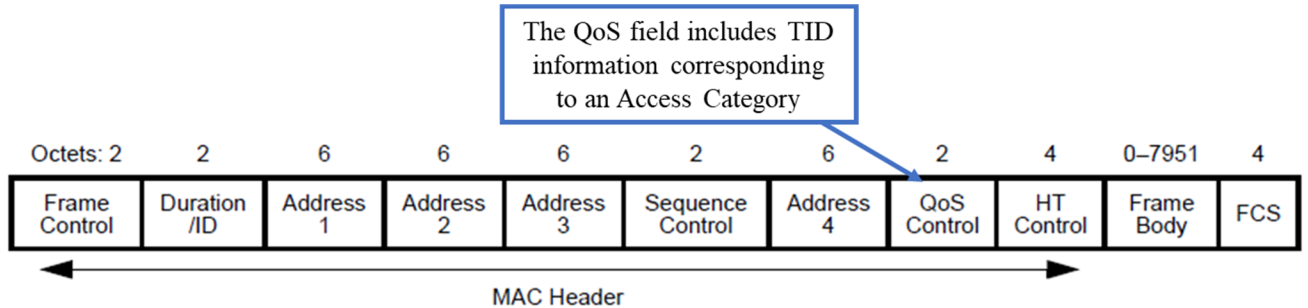


Figure 8-1—MAC frame format

SAMSUNG-1017, FIG 8.1.

Table 9-1—UP-to-AC mappings

Priority	UP (Same as 802.1D user priority)	802.1D designation	AC	Designation (informative)
Lowest ↓ Highest	1	BK	AC_BK	Background
	2	—	AC_BK	Background
	0	BE	AC_BE	Best Effort
	3	EE	AC_BE	Best Effort
	4	CL	AC_VI	Video
	5	VI	AC_VI	Video
	6	VO	AC_VO	Voice
	7	NC	AC_VO	Voice

SAMSUNG-1017, Table 9.1.

157. Thus, a POSITA would have understood and found obvious 1) that

Cherian and Zhou contemplate setting a parameter set timer for all access categories (*an access category*) to be used for the MU EDCA parameters and 2) that an MPDU carries a QoS field with a TID and UP corresponding to *an access category of the MPDU*.

158. Thus, Zhou-Cherian-Kim renders obvious that, *when a MAC protocol data unit (MPDU) included in the trigger-based PPDU does not request an immediate response, set a second parameter set timer for an access category of the MPDU when the transmission of the trigger-based PPDU ends.*

[1.6] when the MPDU included in the trigger-based PPDU requests an immediate response, set the second parameter set timer for the access category of the MPDU for which immediate response is received,

159. As discussed in [1.5], Zhou-Cherian-Kim renders obvious [1.5]-[1.6]. First, as shown in [1.5], a POSITA would have understood and found obvious that *the MPDU [is] included in the trigger-based PPDU*. SAMSUNG-1016, p. 166; *See* [1.5]. Second, Zhou-Cherian-Kim renders obvious configurations in which the MPDU *requests an immediate response*. SAMSUNG-1008, 0064-0065, 0094, 0096, Tables 6-9; *See* [1.5].

TABLE 6

ACK Policy == 00

Normal ACK or Implicit Block ACK Request.

In a frame that is a non-A-MPDU frame or VHT single MPDU:

The addressed recipient returns an ACK or QoS +CF-ACK frame after a short interframe space (SIFS) period, according to the procedures defined in ACK procedure and HCCA transfer rules. A non-DMG STA sets the ACK Policy subfield for individually addressed QoS Null (no data) frames to this value.

Otherwise:

The addressed recipient returns a Block ACK frame, either individually or as part of an A-MPDU starting an SIFS after the PPDU carrying the frame, according to the procedures defined in Block ACK procedure, Generation and transmission of Block ACK frames by an HT STA or DMG STA, Operation of HT-delayed block ACK, Rules for RD initiator, Rules for RD responder, and Explicit feedback beamforming.

SAMSUNG-1008, Table 6.

TABLE 7

ACK Policy == 01

No ACK

The addressed recipient takes no action upon receipt of the frame.

The ACK Policy subfield is set to this value in all individually addressed frames in which the sender does not require acknowledgment. The ACK Policy subfield is also set to this value in all group addressed frames that use the QoS frame format except with a TID for which a block ACK agreement exists.

This value of the ACK Policy subfield is not used for QoS Data frames with a TID for which a block ACK agreement exists.

The ACK Policy subfield for group addressed QoS Null (no data) frames is set to this value.

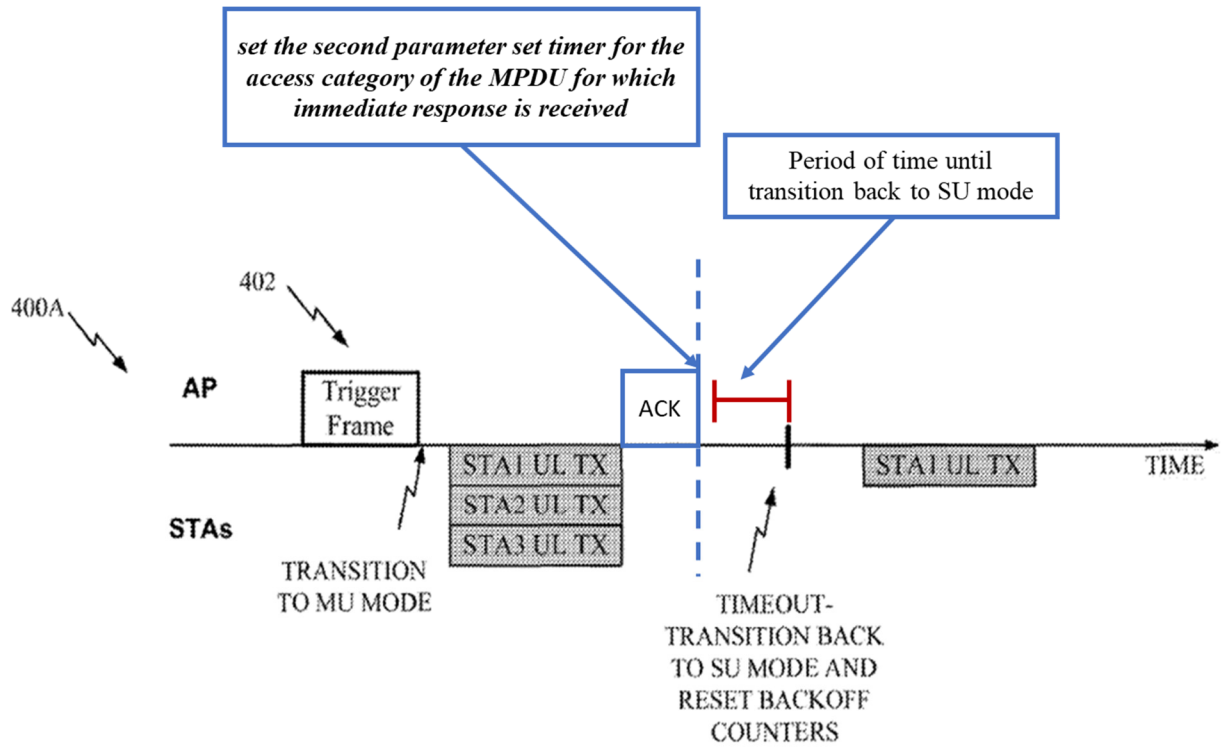
SAMSUNG-1008, Table 7.

160. Third, Zhou-Cherian-Kim renders obvious that the STA can *set the second parameter set timer for the access category of the MPDU for which immediate response is received*. As discussed in [1.5] when a MPDU requests immediate response (equivalently, acknowledgement or ACK), the STA pauses to confirm the transmission was successfully received. *See* [1.5]. When acknowledgement is received (*for which immediate response is received*) the STA *set[s] the second parameter set timer for the access category of the MPDU*. *See* [1.5].

161. Because a POSITA would have understood and found obvious that when an ACK is requested, a transmission is not considered complete until the ACK is received, it would have been obvious to set a timer for which ACK is received (when it is requested). SAMSUNG-1018, 0009 (“A successful transmission occurs when the node either receives an expected acknowledgment correctly, or transmits a frame that does not require an acknowledgment.”). This configuration would have been understood and obvious to a POSITA because the EDCA timer serves to control the amount of time that the MU EDCA contention parameters are used as Cherian teaches. SAMSUNG-1006, 0049, 0076, 0067; SAMSUNG-1007, 0042, 0063 (“indicates the duration of time, in units of TUs, for which the provided MU EDCA parameters are valid,”), 0058 (“Once the timeout period expires, each STA transitions back to an SU mode.”). When entering MU

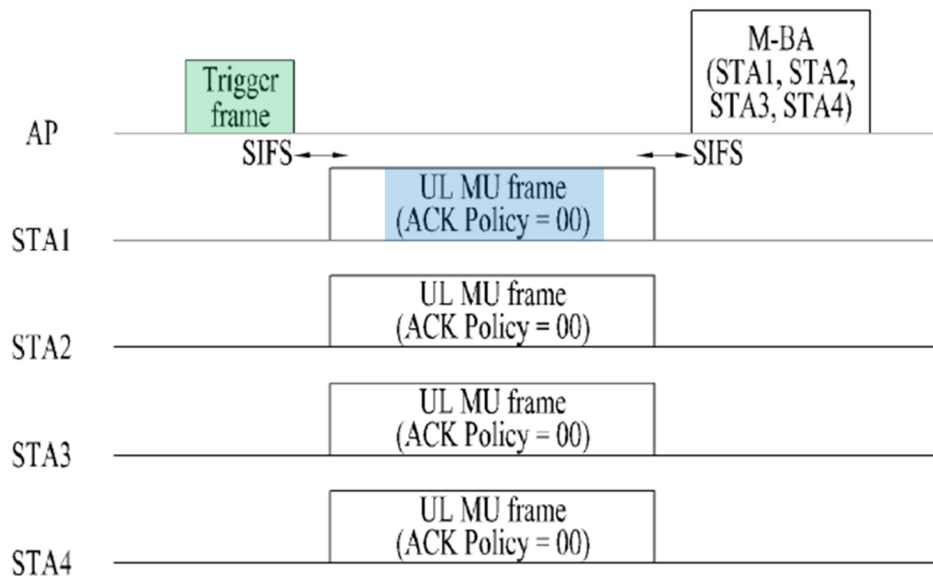
mode and transmitting the simultaneous transmissions described in Zhou-Cherian-Kim, the MU mode parameters are meant to reduce the probability of collision between contention transmissions and the triggered UL-MU transmission. After the STAs complete transmission of the coordinated MU transmissions, the EDCA timer maintains the MU parameter set in operation for a period of time in case other UL-MU transmissions are scheduled. A STA measures the “completion” of the transmission by receiving an ACK—if an ACK is requested—or upon completion of the physical transmission. These two options for setting a timer would have been obvious to a POSITA. *See* [1.5].

162. In more detail, Zhou teaches the STA may “reset [the] timer/counter to zero after the STA 106 . . . transmits a scheduled UL transmission [(UL-MU transmission)] and gets an ACK message.” SAMSUNG-1004, 0075; SAMSUNG-1005, 0081. The incorporation of Zhou’s teaching of when to set the timer with Cherian’s “EDCA timer” and Kim’s ACK, is demonstrated in Cherian and Kim’s annotated figures below.



SAMSUNG-1006, FIG. 4(a).

FIG. 21



SAMSUNG-1008, FIG. 21.

163. In addition, elements [1.5]-[1.6] can include an aggregated MPDU or A-MPDU. An A-MPDU is a collection of MPDUs sent as a single unit. SAMSUNG-1017, p.814 (“An A-MPDU is a sequence of MPDUs carried in a single PPDU.”) When aggregated, each MPDU may contain different acknowledgement requirements (e.g., element [1.5] where the MPDU “does not request immediate response” and element [1.6] where the MPDU “requests immediate response”). The ’879 Patent provides an example of these A-MPDUs with mixed acknowledgement policies in figure 17. SAMSUNG-1001, FIG. 17.

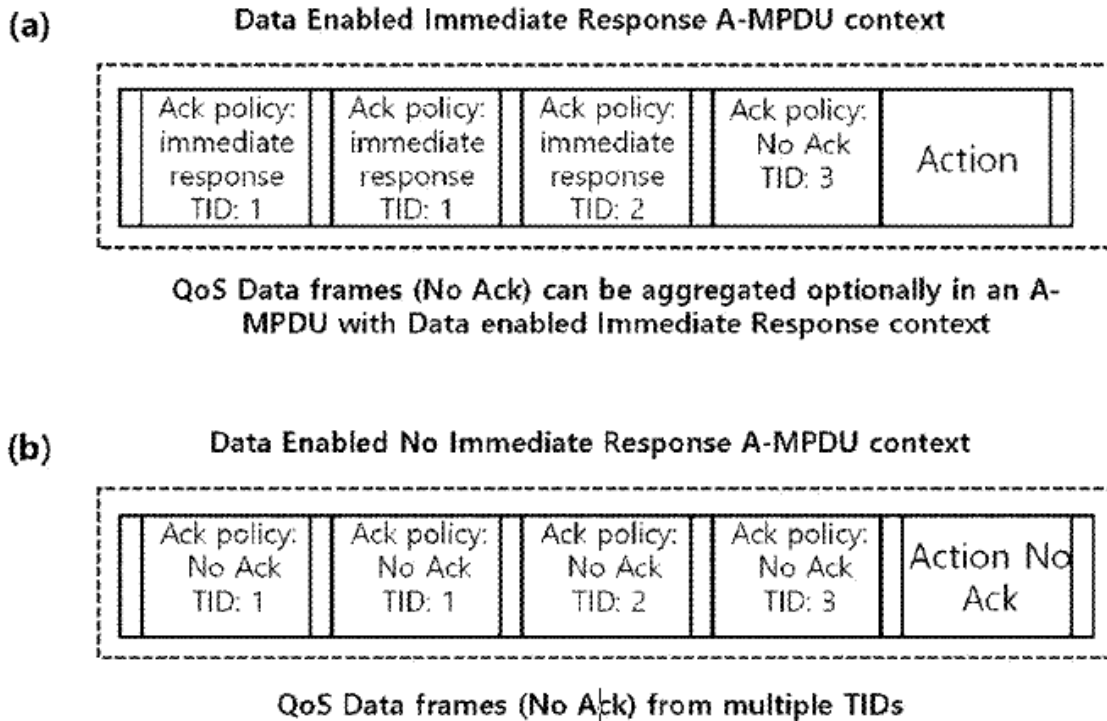


FIG. 17

SAMSUNG-1001, FIG. 17.

164. A POSITA would have understood and found obvious that the foregoing configuration of aggregating MPDUs into an A-MPDU was possible because it is taught in the 802.11 standard that precedes the Critical Date by four years. SAMSUNG-1017, p.1. For example, Tables 8-283 through 8-287 explain when the contents of an A-MPDU would require immediate response. SAMSUNG-1017, pp.814-817. If an A-MPDU has at least one MPDU that requests immediate response, there will be an immediate response following the A-

MPDU. Particularly, Table 8-285 shows that for there to be “no immediate response,” no MPDUs that request an immediate response may be present in the A-MPDU. SAMSUNG-1017, pp.814-817.

Table 8-283—A-MPDU Contexts

Name of Context	Definition of Context	Table defining permitted contents
Data Enabled Immediate Response	The A-MPDU is transmitted outside a PSMP sequence by a TXOP holder or an RD responder including potential immediate responses.	Table 8-284
Data Enabled No Immediate Response	The A-MPDU is transmitted outside a PSMP sequence by a TXOP holder that does not include or solicit an immediate response. See NOTE.	Table 8-285
PSMP	The A-MPDU is transmitted within a PSMP sequence.	Table 8-286
Control Response	The A-MPDU is transmitted by a STA that is neither a TXOP holder nor an RD responder that also needs to transmit one of the following immediate response frames: Ack BlockAck with a TID for which an HT-immediate Block Ack agreement exists	Table 8-287
NOTE—This context includes cases when no response is generated or when a response is generated later by the operation of the delayed Block Ack rules.		

SAMSUNG-1017, Table 8-283.

Table 8-285—A-MPDU contents in the data enabled no immediate response context

MPDU Description	Conditions
Delayed BlockAcks	BlockAck frames for a TID for which an HT-delayed Block Ack agreement exists with the BA Ack Policy subfield equal to No Acknowledgment.
Delayed Block Ack data	QoS Data MPDUs with a TID that corresponds to a Delayed or HT-delayed Block Ack agreement. These have the Ack Policy field equal to Block Ack.
Data without a Block Ack agreement	QoS Data MPDUs with a TID that does not correspond to a Block Ack agreement. These have the Ack Policy field equal to No Ack and the A-MSDU Present subfield equal to 0.
Action No Ack	Management frames of subtype Action No Ack.
Delayed BlockAckReqs	BlockAckReq MPDUs with the BA Ack Policy subfield equal to No Acknowledgment and with a TID that corresponds to an HT-delayed Block Ack agreement.

SAMSUNG-1017, Table 8-283.

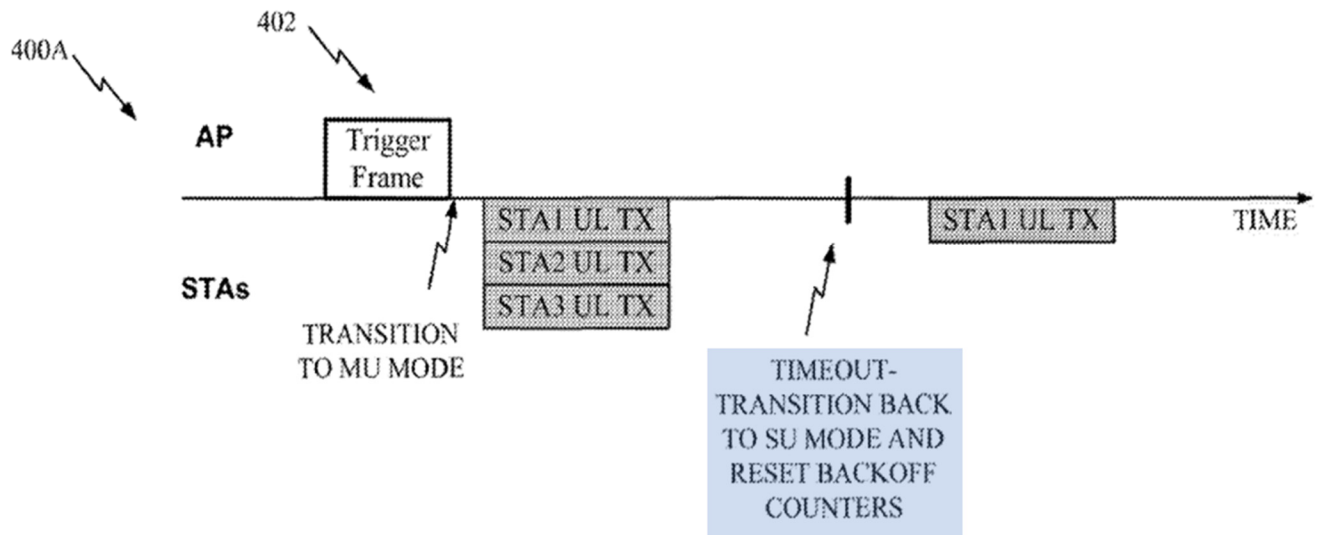
165. Thus, a POSITA would have understood and found obvious that if the “MPDU” recited in elements [1.5]-[1.6] were an A-MPDU, the claim limitations would still be met. For example, if an A-MPDU contained no MPDUs requesting immediate response (e.g., [1.5] all MPDUs “do[] not request immediate response”) then the STA would operate according to [1.5] and set the timer at the end of the transmission. But if the A-MPDU contained at least one MPDU requesting immediate response (e.g., [1.6]), then the STA would wait for the “immediate response” or acknowledgement before setting the timer.

166. Therefore, a POSITA would have understood and found obvious that, whether an A-MPDU or an MPDU, *when the MPDU included in the trigger-based PPDU requests an immediate response*, the STA can *set the second*

parameter set timer for the access category of the MPDU for which immediate response is received (e.g., after the ACK is received).

[1.7] when the second parameter set timer expires, terminate an application of the second parameter set, and

167. Zhou-Cherian-Kim renders obvious [1.7]. For example, Cherian describes that after a “timeout” period (*when the second parameter set timer expires*), the STA transitions back to SU EDCA parameters or, in other words, *terminate[s] an application of the second parameter set* (MU EDCA parameter set). SAMSUNG-1006, 005-0057, 0067, cl. 11, FIG. 4; SAMSUNG-1007, 0049-0050, 0058 (“Once the timeout period expires, each STA transitions back to an SU mode.”), cl. 8 (“the transition back to the SU mode is based on failure to receive, while in the MU mode, a trigger frame from the AP before expiration of a timeout period.”), FIG. 4.



SAMSUNG-1006, FIG. 4(a).

168. Additionally, Zhou teaches a “transition from operating in scheduled mode [(UL-MU mode)] to operating in legacy mode [(UL-SU mode)]” and when a STA switches parameter sets, operations using the previous set of EDCA parameters are “terminate[d].” SAMSUNG-1004, 0067, 0073; SAMSUNG-1005, 0073, 0079. Thus, when Zhou’s timer, reset with Cherian’s value for the MU EDCA timer, expires, use of the previous EDCA parameter set is terminated.

169. A POSITA would have understood and found obvious that, *when* Cherian’s EDCA timer (*the second parameter set timer*) *expires*, the transition back to SU MODE (the claimed *first parameter set*) *terminate[s] application* of the MU EDCA parameters (the claimed *second parameter set*).

[1.8] access a channel according to a priority of data to be transmitted to the base communication terminal by the wireless communication terminal and the parameter set.

170. Zhou-Cherian-Kim renders obvious [1.8]. For example, Zhou discloses equipment using 802.11 standards that “operate under a carrier sense multiple access (CSMA) mechanism for medium access.” SAMSUNG-1004, 0026; SAMSUNG-1005, 0032. A POSITA would have understood and found obvious that CSMA uses EDCA parameters (SU or MU) to ***access a channel according to a priority of data to be transmitted***. SAMSUNG-1004, 0026; SAMSUNG-1005, 0032 (“According to CSMA, devices sense the medium and only transmit when the medium is sensed to be idle.”); SAMSUNG-1017, p.11 (definition of EDCA). A POSITA would have understood and found obvious that accessing a channel “according to a priority of data” involves the use of EDCA parameters associated with contention-based transmissions. The EDCA parameters govern how long each AC must wait before attempting to access the channel. Once each access category's backoff timer counts down to zero, the corresponding queue transmits its data. Because higher-priority categories are assigned shorter contention windows, they are statistically more likely to gain access to the channel sooner, thereby ensuring that data is transmitted in accordance with its assigned priority (e.g., accessed ***“according to a priority of data to be transmitted”***). Moreover, these transmissions occur within a wireless *channel*, which, as discussed, is encompassed by the

concept of the *medium* referenced in the cited materials. *See* [1.4], Section VII.C.

