

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Patent of: Woojin Ahn, et al. Attorney Docket No. 39843-0203IP1  
U.S. Patent No.: 11,664,926  
Issue Date: May 30, 2023  
Appl. Serial No.: 17/157,978  
Filing Date: January 25, 2021  
Title: AGGREGATED-MPDU, METHOD FOR TRANSMITTING  
RESPONSE FRAME THERETO, 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: 6/19/25

By: Mark P. Mahon  
Mark P. Mahon

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## **I. ASSIGNMENT**

1. I have been retained on behalf of Samsung Electronics Co., Ltd. (“Samsung”) to offer technical opinions related to 11,664,926 (“the ‘926 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 ‘926 patent.

2. I have been asked to provide my independent analysis of the ‘926 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 ‘926 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 ‘926 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 am a Teaching Professor in the School of Electrical Engineering and Computer Science at Pennsylvania State University, University Park, PA (“Penn State” or “PSU”). I have worked on telecommunications and wireless networks, including Z-Wave, Bluetooth, Zigbee, Wi-Fi, NFC, AMPS, IS-95, CDMA2000, GSM, EDGE, UMTS/WCDMA, LTE, and 5G cellular systems since 1988.

7. I received my B.S. in Electronics Engineering from the University of Scranton in 1987. I received my M.S. in Electrical Engineering and Ph.D. in Acoustics from Penn State in 1991 and 2001, respectively.

8. In 1988, after I received my bachelor’s degree, I joined the Central Intelligence Agency (CIA) while pursuing my M.S. degree at Penn State part-time. My first job at the CIA involved designing and testing systems to automatically capture and characterize telecommunication signals and emissions from various wireless and computer networking devices.

9. I returned to Penn State in early 1990 to pursue graduate research full-time and complete my M.S. degree. My graduate research work focused on wideband beamforming and adaptive signal processing. After completing my M.S. degree in EE in 1991, I accepted a full-time faculty research position at the Applied Research Lab at PSU, primarily working on classified programs, and began working on diverse radio frequency and acoustic sensor systems including

wireless communications and small wireless networks for acoustic tracking, source localization, and feature extraction.

10. I began pursuing my Ph.D. part-time in 1993 while continuing my faculty research position. In 1997, as part of my faculty research position, I began working on classified programs focused on mathematical analytical modeling of cellular communication networks and the development of hardware and software systems to test against cellular networks. My role was to develop the algorithms and write the code running on a specially developed embedded system. For this work, I received a letter of recognition as the “genius behind the VELA software algorithms” from the Director of National Reconnaissance Office (NRO) Systems Engineering and Technology Office. As part of this same work, I was extensively involved in protocol and signaling analysis as well as researching model-specific performance and unique functional characteristics associated with individual mobile devices. The work involved testing dozens of handsets from many manufacturers in controlled and real-world environments against network simulators and live operational networks for each research project.

11. In 2000, my research extended into utilizing non-orthogonal wavelets for improving detection and localization of cellular handsets from high altitude sensor systems. In 2001, I completed my Ph.D. and my research focused on the utilization of advanced communication signals for wideband characterization and

remote sensing of propagation channels.

12. Beginning in 1997, my cellular communications research work focused on CDMA, GSM, EDGE, UMTS, LTE, and 5G cellular systems primarily under grants sponsored principally by the Department of Defense. This classified research work required 3GPP protocol analysis and development of real-time embedded hardware and software systems capable of interacting with cellular networks and cellular handsets. A large portion of my work was directed at architectures, protocols, software, and signaling.

13. I have been working on classified projects since 1988. Before 1998, because the work was not deemed highly classified, I was able to publish eight journal and conference papers prior to 2000. Between 1999 and 2015, however, I was allowed to publish only one article in an unclassified symposium and published and presented about a dozen articles in classified settings. This is because during this period, the vast majority of my research was highly classified. As a result, nearly all of my research results were summarized in classified reports and not available to the general public. Further, because the U.S. government owns any intellectual property resulting from the sponsored research work, I did not pursue or file patent applications.

14. Beginning in 2003, I was co-principal investigator and technical lead on a 3 year multi-million-dollar research effort for developing the Global

Information Grid (GIG). This project was sponsored by the Secretary of Defense's Office with a goal of developing a real-time, multi-intelligence (multi-Int) network for collecting, processing, storing, disseminating, and managing information on demand for decision makers including the warfighter, combatant command centers, policy makers, and support personnel and was the largest network-centric warfare project in development at the time. My research team (Ubiquitous Automated Information Manager) focused on building and deploying a scalable application to perform real-time, multi-int data fusion to support every user in the system. This software application was deployed in Combat Operation Centers, Joint Interagency Task Force locations, and on various platforms (mobile and small computing environments) used by various warfighters. The fused data sources included various content management systems, supply chain logistic reports, GPS-based reports, new feeds, backend databases, sensor system reports, and various other broad data sources.

15. Beginning in 1994, I worked on various projects that involved the implementation and design of user interfaces to support the use of the research, design, analysis tools and signal processing systems for the end user. The user platforms included a broad array of footprints including, small handheld devices with screens or visual displays and those limited to audio-only inputs, medium sized laptops and small desktop systems, and also large, heavy devices, such as

servers and clusters in operational environments (including combat operations centers and 3D immersive environments).

16. Specifically, for the GIG research effort, I led a team of software engineers to deploy our inferencing tool for a disparate range of end users, from dismounted combat soldiers with only a microphone as an interface to soldiers in mules with smart devices (tablets and laptops with multiple visual display interaction capabilities) to field command centers (medium sized clients with significant video displays and processing power with touch and stylus interfaces to the ) to combat operation centers with high-powered processing and complex user-interface capabilities/modalities.

17. In 2015, I transferred to the School of Electrical Engineering and Computer Science at Penn State as a teaching faculty member. In that role, I have continued teaching graduate and undergraduate courses, guiding Ph.D. and M.S. students in communication and mobile networking (including LTE and 5G cellular networks), and pursuing research in this and related areas. Since 2015, I have been an author on nine refereed papers as listed in my curriculum vitae (CV).

18. Because of my decades of research and my continuing work at Penn State, I have intimate knowledge of telecommunication networks, including the technology involved in the patents in this case. I have been highly recognized as an expert in such systems within the research community. I was recognized twice by

the National Reconnaissance Office with commendation letters for work dealing with detecting cellular signals in low signal to noise ratio environments. The U.S. government awarded me over \$12M in grants between 2003 and 2015 for projects focused on mobile communication devices and networks, in which I served as a Principal Investigator (PI), Co- PI, and/or technical lead.

19. Additionally, during my research career, I interacted extensively with computer scientists and engineers responsible for the design, development, and testing of telephony and data networking systems and testbeds. As a research faculty member, I oversaw engineers and computer scientists that executed many joint projects with development organizations. These interactions exposed me to a wide range of computer scientists and engineers working on telecommunication network technologies. Since 2011, I have been teaching undergraduate and graduate classes in communication and mobile networking and am familiar with the curricula being taught to electrical engineers and computer scientists. The interactions with a wide range of computer scientists and engineers working on telecommunication network technologies and the familiarity with the classes taught to electrical engineers and computer scientists have allowed me to have a good understanding of the level of skills possessed by a person of ordinary skill in the field of cellular technology.

20. I have extensive experience with mobile networks in general and LTE

and 5G specifically. While most of my research efforts between 1998 and 2015 were highly classified, I can state that they included detailed investigation of network architectures, signaling, and functional behavior. A typical research effort would involve studying 3GPP, 3GPP2, IEEE, and other protocol standards to fully comprehend all aspects of L1, L2, and L3 requirements including timing, bit-level construction of the control and user plane messages, and timing characteristics for a given standard as well as functional behavior of network components and user equipment.

21. From 2006 through 2015, my research focused specifically on LTE. My research continues to this day, although I am no longer operating in a classified environment. During this time, I investigated the performance and functional differences of many varied network and handset devices to see how differing signaling and hardware configurations (including MIMO) and environmental factors influenced the behavior of user equipment in a given network environment. This included how diversity techniques (transmit and receive), synchronization, timing, and signal to interference plus noise ratio (SINR) for a given device would affect specific functional aspects including elements of the receiver structure, decoding and demodulation performance, calculation of parameters used by the device for making decisions and deriving parameters reported to the network.

22. As part of my research work, I built several custom CDMA, GSM,

UMTS, and LTE platforms that implemented specific network-side and user equipment-side functionality including custom signal generation and processing structures, particularly the signal processing chains on both the transmit and receive sides. This equipment was developed using network simulation hardware in a laboratory environment and was later tested with corresponding networks in both controlled and fully operational environments. Implementing the transmit and receive chains for custom built protocol-enabled equipment required me to gain an intimate understanding of the relevant 3GPP protocol specifications and the underlying structures. Since 2015, I have been primarily focused on guiding graduate students pursuing research including using code domain non-orthogonal multiple access (NOMA) combined with MIMO sparse coding multiple access to minimize latency and maximize user density in grant free Internet of Things (IoT) environments. Additionally, I am guiding my graduate students in pursuing research in optimized distributed processing algorithms, implementation of block chain coding techniques to improve handover security, and edge computing resource allocation in 4G (LTE)/5G (NR) networks.

23. Much of the classified research work I performed also led to similar approaches for other wireless protocols including IEEE 802.11 and 802.15 (e.g., Zigbee, Bluetooth, and UWB), HART, and other short-range standards as well as HF radio and Wi-MAX.

24. My curriculum vitae, included as an appendix to this declaration, includes a list of publications on which I am a named author. It contains further details regarding my experience, education, publications, and other qualifications to render an expert opinion in connection with this proceeding.

25. In writing this Declaration, I have considered the following: my own knowledge and experience, including my work experience in the fields of wireless communication networks, research and development of wireless signaling, protocols, transmission, and detection techniques, design and construction of wireless test equipment, prototypes, engineering models, and related areas; 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:

26. I have reviewed the '926 patent (SAMSUNG-1001), and relevant excerpts of the prosecution history (SAMSUNG-1002) of the '926 patent.

27. Among various textbooks, documents, and publications, I have also reviewed the following prior art references:

- SAMSUNG-1001 U.S. Patent No. 11,664,926 (“the '926 Patent”)
- SAMSUNG-1002 Excerpts from Prosecution History of the '926 Patent (“the Prosecution History”)
- SAMSUNG-1004 U.S. Patent Pub. No. 2017/0111951 (“Chu”)
- SAMSUNG-1005 IEEE P802.11ax/D1.0, “Draft Standard for

Information technology - Telecommunications and information exchange between systems Local and metropolitan area networks – Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Enhancements for High Efficiency WLAN,” 802.11 Working Group of the LAN/MAN Standards Committee of the IEEE Computer Society (December 1, 2016) (“IEEE-D1”)

- SAMSUNG-1006 Liwen Chu, IEEE 802.11-16/1185r2 “IEEE P802.11 Wireless LANs 5.10.3 A-MPDU comment resolution,” IEEE Standards Ass’n (September 14, 2016) (“IEEE-D2”)
- SAMSUNG-1008 M. Shahwaiz Afaqui et al., “IEEE 802.11ax: Challenges and requirements for future high efficiency Wi-Fi,” (December 20, 2016)(“Afaqui”)
- SAMSUNG-1009 IEEE St 802.11 - 2016, “IEEE Standard for Information technology - Telecommunications and information exchange between systems Local and metropolitan area networks – Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications,” IEEE Computer Society (December 14, 2016) (“IEEE-D3”)
- SAMSUNG-1010 Boris Bellalta, “IEEE 802.11ax: High-Efficiency WLANs,” IEEE Wireless Communications (December, 2015) (“Bellalta”)
- SAMSUNG-1012 Liwen Chu, IEEE 802.11-16/1186r0 “HE Variant HT Control – A-MPDU Content,” IEEE Standards Ass’n (September 12, 2016) (“IEEE-D4”)
- SAMSUNG-1013 Robert Stacey et al., IEEE 802.11-16/0024r1 “Proposed TGax draft specification,” IEEE Standards Ass’n (March 2, 2016) (“IEEE-D5”)
- SAMSUNG-1015 IEEE St 802.11 - 2012, “IEEE Standard for Information technology - Telecommunications and information exchange between systems Local and metropolitan area networks – Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications,” IEEE Computer Society (March 29, 2012) (“IEEE-D6”)

- SAMSUNG-1016 U.S. Patent Pub. No. 2015/0139214 (“Noh”)
- SAMSUNG-1017 U.S. Patent Pub. No. 2012/0230448 (“Kang”)
- SAMSUNG-1018 IEEE P802.11ax/D0.5, “Draft Standard for Information technology - Telecommunications and information exchange between systems Local and metropolitan area networks – Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Enhancements for High Efficiency WLAN(#1121),” 802.11 Working Group of the LAN/MAN Standards Committee of the IEEE Computer Society (September 2016) (“IEEE-D7”)
- SAMSUNG-1020 IEEE St 802.11ac - 2013, “IEEE Standard for Information technology - Telecommunications and information exchange between systems Local and metropolitan area networks – Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications,” IEEE Computer Society (December 18, 2013) (“IEEE-D8”)
- SAMSUNG-1021 Liwen Chu et al., IEEE 802.11-16/0069r0 “Multi-TID A-MPDU in MU Transmission,” IEEE Standards Ass’n (January 18, 2016) (“IEEE-D9”)

28. 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 ’926 patent at the time of the earliest possible priority date of the ’926 patent, and I have done so during my review of these materials. I have been informed by Counsel that the ’926 Patent claims the benefit of priority to an application filed December 21, 2016 (“the Critical Date”). Counsel has informed me that the Critical Date represents the earliest possible priority date to which the challenged claims of the ’926 Patent are entitled, and I have therefore used that Critical Date

in my analysis below.

29. 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.

30. My opinions, as explained below, are based on my education, experience, and expertise in the fields relating to the '926 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 '926 Patent and the prior art discussed below.

### **III. OVERVIEW OF CONCLUSIONS FORMED**

31. 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 1A Claims 1-14 are obvious over Chu and IEEE-D1
- Ground 1B Claims 1-14 are obvious over Chu and IEEE-D2
- Ground 2 Claims 1 and 8 are obvious over IEEE-D3

32. In support of these conclusions, I provide a detailed analysis of the references in Sections IX and X, which reflect my analysis regarding the obviousness of claims 1-14 (“the Challenged Claims”) of the ‘926 patent, and the final conclusion set forth in Section XI.

#### **IV. LEVEL OF ORDINARY SKILL IN THE ART**

33. For purposes of this IPR, a person of ordinary skill in the art (“POSITA”) would have had a Bachelor’s degree in electrical engineering, computer engineering, computer science, or a related field, and 3 years of experience in the research, design or development of wireless communication devices, systems, and/or networks, or the equivalent, as of the Critical Date. Increased educational experience can make up for less work experience, and vice versa.

34. Further, all positions in this declaration are from the vantage point of a POSITA as of the Critical Date.

35. 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.

## **V. LEGAL STANDARDS**

### **A. Terminology**

36. 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 '926 patent was filed January 25, 2021, and claims priority to Korean Patent Application No. 10-2016-0175999 filed December 21, 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 '926 patent as the point in time for claim interpretation purposes. My opinion does not change if the invention date is earlier.

### **B. Legal Standards**

37. 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.

38. 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**

39. 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.

40. 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.

41. 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**

42. 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.

43. 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.

44. 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.

45. 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 be 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."

46. 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.

47. 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.

48. 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.

49. 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.

50. 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.

51. 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.

52. 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.

53. 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**

54. 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. By the Critical Date, I possessed over 20 years of experience working with research and industry partners as part of wireless research and development work, executing as a principal investigator and technical lead, guiding teams of hardware and software engineers, teaching undergrad and graduate courses in wireless communications, mobile networks, wireless security, and computer networks, as well as guiding research of graduate and undergraduate students in these areas. I have participated in dozens of classified and unclassified conferences and meetings as well as being an engaged member of IEEE over the decades.

55. 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 '926 patent and related disciplines; and my experience in working with others involved in this field and related disciplines.

56. In addition, I have analyzed the publications and materials listed

above.

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

## **VII. TECHNOLOGY OVERVIEW**

58. In this section I provide an overview of the relevant technology and state of the technical community before the Critical Date. This description is not intended to be exhaustive, but to provide sufficient background to support and contextualize my analysis below.

59. Wireless local area networks (WLANs) governed by the IEEE 802.11 family of standards have evolved to improve throughput and efficiency. Among many improvements, one notable improvement was the introduction of Medium Access Control (MAC) layer aggregation through Aggregated MAC Protocol Data Unit (A-MPDU). A-MPDU aggregation enables one or more MAC Protocol Data Units (MPDUs) to be transmitted in a single Physical Layer Protocol Data Unit (PPDU), between access point (AP) and one or more client stations. This aggregation supports flexible transmission of different types of data associated with a single traffic identifier (TID) or multiple TIDs within a single transmission.