171. Indeed, Zhou teaches “[u]tilizing EDCA, high-priority data traffic has more opportunity of being sent than a low-priority data traffic because a station with high priority data traffic waits for less time before sending such a data packet, on average, than a station with low priority data traffic.” SAMSUNG-1004, 0003; SAMSUNG-1005, 0002. Cherian also teaches using AC categories and QoS “to attempt access to a medium.” SAMSUNG-1006, 0058, 0049; SAMSUNG-1007, 0051, 0042(“... if packets of different ACs are ready for transmission when a backoff timer expires, the AC with the higher priority may be granted access. Several backoff counters may be implemented with one or more different AC queues per counter (e.g., sharing one transmitter).”). A POSITA would have understood and found obvious that EDCA parameters, known in the art and taught by Zhou and Cherian, serve to enable *access [to] a channel according to a priority of data to be transmitted*.

Claim 2

[2.0] The wireless communication terminal of claim 1, wherein the MPDU included in the trigger-based PPDU is a QoS data frame.

172. Zhou-Cherian-Kim renders obvious [2.0]. For example, Cherian teaches the inclusion of a “MU QoS Info” field within the EDCA parameter set element sent by the AP to the STA, thus instructing the STA to use *a QoS data frame* when transmitting using the MU mode. SAMSUNG-1006, 0075, FIG. 6;

SAMSUNG-1007, 0062, FIG. 5. Because an MPDU that carries QoS data frame is transported within a PPDU, *the MPDU included in the trigger-based PPDU is a QoS data frame. See [1.6].*

Element ID	Length	Element ID Extension	MU QoS Info	MU EDCA Timer	MU AC_BE Parameter Record	MU AC_BK Parameter Record	MU AC_VI Parameter Record	MU AC_VO Parameter Record
Octets: 1	1	1	1	2	2	2	2	2

SAMSUNG-1006, FIG. 6.

173. Moreover, a POSITA would have understood that the 802.11 standard defines a QoS data frame to be a data frame sent by a QoS STA, which is a “STA that implements the QoS facility”. SAMSUNG-1007, p. 19, 414. Such data frames have MAC header that includes “the QoS [Quality of Service] control field.” SAMSUNG-1017, p.31. Additionally, whenever a wireless communication system uses “access categories” or “EDCA” it necessarily includes QoS data frames in at least some transmissions. SAMSUNG-1006, 0049; SAMSUNG-1007, 0042 (“Quality of service (QoS) may be implemented by utilizing several access categories (AC)”). For example, the 802.11 standard defines “access category” and “EDCA” as follows:

access category (AC): A label for the common set of enhanced distributed channel access (EDCA) parameters that are used by a

quality-of-service (QoS) station (STA) to contend for the channel in order to transmit medium access control (MAC) service data units (MSDUs) with certain priorities. SAMSUNG-1017, p.5.

enhanced distributed channel access (EDCA): The prioritized carrier sense multiple access with collision avoidance (CSMA/CA) access mechanism used by quality-of-service (QoS) stations (STAs) in a QoS basic service set (BSS). This access mechanism is also used by the QoS access point (AP) and operates concurrently with hybrid coordination function (HCF) controlled channel access (HCCA). SAMSUNG-1017, p.11.

174. Thus, when the MPDU transmits QoS data related to use of EDCA parameters, *the MPDU included in the trigger-based PPDU* necessarily contains *a QoS data frame*.

175. The 802.11 standard also defines a QoS field in the MPDU. When communicating using EDCA parameters, a POSITA would have understood and found obvious that the MPDUs transmitted in response to a trigger frame include a QoS control field with information to manage the quality of service for that data flow (e.g., EDCA parameter information). Thus, when using the QoS field, *the MPDU included in the trigger-based PPDU is a QoS data frame*.

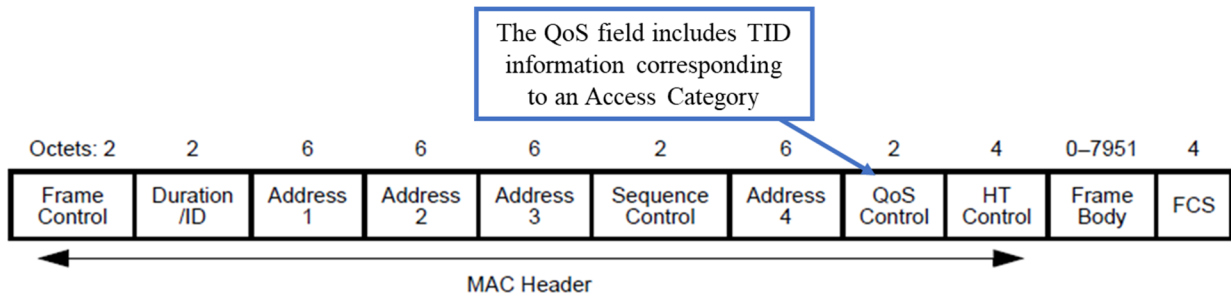


Figure 8-1—MAC frame format

SAMSUNG-1017, FIG. 8.1.

Claim 3

[3.0] The wireless communication terminal of claim 1, wherein the processor is configured to receive a beacon frame from the base wireless communication terminal and obtain information indicating a period of the second parameter set timer from the beacon frame.

176. Zhou-Cherian-Kim renders obvious [3.0]. For example, Zhou states that “EDCA parameters may be . . . included in a beacon frame” received from the AP. SAMSUNG-1004, 0041, 0044, 0060; SAMSUNG-1005, 0047, 0050, 0066. Because beacon frames are management frames periodically sent by APs that can contain scheduling and other network information, a POSITA would have understood and found obvious that the STA’s *processor is configured to receive a beacon frame from the base wireless communication terminal*.

177. Cherian discloses an EDCA parameter set element that “provides information needed by STAs for proper operation of the QoS facility during a Contention Period (CP).” SAMSUNG-1006, 0073; SAMSUNG-1007, 0060.

Cherian discloses that the EDCA parameter set element is transmitted by the AP and received by a STA. SAMSUNG-1006, 0074, 0078; SAMSUNG-1007, 0061, 0065. A POSITA would have understood that the EDCA parameter set element was broadcast network information and therefore could be sent using a beacon frame. Cherian's EDCA parameter set element includes "[t]he MU EDCA Timer [that] indicates the duration of time, in units of TUs, for which the provided MU EDCA parameters are valid after reception of a Trigger frame." SAMSUNG-1006, 0076, FIG. 6; SAMSUNG-1007, 0063, FIG. 5; SAMSUNG-1017, pp.419-420. A POSITA would have understood and found obvious that Cherian's "MU EDCA Timer" is information indicating a period of the second parameter set timer. First, Cherian's MU EDCA timer is data (i.e., *information*) because it is carried within the EDCA parameter set element. Second, Cherian's description above demonstrates the "MU EDCA Timer" is *information indicating a period of the second parameter set timer*. SAMSUNG-1006, 0076; SAMSUNG-1007, 0063("MU EDCA Timer indicates the duration of time, . . . for which . . . MU EDCA parameters are valid."). Cherian's "duration of time" would have been understood and found obvious to equate to a "*period of time*."

Element ID	Length	Element ID Extension	MU QoS Info	MU EDCA Timer	MU AC_BE Parameter Record	MU AC_BK Parameter Record	MU AC_VI Parameter Record	MU AC_VO Parameter Record
Octets: 1	1	1	1	2	2	2	2	2

SAMSUNG-1006, FIG. 6.

178. Zhou teaches that beacon frames are sent by the AP to the STA and can include the EDCA Parameters. SAMSUNG-1004, 0041; SAMSUNG-1005, 0047. When the AP sends a beacon frame, the STA will *receive [the] beacon frame from the base wireless communication terminal* (i.e., the AP). As taught by Cherian, the EDCA Parameter element contains the “MU EDCA Timer.” SAMSUNG-1006, 0076, FIG. 6; SAMSUNG-1007, 0063, FIG. 5. With the EDCA Parameter element sent in the beacon frame, the STA can *obtain information indicating a period of the second parameter set timer from the beacon frame.*

Claim 8

[8.0] An operation method of a wireless communication terminal that wirelessly communicates with a base wireless communication terminal, the method comprising:

179. Zhou-Cherian-Kim renders obvious [8.0]. Zhou describes “methods and apparatuses for selecting enhanced distributed channel access (EDCA) parameters for multi-user (MU) transmissions” to/from the AP. SAMSUNG-1004, 0002, Abstract, cl. 1; SAMSUNG-1005, 0001, 0006. Zhou’s method is for “a

wireless communication system” allowing a plurality of stations to communicate.

SAMSUNG-1004, Abstract, cl. 1; SAMSUNG-1005, 0008, cl. 1(“A method for configuring channel access parameters in a wireless communication system”).

Zhou’s figure 1 demonstrates the wireless communication method as well as

Cherian’s figure 1, both reproduced below. SAMSUNG-1004, FIG. 1;

SAMSUNG-1005, FIG. 1; SAMSUNG-1006, FIG. 1; SAMSUNG-1007, FIG. 1.

Both Zhou and Cherian disclose communication in a wireless network between

STAs and APs (*base wireless communication terminal*). Specifically, Zhou

teaches that various devices (STAs) (*wireless communication terminal*) can

wirelessly communicate[] with a base wireless communication terminal; and

Cherian provides examples of user terminals (STAs) (*wireless communication*

terminal) *that wirelessly communicates with a base wireless communication*

terminal. SAMSUNG-1004, 0005, FIG. 1; SAMSUNG-1005, 0004(“multiple user

terminals (UTs) [(STAs)] to communicate with a single access point”) FIG. 1;

SAMSUNG-1006, 0003, FIG. 1; SAMSUNG-1007, 0002, FIG. 1.

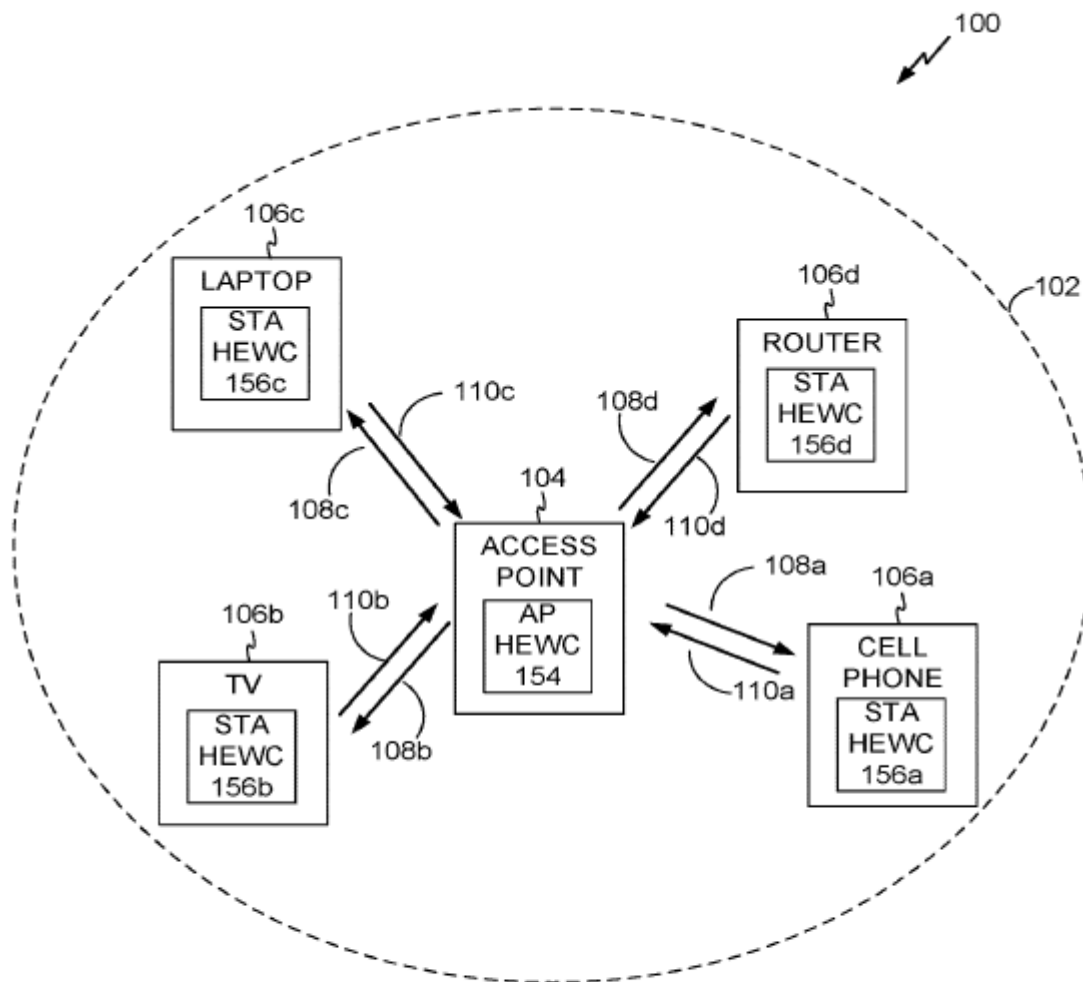


FIG. 1

SAMSUNG-1004, FIG. 1.

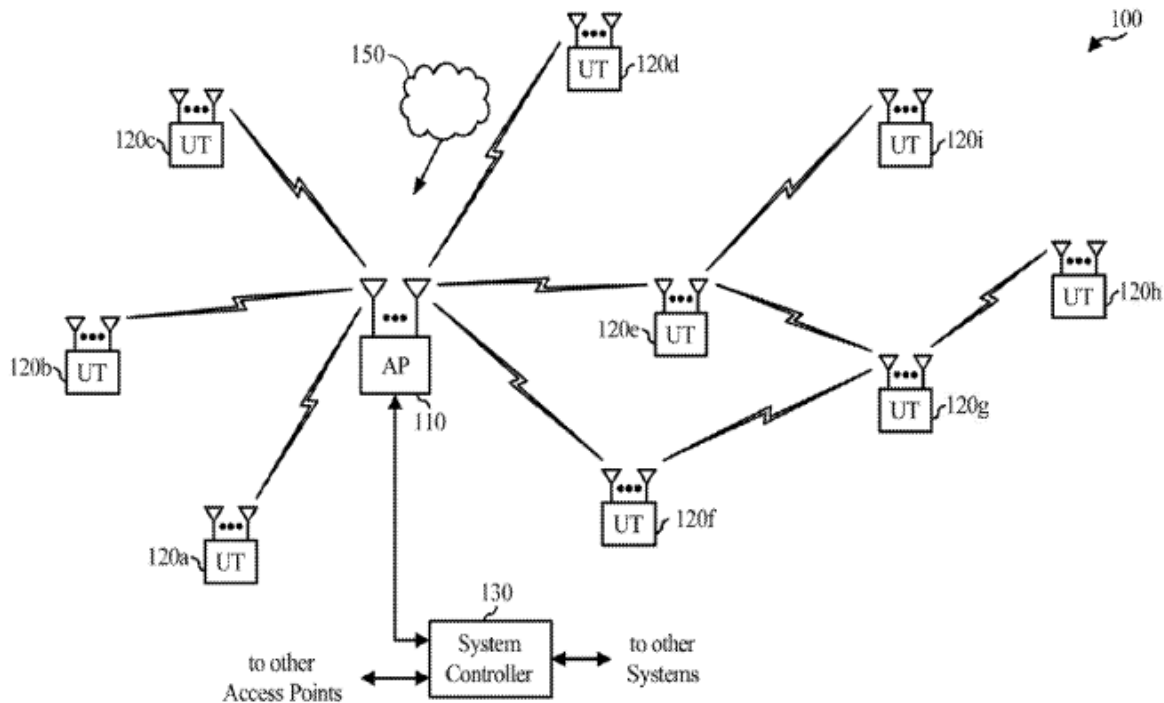


FIG. 1

SAMSUNG-1006, FIG. 1.

180. Thus, Zhou-Cherian-Kim renders obvious *[a]n operation method of a wireless communication terminal that wirelessly communicates with a base wireless communication terminal.*

[8.1] receiving, from the base wireless communication terminal, a trigger frame; wherein the trigger frame triggers a orthogonal frequency division multiple access (OFDMA) uplink transmission of the wireless communication terminal,

181. *See [1.2].*

[8.2] transmitting, to the base wireless communication terminal, a trigger-based physical layer protocol data unit (PPDU) in response to the trigger frame;

182. See [1.3]. Although [1.3] recites “using the transceiver” for transmission, “a transceiver” is not recited in claim 8 and thus, a POSITA would have understood that “*transmitting*” recited in [8.2] would have been accomplished through a wireless communication interface capable of 802.11-like communications.

[8.3] switching a parameter set, which is a set of parameters used for the channel access, from a first parameter set to a second parameter set based on whether the base wireless communication terminal triggers a multi-user uplink transmission participation of the wireless communication terminal;

183. See [1.4]. A POSITA would have understood that the “parameter set switching” accomplished by the STA (*wireless communication terminal*) is used so that the wireless communication terminal may participate in the multi-user uplink (UL-MU) transmission (e.g., *a multi-user uplink [UL-MU] transmission participation of the wireless communication terminal*).

[8.4] when a MAC protocol data unit (MPDU) included in the trigger-based PPDU does not request the immediate response, setting a second parameter set timer for an access category of the MPDU when the transmission of the trigger-based PPDU ends;

184. See [1.5].

[8.5] when the MPDU included in the trigger-based PPDU requests the immediate response, setting the second parameter set timer for the access category of the MPDU for which immediate response is received;

185. See [1.6].

[8.6] when the second parameter set timer expires, terminating an application of the second parameter set;

186. *See* [1.7].

[8.7] accessing a channel according to a priority of data to be transmitted to the base wireless communication terminal and the parameter set; and

187. *See* [1.8].

[8.8] transmitting the data through the channel.

188. Zhou-Cherian-Kim renders obvious [8.8]. As discussed previously, Zhou and Cherian teach that the stations (Zhou's STAs and Cherian's UTs) can "communicate with a single access point by sharing channel resources." SAMSUNG-1004, 0005; SAMSUNG-1005, 0004; SAMSUNG-1006, 0003; SAMSUNG-1007, 0002. Zhou describes that STAs and APs are able to "transmit the information element such that the information element is decodable" by the STA or AP that receives it. SAMSUNG-1004, cl. 11, 0023; SAMSUNG-1005, 0007, 0029("the STA 106 may transmit a reference signal, such as an association probe or request, to the AP 104"). Further, Zhou and Cherian discuss transmission of data (according to a priority of that data) using EDCA parameters to "contend[] for channel access to transmit UL signals." *See* [1.8]; SAMSUNG-1004, 0003, 0042; SAMSUNG-1005, 0002, 0048; SAMSUNG-1006, 0049, 0082; SAMSUNG-1007, 0042, 0069. Indeed, a POSITA would have understood and found obvious that the very purpose of "enhanced distributed channel access (EDCA)" is for "channel access." SAMSUNG-1004, 0003, 0078; SAMSUNG-1005, 0002, 0084. Zhou even claims selecting these "channel access parameters" and "transmitting"

data to a STA. SAMSUNG-1004, cl. 1, 6; SAMSUNG-1005, cl. 10, 13.

189. Thus, a POSITA would have understood and found obvious, through Zhou and Cherian's disclosure of EDCA parameters for transmission and channel access, that Zhou-Cherian-Kim teaches *transmitting the data through the channel*.

Claim 9

[9.0] The method of claim 8, wherein the MPDU included in the trigger-based PPDU is a QoS data frame.

190. See [2.0].

Claim 10

[10.0] The method of claim 8, the method further comprising: receiving a beacon frame from the base wireless communication terminal; and obtaining information indicating a period of the second parameter set timer from the beacon frame.

191. See [3.0].

B. Ground 2 – Combination of Zhou-Cherian-Kim-Ho Renders Obvious Claims 4-5

Claim 4

[4.0] The wireless communication terminal of claim 1, wherein the processor is configured to calculate a random integer value within a contention window (CW),

192. Zhou-Cherian-Kim-Ho renders obvious [4.0] through disclosure of using the EDCA parameters to calculate back off timers for different access categories (ACs). Both Zhou and Ho teach using “channel access parameters [that] can include (but are not limited to) minimum contention window (CW_{min}),

maximum contention window (CW_{max}).” SAMSUNG-1004, 0040; SAMSUNG-1005, 0046; SAMSUNG-1018, 0021, 0024-0031. Specifically, Ho discloses setting “the backoff counter to an integer selected at random from the interval [1, CW] [(*calculate a random integer value within a contention window (CW)*)]” SAMSUNG-1018, 0021. The contention window described in Ho includes “a minimum and maximum CW value.” SAMSUNG-1018, 0024, Table 1.

Contention Window Values

TABLE 1



User Priority	Traffic designation	CW _{min}	CW _{max}
0	Background (BK)	16	64
1	Best effort (BE)	16	32
2	Excellent effort (EE)	8	32
3	Controlled load (CL)	8	16
4	Video (VI)	4	16
5	Voice (VO)	4	8
6	Network control	2	8
7	Emergency or medical event report	1	4

SAMSUNG-1018, Table 1.

193. Ho describes a circuit or *processor* “selecting a new backoff counter value from a range of values defined in part by the new contention window”. SAMSUNG-1018, cl. 15. Thus, a POSITA would have understood and found obvious from Ho that when using EDCA parameters for channel access, *the processor is configured to calculate a random integer value within a contention*

window (CW) for use in the backoff timers for each access category.

[4.1] set a backoff timer based on the random integer value, and

194. As discussed in [4.0], Ho describes “[t]he *backoff counter* [(*timer*)] value (i.e. 3) is *set* by *randomly selecting an integer value* between 1 and CW”.

SAMSUNG-1018, 0045, Abstract, cl 1, 20. A POSITA would have understood and found obvious that a timer or counter used in the context of EDCA parameter backoff procedures are a finite number of obvious solutions. Thus, the Zhou-Cherian-Kim-Ho combination teaches *set[ting] a backoff timer based on the random integer value*.

[4.2] access the channel based on the back off timer and a predetermined slot time

195. Zhou-Cherian-Kim-Ho renders obvious [4.2]. Ho describes that a node will “decrement[] the backoff counter for each detected idle contention slot until the backoff counter reaches 0 . . . then transmit[] data frames.” SAMSUNG-1018, 0045. A POSITA would have understood and found obvious that the purpose of backoff timers were to use the EDCA (i.e., “enhanced distributed channel access”) parameters for *access to the channel based on the back off timer and a predetermined slot time*. Specifically, Ho demonstrates that at a *predetermined slot time* (e.g., a number of time slots equaling the value of the backoff timer), the channel is accessed (e.g., a transmission occurs when the backoff timer reaches zero). SAMSUNG-1018, 0045, Fig. 3, cl. 11 (“transmitting a message on the



196. Thus, a POSITA would have understood and found obvious that when using EDCA parameters for channel access in a contention model, a STA can *access the channel based on the back off timer and a predetermined slot time.*

197. Zhou-Cherian-Kim-Ho renders obvious [4.3]. Specially, Ho discloses “examples of values for CW min and CWmax that may be used in obtaining a

contended allocation.” SAMSUNG-1018, 0024, Table 1. The group of values include CWmin and CWmax values for each of the access categories used with EDCA parameters and are thus a “set.” SAMSUNG-1005, 0070 (“EDCA parameter value (e.g., CWmin=1023 means forbidding CSMA based SU UL Tx for corresponding access category (AC)).”); SAMSUNG-1018, 0024, Table 1. Thus, Ho’s table 1 discloses *the parameter set that comprises a minimum value (CWmin) of the CW and a maximum value (CWmax) of the CW*. See [4.0]; SAMSUNG-1018, 0024, Table 1.