60. Specifically, to support acknowledgment of A-MPDU transmissions, 802.11 family of standards (including 802.11 (2012), 802.11 (2016), 802.11ac

standards) define several acknowledgment response types. Prior to discussion, I would like to note that the 802.11-2016 standard incorporates various prior amendments and revisions, including those from 802.11ac, which incorporated advanced features for Very High Throughput (VHT) technology. SAMSUNG-1009, 11-12 (10-11); *see generally* SAMSUNG-1015, SAMSUNG-1020. These revisions include technical corrections, clarifications, and enhancements to MAC and PHY layer procedures. SAMSUNG-1009, 12 (11).<sup>1</sup>

61. The 802.11 standards referenced above commonly disclose three types of acknowledgment mechanisms for acknowledging A-MPDUs or PPDU encapsulating A-MPDUs: (1) Ack (e.g, Normal Acknowledgement); (2) Compressed Block Acknowledgment (C-BA); and (3) Multi-TID Block Acknowledgment (M-BA). *See, e.g.*, SAMSUNG-1009, 677-681 (676-680), 1292-1295(1291-1294), 1319 (1318), 651-652 (650-651); SAMSUNG-1015, 509-511 (411-413), 912-915 (814-817), 489-490 (391-392); SAMSUNG-1020, 146-147 (116-117), 154 (123).

62. First, an Ack response may be used when an A-MPDU contains only

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<sup>1</sup> For purposes of clarification, the number without the parenthesis refers to the pdf page number of the exhibit, and the number with the parenthesis refers to the page number at the bottom of the document.

a single MPDU (e.g., a VHT Single MPDU). In such cases, when the receiving terminal (e.g., an AP or client station) receives a PPDU containing a single MPDU, it may issue an immediate Ack response after a Short Interframe Space (SIFS) (e.g., immediately upon receipt).

63. Second, when an A-MPDU contains multiple MPDUs associated with the same TID (e.g., single-TID A-MPDU), a Compressed BlockAck (C-BA) response may be used. The C-BA frame typically includes a compact, fixed-length 64-bit bitmap (8 octets), which acknowledges the receipt of multiple MPDUs associated with the same TID. This provides a significantly reduced acknowledgement data size compared to the legacy BlockAck frame, which uses a 1024-bit bitmap (128 octets) and is rarely used in modern deployments. For instance, 802.11 (2016) standard states that “[t]he use of the basic BlockAck variant is obsolete.” *See e.g.*, SAMSUNG-1009, 677-681 (676-680).

64. Third, when an A-MPDU includes MPDUs associated with different TIDs (e.g., multi-TID A-MPDU), a Multi-TID BlockAck response may be used. With the development of the IEEE 802.11ax standard, which is intended to further enhance throughput and transmission efficiency, a more advanced acknowledgment frame format was introduced: the Multi-STA BlockAck (M-BA). This new format extends traditional Multi-TID BlockAck functionality and is optimized for MU (multi-user) environments, including uplink/downlink

Orthogonal Frequency-Division Multiple Access (OFDMA) and MU-Multiple Input, Multiple Output (MIMO) transmissions. For instance, an AP receiving simultaneous transmissions from multiple client stations can respond with a single M-BA frame that acknowledges MPDUs across multiple TIDs and across multiple stations.

65. Importantly, the Multi-STA BlockAck format is also applicable to single-user (SU) transmissions. When a single non-AP STA transmits an A-MPDU containing MPDUs associated with multiple TIDs, the AP can respond with an M-BA frame, or vice versa. Thus, M-BA serves as a general-purpose acknowledgment mechanism that advances the functionality of the Multi-TID BlockAck, supporting both SU and MU transmission contexts. According to IEEE submissions such as IEEE-D9 by Liwen Chu et al., the use of M-BA for SU multi-TID acknowledgment began to appear in public around January 2016, and was reflected in, e.g., (1) early draft of the TGax specification (IEEE-D5) in March 2016 and (2) 802.11ax D1.0 draft (IEEE-D1) in December, 2016. *See* SAMSUNG-1021; SAMSUNG-1013, 15-17; SAMSUNG-1005, 60-66 (34-40).

66. Furthermore, as reflected in later IEEE submissions—such as the one (IEEE-D2) by Liwen Chu again—the use of M-BA frames continued to evolve in the IEEE 802.11ax development process. SAMSUNG-1006. Previously, a multi-TID A-MPDU containing MPDUs with different delimiter information having

varying End of Frame (EOF) field values and different acknowledgment policies (e.g., normal Ack and BlockAck) did not coexist. However, IEEE-D1 (SAMSUNG-1005) and IEEE-D2 (SAMSUNG-1006) introduced a new rule that allowed such mixed-policy MPDUs (e.g., MPDUs with EOF=1 for Ack and MPDUs with EOF=0 for BlockAck) to be aggregated within the same A-MPDU. SAMSUNG-1006, 4-5; SAMSUNG-1005, 219-220 (193-194). This newly introduced rule for multi-TID A-MPDU enables more flexible and efficient multi-TID frame aggregation. Moreover, under this newly introduced rule, when the receiving terminal receives such multi-TID A-MPDU or detects mixed configuration—including MPDUs of different TIDs and policies (e.g., policies that solicit Ack and BlockAck) within a multi-TID A-MPDU—the receiving terminal may be instructed to respond with a Multi-STA BlockAck frame. SAMSUNG-1006, 4-5; SAMSUNG-1005, 219-220 (193-194). This rule may ensure that response frame selection is determined by features relating to MPDUs within multi-TID A-MPDU, such as End of Frame (EOF) field, length field, TID, and/or policy information.

67. In sum, by the time of the Critical Date, the acknowledgment response mechanisms—including Ack, Compressed BlockAck, and Multi-STA BlockAck—were of public knowledge. A POSITA would have understood how to determine the appropriate acknowledgment type based on standard-defined indicators such as

MPDU delimiter fields, TID values, and policy information. The transition toward using Multi-STA BlockAck in both SU and MU contexts was a natural evolution of the protocol, motivated by the desire to reduce transmission complexity—for example, by minimizing the number of data units (e.g., A-MPDUs and PPDU) that need to be constructed and transmitted—and to consolidate acknowledgments within a single, efficient response frame. Accordingly, the use of these acknowledgment mechanisms, and the structural rules governing their selection, would have been readily implemented by a POSITA.

## **VIII. THE ‘926 PATENT**

### **A. Overview of the ‘926 Patent**

68. The ‘926 Patent is directed to “a wireless communication method and a wireless communication terminal for setting various formats of [an] aggregate MPDU [MAC protocol data unit] and the response frame thereto.” SAMSUNG-1001, Abstract.

69. The ‘926 Patent describes a wireless LAN system in which wireless communication terminals—such as non-access point stations (non-AP STAs) and access points (APs)—exchange aggregated MAC data units (A-MPDUs). As illustrated in FIG. 1, each basic service set (BSS) includes STAs (e.g., STA-STA5, outlined in red) and access points (PCP/AP-1 and PCP/AP-2, outlined in green)

connected by a distribution system (DS). SAMSUNG-1001, 6:56-67; 7:1-2; FIG.

1.

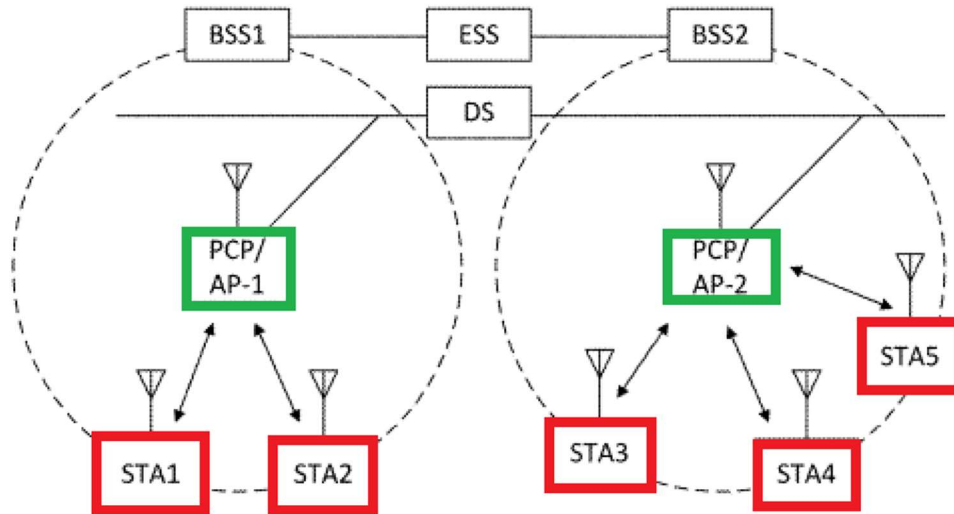


**FIG. 1**

SAMSUNG-1001, FIG. 1.

70. The '926 Patent explains that the “term ‘terminal’ may be used to refer to a non-AP STA, or an AP, or to both terms,” and describes multiple scenarios: one in which a non-AP STA acts as the receiving terminal for receiving an A-MPDU and another in which an AP acts as the receiving terminal for receiving the same. SAMSUNG-1001, 7:8-9, 16:37-41, 42-56, 17:5-7, 45-47, 18:14-16, 19:14-15, 38-40, 20:1-4, 17-19, 55-57; 21:40-44, 40-53, 22:1-4. In each case, the receiving terminal processes the received A-MPDU to determine a type of acknowledgment response. *Id*

71. The '926 Patent classifies the received A-MPDUs into the following

three categories based on MPDU identifiers (e.g., MPDU delimiters) and traffic identifier (TID) information:

- (i) Single MPDU (S-MPDU);
- (ii) Single-TID A-MPDU; and
- (iii) Multi-TID A-MPDU.

*See generally* SAMSUNG-1001; *see also id.*, FIG. 10(a)-(c) (summarized below in Table 1).

72. *Overview of the Received A-MPDU Types and Response Frame*

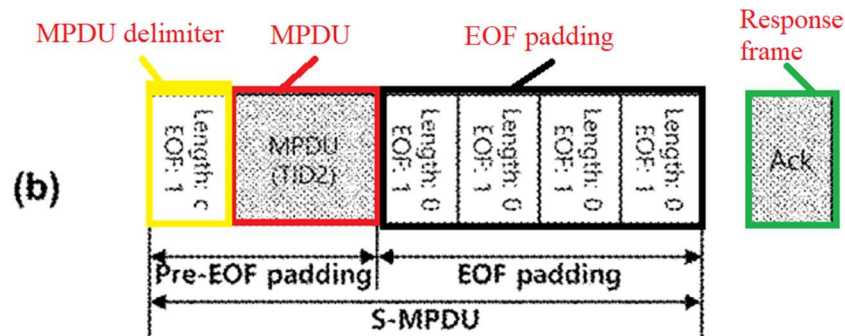
*Determination*

73. As described in Table 1 below, the '926 Patent categorizes three different types of A-MPDUs that may be received by the recipient terminal, along with the corresponding response frames that the recipient terminal transmits.

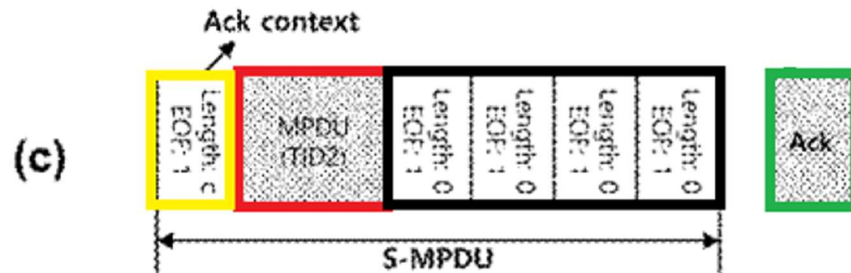
| Type of A-MPDU | A-MPDU Structure and Corresponding Response Frame                                                                                                                                                                                                                                                                                                                                 |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| S-MPDU         | S-MPDU is a single MPDU having an MPDU delimiter with “the value of the EOF [(end of frame)] field is set to 1 and the value of the MPDU length field is set to a non-zero value.” SAMSUNG-1001, 11:27-33; 15:61-62. According to the '926 Patent, this S-MPDU is an A-MPDU containing only one MPDU. SAMSUNG-1001, 15:54-67 (explaining that the MPDU format includes an “A-MPDU |

containing a single MPDU (embodiment of FIG. 10(c)).”), FIG. 10(c).

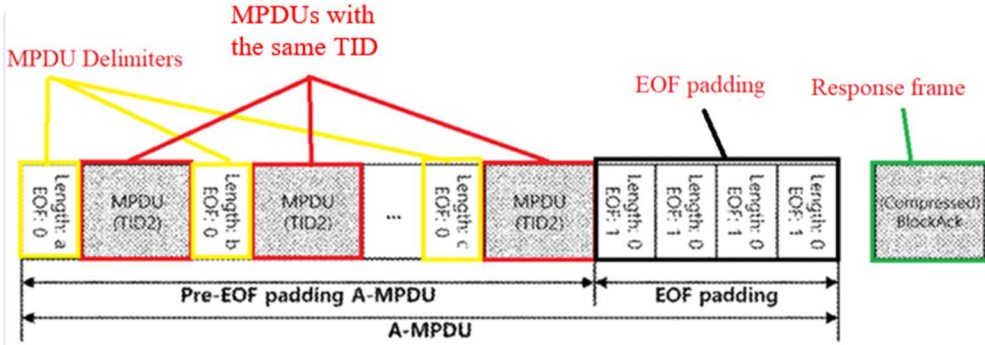
In this context, “[w]hen an S-MPDU is received, the recipient [terminal] may respond with a normal Ack.” SAMSUNG-1001, 11:17-36, FIGS. 6(b) and 10(c). For example, as illustrated below, FIGS. 6(b) and 10(c) disclose the S-MPDU structure and corresponding response frame being an Ack frame. SAMSUNG-1001, FIGS. 6(b), 7(c), 10(c); 15:53-16:27; 12:43-13:33.

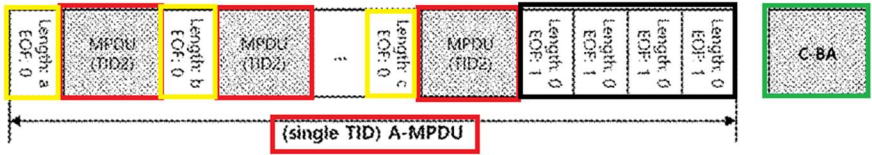


SAMSUNG-1001, FIG. 6(b).

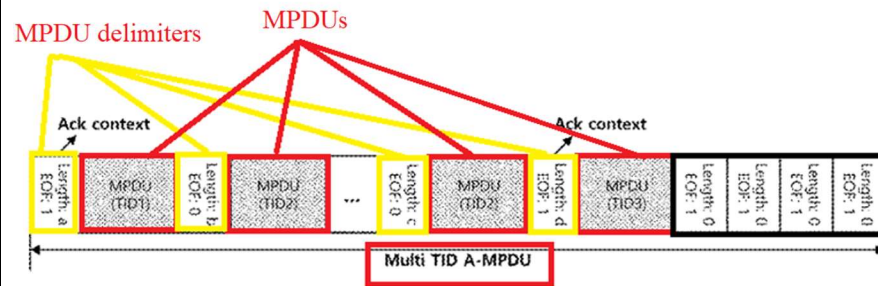


SAMSUNG-1001, FIG. 10(c).

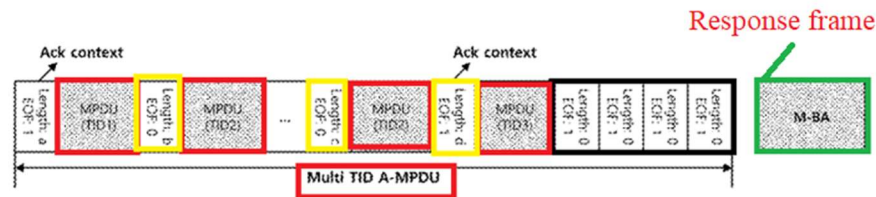
|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <p>Single-TID A-MPDU</p> | <p>A single-TID A-MPDU refers to an A-MPDU where multiple MPDUs all belong to the same TID and have MPDU delimiters with EOF=0 and length≠0 in the pre-EOF padding portion of the A-MPDU. SAMSUNG-1001, 11:1-16; 15:59-61. For example, FIGS. 6(a) and 10(b) (reproduced below) disclose the single-TID A-MPDU structure and corresponding response frame being a Compressed BlockAck (C-BA) frame. SAMSUNG-1001, FIGS. 6(a), 10(b); 11:1-16; 16:5-15. “Referring to FIG. 6(a), a plurality of data MPDUs belonging to TID2 are transmitted via a single A-MPDU. In the EOF padding portion following the pre-EOF padding portion, one or more EOF delimiters with the value of the EOF field set to 1 and the value of the MPDU length field set to 0 are transmitted to indicate the end of the A-MPDU transmission.” SAMSUNG-1001, 11:10-16.</p>  <p>The diagram illustrates the structure of a single-TID A-MPDU. It is divided into two main sections: 'Pre-EOF padding A-MPDU' and 'EOF padding'. The 'Pre-EOF padding A-MPDU' section contains multiple MPDUs (TID2) with delimiters. Each delimiter consists of a 'Length' field and an 'EOF' field. For the first three MPDUs, the 'Length' field is non-zero (a, b, c) and the 'EOF' field is 0. The 'EOF padding' section contains delimiters with a 'Length' field of 0 and an 'EOF' field of 1. A 'Response frame' (Compressed BlockAck) is shown to the right of the A-MPDU.</p> |