Contention Window Values

TABLE 1



User Priority	Traffic designation	CWmin	CWmax
0	Background (BK)	16	64
1	Best effort (BE)	16	32
2	Excellent effort (EE)	8	32
3	Controlled load (CL)	8	16
4	Video (VI)	4	16
5	Voice (VO)	4	8
6	Network control	2	8
7	Emergency or medical event report	1	4

SAMSUNG-1018, Table 1.

Claim 5

[5.0] The wireless communication terminal of claim 1, wherein the processor is configured to calculate a random integer value in a contention window (CW),

198. See [4.0].

[5.1] set a backoff timer based on the random integer value,

199. See [4.1].

[5.2] access the channel based on the back off timer and a predetermined slot time, and

200. See [4.2].

[5.3] if a value of the CW is greater than the maximum value (CWmax) of the CW according to a priority of the data to be transmitted, sets the value of the CW to the CWmax.

201. Zhou-Cherian-Kim-Ho renders obvious [5.3]. For example, Ho teaches that “[a]fter a failed transmission, CW is set by alternately doubling the CW value, but not to exceed CW max for the user priority [(UP)].” SAMSUNG-1018, 0010. Ho further teaches that “if doubling the CW would exceed CW max[UP], the node shall set the CW to CWmax [UP].” SAMSUNG-1018, 0031. Thus, Ho teaches that when doubling the CW value, ***if a value of the CW is greater than*** (Ho describes as exceeding) ***the maximum value (CWmax) of the CW according to a priority*** [or user priority (UP)] ***of the data to be transmitted, sets the value of the CW to the CWmax.*** Likewise, the 802.11 standard teaches that the “contention window for an access category does not exceed the CWmax and instead is maintained at the CWmax.” SAMSUNG-1017, pp.879, 837(“Once [the CW] reaches aCWmax, the CW shall remain at the value of a CWmax until the CW is reset”). The 802.11 standard’s Figure 9-10 exemplifies this concept.

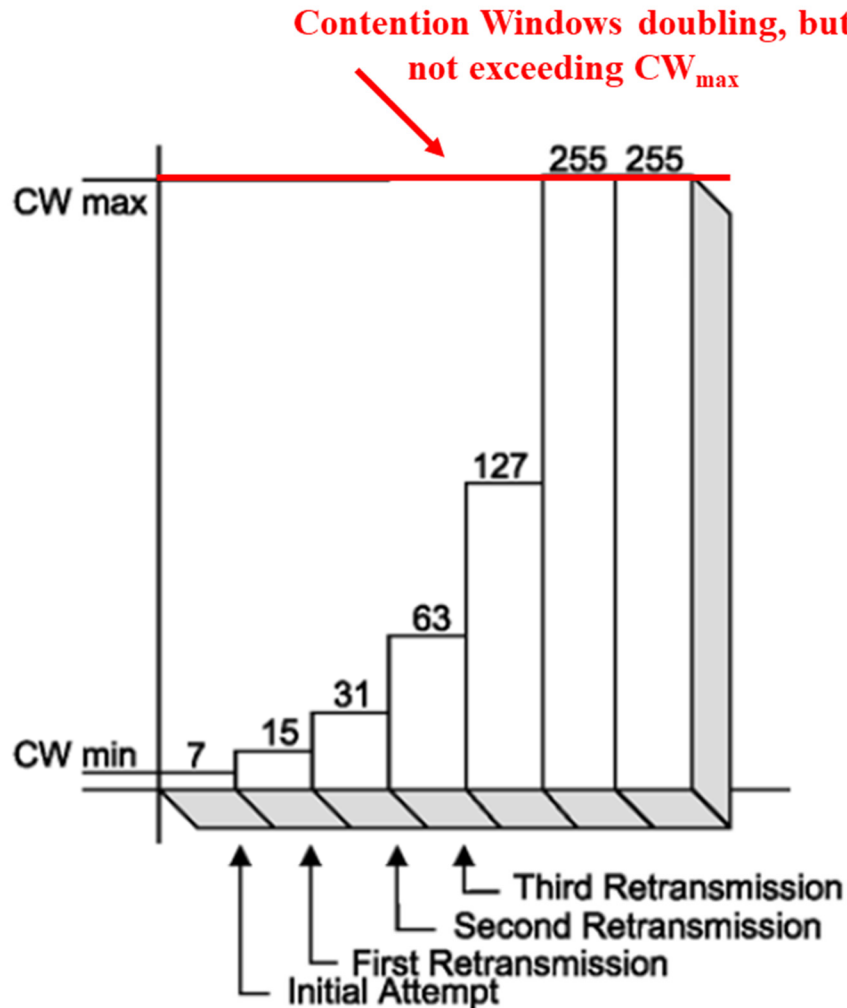


Figure 9-10—Example of exponential increase of CW

SAMSUNG-1017, FIG. 9-10.

C. Ground 3 – Combination of Zhou-Cherian-Kim-Bharghavan Renders Obvious Claims 6-7

Claim 6

[6.0] The wireless communication terminal of claim 1, wherein the processor is configured to operate a plurality of queues that are classified according to an access category of data stored in a queue and performs backoff procedure of

accessing a channel based on a time corresponding to a backoff timer in each of the plurality of queues; and

202. Zhou-Cherian-Kim-Bharghavan renders obvious [6.0]. Bharghavan describes the operation of the multiple 802.11 access categories or queues which can “include ‘VO’(voice), ‘VI’ (video), ‘BE’ (best efforts) or ‘BG’ (background).” SAMSUNG-1010, 6:33-52, 8:1-62; SAMSUNG-1017, p.568, Table 8-104. The data is “processed in separate queues according to QoS indication.” SAMSUNG-1010, 6: 33-52. A POSITA would have understood and found obvious that Bharghavan describes the same access categories taught by the 802.11 standard shown in Table 8-104 below.

Table 8-104—ACI-to-AC coding

ACI	AC	Description
00	AC_BE	Best effort
01	AC_BK	Background
10	AC_VI	Video
11	AC_VO	Voice

SAMSUNG-1017, Table 8-104.

203. The 802.11 standard further corroborates Bharghavan’s description of the well-known use of “queues” for each of the access categories. SAMSUNG-

1017, p.874; SAMSUNG-1006, 0049; SAMSUNG-1007, 0042 (“Quality of service (QoS) may be implemented by utilizing several access categories (AC) which help effectively establish different back-off generation procedure per queue, where each AC uses different queue.”).

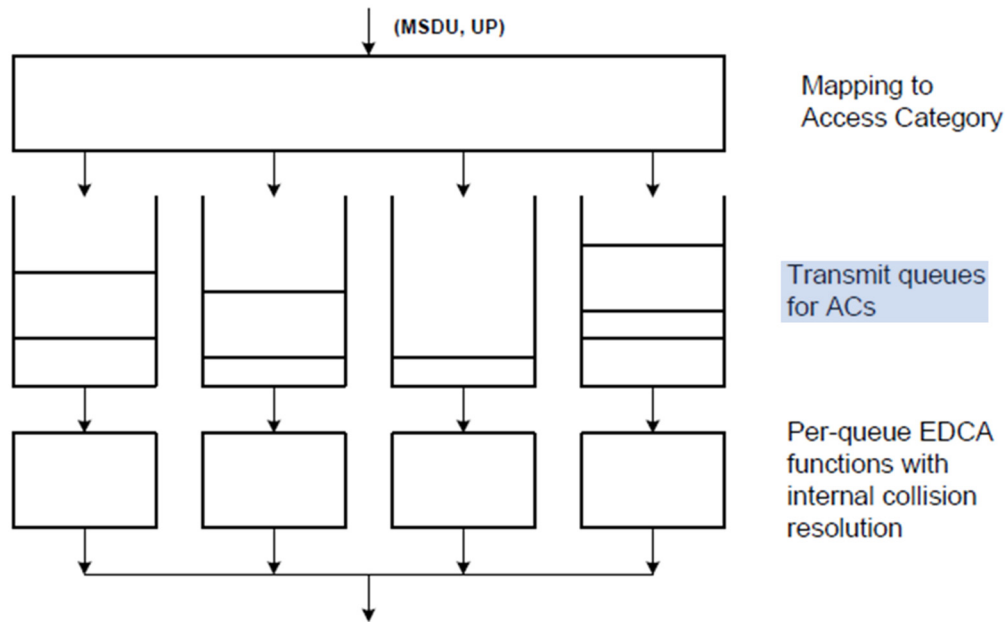


Figure 9-19—Reference implementation model

SAMSUNG-1017, FIG. 9-19.

204. A POSITA would have understood and found obvious that Bharghavan’s queuing of “data flows (or individual messages, or individual message units) in response to their associated QoS” uses the defined access categories (VO, VI, BK, BE) described in Cherian, Bharghavan, and the 802.11 standard. SAMSUNG-1006, 0049; SAMSUNG-1007, 0042; SAMSUNG-1010, 8:1-62; SAMSUNG-1017, pp.568, 874. Thus, Bharghavan describes the method *to*

operate a plurality of queues that are classified according to an access category of data stored in a queue.

205. In operating a queue for each access category, Bharghavan performs the 802.11 standard's defined "backoff procedure." SAMSUNG-1010, 5:29-53; SAMSUNG-1017, pp.878-879. As Cherian describes, this procedure controls the countdown of the backoff timer until the timer reaches zero and a transmission occurs. SAMSUNG-1006, 0049; SAMSUNG-1007, 0041-0042; SAMSUNG-1017, pp.878-879. When a collision in transmission occurs, the backoff procedure will generate the integer random number within the range of CW_{min} and CW_{max} as established in the EDCA parameters discussed in [4.0]-[4.3]. SAMSUNG-1006, 0049; SAMSUNG-1007, 0041-0043; SAMSUNG-1010, 5:29-53 ("Each node selects a random waiting time within the range of the contention window."); SAMSUNG-1017, 878-879 ("The backoff timer is set to an integer value chosen randomly with a uniform distribution taking values in the range [0,CW[AC]] inclusive."), 875-876; *see* [4.0]-[4.3]. Finally, like Cherian, Bharghavan describes using backoff procedures to contend "for access to the medium separately for each type of traffic in response to the one or more contention parameters." SAMSUNG-1006, 0058; 0008, 0022, 0049; SAMSUNG-1007, 0017, 0051, 0042("utilizing several access categories (AC) which help effectively establish different back-off generation procedure per queue, where each AC uses different queue . . . packets

of different ACs are ready for transmission when a backoff timer expires,”);

SAMSUNG-1010, cl.8.

206. Thus, a POSITA would have understood and found obvious that Zhou-Cherian-Kim-Bharghavan *performs backoff procedure of accessing a channel based on a time corresponding to a backoff timer in each of the plurality of queues* because of the description of managing queues according to the backoff procedure for each category so that the STA can access the medium for each access category.

[6.1] when there is no data stored in the queue and the backoff timer corresponding to the queue is 0, perform no operation at a slot boundary of the backoff timer,

207. Zhou-Cherian-Kim-Bharghavan renders obvious [6.1]. Bharghavan describes a process to “determine that it is justified in transmitting a message unit in response to differing criteria for distinct queues.” SAMSUNG-1010, 8:1-52. During this process, the STA may “transmit a message unit in response to any queue that is not empty.” *Id.* Thus, a transmission occurs for queues that are not empty. A POSITA would have understood and found obvious that when a queue is empty there is nothing to transmit. Indeed, the simple common sense of a POSITA would lead to the logical conclusion that there is no need to transmit the “absence” of information in a queue—when the queue is empty, no transmission should occur. This concept is explicitly reflected in the 802.11 standard, which states to

“[d]o nothing for that access function” when a queue is empty. See SAMSUNG-1017, pp.875–876, 878–879. Thus, when Bharghavan describes determining if a transmission from a queue is “justified,” and a POSITA would have understood and found obvious that *when there is no data stored in the queue and the backoff timer corresponding to the queue is 0*, the STA *perform no operation* for that queue *at a slot boundary of the backoff timer*.

[6.2] wherein the backoff timer is set based on a random integer value calculated in a contention window (CW), and is reduced when the channel is idle for a predetermined slot time.

208. Zhou-Cherian-Kim-Bharghavan renders obvious [6.2]. Specifically, like Cherian, Bharghavan teaches that each STA “selects a random waiting time within the range of the contention window.” SAMSUNG-1006, 0048; SAMSUNG-1007, 0041 (“the node starts the backoff procedure by selecting a random initial value for the backoff counter.”); SAMSUNG-1010, 5:29-53. The STA “waits for the medium to be *idle*. . . [and t]he timer is then restarted.” SAMSUNG-1010, 5:29-53. Bharghavan’s teaching is corroborated by the 802.11 standard, which similarly teaches that the backoff timer is based on a value between the CW_{min} and CW_{max} . SAMSUNG-1017, pp.836-837. This range is called the “contention window.” SAMSUNG-1017, p.820 (“The contention window limits a CW_{min} and a CW_{max} , from which the random backoff is computed”). Bharghavan’s selection of the random waiting period is accomplished when a random integer value is

“drawn from a uniform distribution over the interval $[0, CW]$, where CW is an integer within the range of values of the PHY characteristics aCW_{min} and aCW_{max} .” SAMSUNG-1010, 5: 29-53; SAMSUNG-1017, pp.836-837.

209. Thus, Bharghavan teaches, and a POSITA would have understood and found obvious, that *the backoff timer is set based on a random integer value calculated in a contention window (CW)*.

210. Cherian describes that the *backoff timer is reduced when the channel is idle for a predetermined slot time*. For example:

Using CSMA/CA, when a node has a packet ready for transmission, it listens to the channel. Once the channel has been detected free (i.e., the energy level on the channel is lower than the CCA (Clear Channel Assessment) threshold, the node starts the backoff procedure by selecting a random initial value for the backoff counter. The node then starts decreasing the backoff counter while sensing the channel. Whenever a transmission, from either other nodes within the same WLAN or those belonging to other WLANs, is detected on the channel [(when the channel is not idle)], the backoff counter will be paused until the channel is detected free [(*idle*)] again, at which point the countdown is resumed. When the backoff counter reaches zero, the node starts transmitting. SAMSUNG-1006, 0048; SAMSUNG-1007, 0041.

211. The above disclosure of Cherian teaches that the STA can sense the channel is busy by sensing a transmission “from either other nodes within the same

WLAN or those belonging to another WLAN.” Similarly, the STA can detect when the channel is “free” or *idle*. Cherian teaches that when the channel is *idle* the “countdown is resumed.” Thus, Cherian teaches that the *backoff timer is reduced when the channel is idle for a predetermined slot time* or unit of time in which each transmission can occur. SAMSUNG-1006, 0027; SAMSUNG-1007, 0021(“terminals to share the same frequency channel by dividing the transmission signal into different *time slots*,”).

212. The 802.11 standard corroborates this teaching when describing four functions available at a slot boundary: 1) transmission, 2) “[d]ecrement the backoff timer for that access function,” 3) invoke another backoff procedure due to collision, 4) do nothing. SAMSUNG-1017, pp.875-876. Thus, the basic function of the backoff timer (e.g., decrement until transmission), would have been understood and obvious to a POSITA.

213. Of the four available options for a backoff timer defined in the 802.11 standard, only two conditions would satisfy the channel being “idle.” First, if the backoff timer is a non-zero value then transmission does not occur and the access channel is “idle” (e.g., not transmitting). Second, if the backoff timer is zero and there is nothing in the queue, then the channel is “idle” (e.g., not transmitting). A POSITA would have understood that in the first of these two situations (where the timer is non-zero), the timer should be decremented in order to progress to

transmission—indeed that is the point of the backoff timers for each access category. Conversely, no decrementing is needed for a backoff timer at zero with nothing in the queue. Therefore, Zhou-Cherian-Kim-Bharghavan renders obvious that *the backoff timer . . . is reduced when the channel is idle for a predetermined slot time.*

Claim 7

[7.0] The wireless communication terminal of claim 1⁸, wherein when there is no data stored in the queue and the backoff timer corresponding to the queue is 0, the processor is configured to maintain the backoff timer to be 0.

214. Zhou-Cherian-Kim-Bharghavan renders obvious [7.0]. For example, when describing figure 3, Bharghavan, like Zhou and Cherian, teaches a method of using QoS access categories for transmission. SAMSUNG-1004, 0003; SAMSUNG-1005, 0002; SAMSUNG-1006, 0049; SAMSUNG-1007, 0042; SAMSUNG-1010, 8:1-62, FIG. 3. Specifically, when an AC has no data to transmit, “a contention window time for that queue is set to zero.” *Id.* Additionally, the “back-off parameter for that queue is set to zero.” *Id.* A POSITA would have understood and found obvious that the determination of a CW (what the 802.11 standard calls “the backoff procedure”) occurs when the backoff timer reaches zero. SAMSUNG-1017, pp.878-880, 2420. Thus, the determination that the queue

⁸ It appears that claim 7 should depend from claim 6.

is empty would occur when *the backoff timer corresponding to the queue is 0*.

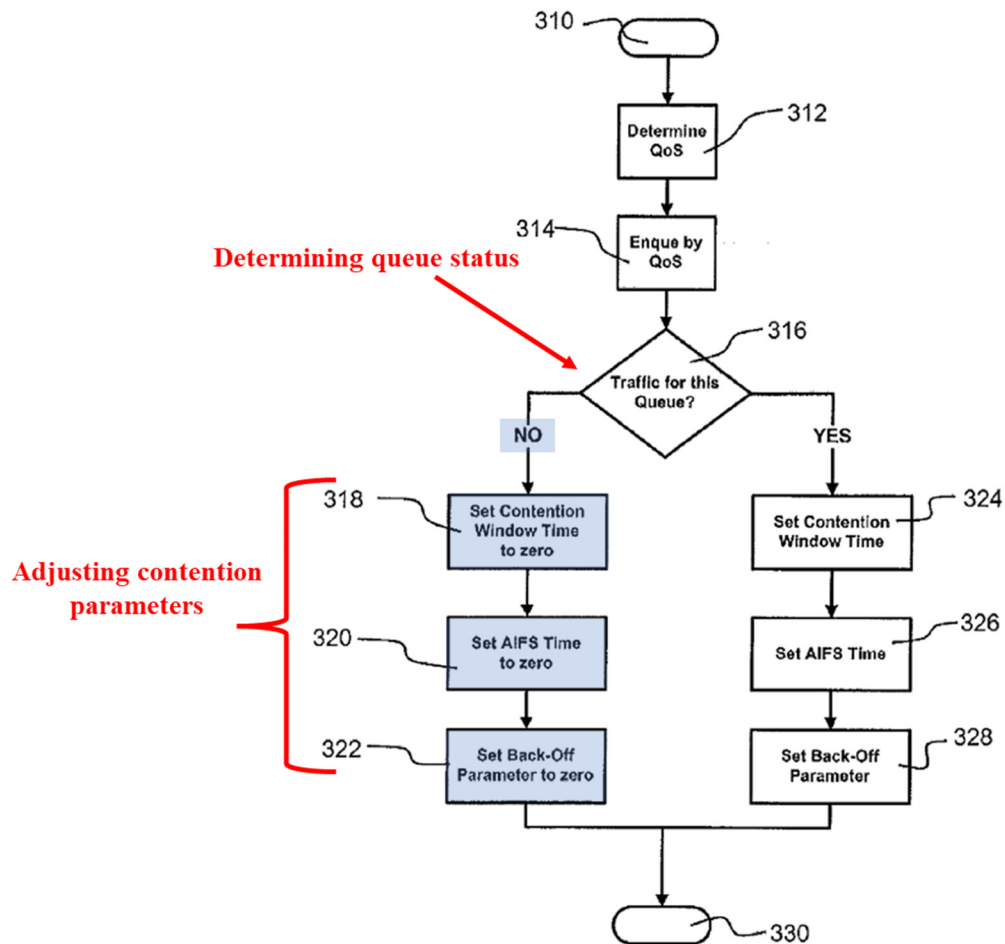


Figure 3

SAMSUNG-1010, FIG. 3.

215. Thus, Bharghavan teaches that *when there is no data stored in the queue and the backoff timer corresponding to the queue is 0, the processor is configured to maintain the backoff timer to be 0*.

XI. CONCLUSION

216. For all the reasons I have noted in the foregoing paragraphs, claims 1-

10 of the '879 Patent are obvious in view of the references discussed above.

I currently hold the opinions set expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.

Appendix B:

ACRONYM	DEFINITION
802.11	IEEE Standards for Wireless Local Area Networks (WLANs)
AC	Access Category
AC BK	Background traffic
AC VO	Voice Traffic
ACK	Acknowledgement
aCWmax	Maximum Contention Window value
aCWmin	Minimum Contention Window value
AIFS	Automatic Inter-Frame Spacing
A-MPDU	Aggregated MAC Protocol Data Unit
AP	Access Point
BE	Best Effort
BK	Background
BLOCK ACK	Acknowledgement used for aggregated data
BSS	Basic Service Set
CA	Collision Avoidance
CP	Contention Period
CSMA	Carrier Sense Multiple Access
CSMA/CA	Carrier Sense Multiple Access with Collision Avoidance
CW	Contention Window
CWAP	Certified Wireless Analysis Professional
CWmin	Minimum Value of CW
CWmax	Maximum Value of CW
EDCA	Enhanced Distributed Channel Access
HCCA	HCF Controlled Channel Access
HCF	Hybrid Coordination Function
IEEE	Institute of Electrical & Electronics Engineers
LLC	Logical Link Control
MAC	Medium Access Control
MHz	Megahertz

ACRONYM	DEFINITION
MIMO	Multiple Input Multiple Output
MPDU	MAC Protocol Data Unit
MSDU	MAC Service Data Unit
MU	Multi-User
MU EDCA	Multi-User Enhance Distributed Channel Access
Multi-STA Block ACK	ACK used for multi-user uplink scenarios
NACK	Negative acknowledgement
OFDMA	Orthogonal Frequency Division Multiple Access
PLCP	Physical Layer Convergence Protocol
PMD	Physical Medium Dependent
PPDU	Physical Layer Protocol Data Unit
PSMP	Power Save Multi-Poll
QoS	Quality of Service
RU	Resource Unit
SC-FDMA	Single Carrier Frequency Division Multiplexing
STA	Station
SU	Single-User
TID	Traffic Identifiers
TXOP	Transmission Opportunity
UL	Uplink
UL-MU	Uplink Multi-User
UL-MU-MIMO	Uplink Multi-User Multiple Input Multiple Output
UL-OFDMA	Uplink Orthogonal Frequency Division Multiple Access
UL-SU	Uplink Single-User
UP	User Priority
UT	User Terminal
VI	Video
VO	Voice
WLAN	Wireless Local Area Network

APPENDIX A

MATTHEW C. VALENTI, P.E.