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                         | <p style="text-align: center;">SAMSUNG-1001, FIG. 6(a).</p>  <p style="text-align: center;">SAMSUNG-1001, FIG. 10(b).</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <p>Multi-TID A-MPDU</p> | <p>Multi-TID A-MPDU generally refers to an A-MPDU that includes MPDUs belonging to different TIDs. SAMSUNG-1001, 11:59-67; 15:57-59; 16:16-27.</p> <p>Particularly, the '926 Patent describes two implementations of multi-TID A-MPDU:</p> <p><b>(1) 1<sup>st</sup> Implementation:</b> includes mixed EOF=0, length≠0 and EOF=1, length≠0 MPDU delimiters (e.g., each MPDU delimiter being followed by a respective MPDU) within the same A-MPDU. SAMSUNG-1001, 13:34-56, 12:43-59, 15:54-67, FIGS. 7(a), 10(a); <i>see generally id.</i>, 11:59-67, 12:1-59. Notably, FIG. 7(a) shows multi-TID A-MPDU that includes both (i) the MPDU delimiters having EOF=1 preceding single MPDUs of distinct TIDs (e.g., TID1 and TID3) and (ii) the MPDU delimiters having EOF=0 for block of MPDUs of same TID (e.g., TID 2). SAMSUNG-1001,</p> |

FIGS. 7(a). FIG. 10(a) discloses another example of this 1<sup>st</sup> Implementation of multi-TID A-MPDU structure and corresponding response frame being a Multi-STA BlockAck (M-BA) frame. SAMSUNG-1001, FIG 10(a); 16:16-27.



SAMSUNG-1001, FIG. 7(a).



SAMSUNG-1001, FIG. 10(a).

**(1) 2<sup>nd</sup> Implementation:** includes only MPDU delimiters having EOF=1, length≠0 (e.g., each MPDU delimiter indicating that a respective MPDU following that MPDU delimiter is a standalone MPDU for each TID). SAMSUNG-1001, 11:65-67; 12:22-67; 13:1-32.

In both implementations, the receiving terminal may respond with an

|  |                                                          |
|--|----------------------------------------------------------|
|  | M-BA frame. SAMSUNG-1001, 12:22-31; 16:16-17; FIG.10(a). |
|--|----------------------------------------------------------|

Table 1.

74. The '926 Patent also describes uplink multi-user transmission, where the AP receives A-MPDUs from one or more STAs and generates a corresponding response frame—such as an Ack, C-BA, or M-BA—for each STA. SAMSUNG-1001, 21:40-67, FIG. 13(a).

75. Policy Information – “First Value” May Govern Immediate Response Transmissions for All Three Response Types

76. The '926 Patent describes that “[w]hether a data frame solicits an immediate response may be indicated through an Ack policy subfield of the QoS control field of the MAC header. According to an embodiment, the Ack policy subfield may indicate the acknowledgment policy for data via four different field values.” SAMSUNG-1001, 14:32-65. For instance, “[i]f the Ack policy subfield is set to the **first value**, the recipient responds to a data frame with a **general Ack or an implicit BlockAck**. . . . an **immediate response** to the data frame is solicited. That is, the recipient transmits an **Ack frame** or a **BlockAck frame** a **SIFS [Short Inter-Frame Space] after a PPDU [Physical Layer Protocol Data Unit] carrying the data frame**.” SAMSUNG-1001, 14:37-43. By contrast, other policy values indicate that **no response is solicited (second value)**, a **non-explicit**

**Ack** (where “**the response is not an Ack frame**”) is solicited (**third value**), or that the recipient **defers a response** (where “**recipient takes no action, except to record its status upon receipt**”) until a later BlockAck request frame is received (**fourth value**). SAMSUNG-1001, 14:45-65.

77. Thus, when the first policy value is used, the recipient terminal transmits an immediate response frame after receiving the physical layer protocol data unit (PPDU) or A-MPDU included in the PPDU, and this response applies to for all three response types (Ack, C-BA, and M-BA responses). SAMSUNG-1001, 16:1-27.

#### **B. Prosecution History of the ‘926 Patent**

78. Examination of the application that became the ‘926 Patent included, among other things, a non-final prior art rejection and responsive arguments along with amendment. To address the prior art rejection, the Applicant amended the independent claims to recite “a type of the response frame is determined as one of an Ack frame, a compressed BlockAck frame, and a Multi-STA BlockAck frame according to a combination of a type of the MPDU determined by the EOF field and the length field, and the Ack policy information” and “the compressed BlockAck frame is used to transmit a response to the one or more MPDUs corresponding to one TID, when the one or more MPDUs correspond to the one TID (traffic IDs).” (Amendments shown in marked up text). SAMSUNG-1002,

207, 209, 213. A Notice of Allowance was subsequently issued. SAMSUNG-1002, 187.

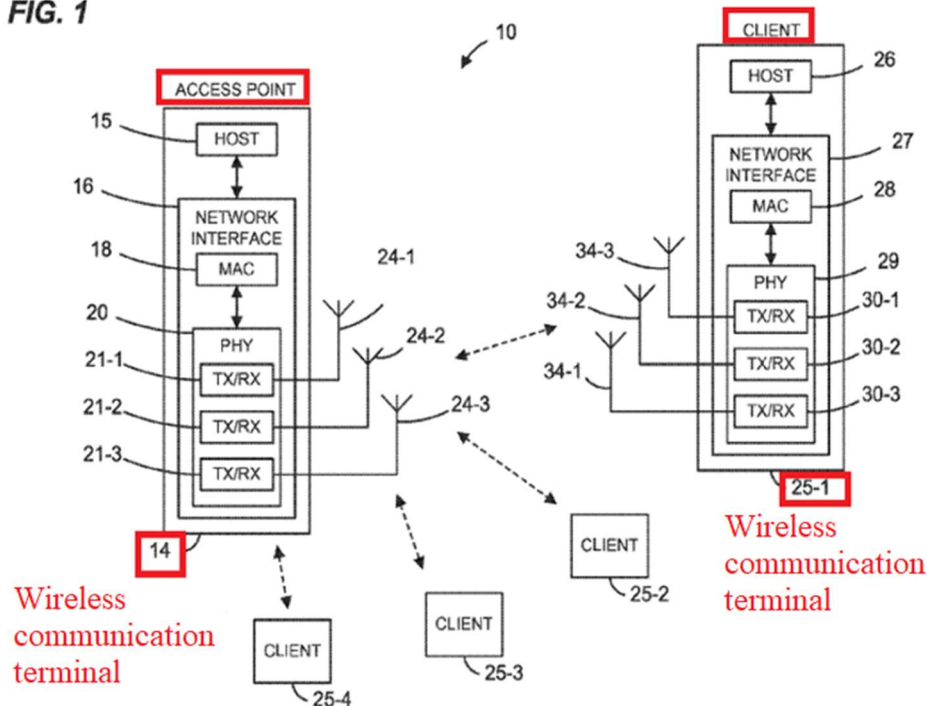
**IX. [GROUNDS 1A/1B] – CHU AND IEEE-D1 or CHU AND IEEE-D2**

**A. REFERENCE 1 (“Chu”)**

79. *Overview of Chu’s System and Support for A-MPDUs*

80. Chu describes systems and methods for transmitting and acknowledging multiple types of data units. SAMSUNG-1004, [0007], [0010], [0032], [0033], [0121]-[0141], claims 1, 12, 17, 20, 21. Specifically, Chu describes systems and methods for: (1) generating aggregate MAC Protocol Data Units (A-MPDUs) that include data units (e.g., MPDUs) associated with one or more TIDs and policy information, and (2) communicating acknowledgement response after receiving the A-MPDUs. SAMSUNG-1004, [0121]-[0142].

FIG. 1



SAMSUNG-1004, FIG. 1.

81. Chu explains that each of the access points (APs) and client stations, such as those illustrated in FIG. 1 above, is capable of (1) generating and receiving A-MPDUs and (2) generating acknowledgment response frames (e.g., including or corresponding to response MPDU) upon receipt of the A-MPDUs. SAMSUNG-1004, FIG. 1 (reproduced above), [0055], [0057], [0060], [0081], [0087], [0121], [0126], [0129], [0134].

82. To begin with, Chu discloses that each of the AP 14 and the client stations 25 (e.g., 25-1, 25-2, 25-3) shown in FIG. 1 above is a “wireless communication terminal.” For example, Chu’s FIG. 1 “is a block diagram of an example wireless local area network (WLAN) 10.” SAMSUNG-1004, [0034], FIG.

1. In this network, AP 14 wirelessly communicates with one or more client stations 25. SAMSUNG-1004, [0034]-[0039]. Chu describes that “one or both of the AP 14 and the client station 25 are configured to receive multiple uplink data units simultaneously transmitted by multiple second communication devices” and that “AP 14 or client station 25 generates an acknowledgment data unit to acknowledge receipt of the multiple data units.” SAMSUNG-1004, [0044]. Moreover, Chu describes both (1) uplink transmission from a single station or multiple stations to an AP and (2) downlink transmission from an AP to a single station or multiple stations. SAMSUNG-1004, [0055]. Because both the AP 14 and the client station 25-1 communicate wirelessly within the WLAN, a POSITA would have understood that each of them constitutes a wireless communication terminal.

83. Each of Chu’s wireless terminals—the AP and client station—features processors and communication units. As shown in FIG. 1, the AP includes a MAC processor and a PHY processor: The AP 14 includes a MAC processor 18 and a PHY processor 20. SAMSUNG-1004, [0034], [0040], FIG. 1. “[T]he MAC processor 18 and the PHY processor 20 are configured to operate according to” several different protocols, including, e.g., the IEEE 802.11ax (High Efficiency protocol), IEEE 802.11ac, IEEE 802.11a, and/or IEEE 802.11n standards. SAMSUNG-1004, [0035]. Similarly, client stations mirror this

architecture: For example, the client station 25-1 includes a MAC processor 28 and a PHY processor 29, and is configured to operate under the same or similar protocol as the AP. SAMSUNG-1004, SAMSUNG-1004, [0043], [0036]-[0037], [0042], FIG. 1.

84. The MAC processors 18 and 28 can generate MAC layer data units (e.g., MPDUs, MAC control frames), and implement MAC layer functions of the communication protocol. SAMSUNG-1004, [0040]-[0043]. The PHY processors 20 and 29 can implement the PHY layer functions, including encapsulating the MAC layer data units into PHY protocol data units (PPDUs) for transmission, and extracting received MAC layer data units from incoming PPDUs. SAMSUNG-1004, [0040]-[0043]. Indeed, it would have been apparent to a POSITA that these MAC and PHY functions could be implemented either in discrete processors or integrated within a single processing unit. Chu explicitly states that, in some examples, the MAC processor is implemented on a first IC and the PHY processor on a second IC, while in another examples, the MAC processor and the PHY processor are implemented on a single IC. SAMSUNG-1004, [0034]-[0042]. Accordingly, it would have been an apparent to combine these processing components into a single processor or to refer to their collective operation as being performed by a processor.

85. Chu's communication units of the AP and client station each include

transceivers. For instance, “[t]he PHY processor 20 [, 29] includes a plurality of transceivers 21 [, 30], and the transceivers 21 [, 30] are coupled to a plurality of antennas 24 [,34].” SAMSUNG-1004, [0034]-[0053], FIG. 1. This setup supports data unit(s) exchanges including PPDU, A-MPDU, or the like. One or more of the transceivers 21, 30 of the AP or the client station can be the communication unit.

86. Both the AP and client stations are fully capable of performing all A-MPDU-related features. As will be described further below, each of the AP and the client station can generate A-MPDUs with one or more MPDUs, TIDs, and policy information, transmit them, receive A-MPDUs, process them, and generate acknowledgment frames (e.g., response frames). Both the AP and the client station are configured to receive and transmit single or multiple data units and generate an acknowledgment data unit to acknowledge receipt of the data unit(s). Moreover, Chu describes both (1) uplink transmission from a single station or multiple stations to an AP and (2) downlink transmission from an AP to a single station or multiple stations.

87. Receiving A-MPDU Within a PPDU, A-MPDU Structure, and Policy Information

88. In particular, both the AP and client stations can receive a PPDU including an A-MPDU having one or more MPDUs. The PHY processors in both the AP and the client station—specifically, PHY processor 20 and PHY processor

29—are each configured to receive PHY data units “such as PHY protocol data units (PPDUs)” that were “received via the antennas 24” (for the AP) or “via the antennas 34” (for the client station), and to “extract MAC layer data units [an A-MPDU (Aggregate-MAC Protocol Data Unit) in which one or more MPDUs are aggregated] encapsulated within the PHY data units.” SAMSUNG-1004, [0040], [0042], [0045]-[0059]. In each case, “the PHY processor . . . provides the extracted MAC layer data units to the MAC processor,” which “processes the MAC layer data units.” SAMSUNG-1004, [0040], [0042], [0045]-[0059]. These MAC layer data units correspond to one or more MPDUs, and the aggregate of one or more such units forms an A-MPDU (Aggregate-MAC Protocol Data Unit). SAMSUNG-1004, [0053], [0040], [0042], [0045]-[0059]. This includes configurations in which an A-MPDU contains only a single MPDU—e.g., a Very High Throughput (VHT) single MPDU—and in which an A-MPDU contains a plurality of aggregated MPDUs. *See, e.g.*, SAMSUNG-1004, [0040], [0042], [0045]-[0059], [0070]-[0076], [0126]-[0132], [0157], [0171]-[0172], claim 12. For example, “VHT single MPDU [VHT S-MPDU],” is defined as an “MPDU that is the only MPDU in an A-MPDU and that is carried in an A-MPDU subframe with 1 in the EOF field.” SAMSUNG-1009, 1371 (1370); ¶60. Accordingly, a POSITA would have recognized that Chu’s A-MPDU format also applies to, and also refers to, a VHT PPDU or VHT S-MPDU context, since VHT S-MPDU “is

the only MPDU in an A-MPDU and that is carried in an A-MPDU subframe,” and it was well-known that VHT PPDU and VHT S-MPDU contexts uses the same or similar A-MPDU format. SAMSUNG-1004, [0072]; SAMSUNG-1009, 1288-1289 (1287-1288), 1288-1295 (1287-1294), 1371 (1370), 651 (650); SAMSUNG-1020, 143-147 (113-117), 64 (34).

89. Chu discloses that the A-MPDU includes one or more subframes. For instance, FIG. 5A depicts A-MPDU 500 that includes a sequence of N subframes, where N may be one or more. SAMSUNG-1004, [0071], [0130]-[0133]. Each subframe includes an MPDU and corresponding delimiter fields (MPDU delimiter field 522), MPDU 524, and optionally a padding field. SAMSUNG-1004, [0070]-[0072]. The delimiter includes MPDU identifier information, including an EOF field (subfield 532) and an MPDU length field (subfield 536). SAMSUNG-1004, FIGS. 5A-5C, [0071]-[0072]. For example, as shown in Chu’s FIG. 5C below, Chu’s MPDU delimiter 532/522 includes an EOF subfield 532 (1 bit) and an MPDU length subfield 536 (14 bits). SAMSUNG-1004, FIGS. 5A-5C, [0071].