IEEE Fellow

Professor

Lane Department of Computer Science and Electrical Engineering
West Virginia University

CONTACT

 929 Riverview Drive
Morgantown, WV 26505 USA
 (304) 685-9322
 valenti@ieee.org
 <http://community.wvu.edu/~mcvalenti/>

EDUCATION

Ph.D. in Electrical Engineering

Virginia Polytechnic Institute & State University (Virginia Tech), Blacksburg, VA, August 1999

M.S. in Electrical Engineering

Johns Hopkins University, Baltimore, MD, May 1995

B.S. in Electrical Engineering

Virginia Polytechnic Institute & State University (Virginia Tech), Blacksburg, VA, May 1992

PROFESSIONAL EXPERIENCE

West Virginia University, Lane Department of Computer Science and Electrical Engineering

Professor – 2010 to present

Associate Professor – 2005 to 2010

Assistant Professor – August 1999 to 2005

Administrative Capacities:

Raymond J. Lane Department Chair – July 2020 to June 2021

Interim Department Chair – July 2019 to June 2020

Center for Identification Technology Research (CITeR), an NSF I/UCRC

Co-Director, WVU Site – August 2024 to present

Director, WVU Site – August 2014 to August 2024

Virginia Tech, Bradley Department of Electrical and Computer Engineering

Bradley Fellow, Graduate Research Assistant, and Instructor – August 1995 to July 1999

U.S. Naval Research Laboratory, Washington, DC

Electronics Engineer – Summer 1991, May 1992 to August 1995

LICENSES

Professional Engineer (P.E.)

Registered in the state of West Virginia since 2011

Amateur Radio License

Amateur Extra Class. Call sign KC8NHN. Licensed since 1999

CITATION INDICES

Total Citations: 7,023

H-index: 37

Data according to Google Scholar on Mar. 1, 2025

Erdős Number: 4 (Erdős – McEliece – Stark – Woerner – Valenti)

TECHNICAL EXPERT EXPERIENCE

1. O'Melveny & Myers LLP for Samsung
 Dates: 2024-2025
 Venue: United States Patent and Trademark Office
 Cases: Petitions for *Inter Partes* Review (IPR) and *Ex Parte* Reexamination (EPR) of US Patent 8,565,331 (owned by Empire Technology Development, LLC). IPR case IPR2024-00897 (petitioned by Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc.)
 Technology: Channel estimation and pilot symbols.
 Activity: Expert Declaration (in support of IPR and EPR Petitions).
2. O'Melveny & Myers LLP for Samsung
 Dates: 2024-2025
 Venue: United States Patent and Trademark Office
 Cases: Petition for *Inter Partes* Review (IPR) of US Patent Nos. 8,798,120 (owned by Empire Technology Development, LLC). IPR case IPR2024-00896 (petitioned by Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc.)
 Technology: Single- and multi-antenna communications.
 Activity: Expert Declarations (in support of IPR Petitions). Deposition (Mar. 7, 2025).
3. Fish & Richardson for Motorola
 Dates: 2024
 Venue: US. International Trade Commission (ITC)
 Cases: Motorola Mobility LLC v. Ericsson AB, Telefonaktiebolaget LM Ericsson, and Ericsson Inc. In the Matter of Certain Cellular Base Station Communication Equipment
 US. International Trade Commission (ITC) Investigation No. 337-TA-1388
 Technology: 5G NR wireless technology. Reference symbols. Power headroom reporting.
 Activity: Expert Report (infringement, domestic industry practice), rebuttal report (validity). Deposition (July 30, 2024). Court testimony (ITC bench trial): direct (Sept. 5-6, 2024) and rebuttal (Sept. 23, 2024).
4. Fish & Richardson for General Motors, Nissan, Tesla, and Honda
 Dates: 2023-2024
 Venue: United States Patent and Trademark Office
 Cases: Petition for *Inter Partes* Review (IPR) of US Patent No. 10,447,450 (owned by Neo Wireless, LLC). IPR cases IPR2022-01567 (petitioned by Volkswagen Group of America, Inc., America Honda Motor Co., Inc., General Motors LLC, Nissan North America, Inc., and Tesla, Inc.)
 Technology: Resource allocation in an OFDM-based wireless cellular downlink.
 Activity: Substitute Expert Declaration (in support of IPR Petitions). Deposition (Feb. 8, 2024).
5. Fish & Richardson for General Motors, Nissan, Tesla, Honda, and Ford
 Dates: 2023-2024
 Venue: United States Patent and Trademark Office
 Cases: Petition for *Inter Partes* Review (IPR) of US Patent No. 10,075,941 (owned by Neo Wireless, LLC). IPR cases IPR2022-01537 (petitioned by Ford Motor Company, America Honda Motor Co., Inc., General Motors LLC, Nissan North America, Inc., and Tesla, Inc.)
 Technology: Link adaptation in an OFDM-based wireless cellular downlink.
 Activity: Substitute Expert Declaration (in support of IPR Petitions). Deposition (Feb. 9, 2024).

6. DLA Piper for Motorola
 Dates: 2023
 Venue: US. International Trade Commission (ITC)
 Case: Maxell, Ltd. v. Motorola Mobility LLC, Lenovo Group Ltd., and Lenovo (U.S.) Inc.
 In the Matter of Certain Mobile Electronic Devices
 US. International Trade Commission (ITC) Investigation No. 337-TA-1324
 Technology: LTE and 5G NR wireless technology. Dual connectivity operation.
 Activity: Expert Report (invalidity), rebuttal report (noninfringement, domestic industry practice). Deposition (Mar. 15, 2023). Prepared to give court testimony.
Case settled on June 20, 2023, two days before the hearing was scheduled to start.
7. Sidley Austin for Lenovo
 Dates: 2022-2023
 Venue: United States District Court; District of Delaware
 Cases: Interdigital Technology Corporation v. Lenovo Holding Company, Inc.,
 Civil Action No. 19-1590-LPS
 Technology: Wireless technology including control signaling for LTE and HSPA.
 Activity: Expert Reports (invalidity and noninfringement). Deposition (Aug. 26, 2022).
8. Kirkland & Ellis for Samsung
 Dates: 2022-2023
 Venue: United States Patent and Trademark Office
 Cases: Petition for *Inter Partes* Review (IPR) of US Patent Nos. 7,116,710; 7,421,032;
 7,916,781; and 8,284,833 (all owned by California Institute of Technology and petitioned
 by Samsung Electronics Co., Ltd)
 Technology: Forward error correction (FEC) coding including low density parity check (LDPC)
 codes and irregular repeat accumulate (IRA) codes.
 Activity: Expert Declarations (in support of IPR Petitions). *Case settled.*
9. Fish & Richardson for Apple
 Dates: 2022
 Venue: United States District Court; Eastern District of Texas Marshall Division
 Cases: Ericsson, Inc. and Telefonaktiebolaget L.M. Ericsson v. Apple Inc.,
 Civil Action No. 2:21-cv-0036
 Technology: 5G NR wireless technology.
 Activity: Expert Reports (Patent portfolio technical evaluation and rebuttal). Deposition (Sept.
 28, 2022). Prepared to give testimony before a jury.
Case settled on December 8, 2022 after the fourth day of trial.
10. Fish & Richardson for Apple and its Brazilian entities
 Dates: 2022
 Venue: Brazil Courts: (1) 1st Business Court of the Capital District of Rio de Janeiro State (Case
 No. 0010664-19.2022.8.19.0001), and (2) Federal Court of Rio de Janeiro, 31st Court
 specialized in IP matters (Case No. 5016043-83.2022.4.02.5101)
 Cases: (1) Telefonaktiebolaget L.M. Ericsson vs. Allied Tecnologia S.A. and (2) Apple
Computer Brasil Ltda. and Allied Tecnologia S.A. vs. Telefonaktiebolaget L.M. Ericsson
 Technology: Wireless technology including random access signaling for LTE.
 Activity: Expert Declarations (invalidity, noninfringement, and rebuttal).

11. Erise IP for Apple
 Dates: 2021-2022
 Venue: United States Patent and Trademark Office
 Cases: Petition for *Inter Partes* Review (IPR) of US Patent Nos. 8,023,990; 8,798,658; and 9,277,436 (all owned by Ericsson). IPR cases IPR2021-00459, IPR2022-00461, and IPR2022-00467 (petitioned by Apple Inc.). Request for Ex Parte Re-examination of US Patent No 10,476,722 (owned by Ericsson). Attorney Docket No. Apple.990
 Technology: Wireless technology including minimization of drive testing (MDT) and 5G NR synchronization.
 Activity: Expert Declarations (in support of IPR Petitions and Ex Parte Re-examination). Deposition (Sept. 21, 2022 for the '658 patent).
12. Foley Hoag for Rideshare Displays, Inc.
 Dates: 2021-2022
 Venue: United States Patent and Trademark Office
 Cases: Patent owner's response to *Inter Partes* Review (IPR) of US Patent Nos. 9,892,637; 10,169,987; 10,395,525; 10,559,199; and 10,748,417 (all owned by Rideshare Displays, Inc.). IPR cases IPR2021-01598 to IPR2021-01602 (petitioned by Lyft, Inc.)
 Technology: Vehicle identification technology.
 Activity: Expert Declarations (in support of Patent Owner's responses to IPR Petitions, responses to Board's decision to institute, and motions to amend claims). Deposition (Sept. 9, 2022).
13. Fish & Richardson for LG Electronics, Inc., LG Electronics USA, Inc., Dell Inc., and Dell Technologies, Inc.
 Dates: 2021-2022
 Venue: United States Patent and Trademark Office
 Cases: Petition for *Inter Partes* Review (IPR) of US Patent Nos. 8,467,366 and 10,833,908 (owned by Neo Wireless LLC). IPR cases IPR2021-01480 and IPR2022-00277 (petitioned by Dell Inc.)
 Technology: Wireless technology including OFDM transmissions, random access, and ranging signals.
 Activity: Expert Declarations (in support of IPR Petitions).
14. Kirkland & Ellis for Lenovo
 Dates: 2020-2021
 Venue: UK High Court
 Cases: InterDigital Technology Corporation and others v Lenovo Group Limited and others (Claim No. HP-2019 000032)
 Technology: Wireless technology including control signaling for LTE.
 Activity: Expert Report (invalidity, non-essentiality, two rebuttal reports). Court Testimony (UK bench trial): Mar. 5-9, 2021.
15. Fish & Richardson for LG Electronics, Inc.
 Dates: 2019-2020
 Venue: United States Patent and Trademark Office
 Cases: Petition for *Inter Partes* Review (IPR) of US Patent No. 7,039,435 (owned by Bell Northern Research). IPR case IPR2020-00319 (petitioned by LG Electronics, Inc.)
 Technology: Wireless technology including power control of wireless transmissions.
 Activity: Expert Declaration (in support of IPR Petition).

16. Fish & Richardson for Apple
 Dates: 2017-2019
 Venue: United States District Court; Southern District of California
 Cases: Apple Inc. v. Qualcomm Inc., Civil Action No. 3:17-cv-00108
 Technology: LTE wireless technology.
 Activity: Expert Report (Patent portfolio technical evaluation). Deposition (Oct. 17, 2018).
Testimony before jury was scheduled for April 22, 2019, but case settled after opening arguments.
17. Quinn Emanuel Urquhart & Sullivan for Samsung
 Dates: 2017-2018
 Venue: United States District Court; Northern District of California (San Francisco Division) and United States Patent and Trademark Office
 Cases: Samsung Electronics Co., LTD, et al. (counterclaim-plaintiffs) v. Huawei Technologies Co., LTD., et al. (counterclaim-defendants), Case No. 16-cv-02787-WHO
 Huawei Technologies Co., LTD vs. Samsung Electronics Co., LTD, Case IPR2017-01974 (US Patent 8,457,588)
 Huawei Technologies Co., LTD vs. Samsung Electronics Co., LTD, Case IPR2017-01982 (US Patent 8,228,827)
 Technology: LTE wireless technology.
 Activity: Declarations (Claim Construction, 2 Patent Owner's Responses to Petition for IPR); Expert Report (Infringement); Rebuttal Report (Validity). Depositions (June 20, 2018, Aug. 10, 2018, Aug. 11, 2018).
18. Baker Botts for AT&T; Gibson, Dunn & Crutcher for T-Mobile
 Dates: 2016-2017
 Venue: United States District Court; District of Delaware
 Cases: (a) Intellectual Ventures I LLC v. AT&T Mobility LLC et al., Civil Action No. 12-CV-193-LPS (D. Del.); Intellectual Ventures I LLC v. AT&T Mobility LLC et al., Civil Action No. 1:15-CV-00799-LPS.
 (b) Intellectual Ventures I LLC v. T-Mobile USA Inc. et al. D. Del. Case No. 1:13-cv-1632-LPS.
 Technology: HSDPA wireless technology.
 Activity: Expert Report; Declaration; Sur-Reply Report. Deposition (Mar. 23, 2017).
19. Rothwell Figg for LG; Paul Hastings for Samsung; Mayer Brown for Motorola Mobility
 Dates: 2016
 Venue: United States District Court; Southern District of California
 Cases: (a) Odyssey Wireless Inc. v. LG Electronics USA, Inc. et al., Civil Action No. 3:15-cv-01746-H-RBB (S.D. Cal.).
 (b) Odyssey Wireless Inc. v. Samsung Electronics Co. et al., Civil Action No. 3:15-cv-01738-H-RBB (S.D. Cal.).
 (c) Odyssey Wireless Inc. v. Motorola Mobility, Civil Action No. 3:15-cv-01741-H-RBB (S.D. Cal.).
 Technology: LTE wireless technology.
 Activity: Expert Report (noninfringement). Deposition (Aug. 24, 2016).

20. Sheppard Mullin for Samsung; Gibson Dunn and Wilmer Hale for Intel; Boies Schiller for Apple
 Dates: 2016
 Case: Various regulatory agencies' investigations of Qualcomm Incorporated ("Qualcomm"), including the Korean Fair Trade Commission (the "KFTC") and the United States Federal Trade Commission (the "FTC").
 Technology: LTE wireless technology.
 Activity: Declaration (technical analysis of patent portfolio).

21. Boies, Schiller & Flexner for Apple; Sheppard, Mullin, Richter & Hampton for HTC; Kilpatrick Townsend & Stockton for Lenovo and Motorola Mobility; Quinn Emanuel Urquhart & Sullivan for Samsung; McDermott Will & Emery for ZTE; Sidley Austin for Microsoft
 Dates: 2016
 Venue: United States District Court; District of Delaware
 Cases: (a) Evolved Wireless, LCC, v. Apple Inc., Civil Action No. 1:15-cv-00542-SLR.
 (b) Evolved Wireless, LCC, v. HTC Corporation and HTC America, Inc., Civil Action No. 1:15-cv-00543-SLR. (c) Evolved Wireless, LCC, v. Lenovo Group Ltd., Lenovo (United States) Inc., and Motorola Mobility, Civil Action No. 1:15-cv-00544-SLR.
 (d) Evolved Wireless, LCC v. Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc., Civil Action No. 1:15-cv-00545-SLR. (e) Evolved Wireless, LCC v. ZTE Corporation, ZTE (USA) Inc., and ZTE Solutions Inc., Civil Action No. 1:15-cv-00546-SLR. (f) Evolved Wireless, LCC v. Microsoft Corporation, Microsoft Mobile OY and Nokia Inc., Civil Action No. 1:15-cv-00547-SLR.
 Technology: LTE wireless technology.
 Activity: Declaration (claim construction).

22. Williams & Connolly
 Dates: 2015
 Case: Confidential Parties (Leading Global Wireless Communication Companies)
 Consolidated Arbitrations Under the International Chamber of Commerce Rules.
 Technology: LTE wireless technology.
 Activity: Expert Report (patent portfolio technical evaluation).

23. Kirkland & Ellis for Samsung
 Dates: 2013
 Case: Samsung Electronics and Samsung Telecommunications America v. Ericsson Inc.
 In the Matter of Certain Wireless Communications Equipment and Articles Therein
 US. International Trade Commission (ITC) Investigation No. 337-TA-866
 Technology: LTE wireless technology.
 Activity: Expert Report (infringement, domestic industry practice), rebuttal report (validity).
 Court testimony (ITC bench trial): direct (Oct. 23, 2013) and rebuttal (Oct. 30, 2013).

24. Quinn Emanuel Urquhart & Sullivan, LLP for Samsung
 Dates: 2013
 Case: Samsung Electronics GmbH v. Apple Inc.
 German Patent Court, Case Number 5 Ni 49/11
 Technology: Turbo codes; LTE wireless technology.
 Activity: Declaration (validity).

25. Kirkland & Ellis for DIRECTV
 Dates: 2009
 Case: Rembrandt Data Technologies v. DIRECTV, Inc., et al.
 Eastern District of Virginia, Case No. 1:08cv1009
 Technology: Telephone modems; set-top boxes.
 Activity: Rebuttal Expert Report (non-infringement). Deposition (May 20, 2009).

26. Kirkland & Ellis for Samsung
 Dates: 2006
 Case: Samsung Electronics and Samsung Telecommunications America v. Ericsson Inc.
 In the Matter of Certain Wireless Communications Equipment, Articles Therein, and
 Products Containing the Same
 ITC Investigation No. 377-TA-577
 Technology: WCDMA/UMTS wireless technology; mobile phone handsets.
 Activity: Declaration (domestic industry practice). Deposition (Nov. 17, 2006).

OTHER RECENT TECHNICAL CONSULTING

1. 4D Tech Solutions, Morgantown, WV
Nonorthogonal Frequency Division Multiplexing
 July 2017 to December 2018.
2. WPL, Manhattan Beach, CA
Survivable, Secure and Dependable Wireless Communications
 August 2016 to February 2017.

HONORS AND AWARDS

IEEE Communications Society, Communication Theory Technical Committee Outstanding Service Award (2021)

Career award for service to the communication theory community

IEEE MILCOM Award for Sustained Technical Achievement (2019)

Career award for contributions to military communications

Fellow, Institute of Electrical and Electronics Engineers (IEEE)

Elevated to Fellow in 2018 for contributions to cooperative diversity and the development of distributed turbo codes

WVU Foundation Outstanding Teaching Award (2013)

Highest teaching award at West Virginia University

Outstanding Teacher (2012, 2009, 2006, 2003, and 2001)

Outstanding Advisor (2012, 2004)

Outstanding Researcher (2008, 2001, and 2000)

West Virginia University, Statler College of Engineering & Mineral Resources (College-level awards)

Bradley Fellow, August 1995-May 1998

Virginia Tech, Bradley Department of Electrical Engineering (highest departmental fellowship)

PUBLICATIONS

Refereed Journal Articles

1. N.A. Schmid, **M.C. Valenti**, K.M. Hampel, J. Zuo, P. Das, S. Schuckers, and J. Skufca, "Uniqueness of iris pattern based on the auto-regressive model," *Sensors*, vol. 24, no. 9, p. article number 2797, April 2024.
2. P. Das, R. Plesh, V. Talreja, N.A. Schmid, **M.C. Valenti**, J. Skufca, and S. Schuckers, "Empirical assessment of end-to-end iris recognition system capacity," *IEEE Transactions on Biometrics, Behavior, and Identity Science*, vol. 5, no. 2, pp. 154-169, April 2023.
3. F. Taherkhani, V. Talreja, J. Dawson, **M.C. Valenti**, and N.M. Nasrabadi "Profile to frontal face recognition in the wild using coupled conditional generative adversarial network," *IET Biometrics*, vol. 11, no. 3, pp. 260-272, May 2022.
4. T. Ketseoglou, **M.C. Valenti**, and E. Ayanoglu "Millimeter wave massive MIMO downlink per-group communications with hybrid linear precoding," *IEEE Transactions on Vehicular Technology*, vol. 70, no. 7, pp. 6841-6854, July 2021.

5. V. Talreja, **M.C. Valenti** and N.M. Nasrabadi, "Deep hashing for secure multimodal biometrics," *IEEE Transactions on Information Forensics and Security*, vol. 16, pp. 1306-1321, 2021.
6. F. Taherkhani, V. Talreja, **M.C. Valenti**, and N.M. Nasrabadi "Error-corrected margin-based deep cross-modal hashing for facial image retrieval," *IEEE Transactions on Biometrics, Behavior, and Identity Science*, vol. 2, no. 3, pp. 279-293, July 2020.
7. E. Hriba and **M.C. Valenti**, "Correlated blocking in mmwave cellular networks: Macrodiversity, outage, and interference," *Electronics (Special Issue on Millimeter-Wave (mmWave) Communications)*, vol. 8, no. 10, article number 1187, Oct. 2019.
8. T. Ferrett and **M.C. Valenti**, "Noncoherent LDPC-coded physical-layer network coding using multitone FSK," *IEEE Transactions on Communications*, vol. 66, no. 6, pp. 2384-2395, June 2018.
9. D. Torrieri, S. Talarico, and **M.C. Valenti**, "Analysis of a frequency-hopping millimeter-wave cellular uplink," *IEEE Transactions on Wireless Communications*, vol. 15, no. 10, pp. 7089-7098, Oct. 2016.
10. K. Venugopal, **M.C. Valenti**, and R. W. Heath, Jr., "Device-to-device millimeter wave communications: Interference, coverage, rate, and finite topologies," *IEEE Transactions on Wireless Communications*, vol. 15, no. 9, pp. 6175-6188, Sept. 2016.
11. D. Torrieri, S. Talarico, and **M.C. Valenti**, "Performance comparisons of geographic routing protocols in mobile ad hoc networks," *IEEE Transactions on Communications*, vol. 63, no. 11, pp. 4276-4286, Nov. 2015.
12. P. Rost, S. Talarico, and **M.C. Valenti**, "The complexity-rate tradeoff of centralized radio access networks," *IEEE Transactions on Wireless Communications*, vol. 14, no. 11, pp. 6164-6176, Nov. 2015.
13. **M.C. Valenti**, D. Torrieri, and S. Talarico, "A direct approach to computing spatially averaged outage probability," *IEEE Communications Letters*, vol. 18, no. 7, pp. 1103-1106, July 2014.
14. S. Talarico, N.A. Schmid, M. Alkhweldi, and **M.C. Valenti**, "Distributed estimation of a parametric field: Algorithms and performance analysis," *IEEE Transactions on Signal Processing*, vol. 62, no. 5, pp. 1041-1053, Mar 1, 2014.
15. D. Torrieri, **M.C. Valenti**, and S. Talarico, "An analysis of the DS-CDMA cellular uplink for arbitrary and constrained topologies," *IEEE Transactions on Communications*, vol. 61, no. 8, pp. 3318-3326, Aug. 2013.
16. D. Torrieri and **M.C. Valenti**, "Exclusion and guard zones in DS-CDMA ad hoc networks," *IEEE Transactions on Communications*, vol. 61, no. 6, pp. 2468-2476, June 2013.
17. D. Torrieri and **M.C. Valenti**, "The outage probability of a finite ad hoc network in Nakagami fading," *IEEE Transactions on Communications*, vol. 60, pp. 3509-3518, Nov. 2012.
18. **M.C. Valenti** and X. Xiang, "Constellation shaping for bit-interleaved LDPC coded APSK," *IEEE Transactions on Communications*, vol. 60, pp. 2960-2970, Oct. 2012.
19. **M.C. Valenti**, D. Torrieri, and T. Ferrett, "Noncoherent physical-layer network coding with FSK modulation: Relay receiver design issues," *IEEE Transactions on Communications*, vol. 59, no. 9, pp. 2595-2604, Sept. 2011.
20. D. Torrieri and **M.C. Valenti**, "Rapidly-converging series representations of a mutual-information integral," *ISRN Communications and Networking*, vol. 2011, Article ID 546205, 6 pages, 2011.
21. **M.C. Valenti**, S. Cheng, and D. Torrieri "Iterative multisymbol noncoherent reception of coded CPFSK," *IEEE Transactions on Communications*, vol. 58, no. 7, pp. 2046-2054, July 2010.
22. D. Torrieri and **M.C. Valenti**, "Efficiently decoded full-rate space-time block codes," *IEEE Transactions on Communications*, vol. 58, no. 2, pp. 480-488, Feb. 2010.
23. S. Cheng, **M.C. Valenti**, and D. Torrieri, "Coherent continuous-phase frequency-shift keying: Parameter optimization and code design," *IEEE Transactions on Wireless Communications*, vol. 8, no. 4, pp. 1792-1802, Apr. 2009.

24. D. Torrieri and **M.C. Valenti**, "Constellation labeling maps for low error floors," *IEEE Transactions on Wireless Communications*, vol. 7, no. 12, pp. 5401-5407, Dec. 2008.
25. D. Torrieri, S. Cheng, and **M.C. Valenti**, "Robust frequency hopping for interference and fading channels," *IEEE Transactions on Communications*, vol. 56, no. 8, pp. 1343-1351, Aug. 2008.
26. K. Vardhe, D. Reynolds, and **M.C. Valenti**, "The performance of multi-user cooperative diversity in an asynchronous CDMA uplink," *IEEE Transactions on Wireless Communications*, vol. 7, no. 5, pp. 1930-1940, May 2008.
27. R. Iyer Seshadri and **M.C. Valenti**, "Capacity-based parameter optimization of bit-interleaved coded CPM with differential detection," *IEEE Transactions on Vehicular Technology*, vol. 57, no. 1, pp. 345-353, Jan. 2008.
28. S. Cheng, **M.C. Valenti**, and D. Torrieri, "Robust iterative noncoherent reception of coded FSK over block fading channels," *IEEE Transactions on Wireless Communications*, vol. 6, no. 9, pp. 3142-3147, Sept. 2007.
29. S. Wei, D.L. Goeckel, and **M.C. Valenti**, "Asynchronous cooperative diversity," *IEEE Transactions on Wireless Communications*, vol. 5, no. 6, pp. 1547-1557, June 2006.
30. B. Zhao and **M.C. Valenti**, "Position-based relaying with hybrid-ARQ for efficient ad hoc networking," *EURASIP Journal on Wireless Communications and Networking*, vol. 5, no. 5, pp. 610-624, Dec. 2005.
31. **M.C. Valenti** and S. Cheng, "Iterative demodulation and decoding of turbo coded M-ary noncoherent orthogonal modulation," *IEEE Journal on Selected Areas in Communications*, vol. 23, no. 9, pp. 1738-1747, Sept. 2005.
32. J. Sun and **M.C. Valenti**, "Joint synchronization and SNR estimation for turbo codes in AWGN channels," *IEEE Transactions on Communications*, vol. 53, no. 7, pp. 1136-1144, July 2005.
33. B. Zhao and **M.C. Valenti**, "Practical relay networks: A generalization of hybrid-ARQ," *IEEE Journal on Selected Areas in Communications*, vol. 23, no. 1, pp. 7-18, Jan. 2005.
34. B. Zhao and **M.C. Valenti**, "Distributed turbo coded diversity for the relay channel," *IEE Electronics Letters*, vol. 39, no. 10, pp. 786-787, May 15, 2003.
35. **M.C. Valenti** and J. Sun, "The UMTS turbo code and an efficient decoder implementation suitable for software defined radios," *International Journal on Wireless Information Networks*, vol. 8, no. 4, pp. 203-216, Oct. 2001.
36. **M.C. Valenti** and B.D. Woerner, "Pilot symbol assisted detection of turbo codes over flat-fading channels," *IEEE Journal on Selected Areas in Communications*, vol. 19, pp. 1697-1705, Sept. 2001.
37. **M.C. Valenti** and B.D. Woerner, "Iterative multiuser detection, macrodiversity combining and decoding for the TDMA cellular uplink," *IEEE Journal on Selected Areas in Communications*, vol. 19, pp. 1570-1583, Aug. 2001.
38. **M.C. Valenti** and B.D. Woerner, "Distributed multiuser detection for the TDMA cellular uplink," *IEE Electronics Letters*, vol. 35, no. 21, pp. 1803-1804, Oct. 21, 1999.
39. **M.C. Valenti** and B.D. Woerner, "Refined channel estimation for coherent detection of turbo codes over flat-fading channels," *IEE Electronics Letters*, vol. 34, no. 17, pp. 1648-1649, Aug. 20, 1998.

Magazine Articles

1. D. Reed and **M. Valenti**, "IEEE International Conference on Communications 2024 (ICC 2024): 9-13 June 2024, Denver, Colorado, USA," *IEEE Communications Magazine*, vol. 63, no. 1, pp. 6-7, Jan. 2025.
2. P. Rost, I. Berberana, A. Maeder, H. Paul, V. Suryaprakash, **M.C. Valenti**, D. Wubben, A. Dekorsy, and G. Fettweis, "Benefits and challenges of virtualization in 5G radio access networks," *IEEE Communications Magazine*, vol. 53, no. 12, *Communications Standards Supplement*, pp. 75-82, Dec. 2015.

3. N. Chandran and **M.C. Valenti**, “Cellular communication systems: Three generations of evolution in wireless technology,” *IEEE Potentials*, vol. 20, no. 1, pp. 32-35, Feb./March 2001.

Book Chapters

1. E. Hriba and **M.C. Valenti**, “Correlated blocking in mmwave cellular networks: Macrodiversity, outage, and interference,” in *Millimeter-Wave (mmWave) Communications*, MDPI, 2020, pp. 137-153.
2. V. Talreja, T. Ferrett, **M.C. Valenti**, and A. Ross, “A framework for secure selfie-based biometric authentication in the cloud,” Chapter 14 of *Selfie Biometrics: Advances and Challenges*, Springer, 2019, pp. 275-297.
3. P. Rost, **M.C. Valenti**, S. Talarico, and A. Maeder, “The tradeoff of computational complexity and achievable rates in C-RANs,” Chapter 3 of *Cloud Radio Access Networks: Principles, Technologies, and Applications*, Cambridge University Press, 2017.
4. **M.C. Valenti** and M. Fanaei, “The interplay between modulation and channel coding,” Chapter 5 of *Transmission Techniques for Digital Communications*, Elsevier, 2016.
5. **M.C. Valenti** and D. Reynolds, “Distributed space-time block codes,” Chapter 6 in *Cooperative Cellular Wireless Networks*, Edited by E. Hossain, D.I. Kim, and V.K. Bhargava, Cambridge University Press, 2011, pp. 153-175.
6. **M.C. Valenti**, S. Cheng, and R. Iyer Seshadri, “Turbo and LDPC codes for digital video broadcasting,” in *Turbo Code Application: A Journey from a Paper to Realization*, Edited by K. Sripimanwat, Springer, 2005.
7. **M.C. Valenti** and J. Sun, “Turbo codes,” in *Handbook of RF and Wireless Technologies*, Edited by F. Dowla Editor, Newnes Press, 2004, pp. 375-399.

Refereed Conference Papers

1. I.D. Lutz and **M.C. Valenti**, “Bridging the security gap: Lessons from 5G and what 6G should do better,” in *Proc., Int. Conf. on Computing, Networking, and Commun. (ICNC)*, (Honolulu, HI), Feb. 2025.
2. S. Roy and **M.C. Valenti**, “When URLLC is worse than Rayleigh: Error rates of Lomax fading,” in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Washington, DC), Oct. 2024.
3. J.D. Pabon, **M.C. Valenti**, and X. Yu, “Where to deploy an airborne relay in unknown environments: Feasible locations for throughput and LoS enhancement,” in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Boston, MA), Nov. 2023.
4. J.D. Pabon, S. Alkhandari, **M.C. Valenti**, and X. Yu, “Air-aided communication between ground assets in a Poisson forest,” in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Rockville, MD), Nov. 2022.
5. V. Talreja, N.M. Nasrabadi, and **M.C. Valenti**, “Attribute-based deep periocular recognition: Leveraging soft biometrics to improve periocular recognition,” in *Proc. Winter Conf. on Applications of Computer Vision (WACV)*, (Waikoloa, HI), Jan. 2022.
6. E. Hriba, **M.C. Valenti**, and R.W. Heath, Jr. “Optimization of a millimeter-wave UAV-to-ground network in urban deployments,” in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (San Diego, CA), Nov. 2021.
7. A. Ammar, **M.C. Valenti**, and D. Reynolds, “Relay selection with wireless energy transfer in mmwave networks” in *Proc. IEEE Consumer Communications & Networking Conference (CCNC)*, Jan. 2021.
8. F. Taherkhani, V. Talreja, J. Dawson, **M.C. Valenti**, and N.M. Nasrabadi, “PF-cpGAN: Profile to frontal coupled GAN for face recognition in the wild” in *Proc. IEEE Int. Joint Conf. on Biometrics (IJCB)*, (Houston, TX), Sept. 2020. Best Biometric Student Paper Award.
9. T. Ketseoglu, **M.C. Valenti**, and E. Ayanoglu, “Millimeter wave massive MIMO downlink per group communications with hybrid linear precoding,” in *Proc. Asilomar Conf. on Signals, Sys., & Computers*, (Pacific Grove, CA), Nov. 2019.

10. E. Hriba and **M.C. Valenti**, “The potential gains of macrodiversity in mmwave cellular networks with correlated blocking,” in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Norfolk, VA), Nov. 2019.
11. V. Talreja, F. Taherkhani, **M.C. Valenti**, and N.M. Nasrabadi, “Attribute-guided coupled GAN for cross-resolution face recognition,” in *Proc. IEEE Int. Conf. on Biometrics: Theory, Applications, & Systems (BTAS)*, (Tampa, FL), Sept. 2019.
12. V. Talreja, **M.C. Valenti**, and N.M. Nasrabadi, “Zero-shot deep hashing and network based error correction for face template protection,” in *Proc. IEEE Int. Conf. on Biometrics: Theory, Applications, & Systems (BTAS)*, (Tampa, FL), Sept. 2019.
13. V. Talreja, S. Soleymani, **M.C. Valenti**, and N.M. Nasrabadi, “Learning to authenticate with deep multibiometric hashing and neural network decoding,” in *Proc. IEEE Int. Conf. on Commun. (ICC)*, (Shanghai, China), May 2019.
14. V. Talreja, F. Taherkhani, **M.C. Valenti**, and N.M. Nasrabadi, “Using deep cross-modal hashing and error-correcting codes for improving the efficiency of attribute-guided facial image retrieval,” in *Proc. IEEE Global Conf. on Signal and Information Processing (GlobalSIP)*, (Anaheim, CA), Nov. 2018.
15. E. Hriba and **M.C. Valenti**, “The impact of correlated blocking on millimeter-wave personal networks,” in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Los Angeles, CA), Oct. 2018.
16. S. Talarico, **M.C. Valenti**, and M. DiRenzo, “Outage correlation in finite and clustered wireless networks,” in *Proc. IEEE Int. Symp. on Personal, Indoor, & Mobile Radio Commun. (PIMRC)*, (Bologna, Italy), Sept. 2018.
17. V. Talreja, T. Ferrett, **M.C. Valenti**, and A. Ross, “Biometrics-as-a-Service: A framework to promote innovative biometric recognition in the cloud,” in *Proc. IEEE Int. Conf. on Consumer Electronics (ICCE)*, (Las Vegas, NV), Jan. 2018.
18. E. Hriba, **M.C. Valenti**, K. Venugopal, and R. W. Heath, Jr., “Accurately accounting for random blockage in device-to-device mmwave networks,” in *Proc. IEEE Global Commun. Conf. (GLOBECOM)*, (Singapore), Dec. 2017.
19. V. Talreja, **M.C. Valenti**, and N.M. Nasrabadi, “Multibiometric secure system based on deep learning,” in *Proc. IEEE Global Conf. on Signal and Information Processing (GlobalSIP)*, (Montreal, Canada), Nov. 2017.
20. T. Ferrett and **M.C. Valenti**, “Noncoherent analog network coding using LPDC-coded FSK,” to appear in *Proc. IEEE Int. Conf. on Commun. (ICC)*, (Paris, France), May 2017.
21. K. Whetzel and **M.C. Valenti**, “Complexity-aware scheduling for an LDPC encoded C-RAN uplink,” in *Proc. Conf. on Info. Sci. and Sys. (CISS)*, (Baltimore, MD), Mar. 2017.
22. S. Talarico, **M.C. Valenti**, and T.R. Halford, “Controlled barrage regions: Stochastic modeling, analysis, and optimization,” in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Baltimore, MD), Nov. 2016.
23. P. Rost, A. Maeder, **M.C. Valenti**, and S. Talarico, “Computationally aware sum-rate optimal scheduling for centralized radio access networks,” in *Proc. IEEE Global Commun. Conf. (GLOBECOM)*, (San Diego, CA), Dec. 2015.
24. S. Talarico and **M.C. Valenti**, “Frequency hopping on a 5G millimeter uplink,” in *Proc. Asilomar Conf. on Signals, Sys., & Computers*, (Pacific Grove, CA), Nov. 2015. [invited paper](#).
25. K. Venugopal, **M.C. Valenti**, and R. W. Heath, Jr., “Analysis of millimeter-wave networked wearables in crowded environments,” in *Proc. Asilomar Conf. on Signals, Sys., & Computers*, (Pacific Grove, CA), Nov. 2015. [invited paper](#).
26. T. Ferrett and **M.C. Valenti**, “Reduced complexity detection for network-coded slotted ALOHA using sphere decoding,” in *Proc. Asilomar Conf. on Signals, Sys., & Computers*, (Pacific Grove, CA), Nov. 2015.
27. D. Torrieri, S. Talarico, and **M.C. Valenti**, “Performance analysis of a fifth-generation cellular uplink,” in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Tampa, FL), Oct. 2015.

28. D. Torrieri, S. Talarico, and **M.C. Valenti**, "Optimization of an adaptive frequency-hopping networks," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Tampa, FL), Oct. 2015.
29. T. Ferrett and **M.C. Valenti**, "LDPC Code Design for Noncoherent Physical Layer Network Coding," in *Proc. IEEE Int. Conf. on Commun. (ICC)*, (London, UK), June 2015.
30. K. Venugopal, **M.C. Valenti**, and R. W. Heath, Jr., "Interference in finite-sized highly dense millimeter wave networks," in *Proc. Information Theory and Applications (ITA) Workshop*, (San Diego, CA), Feb. 2015. invited paper.
31. **M.C. Valenti**, S. Talarico, and P. Rost, "The role of computational outage in dense cloud-based centralized radio access networks," in *Proc. IEEE Global Commun. Conf. (GLOBECOM)*, (Austin, TX), Dec. 2014.
32. D. Torrieri, S. Talarico, and **M.C. Valenti**, "Performance analysis of geographic routing protocols in ad hoc networks," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Baltimore, MD), Oct. 2014.
33. S. Talarico, **M.C. Valenti**, and T.R. Halford, "Unicast barrage relay networks: Outage analysis and optimization," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Baltimore, MD), Oct. 2014.
34. A.S. Bommagani, **M.C. Valenti**, and A. Ross, "A framework for secure cloud-empowered mobile biometrics," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Baltimore, MD), Oct. 2014.
35. M. Fanaei, A. Tahmasbi-Sarvestani, Y.P. Fallah, G. Bansal, **M.C. Valenti**, and J. Kenny, "Adaptive content control for communication amongst cooperative automated vehicles," in *Proc. IEEE International Symposium on Wireless Vehicular Communications (WIVEC)*, (Vancouver, Canada), Sept. 2014.
36. M. Fanaei, **M.C. Valenti**, and N. Schmid, "Effects of spatial randomness on locating a point source with distributed sensors," in *Proc. IEEE Int. Conf. on Commun. (ICC) Workshop on Advances in Network Localization and Navigation (ANLN)*, (Sydney, Australia), June 2014, *invited paper*.
37. S. Talarico and **M.C. Valenti**, "An accurate and efficient analysis of an MBSFN network," in *Proc. IEEE Int. Conf. on Acoustics, Speech, and Signal Processing (ICASSP)*, (Florence, Italy), May 2014.
38. M. Fanaei, **M.C. Valenti**, A. Jamalipour, and N. Schmid, "Optimal power allocation for distributed BLUE estimation with linear spatial collaboration," in *Proc. IEEE Int. Conf. on Acoustics, Speech, and Signal Processing (ICASSP)*, (Florence, Italy), May 2014.
39. D. Torrieri, **M.C. Valenti**, and S. Talarico, "Analysis of multi-cell downlink cooperation with a constrained spatial model," in *Proc. IEEE Global Commun. Conf. (GLOBECOM)*, (Atlanta, GA), Dec. 2013.
40. D. Torrieri, S. Talarico, and **M.C. Valenti**, "Multihop routing in ad hoc networks," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (San Diego, CA), Nov. 2013.
41. M. Fanaei, **M.C. Valenti**, and N.A. Schmid, "Power allocation for distributed BLUE estimation with full and limited feedback of CSI," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (San Diego, CA), Nov. 2013.
42. M. Fanaei, **M.C. Valenti**, and N.A. Schmid, "Limited-feedback-based channel-aware power allocation for linear distributed estimation," in *Proc. Asilomar Conf. on Signals, Sys., & Computers*, (Pacific Grove, CA), Nov. 2013.
43. D. Torrieri, **M.C. Valenti**, and S. Talarico, "A new analysis of the DS-CDMA cellular uplink under spatial constraints," in *Proc. IEEE Int. Conf. on Commun. (ICC)*, (Budapest, Hungary), June 2013.
44. **M.C. Valenti**, D. Torrieri, and S. Talarico, "Adjacent-channel interference in frequency-hopping ad hoc networks," in *Proc. IEEE Int. Conf. on Commun. (ICC)*, (Budapest, Hungary), June 2013.
45. T. Ferrett, **M.C. Valenti**, and D. Torrieri, "An iterative noncoherent relay receiver for the two-way relay channel," in *Proc. IEEE Int. Conf. on Commun. (ICC)*, (Budapest, Hungary), June 2013.

46. **M.C. Valenti**, D. Torrieri, and S. Talarico, "A new analysis of the DS-CDMA cellular downlink under spatial constraints," in *Proc. Int. Conf. on Computing, Networking, and Commun. (ICNC)*, (San Diego, CA), Jan. 2013.
47. X. Xiang and **M.C. Valenti**, "Closing the gap to the capacity of APSK: Constellation shaping and degree distributions," in *Proc. Int. Conf. on Computing, Networking, and Commun. (ICNC)*, (San Diego, CA), Jan. 2013.
48. D. Torrieri and **M.C. Valenti**, "Guard zones and the near-far problem in DS-CDMA ad hoc networks," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Orlando, FL), Nov. 2012, pp. 86-91.
49. **M.C. Valenti**, D. Torrieri, and S. Talarico, "Optimization of a finite frequency-hopping ad hoc network in Nakagami fading," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Orlando, FL), Nov. 2012, pp. 192-197.
50. N. Schmid, M. Alkhweldi, and **M.C. Valenti**, "Distributed estimation of a parametric field using sparse noisy data," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Orlando, FL), Nov. 2012.
51. T. Ferrett, H. Ochiai, and **M.C. Valenti**, "Physical-layer network coding using FSK modulation under frequency offset," in *Proc. IEEE Vehicular Tech. Conf. (VTC)*, (Yokohama, Japan), May 2012.
52. T. Ferrett, **M.C. Valenti**, and D. Torrieri, "Noncoherent digital network coding using multi-tone CPFSK," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Baltimore, MD), Nov. 2011.
53. X. Xiang and **M.C. Valenti**, "Improving DVB-S2 performance through constellation shaping and iterative demapping," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Baltimore, MD), Nov. 2011.
54. **M.C. Valenti** and X. Xiang, "Constellation shaping for bit-interleaved coded APSK," in *Proc. IEEE Int. Conf. on Commun. (ICC)*, (Kyoto, Japan), June 2011.
55. **M.C. Valenti**, "An information-theoretic approach to accelerated simulation of hybrid-ARQ systems," in *Proc. IEEE Int. Conf. on Commun. (ICC)*, (Kyoto, Japan), June 2011.
56. C. Nannapaneni, **M.C. Valenti**, and X. Xiang, "Constellation shaping for communication channels with quantized outputs," in *Proc. Conf. on Info. Sci. and Sys. (CISS)*, (Baltimore, MD), Mar. 2011.
57. T. Ferrett, **M.C. Valenti**, and D. Torrieri, "Receiver design for Noncoherent digital network coding," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (San Jose, CA), Nov. 2010.
58. **M.C. Valenti**, S. Cheng, and D. Torrieri, "Iterative multisymbol noncoherent reception of coded CPFSK," in *Proc. IEEE Military Communications Conference (MILCOM)*, (Boston, MA), Oct. 2009.
59. **M.C. Valenti**, D. Torrieri, and T. Ferrett, "Noncoherent Physical-Layer Network Coding Using Binary CPFSK Modulation," in *Proc. IEEE Military Communications Conference (MILCOM)*, (Boston, MA), Oct. 2009.
60. D. Torrieri and **M.C. Valenti**, "Efficient space-time block codes designed by a genetic algorithm," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (San Diego, CA), Nov. 2008.
61. **M.C. Valenti**, R. Doppalapudi, and D. Torrieri, "A genetic algorithm for designing constellations with low error floors," in *Proc. Conf. on Info. Sci. and Sys. (CISS)*, (Princeton, NJ), Mar. 2008.
62. D. Buckingham and **M.C. Valenti**, "The information-outage probability of finite-length codes over AWGN channels," in *Proc. Conf. on Info. Sci. and Sys. (CISS)*, (Princeton, NJ), Mar. 2008.
63. S. Cheng, **M.C. Valenti**, and D. Torrieri, "Coherent and multi-symbol noncoherent CPFSK: Capacity and code design," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Orlando, FL), Oct. 2007.
64. D. Torrieri and **M.C. Valenti**, "Constellation labeling maps for low error floors," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Orlando, FL), Oct. 2007.
65. Rohit Iyer Seshadri, S. Cheng, and **M.C. Valenti**, "The BICM capacity of coherent continuous-phase frequency shift keying," in *Proc. IEEE Vehicular Tech. Conf. (VTC)*, (Baltimore, MD), Oct. 2007.