**FIG. 5A**

520 = Example of one or more  
A-MPDU subframes 502, 504, 506

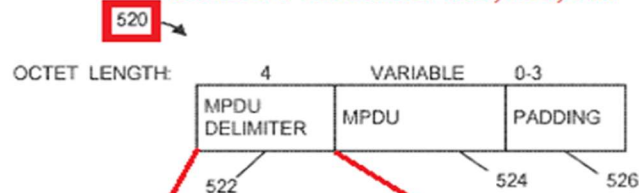


**FIG. 5B**

530 = Example of  
MPDU delimiter 522

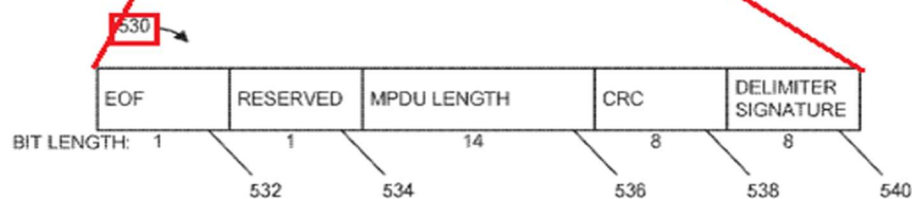
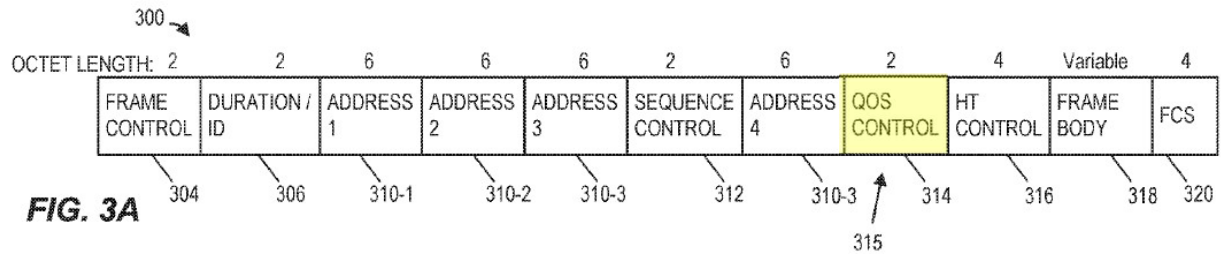


**FIG. 5C**

SAMSUNG-1004, FIGS. 5A-5C.

90. Chu also discloses that A-MPDU includes acknowledgment policy (Ack policy) information associated with one or more MPDUs. For example, Chu's FIG. 3A illustrates a diagram of an example MPDU (such as MPDU 300) for a data frame that can be included in either a downlink data unit transmitted by the AP 14 to one or more client stations or in an uplink data unit transmitted by a single client station 25 to the AP. SAMSUNG-1004, [0055]-[0057]. Chu explains that "[t]he MPDU 300 generally corresponds to a MAC frame format as described in the IEEE 802.11-2012 Standard" in various examples and that "[t]he MPDU 300

includes . . . a QoS control field 314.” SAMSUNG-1004, [0058]. “[T]he QoS control field 314 includes an acknowledgment policy field 315 having two bits that identify an acknowledgment policy (Ack Policy) that is followed upon delivery of the corresponding MPDU.” SAMSUNG-1004, [0059]. Chu explains that the same QoS control field 314 in MPDU 300 can be used for MPDUs in A-MPDU 500. SAMSUNG-1004, [0070], [0073]-[0075].



SAMSUNG-1004, FIG. 3A.

91. Chu discloses that the AP 14 or the client station 25 can set: (i) the acknowledgment policy bits in the QoS control field 314 to indicate an “immediate Ack/BA [BlockAck],” and (ii) the EOF field 532 of the MPDU delimiter 530 to 1 or 0, along with a non-zero MPDU Length field 536. These settings specify acknowledgment policy for a corresponding MPDU in an A-MPDU. SAMSUNG-1004, [0073]-[0076], [0129]-[0133], [0161], claims 12, 15.

92. For example, Chu describes that “AP 14 or client station 25 sets i) the acknowledgment policy bits of the corresponding QoS control field 314 to an

immediate Ack/BA [(“Block Ack”)] and ii) sets the EOF field 532 of the corresponding MPDU delimiter 530 to 1 and the MPDU Length field 534 to a non-zero value in order to indicate an acknowledgment policy for the corresponding MPDU within an OFDMA A-MPDU.” SAMSUNG-1004, [0073]-[0076], [0129]-[0133], [0161], claims 12, 15. Moreover, Chu describes that “[t]he AP 14 utilizes the EOF field 532 and the MPDU Length field 534 to differentiate between a normal acknowledgment request and a block acknowledgment request,” since “the acknowledgment policy bits of the QoS control field 314 by themselves do not provide for an indication to differentiate Ack and BA within an A-MPDU.” SAMSUNG-1004, [0073]-[0076], [0129]-[0133], [0161], claims 12, 15.

93. For example, in some cases, “the AP 14 sets the EOF field 532 to 1, sets the MPDU length field 536 to a non-zero value, and sets the acknowledgment policy bits of the corresponding QoS control field 314 [e.g., within MPDU of A-MPDU 500] to a normal acknowledgment policy (e.g., a value of ‘00’).” SAMSUNG-1004, [0074], [0073], [0129]-[0133] (explaining that the client station performs similar operations), [0161]; SAMSUNG-1021, 11-12; SAMSUNG-1005, 219 (193); SAMSUNG-1006, 4. In some cases, “the AP 14 sets the EOF field 532 to 0, sets the MPDU length field 536 to a non-zero value, and sets the acknowledgment policy bits of the corresponding QoS control field 314 [within MPDU of A-MPDU 500] to an implicit block acknowledgment request (e.g., a

value of ‘00’).” SAMSUNG-1004, [0075], [0073], [0129]-[0133] (explaining that the client station performs similar operations); SAMSUNG-1005, 219 (193); SAMSUNG-1006, 4; *see also* SAMSUNG-1021, 11-12. Because both the AP and the client station can set bits in the QoS control field in an A-MPDU to specify an “implicit block acknowledgment request” in the above-noted matter, Chu discloses that the A-MPDU includes Ack policy information related to a block Ack for the one or more MPDUs.

94. The EOF and MPDU Length fields thus, in combination with the acknowledgment policy bits (e.g., policy information), are used to distinguish between a normal acknowledgment and a block acknowledgment, as the acknowledgment policy bits alone do not provide this differentiation, at least in the immediate context. SAMSUNG-1004, [0073]-[0076], [0129]-[0133], [0161], claims 12, 15. For example, the AP 14 can set the EOF field to 1, the MPDU length field to a non-zero value, and the acknowledgment policy field to “00” to indicate a normal acknowledgment policy. SAMSUNG-1004, [0074], [0073], [0129]-[0133], [0161]; SAMSUNG-1021, 11-12; SAMSUNG-1005, 219 (193); SAMSUNG-1006, 4. Moreover, for example, the AP can set EOF to 0, the MPDU length field to a non-zero value, and the same acknowledgment policy value (“00”) to represent an implicit block acknowledgment policy. SAMSUNG-1004, [0075], [0073], [0129]-[0133]. This is also disclosed in prior art. SAMSUNG-1021, 11-

12; SAMSUNG-1005, 219 (193); SAMSUNG-1006, 4.

95. Moreover, Chu's claim 15 further confirms this context where a policy value (or Ack policy information related to a block Ack) encompasses both "normal acknowledgment policy" and "implicit block acknowledgment" policy. For example, claim 15 recites that "setting an acknowledgment policy field of a quality of service (QoS) control field of the first MPDU to a predetermined value that indicates an immediate block acknowledgment" and that "the predetermined value of the end of frame field for the first MPDU, the non-zero value of the MPDU length field for the first MPDU, and the predetermined value of the acknowledgment policy field for the first MPDU indicate that the first MPDU requests an Ack." SAMSUNG-1004, claim 15.

96. Moreover, a POSITA would have recognized that Chu's policy value (e.g., "00") representing "immediate Ack/BA" context is consistent with the well-known 802.11 policy setting (e.g., 802.11 standard (2012), 802.11 standard (2016)) for the A-MPDU, where the policy value (e.g., 00) represents either "normal ack" policy or "implicit block ack" policy. *See* SAMSUNG-1009, 651 (650), Table 9-9; SAMSUNG-1015, 489-490 (391-392), Table 8-6; SAMSUNG-1020, 64 (34).

97. Once the AP or the client station receives PPDU or A-MPDU within the PPDU, "the PHY processor 20[, 29] is configured to . . . extract MAC layer data units encapsulated within the PHY data units." SAMSUNG-1004, [0040]-

[0043]. These extracted MAC data units are then processed to determine whether they conform to the expected communication protocol. As an example, Chu explains that “the MAC processor 18[, 28] and the PHY processor 20[, 29] . . . are configured to process received data units conforming to the first communication protocol . . . and to determine that such data units conform to the first communication protocol.” SAMSUNG-1004, [0041], [0043]. Upon this determination, the AP or the client station generates an acknowledgment data unit for transmission, to acknowledge receipt of the data unit(s). SAMSUNG-1004, [0044], [0060]-[0063]. For instance, Chu describes that the MPDU 350 can be included in an acknowledgment data unit sent by the AP to a single or multiple client stations in response to an uplink data unit received by the AP from the single or multiple client stations. SAMSUNG-1004, [0060]-[0063], [0075], [0125]-[0128]. Additionally, Chu explains that the same MPDU 350 can also be used in an acknowledgment data unit transmitted by a client station to the AP, acknowledging a downlink data unit received by the client station from the AP. SAMSUNG-1004, [0060]-[0063], [0075], [0125]-[0133].