66. D. Torrieri, S. Cheng, and **M.C. Valenti**, "Robust frequency-hopping system for channels with interference and frequency-selective fading," in *Proc. IEEE Int. Conf. on Commun. (ICC)*, (Glasgow, Scotland), June 2007.
67. R. Rajagopalan, D. Reynolds, **M.C. Valenti**, B.D. Woerner, "The impact of an antenna array in a relay network," in *Proc. IEEE Int. Conf. on Commun. (ICC)*, (Glasgow, Scotland), June 2007.
68. S. Cheng, R. Iyer Seshadri, **M.C. Valenti**, and D. Torrieri, "The capacity of noncoherent continuous-phase frequency shift keying," in *Proc. Conf. on Info. Sci. and Sys. (CISS)*, (Baltimore, MD), Mar. 2007.
69. S.A. Ahmad and **M.C. Valenti**, "A practical hybrid-ARQ protocol using noncoherent orthogonal modulation," in *Proc. Conf. on Info. Sci. and Sys. (CISS)*, (Baltimore, MD), Mar. 2007.
70. K.G. Vardhe, D. Reynolds, and **M.C. Valenti**, "Outage probability of a multi-user cooperation protocol in an asynchronous CDMA cellular uplink," in *Proc. Conf. on Info. Sci. and Sys. (CISS)*, (Baltimore, MD), Mar. 2007.
71. S. Cheng and **M.C. Valenti**, "Union bound analysis of bit interleaved coded orthogonal modulation with differential precoding," in *Proceedings of the International Symposium on Information Theory (ISIT)*, (Seattle, WA), July 2006.
72. R. Iyer Seshadri and **M.C. Valenti**, "A capacity-based approach for designing bit-interleaved coded GFSK with noncoherent detection," in *Proceedings of the International Symposium on Information Theory (ISIT)*, (Seattle, WA), July 2006.
73. R. Iyer Seshadri and **M.C. Valenti**, "Soft-in/soft-out noncoherent sequence detection for Bluetooth: Capacity, error rate and throughput analysis," in *Proceedings of the IEEE Wireless Commun. & Networking Conf. (WCNC)*, (Las Vegas, NV), Apr. 2006, pp. 1354-1359.
74. T. Ghanim and **M.C. Valenti**, "The throughput of hybrid-ARQ in block fading under modulation constraints," in *Proceedings of the Conference on Information Sciences and Systems (CISS)*, (Princeton, NJ), Mar. 2006.
75. S. Cheng, **M.C. Valenti**, and D. Torrieri, "Turbo-NFSK: Iterative estimation, noncoherent demodulation, and decoding for fast fading channels," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Atlantic City, NJ), Nov. 2005, pp. 3193-3199.
76. S. Cheng and **M.C. Valenti**, "Macrodiversity packet combining for the IEEE 802.11a uplink," in *Proc. IEEE Wireless Commun. & Networking Conf. (WCNC)*, (New Orleans, LA), Mar. 2005, pp. 88-93.
77. B. Zhao, R. Iyer Seshadri, and **M.C. Valenti**, "Geographic random forwarding with hybrid-ARQ for ad hoc networks with rapid sleep cycles," in *Proc. IEEE Global Telecommun. Conf. (GLOBECOM)*, (Dallas, TX), Dec. 2004, pp. 3047-3052.
78. S. Cheng and **M.C. Valenti**, "Bit-interleaved turbo-coded noncoherent orthogonal modulation with iterative demodulation and decoding: Capacity limits and convergence analysis," in *Proc. Asilomar Conference on Signals, Systems, and Computers*, (Pacific Grove, CA), Nov. 2004, pp. 2020-2024.
79. J. Sun and **M.C. Valenti**, "Optimum frame synchronization for preamble-less packet transmission of turbo codes," in *Proc. Asilomar Conference on Signals, Systems, and Computers*, (Pacific Grove, CA), Nov. 2004, pp. 1126-1130.
80. **M.C. Valenti** and B. Zhao, "Hybrid-ARQ based intra-cluster geographic relaying," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Monterey, CA), Nov. 2004, pp. 805-811, [invited paper](#).
81. **M.C. Valenti**, E. Hueffmeier, B. Bogusch, and J. Fryer, "Towards the capacity of noncoherent orthogonal modulation: BICM-ID for turbo coded NFSK," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Monterey, CA), Nov. 2004, pp. 1549-1555.
82. S. Wei, D. Goeckel, and **M. Valenti**, "Asynchronous cooperative diversity," in *Proc. Conf. on Info. Sci. and Sys. (CISS)*, (Princeton, NJ), Mar. 2004, 6 pages.
83. G.J. Raux, A. Feliachi, and **M.C. Valenti**, "Telecommunication of stabilizing signals in power systems," in *Proc. North American Power Symposium (NAPS)*, (Rolla, MO), Oct. 2003, 5 pages.

84. B. Zhao and **M.C. Valenti**, "Some new adaptive protocols for the wireless relay channel," in *Proc. Allerton Conf. on Commun., Control, and Comp.*, (Monticello, IL), Oct. 2003, pp. 1588-1589.
85. **M.C. Valenti** and B. Zhao, "Distributed turbo codes: Towards the capacity of the relay channel," in *Proc. IEEE Vehicular Tech. Conf. (VTC)*, (Orlando, FL), Oct. 2003, pp. 6-9.
86. J. Sun and **M.C. Valenti**, "Synchronization of turbo codes based on online statistics," in *Proc. IEEE Int. Conf. on Commun. (ICC)*, (Anchorage, AK), May 2003, pp. 2733-2737.
87. B. Zhao and **M.C. Valenti**, "Convergence analysis of a new class of flexible hybrid concatenated codes," in *Proc. Southeastern Symp. Sys. Theory (SSST)*, (Morgantown, WV), Mar. 2003, pp. 283-287.
88. **M.C. Valenti** and N. Correal, "Exploiting Macrodiversity in Dense Multihop Networks and Relay Channels," in *Proc. IEEE Wireless Commun. & Networking Conf. (WCNC)*, (New Orleans, LA), Mar. 2003, pp. 1877-1882.
89. **M.C. Valenti**, "Improving uplink performance by macrodiversity combining packets from adjacent access points," in *Proc. IEEE Wireless Commun. & Networking Conf. (WCNC)*, (New Orleans, LA), Mar. 2003, pp. 636-641.
90. **M.C. Valenti** and M. Robert, "Improving the QoS of Bluetooth through turbo coding," in *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Los Angeles, CA), Oct. 2002, pp. 1057-1061.
91. **M.C. Valenti** and M. Robert, "Custom coding, adaptive rate control, and distributed detection for Bluetooth," in *Proc. IEEE Vehicular Tech. Conf. (VTC)*, (Vancouver, BC), Sept. 2002, pp. 918-922.
92. S. Krishnamoorthy, M. Robert, S. Srikanteswara, **M.C. Valenti**, C. Anderson, and J.H. Reed, "Channel frame error rate for Bluetooth in the presence of microwave ovens," in *Proc. IEEE Vehicular Tech. Conf. (VTC)*, (Vancouver, BC), Sept. 2002, pp. 927-931.
93. N.S. Correal, J. Heck, and **M.C. Valenti**, "An analog turbo decoder for an (8,4) product code," in *Proc. IEEE Midwest Symp. on Circuits & Sys. (MWSCAS)*, (Tulsa, OK), Aug. 2002, pp. 632-635.
94. B. Naduvathuparambil, **M.C. Valenti**, and A. Feliachi, "Communication delays in wide area measurement systems," in *Proc. Southeastern Symp. Sys. Theory (SSST)*, (Huntsville, AL), Mar. 2002, pp. 118-122.
95. **M.C. Valenti**, M. Robert, and J.H. Reed, "On the throughput of Bluetooth data transmissions," in *Proc. IEEE Wireless Commun. & Networking Conf. (WCNC)*, (Orlando, FL), Mar. 2002, pp. 119-123.
96. B. Zhao and **M.C. Valenti**, "Per-survivor based detection of DPSK modulated high rate turbo codes over Rayleigh fading channels," in *Proc. Asilomar Conference on Signals, Systems, and Computers*, (Pacific Grove, CA), Nov. 2001, pp. 1026-1030, [invited paper](#).
97. **M.C. Valenti**, "An efficient software radio implementation of the UMTS turbo codec," in *Proc. IEEE International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC)*, (San Diego, CA), Oct. 2001, pp. 108-113.
98. Y. Tang and **M.C. Valenti**, "Coded transmit macrodiversity: Block space-time codes over distributed antennas," in *Proc. IEEE Vehicular Technology Conference (VTC)*, (Rhodes, Greece), May 2001, pp. 1435-1438.
99. N. Chandran and **M.C. Valenti**, "Hybrid ARQ using Serial Concatenated Convolutional Codes over Fading Channels" in *Proc. IEEE Vehicular Technology Conference (VTC)*, (Rhodes, Greece), May 2001, pp. 1410-1414.
100. **M.C. Valenti**, "Inserting turbo code technology in the DVB satellite broadcasting system," in *Proc. Military Communications International Symposium (MILCOM)*, (Los Angeles, CA), Nov. 2000, pp. 650-654.
101. **M.C. Valenti**, "Iterative channel estimation and decoding of turbo codes over flat-fading channels," in *Proc. IEEE Wireless Communications and Networking Conference (WCNC)*, (Chicago, IL), Sept. 2000, pp. 1019-1024, [invited paper](#).

102. **M.C. Valenti**, "An optimal soft-output multiuser detection algorithm and its applications," in *Proc. Second International Symposium of Turbo Codes and Related Topics*, (Brest, France), Sept. 2000, pp. 177-180.
103. Y. Wu and **M.C. Valenti**, "An ARQ technique using related parallel and serial concatenated convolutional codes," in *Proc. Int. Conf. on Commun. (ICC)*, (New Orleans, LA), June 2000, pp. 1390-1394.
104. **M.C. Valenti** and B.D. Woerner, "A bandwidth efficient pilot symbol technique for coherent detection of turbo codes over fading channels," in *Proc. Military Communications International Symposium (MILCOM)*, (Atlantic City, NJ), Nov. 1999, pp. 81-85.
105. **M.C. Valenti** and B.D. Woerner, "Combined multiuser detection and channel decoding with receiver diversity," in *Proc. IEEE Global Telecommun. Conf. (GLOBECOM), Commun. Theory Mini-Conf.*, (Sydney, Australia), Nov. 1998, pp. 137-142.
106. **M.C. Valenti** and B.D. Woerner, "Multiuser detection with base station diversity," in *Proc. IEEE Int. Conf. on Universal Personal Commun. (ICUPC)*, (Florence, Italy), Oct. 1998, pp. 1189-1194.
107. **M.C. Valenti** and B.D. Woerner, "Iterative multiuser detection for convolutionally coded asynchronous DS-CDMA," in *Proc. IEEE Int. Symp. on Personal, Indoor, & Mobile Radio Commun. (PIMRC)*, (Boston, MA), Sept. 1998, pp. 213-217.
108. **M.C. Valenti** and B.D. Woerner, "Performance of turbo codes in interleaved flat fading channels with estimated channel state information," in *Proc. IEEE Vehicular Tech. Conf. (VTC)*, (Ottawa, ON), May 1998, pp. 66-70.
109. **M.C. Valenti** and B.D. Woerner, "Combined multiuser reception and channel decoding for TDMA cellular systems," in *Proc. IEEE Vehicular Tech. Conf. (VTC)*, (Ottawa, ON), May 1998, pp. 1915-1919.
110. **M.C. Valenti** and B.D. Woerner, "Variable latency turbo codes for wireless multimedia applications," in *Proc. Int. Symp. on Turbo Codes & Related Topics*, (Brest, France), Sept. 1997, pp. 216-219.

Other Conference Papers

111. S. Talarico, **M.C. Valenti**, and D. Torrieri, "Analysis and optimization of a frequency hopping ad hoc network in Rayleigh fading," in *Proc. Virginia Tech Symp. on Wireless Personal Commun.*, (Blacksburg, VA), May 2012.
112. M. Fanaei, **M.C. Valenti**, and N. Schmid, "Distributed parameter estimation in wireless sensor networks using fused local observations," in *Proc. SPIE Wireless Sensing, Localization, and Processing VII*, (Baltimore, MD), Apr. 2012.
113. M. Fanaei, **M.C. Valenti**, N. Schmid and V. Kulathumani, "Channel-aware distributed classification using binary local decisions," in *Proc. SPIE Signal Processing, Sensor Fusion, and Target Recognition XX*, (Orlando, FL), Apr. 2011.
114. X. Chen, S. Gong, N.A. Schmid, and **M.C. Valenti**, "UAV based distributed ATR under realistic simulated environmental effects," in *Proc. SPIE Signal Processing, Sensor Fusion, and Target Recognition XVI*, (Orlando, FL), Apr. 2007.
115. R. Iyer Seshadri and **M.C. Valenti**, "A capacity-based search for energy and bandwidth efficient bit-interleaved coded noncoherent GFSK," in *Proceedings of the Virginia Tech Symp. on Wireless Personal Commun.*, (Blacksburg, VA), June 2006.
116. B. Zhao and **M.C. Valenti**, "Cooperative diversity using distributed turbo codes," in *Proc. Virginia Tech Symp. on Wireless Personal Commun.*, (Blacksburg, VA), June 2003, pp. 143-152.
117. N. Chandran and **M.C. Valenti**, "Bridging the gap between parallel and serial concatenated codes," in *Proc. Virginia Tech Symp. on Wireless Personal Commun.*, (Blacksburg, VA), June 2002, pp. 145-154.
118. B. Zhao and **M.C. Valenti**, "Iterative demodulation and decoding of DPSK modulated turbo codes over Rayleigh fading channels," in *Proc. Virginia Tech Symposium on Wireless Personal Communications*, (Blacksburg, VA), June 2001, pp. 259-270.

119. D. Baker and M.C. Valenti, "The impact of channel estimation errors on space time block codes," in *Proc. Virginia Tech Symposium on Wireless Personal Communications*, (Blacksburg, VA), June 2001, pp. 175-186.
120. M.C. Valenti, "Turbo codes and iterative processing," in *Proc. IEEE New Zealand Wireless Commun. Symp.*, (Auckland, New Zealand), Nov. 1998.

PRESENTATIONS

Invited Research Seminars and Tutorial Presentations

1. "Building a secure 6G: Lessons from 5G vulnerabilities and future directions," plenary, *International Conference on Computing, Networking, and Communications* (Honolulu, HI), Feb. 19, 2025.
2. "Deep hashing for secure biometrics," invited seminar, *University of North Dakota* (Grand Forks, ND), February 22, 2024.
3. "Air-assisted broadband communications," invited seminar, *Hughes Network Systems* (Germantown, MD), August 4, 2022.
4. "Unlocking the promise of 5G," invited seminar, *University of South Carolina* (Columbia, SC), April 1, 2022.
5. "Cloud radio access networks for 5G communications," invited seminar, *Hughes Network Systems* (Germantown, MD), June 8, 2018.
6. "Cloud radio access networks for 5G communications," invited seminar, *Michigan Technological University* (Houghton, MI), April 13, 2018.
7. "Centralized radio access networks: Moving baseband to the Cloud," a half-day tutorial presented at the *IEEE International Conference on Communications* (Kuala Lumpur, Malaysia), May 27, 2016.
8. "The computational requirements of centralized RAN," invited presentation, *Communication Theory Workshop* (Nafplio, Greece), May 16, 2016.
9. "Research challenges in biometrics," invited seminar, *Biometrics Institute meeting* (Australian Embassy, Washington, DC), Sep. 15, 2015.
10. "Computational outage: A new KPI for C-RAN," invited seminar, *University of Southampton* (Southampton, UK), June 12, 2015.
11. "Centralized radio access networks: Moving baseband to the Cloud," a half-day tutorial presented at the *Virginia Tech Symposium on Wireless Personal Communications and Annual Wireless Summer School*, (Blacksburg, VA), May 28, 2015.
12. "Coverage and rate in finite-sized device-to-device millimeter wave networks," invited seminar, *McGill University* (Montreal, Quebec), Mar. 23, 2015.
13. "Centralized radio access networks: The case for baseband in the cloud," invited seminar, *University of Toronto* (Toronto, ON), Nov. 12, 2014.
14. "Centralized radio access networks: The case for baseband in the cloud," invited seminar, *University of New Mexico* (Albuquerque, NM), Oct. 31, 2014.
15. "Mobile biometrics in the cloud," invited presentation, *Smart Card Alliance Government Conference* (Washington, DC), Oct. 30, 2014.
16. "Computational communication theory: A modern tool for engineering future wireless networks," invited seminar, *Motorola Labs* (Plantation, FL), May 23, 2014.
17. "Interference and spatial modeling in wireless networks," invited seminar, *University at Buffalo, The State University of New York* (Buffalo, NY), May 15, 2014.
18. "Interference and spatial modeling in wireless networks," invited seminar, *University of Pisa* (Pisa, Italy), May 5, 2014.

19. "A day in the life of an LTE handset," a half-day tutorial presented at the *Virginia Tech Symposium on Wireless Personal Communications and Annual Wireless Summer School*, (Blacksburg, VA), May 30, 2013.
20. "Interference and spatial modeling in wireless networks," invited seminar, *Clemson University*, May 28, 2013
21. "Constellation shaping for LDPC-coded APSK," invited seminar, *Hughes Network Systems* (Germantown, MD), Mar. 14, 2013.
22. "The LTE physical layer," a half-day tutorial presented at the *Virginia Tech Symposium on Wireless Personal Communications*, (Blacksburg, VA), June 1, 2012.
23. "A high-performance computing approach to wireless network optimisation," invited seminar, *University of Auckland* (Auckland, New Zealand), Feb. 3, 2012.
24. "Communication theory in the cloud: The transformative power of cheap utility computing," plenary, *Australian Communication Theory Workshop* (Wellington, New Zealand), Jan. 30, 2012.
25. "Modern digital satellite television: How it works," invited seminar, *United States Naval Academy*, Nov. 7, 2011.
26. "Modern digital satellite television: How it works," invited seminar, *Georgia Institute of Technology*, Nov. 1, 2011.
27. "The transmission capacity of frequency-hopping ad hoc networks," invited seminar, *Osaka University*, June 13, 2011.
28. "LDPC codes: Achieving the capacity of the binary erasure channel," invited talk, *Math/CS Colloquium* (West Virginia University, Morgantown, WV), Nov. 30, 2009.
29. "Communication theory in the cloud," invited seminar, *University of Toronto*, Oct. 30, 2009.
30. "Channel coding for IEEE 802.16e mobile WiMAX," a half-day tutorial presented at the *IEEE International Conference on Communications* (Dresden, Germany), June 18, 2009.
31. "Channel coding for IEEE 802.16e mobile WiMAX," a half-day tutorial presented at the *Virginia Tech Symposium on Wireless Personal Communications* (Blacksburg, VA), June 4, 2009.
32. "Mutual information as a tool for the design, analysis, and testing of modern communication systems," invited seminar presented to *Hughes Network Systems*, (Germantown, MD), June 8, 2007.
33. "Turbo and LDPC codes: Implementation, simulation, and standardization," a half-day tutorial presented at the *16th Virginia Tech/MPRG Symposium on Wireless Personal Communications and 2nd Annual Wireless Summer School*, (Blacksburg, VA), June 2006.
34. "Distributed Simulation of Modern Communication Systems Using the Global Grid Exchange," invited presentation, *Teaming to Win Conference*, Stonewall Jackson Resort (Walkersville, WV), June 1, 2006.
35. "Distributed Simulation of Modern Communication Systems Using the Global Grid Exchange," invited presentation, *West Virginia University Computing & Technology Symp.*, Apr. 12, 2006.
36. "Modern wireless network design based on constrained capacity," invited seminar, *Pittsburgh Signal Processing Society Seminar*, University of Pittsburgh, April 20, 2005.
37. "Coded-protocols for implementing cooperative diversity," invited research colloquium, *Motorola Corporate Research Labs*, (Schaumburg, IL), June 30, 2004.
38. "Bluetooth: Throughput analysis and tricks to improve performance," invited seminar, *Ohio University*, (Athens, OH), May 15, 2002.
39. "Bluetooth: Link and physical layer," invited research colloquium, *Motorola Florida Research Labs*, (Plantation, FL), Mar. 25, 2002.
40. "Turbo codes and iterative processing," invited research colloquium, *Motorola Florida Research Labs*, (Plantation, FL), Mar. 22, 2002.

41. "Emerging wireless standards," invited presentation, *Second YAS Broadband Venture Seminar*, West Virginia University, (Morgantown, WV), Sept. 7, 2001.
42. "Wireless communications research at West Virginia University," invited research colloquium, *National Radio Astronomy Observatory (NRAO)*, (Green Bank, WV), June 13, 2000.

Oral Conference Presentations

1. "When URLLC is worse than Rayleigh: Error rates of Lomax fading," *Proc. IEEE Military Commun. Conf. (MILCOM)*, (Washington, DC), Oct. 30, 2024.
2. "Where to deploy an airborne relay in unknown environments: Feasible locations for throughput and LoS enhancement," *IEEE Military Commun. Conf. (MILCOM)*, (Boston, MA), Nov. 2, 2023.
3. "Learning to authenticate with deep multibiometric hashing and neural network decoding," *IEEE International Conference on Communications (ICC)*, (Shanghai, China), May 21, 2019.
4. "The impact of correlated blocking on millimeter-wave personal networks," *IEEE Military Commun. Conf. (MILCOM)*, (Los Angeles, CA), Oct. 29, 2018.
5. "Outage correlation in finite and clustered wireless networks," *IEEE Int. Symp. on Personal, Indoor, & Mobile Radio Commun. (PIMRC)*, (Bologna, Italy), Sept. 12, 2018.
6. "Accurately accounting for random blockage in device-to-device mmwave networks," *IEEE Global Commun. Conf. (GLOBECOM)*, (Singapore), Dec. 5, 2017.
7. "Controlled barrage regions: Stochastic modeling, analysis, and optimization," *IEEE Military Commun. Conf. (MILCOM)*, (Baltimore, MD), Nov. 2016.
8. "Frequency hopping on a 5G millimeter uplink," *Asilomar Conf. on Signals, Sys., & Computers*, (Pacific Grove, CA), Nov. 2015
9. "Optimization of an adaptive frequency-hopping networks," *IEEE Military Commun. Conf. (MILCOM)*, (Tampa, FL), Oct. 2015.
10. "Effects of spatial randomness on locating a point source with distributed sensors," *IEEE Int. Conf. on Commun. (ICC) Workshop on Advances in Network Localization and Navigation (ANLN)*, (Sydney), June 2014.
11. "An iterative noncoherent relay receiver for the two-way relay channel," *IEEE Int. Conf. on Commun. (ICC)*, (Budapest, Hungary), June 2013.
12. "Closing the gap to the capacity of APSK: Constellation shaping and degree distributions," *Int. Conf. on Computing, Networking, and Commun. (ICNC)*, (San Diego, CA), Jan. 2013.
13. "Analysis and optimization of a frequency hopping ad hoc network in Rayleigh fading," *Virginia Tech Symp. on Wireless Personal Commun.*, (Blacksburg, VA), May 30, 2012.
14. "Iterative multisymbol noncoherent reception of coded CPFSK," presented at the *IEEE Military Communications Conference (MILCOM)*, (Boston, MA), Oct. 19, 2009.
15. "Robust frequency-hopping system for channels with interference and frequency-selective fading," *IEEE Int. Conf. on Commun. (ICC)*, (Glasgow, Scotland), June 2007.
16. "The impact of an antenna array in a relay network," *IEEE Int. Conf. on Commun. (ICC)*, (Glasgow, Scotland), June 2007.
17. "Macrodiversity packet combining for the IEEE 802.11a uplink," *IEEE Wireless Commun. & Networking Conf. (WCNC)*, (New Orleans, LA), Mar. 2005.
18. "Bit-interleaved turbo-coded noncoherent orthogonal modulation with iterative demodulation and decoding: Capacity limits and convergence analysis," *Asilomar Conference on Signals, Systems, and Computers*, (Pacific Grove, CA), Nov. 2004.
19. "Hybrid-ARQ based intra-cluster geographic relaying," *IEEE Military Commun. Conf. (MILCOM)*, (Monterey, CA), Nov. 2004, invited presentation.

20. "Towards the capacity of noncoherent orthogonal modulation: BICM-ID for turbo coded NFSK," *IEEE Military Commun. Conf. (MILCOM)*, (Monterey, CA), Nov. 2004.
21. "Some new adaptive protocols for the wireless relay channel," *Allerton Conf. on Commun., Control, and Comp.*, Monticello, IL, Oct. 3, 2003.
22. "Cooperative diversity using distributed turbo codes," *Virginia Tech Symp. on Wireless Personal Commun.*, Blacksburg, VA, June 6, 2003.
23. "Exploiting Macrodiversity in Dense Multihop Networks and Relay Channels," *IEEE Wireless Commun. & Networking Conf. (WCNC)*, New Orleans, LA, Mar. 20, 2003.
24. "Improving uplink performance by macrodiversity combining packets from adjacent access points," *IEEE Wireless Commun. & Networking Conf. (WCNC)*, New Orleans, LA, Mar. 19, 2003.
25. "Improving the QoS of Bluetooth Through Turbo Coding," *IEEE Military Commun. Conf. (MILCOM)*, Los Angeles, CA, Oct. 8, 2002.
26. "Custom coding, adaptive rate control, and distributed detection for Bluetooth," *IEEE Vehicular Tech. Conf. (VTC)*, Vancouver, BC, Sept. 26, 2002.
27. "An analog turbo decoder for an (8,4) product code," *IEEE Midwest Symp. on Circuits & Sys. (MWSCAS)*, Tulsa, OK, Aug. 7, 2002.
28. "Bridging the gap between parallel and serial concatenated codes," *Virginia Tech Symp. on Wireless Personal Commun.*, Blacksburg, VA, June 7, 2002.
29. "On the throughput of Bluetooth data transmissions," *IEEE Wireless Commun. & Networking Conf. (WCNC)*, (Orlando, FL), Mar. 18, 2002.
30. "Per-survivor based detection of DPSK modulated high rate turbo codes over Rayleigh fading channels," *Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, Nov. 2001, invited presentation.
31. "An efficient software radio implementation of the UMTS turbo codec," *IEEE International Symp. on Personal, Indoor, and Mobile Radio Communications (PIMRC)*, San Diego, CA, Oct. 2001.
32. "The impact of channel estimation errors on space time block codes," *Virginia Tech Symposium on Wireless Personal Communications*, Blacksburg, VA, June 2001.
33. "Coded transmit macrodiversity: Block space-time codes over distributed antennas," *IEEE Vehicular Technology Conference (VTC)*, Rhodes, Greece, May 2001.
34. "Hybrid ARQ using Serial Concatenated Convolutional Codes over Fading Channels" *IEEE Vehicular Technology Conference (VTC)*, Rhodes, Greece, May 2001.
35. "Inserting turbo code technology in the DVB satellite broadcasting system," *Military Communications International Symposium (MILCOM)*, Los Angeles, CA, Nov. 2000.
36. "Iterative channel estimation and decoding of turbo codes over flat-fading channels," *Wireless Communications and Networking Conference (WCNC)*, Chicago, IL, Sept. 2000, invited presentation.
37. "An optimal soft-output multiuser detection algorithm and its applications," *Second International Symposium of Turbo Codes and Related Topics*, Brest, France, Sept. 2000.
38. "An ARQ technique using related parallel and serial concatenated convolutional codes," *Int. Conf. on Commun. (ICC)*, New Orleans, LA, June 2000.
39. "A bandwidth efficient pilot symbol technique for coherent detection of turbo codes over fading channels," *Military Communications International Symp. (MILCOM)*, Atlantic City, NJ, Nov. 1999.
40. "Turbo codes and iterative processing," in *Proc. IEEE New Zealand Wireless Commun. Symp.*, (Auckland, New Zealand), Nov. 1998.
41. "Combined multiuser detection and channel decoding with receiver diversity," in *Proc. IEEE Global Telecommun. Conf. (GLOBECOM)*, *Commun. Theory Mini-Conf.*, (Sydney, Australia), Nov. 1998.

42. "Iterative multiuser detection for convolutionally coded asynchronous DS-CDMA," in *Proc. IEEE Int. Symp. on Personal, Indoor, & Mobile Radio Commun. (PIMRC)*, (Boston, MA), Sept. 1998.
43. "Performance of turbo codes in interleaved flat fading channels with estimated channel state information," in *Proc. IEEE Vehicular Tech. Conf. (VTC)*, (Ottawa, ON), May 1998.
44. "Combined multiuser reception and channel decoding for TDMA cellular systems," in *Proc. IEEE Vehicular Tech. Conf. (VTC)*, (Ottawa, ON), May 1998, pp. 1915-1919.

Poster Presentations

1. "Multibiometric secure system based on deep learning," *poster presentation, IEEE Global Conf. on Signal and Information Processing (GlobalSIP)*, (Montreal, Canada), Nov. 2017.
2. "Interference correlation in fixed and finite networks," *poster presentation, 2015 Communication Theory Workshop*, (Laguna Beach, CA), May 11, 2015.
3. "The role of computational outage in dense cloud-based centralized radio access networks," *poster presentation, IEEE Global Commun. Conf. (GLOBECOM)*, (Austin, TX), Dec. 2014.
4. "A direct approach to spatial averaging: Revisiting Baccelli's Result," *poster presentation, 2014 IEEE Communication Theory Workshop*, (Curacao), May 26, 2014.
5. "An information-theoretic approach to accelerated simulation of hybrid-ARQ systems," *poster presentation, IEEE Int. Conf. on Commun. (ICC)*, (Kyoto, Japan), June 2011.
6. "Optimum frame synchronization for preamble-less packet transmission of turbo codes," *poster presentation, Asilomar Conference on Signals, Systems, and Computers*, (Pacific Grove, CA), Nov. 2004.
7. "Scaling cooperative diversity to large networks," *poster presentation, NATO Workshop on Cross-Layer Issues in the Design of Tactical Mobile Ad Hoc Wireless Networks*, (US Naval Research Laboratory, Washington, DC), June 2-3, 2004.
8. "Iterative demodulation and decoding of DPSK modulated turbo codes over Rayleigh fading channels," *poster presentation, Virginia Tech Symposium on Wireless Personal Communications*, (Virginia Tech, Blacksburg, VA), June 2001.
9. "Variable latency turbo codes for wireless multimedia applications," in *Proc. Int. Symp. on Turbo Codes & Related Topics*, (Brest, France), Sept. 1997.

GRANTS AND CONTRACTS

Awards Made to the Center for Identification Technology Research

Description: These are funds secured from the NSF and the CITeR Industrial Affiliates. The funds are used to operate the center and to fund research projects selected by the Affiliates.

Research Title	Granting Agency	Dates of Award	Agency Funding	Role
IUCRC Phase III West Virginia University: Center for Identification Technology Research (CITeR)	National Science Foundation	8/1/2024 to 7/31/2029	\$200,000	Co-PI
CITeR Affiliation Membership: Athena Sciences Corporation (Phase III)	Athena Sciences Corporation	8/1/2024 to 7/31/2029	\$10,000	Co-PI
CITeR Affiliation Membership: FBI Membership (Phase III)	US Department of Justice: FBI	8/1/2024 to 7/31/2029	\$100,000	Co-PI
I/UCRC Phase II: I/UCRC for Identification Technology Research	NSF (and Federal Affiliate Members)	3/15/2017 to 12/31/2025	\$4,356,813	PI
CITeR Affiliation Membership: Athena Sciences Corp. (Phase II)	Athena Sciences Corporation	11/1/2019 to 12/31/2025	\$40,000	PI
CITeR Affiliation Membership: InCadence Membership	InCadence Strategic Solutions Corporation	6/1/2017 to 12/31/2025	\$50,000	PI

CITeR Affiliation Membership: FBI Membership (Phase II)	US Department of Justice: FBI	3/15/2017 to 12/31/2025	\$510,000	PI
CITeR Affiliation Membership: Northrop Grumman Corporation	Northrop Grumman Corporation	6/1/2017 to 12/31/2025	\$170,000	PI
CITeR Affiliation Membership: MorphoTrak	MorphoTrak (Idemia)	6/1/2017 to 12/31/2025	\$40,000	PI
CITeR Affiliation Membership: Stereovision Imaging, Inc.	Stereovision Imaging, Inc.	1/1/2019 to 12/31/2025	\$50,000	PI
Collaborative Research: I/UCRC for Identification Technology (CITeR)	National Science Foundation (and Affiliate Members)	3/15/2011 to 2/28/2018	\$3,363,384	PI
I/UCRC FRP: Collaborative Research: Enabling Biometrics Research in the Cloud: Design and Demonstration	National Science Foundation	8/1/2013 to 7/31/2014	\$65,000	Co-PI

Awards Made by the Center for Identification Technology Research

Description: These are research projects that were selected by the CITeR Industrial Affiliates Board to fund projects for which Valenti was named as PI or co-PI (i.e., I was materially involved in the research).

Research Title	Granting Agency	Dates of Award	Agency Funding	Role
Uniqueness and Permanence of Iris	Center for Identification Technology Research	8/14/2019 to 12/31/2020	\$25,000	Co-PI
Deep Virtual Line-Up Using Soft Biometrics	Center for Identification Technology Research	1/1/2019 to 12/31/2019	\$35,000	PI
Deep Hashing for Secure Multimodal Biometrics	Center for Identification Technology Research	1/1/2018 to 12/31/2018	\$50,000	PI
A Forensic Approach to Iris Analysis	Center for Identification Technology Research	8/16/2015 to 8/15/2016	\$20,000	PI
A Cloud-based Biometric Service Model for Iris and Ocular Recognition Using a Smartphone	Center for Identification Technology Research	1/2/2015 to 1/1/2016	\$29,000	PI
Cloud-Empowered Mobile Biometrics	Center for Identification Technology Research	4/15/2013 to 5/15/2014	\$34,400	PI

Other Research Awards

Description: These are awards made outside of the context of CITeR.

Research Title	Granting Agency	Dates of Award	Agency Funding	Role
2024 DoD Cyber Service Academy	DoD Chief Information Office (CIO)	8/15/2024 to 8/14/2025	\$290,589	PI
2023 DoD Cybersecurity Scholarship Program	US DoD/NSA	9/8/2023 to 12/7/2024	\$120,814	PI
2022 DoD Cybersecurity Scholarship Program	US DoD/NSA	9/7/2022 to 9/7/2024	\$131,568	PI
Strengthening Investigative Tools and Technology	WV DMAPS State Police	10/1/2022 to 9/30/2024	\$138,253	PI
Strengthening Investigative Tools and Technology	WV DMAPS State Police	10/1/2021 to 9/30/2022	\$99,999	PI
Survivable, Secure, and Dependable Wireless Communications	WPL, Inc. (Subcontract of phase II SBIR award from AFRL)	1/1/2018 to 12/31/2019	\$124,650	PI (Sole)
Iris Liveness Detection	MorphoTrak	9/1/2016 to 8/31/2017	\$50,000	PI
Intelligent Camera Networks for the Recognition of Human Activities in Urban Environments	Office of Naval Research	9/3/2009 to 9/2/2013	\$604,505	Co-PI

CRI: CRD: A Web-Accessible Grid-Computing Resource for the Telecommunications Research Community	National Science Foundation	5/01/2008 to 4/30/2013	\$578,351	PI (Sole)
Advanced Communications for Wireless Sensor Networks	US Army Research Laboratory	9/29/2010 to 12/31/2012	\$2,720,000	Co-PI
Radiation Hardened Interceptor Communications, Phase II.	Welkin Sciences, LLC (Subcontract of phase II STTR from MDA)	6/15/2009 to 5/31/2011	\$225,000	PI (Sole)
Initiatives in Computational-Based Discovery	WVU Research Corp. (PSCoR)	1/7/2009 to 12/31/2009	\$28,784	PI
Evolutionary Design of Near-Optimal Space Links	Parabon Computation (NASA subcontract)	2/12/2007 to 2/28/2008	\$59,177	PI (Sole)
Phase II of Development of a Concept for Swarmed mini-UAVs for Automatic Target Recognition	Augusta Systems (Subcontract of phase II STTR from US Navy)	9/1/2005 to 8/31/2007	\$277,498	PI
Retrieval and Reconstruction of Magnetic Data Using Scanning Probe Microscopy	Federal Government (classified agency)	8/31/2004 to 8/30/2007	\$683,168	Co-PI
Multiterminal Relaying Strategies	Welkin Sciences, LLC (Subcontract of phase I STTR award – MDA)	10/1/2007 to 3/28/2007	\$30,000	PI (Sole)
Proximity Based Protocols for Highly Mobile Large Scale Ad Hoc Networks	Augusta Systems (Subcontract of US Navy award)	2/1/2006 to 12/31/2006	\$75,000	PI
Improved Code and Receiver Design for IFICS	Xenotran (Subcontract of phase II SBIR award from MDA)	4/15/2005 to 8/15/2006	\$87,585	PI (Sole)
Efficient & Reusable Framework for Deep Space Mission Communication Applications	NASA	7/1/2005 to 6/30/2006	\$20,000	PI (Sole)
Development of a Concept for Swarmed mini-UAVs for Automatic Target Recognition	Augusta Systems (Subcontract of phase I STTR award from ONR)	7/1/2004 to 9/15/2005	\$42,000	PI
Software Radio Architectures for Deep Space Communications	NASA	7/1/2004 to 6/30/2005	\$20,000	PI (Sole)
Advanced Packet-Based Communications: Turbo Coding, Synchronization, and Automatic Repeat Request	Office of Naval Research	4/1/2000 to 6/30/2004	\$345,000	PI (Sole)
Macrodiversity-Reception for the Wireless LAN Uplink: Feasibility Study and Application to IEEE 802.11a	Cisco Systems (University Research Program via WVU Foundation)	1/1/2003 to 12/31/2003	\$39,900	PI (Sole)
Integrated Computing, Communication and Distributed Control of Deregulated Electric Power Systems	Department of Energy (DOE EPSCoR)	10/1/2000 to 9/30/2003	\$900,000	Co-PI
Development of Modules for VisSim/Comm	Eritek, Inc.	5/15/2001 to 12/31/2001	\$9,216	PI (Sole)
Turbo Space-Time Codes for High Data Rate Wireless Communications	NASA	5/15/2000 to 5/14/2001	\$13,333	PI (Sole)
Turbo Code Consulting	Coleman Research Corporation (now L3)	2/1/2000 to 7/31/2000	\$14,475	PI (Sole)

— PROFESSIONAL SERVICE —

Professional Membership

Fellow, Institute of Electrical and Electronics Engineers (IEEE)

Student Member 1992, Member 1999, Senior Member 2007, Fellow 2018

Member, American Society for Engineering Education (ASEE) – 2015-2016, 2021-2022

Member, Electrical and Computer Engineering Department Head Association (ECEDHA) – 2019-2021

Member, Radio Club of America – 1999-present

Member, Phi Kappa Phi – 1991-present

Member, Eta Kappa Nu – 1990-present

Professional Committees, Councils, and Boards

Member, IEEE Communications Society Fellow Evaluation Committee – 2024-2025

Member, IEEE Communications Society Ad Hoc Committee on Diversity – 2021-2025

Member, IEEE Communication Theory Technical Committee (IEEE Comm. Society) – 2007-present

Chair, 2015-2016

Vice Chair, 2013-2014

Member, IEEE Communications Society Publication Misconduct Review Committee – 2022-2024

Member, IEEE Communications Society Governance Committee – 2019-2021

Member, IEEE Communications Society Conference Council – 2018-2021

Member, IEEE Communications Society Online Content Board – 2018-2021

Member, IEEE Communications Society Technical Committees Board – 2015-2016 and 2018-2021

Journal Editorships and Leadership

Member, Steering Committee, *IEEE Trans. on Wireless Commun.* – 2021-2024 (**Chair** 2023-2024)

Senior Editor, *IEEE Communications Society Best Readings* – 2022-present

Editor-in-Chief, *IEEE Communications Society Best Readings* – 2015-2022

Best Readings is an online repository of curated content. It publishes several issues per year, with each issue devoted to a particular technology. Examples include *Massive MIMO*, *Nanoscale Communication Networks*, *Cloud Communications and Networking*, and *Device-to-Device Communications*.

Member, *ECEDHA Source Editorial Committee* – 2020-2022

Shaped content in *the Source*, the newsletter for ECE department heads.

Member, Executive Editorial Committee, *IEEE Transactions on Wireless Communications*,

Member: 2014-2017. Chair: 2016-2017.

This committee assists the Editor-in-Chief with the screening of submissions, providing early reject decisions and assignment to Area Editors.

Editor, *IEEE Transactions on Communications* – 2013-2017

Associate Editor, *IEEE Wireless Communications Letters* – 2011-2014

Associate Editor, *IEEE Transactions on Wireless Communications* – 2007-2011

Associate Editor, *IEEE Transactions on Vehicular Technology* – 2003-2007

Conference – Steering Committee

IEEE Communications Society's GLOBECOM/ICC Technical Content (GITC) Committee

Chair – 2018-2021

Vice Chair – 2016-2017

Member – 2015-2021

GITC is the (technical) steering committee for GLOBECOM and ICC, the flagship conferences on communication technology sponsored by the IEEE Communications Society.

IEEE Communications Society's GLOBECOM/ICC Management & Strategy (GIMS) Committee

Member – 2018-2021

This is the (non-technical) steering committee for GLOBECOM and ICC, the flagship conferences on communication technology sponsored by the IEEE Communications Society.

IEEE Military Communications Conference (MILCOM) Board

Member (non-voting) – 2014-2020

This is the steering committee for MILCOM, the flagship IEEE/AFCEA conference on military conference.

Conference – Top-Level Leadership

Technical Program Co-Chair, *IEEE Global Communications Conference (GLOBECOM) 2026*, Macao, China, Dec. 2026

Technical Program Chair, *IEEE International Conference on Communications (ICC) 2024*, Denver, Colorado, June 2024

Technical Program Co-Chair, *IEEE International Conference on Communications (ICC) 2021*, Montreal, Canada, June 2021 (due to COVID-19, the conference was held online)

Technical Program Chair, *IEEE Military Communications Conference (MILCOM) 2017*, Baltimore, MD, Oct. 2017

Unclassified Technical Program Chair, *IEEE Military Communications Conference (MILCOM) 2016*, Baltimore, MD, Oct. 2016

Technical Program Vice Chair, *IEEE Military Communications Conference (MILCOM) 2015*, Tampa, FL, Oct. 2015

Technical Program Vice Chair, *IEEE Global Communications Conference (GLOBECOM) 2013*, Atlanta, GA, Dec. 2013

Conference – Other Leadership Roles

Student Travel Grants Co-Chair, *IEEE International Conference on Communications (ICC) 2026*, Glasgow, Scotland, June 2026

Member, Awards Committee, *IEEE Wireless Communications and Networking Conference*, Milan, Italy, March 2025.

Workshops Co-Chair, *IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC) 2023*, Toronto, ON, Sept. 2023

Member, *IEEE MILCOM Technical Achievement Award Committee*, 2021-2023

Awards Chair, *IEEE International Conference on Communications (ICC) 2022*, Seoul, Korea, May 2022

Track Co-Chair, Waveforms and Signal Processing Track, *IEEE Military Communications Conference (MILCOM) 2021*, San Diego, CA, Nov. 2021

Symposium Co-Chair, Communication Theory Symposium, *IEEE International Conference on Communications (ICC) 2019*, Shanghai, China, June 2019

Workshop Co-Chair, *4th International Workshop on 5G Architecture*, *2017 International Conference on Communications (ICC) Workshops*, Paris, France, May 2017

Symposium Co-Chair, Wireless Communications Symposium, IEEE Global Communications Conference (GLOBECOM) 2015, San Diego, CA, Dec. 2015

Track Co-Chair, Waveforms and Signal Processing Track, IEEE Military Communications Conference (MILCOM) 2014, San Diego, CA, Oct. 2014

Track Co-Chair, Waveforms and Signal Processing Track, IEEE Military Communications Conference (MILCOM) 2012, Orlando, FL, Oct./Nov. 2012

Symposium Co-Chair, Communication Theory Symposium, IEEE International Conference on Communications (ICC) 2011, Kyoto, Japan, June 2011

Track Co-Chair, Waveforms and Signal Processing Track, IEEE Military Communications Conference (MILCOM) 2010, San Jose, California, Oct./Nov. 2010

Symposium Co-Chair, Wireless Communications Symposium, IEEE International Conference on Communications (ICC) 2009, Dresden, Germany, May 2009

Track Co-Chair, Transmission Technologies, IEEE Vehicular Technology Conference (VTC) Fall-2007, Baltimore, MD, Oct. 2007

Workshop Co-chair, “Infrastructure and Applications for the Mobile Internet,” IEEE Int. Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE), Cambridge, MA, June 2001

Conference – Program Committee Membership

Member, Technical Program Committee, IEEE Global Telecommunications Conference (GLOBECOM), 2005-2024

Member, Technical Program Committee, IEEE International Conference on Communications (ICC), 2005, 2007-2009, 2012-2025

Member, Technical Program Committee, IEEE Military Communications Conference (MILCOM), 2004, 2005, 2010-2017, 2021-2024

Member, Technical Program Committee, International ITG Conference on Systems, Communications, and Coding (SCC), 2025

Member, Technical Program Committee, IEEE International Conference on Computer Communications (INFOCOM) 2018, Honolulu, HI, Apr. 2018. Distinguished TPC Member

Member, Technical Program Committee, IEEE Wireless Communications & Networking Conference (WCNC), 2006-2010, 2014, 2017, 2018

Member, Technical Program Committee, IEEE Vehicular Technology Conference (VTC), 2012-2014

Member, Technical Program Committee, Wireless Telecommunications Symposium (WTS), 2015

Member, Technical Program Committee, 7th International Symposium on Turbo Codes & Iterative Processing, 2012

Member, Technical Program Committee, European Wireless Conference, 2008

Member of Technical Program Committee, Symposium on Cooperative Networks, IEEE WirelessCom, 2005

Conference – Session Chair or Session Organizer

Session Chair, “ML-2,” International Conference on Computing, Networking, and Communications (ICNC), (Honolulu, HI), Feb. 19, 2025.

Session Chair, “Energy Management Strategies,” IEEE Int. Symp. on Personal, Indoor, & Mobile Radio Commun. (PIMRC), (Bologna, Italy), Sept. 10, 2018.

Session Organizer and Chair, “5G Cellular Networks,” Asilomar Conference on Signals, Systems, and Computers, (Pacific Grove, CA), Nov. 2015.

Session Chair, “Cooperative Communications,” *IEEE Global Communications Conference (GLOBECOM)*, Austin, TX, Dec. 11, 2014.

Session Chair, “Cooperative Communications (session 1),” *IEEE Military Communications Conference (MILCOM)*, (San Diego, CA), Nov. 18, 2013.

Session Chair, “Relay Channels II (session CT-11),” *IEEE International Conference on Communications (ICC)*, (Budapest, Hungary), June 12, 2013.

Session Chair, “Cooperative Networks (session WSP-20),” *IEEE Military Communications Conference (MILCOM)*, (San Jose, CA), Nov. 3, 2010.

Session Chair and Organizer, “Interference and Fading I (session U116),” *IEEE Military Communications Conference (MILCOM)*, (Boston, MA), Oct. 20, 2009.

Session Chair, “CDMA (session WCS-19),” *IEEE International Conference on Communications (ICC)*, (Dresden, Germany), June 16, 2009.

Session Chair, “Topics in Networking (session FA2),” *Conf. on Info. Sci. and Sys. (CISS)*, (Baltimore, MD), Mar. 2007.

Session Chair, “Modulation and Coding (session 4C),” *IEEE Vehicular Tech. Conf. (VTC)*, (Baltimore, MD), Oct. 2, 2007.

Session Chair, “Space-time Communication (session MCS-10),” *IEEE Military Communications Symposium (MILCOM)*, (Orlando, FL), Oct. 31 2007.

Session Organizer, “Coding and Modulation for Noncoherent Channels,” *IEEE Military Communications Symposium (MILCOM)*, (Atlantic City, NJ), Nov. 2005.

Session Chair, “Phy 22: Space Time Codes I,” *IEEE Wireless Communications & Networking Conference (WCNC) 2005*, (New Orleans, LA), Mar. 2005.

Session Chair, “Phy 23: Space Time Codes II,” *IEEE Wireless Communications & Networking Conference (WCNC) 2005*, (New Orleans, LA), Mar. 2005.

Session Organizer, “Advanced Coding Techniques,” *IEEE Military Communications Symposium (MILCOM)*, (Monterey, CA), Nov. 2004.

Session Chair and Organizer, “FEC,” *Asilomar Conference on Signals, Systems, and Computers*, (Pacific Grove, CA), Nov. 2004.

Session Chair: “Performance Analysis 8,” *IEEE Vehicular Tech. Conf. (VTC)*, (Vancouver, BC), Sept. 2002.

Session Chair and Organizer: “High Data Rate Modulation and Coding Techniques,” *IEEE Midwest Symposium on Circuits and Systems (MWSCAS)*, (Tulsa, OK), Aug. 2002.

Reviewer/Panelist: Funding Agencies

National Research Foundation, *Panelist and Reviewer for Enhanced Access to the Radio Spectrum (EARS) Program (2016), BigData Program (2015), CyberSEES Program (2014), Communications Research Program (2002 and 2005), Integrative, Hybrid and Complex Systems (IHCS) Program (2007), Communications and Information Foundations (CIF) Program (2010 and 2012), Accelerating Innovation Research (AIR) Program (2011), Industry & University Cooperative Research Program (I/UCRC) Program (2012, 2016, and 2018), Spectrum Energy Efficiency, and Security (SpecEES) Program (2017), and CISE Community Research Infrastructure (CCRI) (2021)*

Air Force Office of Scientific Research, *Proposal reviewer for Dynamics & Controls Program, 2007*

Army Research Office, *Proposal reviewer for Wireless Communications and Networks program, 2004, 2005, 2008, 2011, 2013, 2014, and 2017*

Tennessee EPSCoR State Committee, *Reviewed Pre-Proposal for DoD EPSCoR Competition, 2004*

Louisiana Board of Regents, *Reviewed proposal for Pilot Funding for New Research Program, 2016*

Reviewer: Publications

Journal Reviewer (IEEE Journals): *IEEE Trans. on Aerospace and Electronic Systems, IEEE Communications Letters, IEEE Journal on Selected Areas of Communications, IEEE Signal Processing Letters, IEEE Trans. on Broadcasting, IEEE Trans. on Circuits and Systems, IEEE Trans. on Communications, IEEE Trans. on Education, IEEE Trans. on Information Theory, IEEE Trans. on Networking, IEEE Trans. on Mobile Computing, IEEE Trans. on Signal Processing, IEEE Trans. on Vehicular Tech., IEEE Trans. on Wireless Communications, IEEE Vehicular Technology Magazine, IEEE Wireless Communications Magazine, IEEE Trans. on Reliability.*

Journal Reviewer (non-IEEE): *ACM Mobile Communications Review, Arabian Journal of Science and Engineering, Applied Mathematics E-Notes, EURASIP Journal on Applied Signal Processing, IASTED International Journal of Computers and Applications (IASTED), IEE Electronics Letters, IEE Communications, Wireless Communications & Mobile Computing (Wiley)*

Conference Reviewer: *IEEE Global Communications Conference (GLOBECOM), IEEE Int. Conf. on Communications (ICC), IEEE Int. Symp. on Information Theory (ISIT), IEEE Int. Symp. on Information Theory and its Applications (ISITA), IEEE Int. Symp. on Personal, Indoor and Mobile Radio Communications (PIMRC), IEEE Int. Symp. on Spread Spectrum Techniques and Applications (ISSSTA), IEEE Int. Symp. on Wireless Communication Systems (ISWCS), IEEE Int. Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP), IEEE Int. Workshop on Signal Processing Advances in Wireless Communications (SPAWC), IEEE Military Communications Conf. (MILCOM), IEEE Vehicular Tech. Conf. (VTC), IEEE Wireless Commun. & Networking Conf. (WCNC), Int. Conf. on Commun. Systems (ICCS), Int. Symp. on Turbo Codes & Iterative Processing, Int. Symp. on Modeling & Optimization in Mobile, Ad Hoc, and Wireless Network.*

Book and Book Proposal Reviewer: *Cambridge University Press, Springer, Wiley & Sons, and Kluwer*

— INSTITUTIONAL SERVICE —

Service to the University

Member, WVU Board of Governors – 2017-2019

Member, WVU Faculty Senate – 2006-2009; 2012-2019; 2022-2025

Secretary – 2018-2019

Chair – 2017-2018

Chair-elect – 2016-2017; 2025-2026

Member, WVU Faculty Senate Executive Committee – 2015-2019; 2025-2027

Chair – 2017-2018

Member, Faculty Senate Curriculum Committee – 2012-2017, 2024-2025

Chair – 2015-2017

Chair-elect – 2014-2015

Member, Faculty Senate Student Recruitment and Retention Committee – 2023-2025

Member, Faculty Senate Service Committee – 2022-2025

Member, Faculty Senate Committee on Committees – 2016-2019

Member, Faculty Senate Faculty Welfare Committee – 2016-2018

Member, Faculty Senate General Education Committee – 2016-2017

Member, Presidential Search Committee – 2014

Member, Faculty Senate Library Committee – 2005-2008

Chair – 2007-2008

Member, WVU Graduate Mentoring Awards Committee, 2022

Member, WVU Educational Responsibility Roundtable – 2012-2014

Roundtable charged with developing a plan for meeting Goal 1 of WVU's Strategic Plan: "Engage undergraduate, graduate, and professional students in a challenging academic environment" and resulting in the development of the General Education Foundations (GEF)

Member, Heebink Award Selection Committee – 2014-2016

Award for distinguished service to the state of West Virginia

Member, Committee to Conduct 5-year Review of the Dean of Libraries – 2008-2009

Member, Wireless Task Force – 2001-2002

Charged to study the impact and implementation of a campus-wide wireless network

Associate Member, Mountain Honorary – 2004-present

Faculty Advisor, WVU Amateur Radio Club – 1999-present

Service to the College

Member, Committee to Conduct 5-year Review of the Dean of the Statler College of Engineering – 2025

Member, Statler College Research Council – 2021-2023

Member, Statler Promotion and Tenure Committee – 2015-2019 and 2021-2024

Chair – 2017-2018 and 2022-2023

Member, Undergraduate Academic Affairs Committee, Statler College – 2010-2019

Chair – 2011-2014

Member, ABET Leadership Team, Statler College of Eng. & Mineral Res. – 2012-2015; 2018-2021

Committee charged with preparing for 2015 and 2021 ABET visits.

Member, Freshman Engineering Faculty Promotion Committee – 2013

Member, Outstanding Advisor Selection Committee, College of Eng. & Mineral Res. – 2010 and 2012

Member, Library Committee, College of Engineering and Mineral Resources – 2004-2008

Chair – 2006-2007

Member, Teaching Award Committee, College of Engineering and Mineral Resources – 2008 and 2022

Service to the Department

PoC, National Center of Academic Excellence in Cybersecurity (NCAE-C) – 2023-present

Faculty Advisor, WVU chapter of Eta Kappa Nu (HKN), the EE honor society – 2002-2017

Member, CSEE Faculty Evaluation Committee – 2000-02, 2005-07, 2010-12, 2013-15, and 2024-25

Chair – 2014-2015 and 2024-2025

Member, CSEE Faculty Search Committee – 2001-2002, 2002-2003, and 2014-2015

Chair – 2014-2015

Member, EE Curriculum Committee – 1999-2023

Chair – 2010-2019

Member, CSEE Graduate Affairs Committee – 2010-2015

Chair, EE Graduate Curriculum Committee – 2007-2010

Member, CSEE Computer Systems Committee – 2004-2015

Chair – 2004-2006

Chair, Lane Fellowship Committee – 2000-2003

STUDENTS ADVISED

Completed Ph.D. Students (Doctoral Committee Chair)

1. **Shi Cheng**, *Coded Continuous-phase FSK: Information Theoretic Limits and Receiver Design*, Nov. 12, 2007.
2. **Mohammad Fanaei**, *Distributed Detection and Estimation in Wireless Sensor Networks*, July 22, 2016.
3. **Terry Ferrett**, *Receiver Design for Physical-Layer Network Coding in the Two-Way Relay Channel*, July 21, 2017.
4. **Enass Hriba**, *Analysis of Millimeter-Wave Networks: Blockage, Antenna Directivity, Macrodiversity, and Interference*, Oct. 14, 2021.
5. **Rohit Iyer Seshadri**, *Capacity-Based Parameter Optimization of Bandwidth Constrained CPM*, Aug. 31, 2007.
6. **Jian Sun**, *Synchronization for Capacity-Approaching Coded Systems*, Oct. 25, 2004.
7. **Salvatore Talarico**, *Role of Interference and Computational Complexity in Modern Wireless Networks: Analysis, Optimization and Design*, Sept. 10, 2015.
8. **Veeru Talreja**, *Integration of Deep Hashing and Channel Coding for Biometric Security and Biometric Retrieval*, July 16, 2021.
9. **Xingyu Xiang**, *Optimization of a Coded-Modulation System with Shaped Constellation*, Apr. 12, 2013.
10. **Bin Zhao**, *Multiterminal Relay Networks: Performance Bounds, Protocol Design, and Channel Coding Strategies*, Apr. 19, 2004.

Completed M.S. Students (Thesis or Problem Report – Committee Chair)

1. **Syed Amaar Ahmad**, *A Robust Hybrid-ARQ Protocol for Relay Networks*, Apr. 4, 2007.
2. **Naga Gopi Krishna Alapati**, *Green Cellular Networks: When Should a Base Station Be Turned Off?*, Dec. 2, 2015.
3. **Raneem Alghawi**, *Network Slicing in 5G: Admission, Scheduling, and Security*, July 20, 2022.
4. **Shaikha Alkandari**, *Air-Assisted Communications Using Line-of-Sight Links*, July 20, 2022.
5. **Maryam Amini**, *Enhancing 5G Fixed Wireless Access in Rural Settings via Machine Learning-Driven Resource Optimization*, Apr. 15, 2024.
6. **Deepthi Ancha**, *Implementation of Tail-Biting Convolutional Codes*, Nov. 7, 2008.
7. **Rahul Annareddy**, *Incentive Analysis of Blockchain Technology*, Nov. 18, 2022.
8. **Geetanjalee Athavale**, *Enabling Wireless Data Applications on Mobile Devices*, Oct. 28, 2002.
9. **Dirk Baker**, *Space-Time Block Coding with Imperfect Channel Estimates*, Apr. 10, 2001.
10. **Sri Lakshmi Balineni**, *Stochastic Geometry Analysis of a Class of Cooperative Relaying Protocols*, Apr. 18, 2017.
11. **Anupama Battula**, *Implementation of Extrinsic Information Transfer Charts*, Oct. 24, 2008.
12. **Aruna Sri Bommagani**, *Distributed Monte Carlo Simulation*, Nov. 3, 2011.
13. **David Buckingham**, *Information Outage Analysis of Finite-Length Codes*, Apr. 7, 2008.
14. **Anthony Carrola**, *Synthesizing Realistic Substitute Data for a Law Enforcement Database Using a Python Library*, April 15, 2022.

15. **Naveen Chandran**, *Hybrid ARQ with Parallel and Serial Concatenated Convolutional Codes for Next Generation Wireless Communications*, June 19, 2001.
16. **Sheetu Dasari**, *Implementation & Analysis of a Hybrid-ARQ Based Cooperative Diversity Protocol Using Reed-Solomon Codes*, Nov. 14, 2005.
17. **John Deal**, *Fractal Analysis of Fingerprints*, Nov. 12, 2007.
18. **Raghu Doppalapudi**, *Optimization of Bit Interleaved Coded Modulation Using Genetic Algorithms*, Oct. 20, 2008.
19. **Terry Ferrett**, *Data Recovery from Magnetic Media Using Magnetic Force Microscopy*, Apr. 25, 2008.
20. **Ramesh Gali**, *A Tool for the Statistical Analysis and Post-Processing of Distributed Sensor Network Data*, Mar. 31, 2003.
21. **Anusha Gangadi**, *Object-Oriented Implementation of LTE Turbo Codes*, Nov. 5, 2010.
22. **Timothy Gerkin**, *Implementation of LDPC Codes Using the IEEE 802.16e Standard*, Apr. 9, 2008.
23. **Tarik Ghanim**, *Analysis of Hybrid-ARQ Based Relaying Protocols under Modulation Constraints*, Apr. 26, 2006.
24. **Ruthika Gunda**, *Simulation of the Physical Link Layer of GSM*, July 8, 2004.
25. **Ramana Inturi**, *Implementing Test Automation with Selenium WebDriver*, Oct. 16, 2023.
26. **Sai Deepthi Katragunta**, *Simulation of the Performance of IEEE 802.16-2004 Fixed Broadband Wireless Access Technology*, Jan. 17, 2007.
27. **Raja Katuri**, *Efficient Simulation of Communication Systems on a Desktop Grid*, Aug. 25, 2006.
28. **Haranath Madineni**, *A Diagnostic Tool for Performance Assessment of Bluetooth Data Transmissions*, Dec. 4, 2003.
29. **Sushma Mamidipaka**, *Implementation of Block Turbo Codes from IEEE 802.16 Standard*, Oct. 27, 2008.
30. **Gopal Manchikanti**, *A Framework for Developing Wireless Applications*, May 1, 2001.
31. **Mamatha Mannava**, *Simulation of the Performance of IEEE 802.16-2004 Wireless MAN-OFDM PHY Layer*, Apr. 11, 2008.
32. **Sundara Ram Matta**, *Visualizing Outage Performance in Wireless Networks in the Presence of Rayleigh Fading*, Dec. 4, 2015.
33. **Brianna Maze**, *Analysis of Hamming and Bernard's Patent and the Bluetooth Standard*, Apr. 25, 2016.
34. **John Mazzie**, *Relay Communications Over Frequency-Selective Fading Channels*, Apr. 11, 2008.
35. **Lokesh Merupula**, *Simulation of IEEE 802.11a PHY Layer*, Sept. 9, 2004.
36. **Biju Naduvathuparambil**, *Telecommunications for a Deregulated Power Industry*, July 12, 2002.
37. **Chandana Nannapaneni**, *Constellation Shaping for Communication Channels with Quantized Outputs*, Nov. 11, 2010.
38. **Nisha Narasimhan**, *Data Synchronization for Bluetooth Networks*, Dec. 4, 2003.
39. **Senthil Ramamurthy**, *Multiple Quantum Filtered Localized Spectroscopy at 3T*, Apr. 14, 2004.
40. **Vasavi Rangammagari**, *Optical-Based ATR Algorithms for Applications in Swarmed UAVs*, Aug. 4, 2006.
41. **Guillaume Raux**, *Telecommunication of Stabilizing Signals in Power Systems*, Apr. 18, 2003.
42. **Sumit Sharma**, *Optimization of an iDEN Cellular Network*, Feb. 18, 2005.

43. **Yipeng Tang**, *DSP Implementation of Trellis Coded Modulation and Distributed Space Time Coding*, Jan. 25, 2001.
44. **Sujay Telang**, *Wireless Streaming Multimedia Applications*, Oct. 2, 2000.
45. **Srinivas Vemury**, *Comparison of Decoding Algorithms for LDPC Codes*, April 16, 2004.
46. **Kyle Whetzel**, *Complexity Aware C-RAN Scheduling for LDPC Codes over BEC*, Dec. 21, 2016.

External Dissertation Examiner

Served as an external examiner or committee member for the following Ph.D. students:

1. **J.P.K. Chu**, University of Toronto (Canada), *Design and Analysis of Coded Cooperation in Relay Networks*, Oct. 30, 2009.
2. **Mark Flanagan**, University College, Dublin (Ireland), *Combined Equalization and Coding for Dispersive Communication Channels*, Apr. 4, 2005.
3. **Jing Guo**, Australian National University (Australia), *Stochastic Geometry for Modeling, Analysis and Design of Future Wireless Networks*, May 4, 2016.
4. **Nadhiya Mohd Kamal**, University of Auckland (New Zealand), *Throughput Performance of Wireless Networks*, June 12, 2018.
5. **Saeed Khosravirad**, McGill University (Canada), *Performance Limits for Incremental Redundancy Hybrid Automatic Repeat Request (HARQ) over Fading Channel*, Mar. 23, 2015.
6. **Yicheng Lin**, University of Toronto (Canada), *Performance Analysis and Optimization of Wireless Heterogeneous Networks*, Nov. 12, 2014.
7. **L. Pujji**, University of Auckland (New Zealand), *Optimisation of Base Station Placement for Indoor Wireless Communications*, Dec. 2011.
8. **Nourhan Hesham Soliman**, University of British Columbia (Canada), *Performance Analysis of Large Scale Networks in the Finite Blocklength Regime*, June 25, 2024.
9. **Tiaza Thasthakeer**, University of Auckland (New Zealand), *Stochastic Geometry Approach on Modelling Finite Millimetre Wave Outdoor Cellular Networks*, July 19, 2021.
10. **Kiran Venugopal**, University of Texas (Austin, TX), *Millimeter Wave Wearable Communication Networks*, May 11, 2017.
11. **J.K.L. Wong**, University of Auckland (New Zealand), *Automatic Planning and Optimization of In-Building CDMA Systems*, Oct. 2006.

Undergraduate Students

Faculty advisor for 15 completed senior design projects.

Supervised and supported undergrad researchers during summers of 2002, 2003, 2006, 2010, and 2013, including through the WVU Summer Undergraduate Research Experience (SURE) program.

Until 2018, was academic advisor to approximately 25 EE, CPE, and dual (CPE/EE and CPE/BIOM) majors per semester, including honors students (after that, advising became a College-level function).

INSTRUCTION

Course Development

Developed the following courses (Submitted new course proposals and shepherded through approval by the WVU Faculty Senate – permanent course numbers indicated):

Engineering Professionalism Seminar // Engineering for Societal Impact (CSEE 380)

Wireless Networking (CPE 462)

Wireless Communication Systems (EE 562)

Coding Theory (EE 567)

Undergraduate Courses Taught

Course Number	Title	Semester	Number of Students
BIOM 426	Biometric Systems	Fall 2021	11 (team taught – 10%)
		Fall 2020	11 (team taught – 10%)
CSEE 380	Engineering for Societal Impact	Spring 2025	120
		Fall 2024	94
	Engineering Professionalism Seminar	Spring 2024	86
		Fall 2023	55
		Spring 2023	80
		Fall 2022	74
		Spring 2022	121
		Fall 2021	58
		Spring 2021	83
EE 329	Signals & Systems II	Spring 2005	43
		Spring 2004	63
		Spring 2002	38
EE 461	Introduction to Communication Systems	Fall 2002	44
		Fall 2001	36
		Fall 2000	14
		Fall 1999	16
EE 463	Digital Signal Processing Fundamentals	Spring 2025	14
		Spring 2010	25
		Spring 2009	34
		Spring 2008	35
		Spring 2007	44
		Spring 2006	36
CPE 462	Wireless Networking	Fall 2024	31
		Fall 2023	21
		Fall 2022	15
		Fall 2021	11
		Fall 2020	12
		Fall 2019	14
		Fall 2018	14
		Fall 2017	6
		Fall 2016	13
		Fall 2015	10
		Fall 2013	24
		Fall 2012	30
		Fall 2010	15
		Fall 2008	22
		Fall 2005	30
		Fall 2004	43
		Fall 2003	34
		Spring 2003	4

Graduate Courses Taught

Course Number	Title	Semester	Number of Students
EE 513	Stochastic Systems Theory	Fall 2014	33
		Fall 2011	27
		Fall 2009	35
		Fall 2006	63
		Fall 2004	51
		Fall 2002	39
		Fall 2001	27
EE 561	Communication Theory	Spring 2024	4
		Spring 2022	6
		Spring 2019	4
		Spring 2017	11
		Spring 2015	24
		Spring 2013	18
		Spring 2011	25
		Spring 2009	27
		Spring 2007	38
		Spring 2003	27
		Spring 2001	14
		Spring 2000	9
EE 562	Wireless Communication Systems	Fall 2007	8
		Fall 2000	14
EE 567	Coding Theory	Spring 2023	6
		Spring 2018	4
		Spring 2016	19
		Spring 2014	28
		Spring 2012	16
		Spring 2010	29
		Spring 2008	24
		Spring 2006	19
CS/EE/CPE 796	Graduate Seminar (1 credit hour)	Spring 2004	27
		Fall 2016	44
		Spring 2016	37
		Fall 2015	65
		Spring 2015	43
		Fall 2014	59
		Spring 2014	56
		Fall 2013	60
		Spring 2013	58
		Fall 2012	73
		Spring 2012	51
		Fall 2011	65
		Spring 2011	45
		Fall 2010	46
		Spring 2010	39
		Fall 2009	64
		Spring 2009	48
		Fall 2008	57
		Spring 2008	38
		Fall 2007	40
		Spring 2007	66
		Fall 2006	67
		Spring 2006	52
		Fall 2005	50
		Spring 2004	86
		Fall 2003	50
		Spring 2003	80

Course Materials and Workbooks

- M.C. Valenti, The Wireless Networking Workbook, 2013; revised 2018.
A 33-page companion for CPE 462 (Wireless Networking) initially used Fall 2013.
- M.C. Valenti, The Coding Theory Workbook, 2012; revised 2016.
A 56-page companion for EE 567 (Coding Theory) initially used during the Spring 2012.
- M.C. Valenti, The DSP Workbook, 2011; revised 2025.
A 113-page companion text for EE 463 used by Prof. Brian Woerner during the Spring 2011 semester and Prof. Reynolds during the Spring 2012 and 2013 semesters. An “instructor edition” was also created, which contains worked out exercises (which are blank in the student edition).
- M.C. Valenti, Solutions Manual for the DSP Workbook, 2011; revised 2025.
A 63-page solutions manual for the end-of-chapter exercises.
- M.C. Valenti, The Signals and Systems Workbook, 2002, revised 2005.
A 75-page companion text for EE 329 developed during the Spring 2002 semester and used since then by other faculty at WVU and by Prof. Anderson at the United States Naval Academy
- M.C. Valenti, Solutions Manual for the Signals and Systems Workbook, 2002, revised 2005.
A 75-page solutions manual for the end-of-chapter exercises.

Independent Study

Led undergraduate and graduate students in the following asynchronous learning experiences:

DSP Implementation of Communication Systems

Wireless Application Protocol

Wireless Networking

Wireless Communication Systems