98. As described above, once the AP or the client station receives PPDU or A-MPDU within the PPDU, the AP or the client station can transmit an acknowledgment frame. Specifically, Chu discloses three different types of response frames or contexts, as further described below.

99. Determination of Response Frame Type – Ack Frame

100. In particular, Chu discloses determination of Ack frame based on (1) the type of the MPDU determined by EOF and length field, and (2) the policy information (e.g., policy bits or value), as described below.

101. Chu describes that an acknowledgment (Ack) frame may be transmitted in response to a single MPDU included within an A-MPDU. For example, Chu explains that “one or more of the OFDM data units 270 [or OFDM data unit 200] is a single MPDU (e.g., a single VHT MPDU . . . ) . . . included in a PPDU,” where the “VHT single MPDU” has EOF field 532 set by “the AP 14 or client station 25” to 1 “in an MPDU delimiter of a VHT single MPDU.” SAMSUNG-1004, [0053], [0072], [0045], [0047], [0049]. Again, as described above, VHT single MPDU is an “MPDU that is the only MPDU in an A-MPDU and that is carried in an A-MPDU subframe with 1 in the EOF field.” SAMSUNG-1009, 1371 (1370); ¶88. Moreover, the MPDU length indicated by a length field of MPDU delimiter of VHT single MPDU is nonzero since there is MPDU present. SAMSUNG-1005, 132 (106); SAMSUNG-1009, 1290 (1289); SAMSUNG-1020, 145 (115). For instance, the IEEE 802.11 standards (IEEE 802.11ac, 802.11ax, 802.11 general standards that encompasses various prior amendments and revisions), which are incorporated by Chu fully by reference, clarify that the MPDU Length field reflects the size of the MPDU, and that a value of zero does

not indicate a valid MPDU. SAMSUNG-1005, 132 (106); SAMSUNG-1009, 1290 (1289); SAMSUNG-1020, 145 (115); SAMSUNG-1004, [0004], [0035]-[0036]; *see also supra* ¶60.

102. In addition to the MPDU delimiter structure, Chu explains that the acknowledgment behavior is controlled at least in part by an acknowledgment policy bits or value encoded in the QoS control field of the MPDU. Chu discloses that the acknowledgment policy bits can be set to specific values indicating the type of acknowledgment expected. For example, Chu states that when the EOF field in the MPDU delimiter is set to a “first predetermined value,” such as 1, it “indicates a normal acknowledgment policy to acknowledge a single data unit to be transmitted to the second communication device.” SAMSUNG-1004, [0159], [0129]-[0133], [0074]. Chu also states that “in some embodiments and/or scenarios, the AP 14 or client station 25 aggregates a management frame or a data frame that corresponds to a normal acknowledgment (e.g., which asks for Ack).” SAMSUNG-1004, [0073], [0129]-[0133]. In this context, a “normal Ack” MPDU is one where the EOF field is 1, the MPDU length field is non-zero, and the acknowledgment policy field is set to a value such as “00.” SAMSUNG-1004, [0073]-[0074].

103. Third, as described in Chu and further confirmed by corroborating prior art references, “the acknowledgment policy bits of the corresponding QoS

control field” of the VHT S-MPDU can be set to a value that indicates “a normal acknowledgment policy” or “implicit block acknowledgment policy,” for example, “a value of ‘00’” that can correspond to “Normal Ack or Implicit Block Ack Request.” SAMSUNG-1004, [0074], [0161]; SAMSUNG-1009, 651 (650), Table 9-9; SAMSUNG-1020, 64 (34), Table 8-6; SAMSUNG-1009, 1371 (1370) (noting that for VHT single MPDU, “[d]ata frame could indicate an Ack Policy of ‘Normal Ack’, which solicits an Ack frame immediate response”).

104. Accordingly, Chu describes determination of an *Ack frame* in response to receiving a VHT single MPDU that has (1) a single standalone MPDU or single normal ACK MPDU determined by EOF field being set to 1 and nonzero MPDU length and (2) policy bits (e.g., “00”) indicating normal acknowledgment or implicit block acknowledgment. SAMSUNG-1004, [0053], [0047], [0049], [0072]-[0074], [0129]-[0133], [0159].

105. Moreover, Chu’s determination of an Ack frame in response to a VHT single MPDU is also consistent with the IEEE 802.11 standards that Chu’s system is compatible with and that are incorporated by Chu fully by reference. SAMSUNG-1004, [0004], [0058]-[0059], [0062], [0072], [0035]-[0036]. For instance, 802.11 standards, such as the 802.11ac standard and the general 802.11 standard (2016) (that encompasses various prior amendments and revisions compatible with Chu), disclose that “[t]he addressed recipient returns an ACK or

QoS +CF-Ack frame after a short interframe space (SIFS) period” in response to VHT single MPDU (having EOF field being set to 1 and nonzero MPDU length) and the corresponding policy control bits being “00.” SAMSUNG-1020, 64 (34), 38 (8); SAMSUNG-1009, 11-12 (10-11), 1319 (1318) (“An Ack frame might be sent in immediate response to a VHT single MPDU in the VHT MU PPDU”), 1371 (1370) (“Data frame could indicate an Ack Policy of “Normal Ack”, which solicits an Ack frame immediate response”), 651 (650), Table 9-9, 1290 (1289), Table 9-422; SAMSUNG-1012, 9-10; *see also* ¶60. Accordingly, a POSITA would have understood that a VHT single MPDU is responded to with an Ack frame as a matter of standard protocol.

106. Moreover, when Chu’s teachings are considered in view of the 802.11ax standard (SAMSUNG-1005, SAMSUNG-1006), it would have been clear to a POSITA that Chu explains or suggests the Ack frame context. Chu explains that the “IEEE Standard 802.11ax” was “incorporated herein fully by reference.” SAMSUNG-1004, [0004].

107. Under the IEEE 802.11ax standard (or protocol), “[i]f the preceding PPDU contains an MPDU that requires an Ack frame response, a single Ack frame” is generated. The standard explains that “[a]n Ack frame might be sent in immediate response carried in SU [singler user] format to a Single MPDU in the VHT MU [multi-user] PPDU,” confirming that a type of the response frame is

determined as an *Ack frame* in response to a VHT Single MPDU (which has EOF=1 and nonzero MPDU length field). SAMSUNG-1005, 145-146 (119-120), 135 (109); SAMSUNG-1013, 31 (“Ack frame might be sent in immediate response to a VHT single MPDU in the VHT MU 23 PPDU or the HE MU PPDU”), 41 (corroborating that “the receiver STA responds with: — An Ack frame when the received fragment is contained in a VHT single MPDU that solicits the immediate response”); SAMSUNG-1012, 9-10 (noting that “VHT single MPDU context” corresponds to “A-MPDU transmitted within a VHT PPDU or a HE PPDU and contains a VHT single MPDU” and corroborating the “Ack” context); SAMSUNG-1006, 4 (disclosing that an MPDU with a TID and an EOF=1 can solicit Ack).

108. *Determination of Response Frame Type – Compressed BlockAck frame*

109. Chu discloses determination of BlockAck after a SIFS (Short Inter-Frame Space period), corresponding to the compressed BlockAck frame, based on (1) the type of the MPDU determined by the EOF and length field and (2) the policy information (e.g., policy bits or value).

110. First, Chu explicitly discloses that “the *EOF field* 532 and the *MPDU Length field* 534 [can be used] to differentiate between a normal acknowledgment request and a block acknowledgment request [of MPDU]” and explains that setting

the EOF field to a “second predetermined value,” such as **EOF = 0**, “indicates a **block acknowledgment policy** to acknowledge **multiple data units** to be transmitted to the second communication device.” SAMSUNG-1004, [0073]-[0075], [0129]-[0133], [0159], claims 12, 15. Chu explains that such MPDU “that has an acknowledgment policy corresponding to a **block acknowledgment** (e.g., where the recipient responds with a BlockAck after SIFS period)” can be referred to as a “**‘block ack’ MPDU**.” SAMSUNG-1004, [0075].

111. Chu also explains that “in response to the receipt of an *MPDU* corresponding to an *EOF field* 532 being **set to 0** and [an] implicit block acknowledgment request,” which has “**policy bits**” set to, e.g., “**a value of ‘00’**,” (*the policy information*), “the recipient acknowledges the MPDU with a **BlockAck after a SIFS period [compressed BlockAck frame]**.” SAMSUNG-1004, [0075].

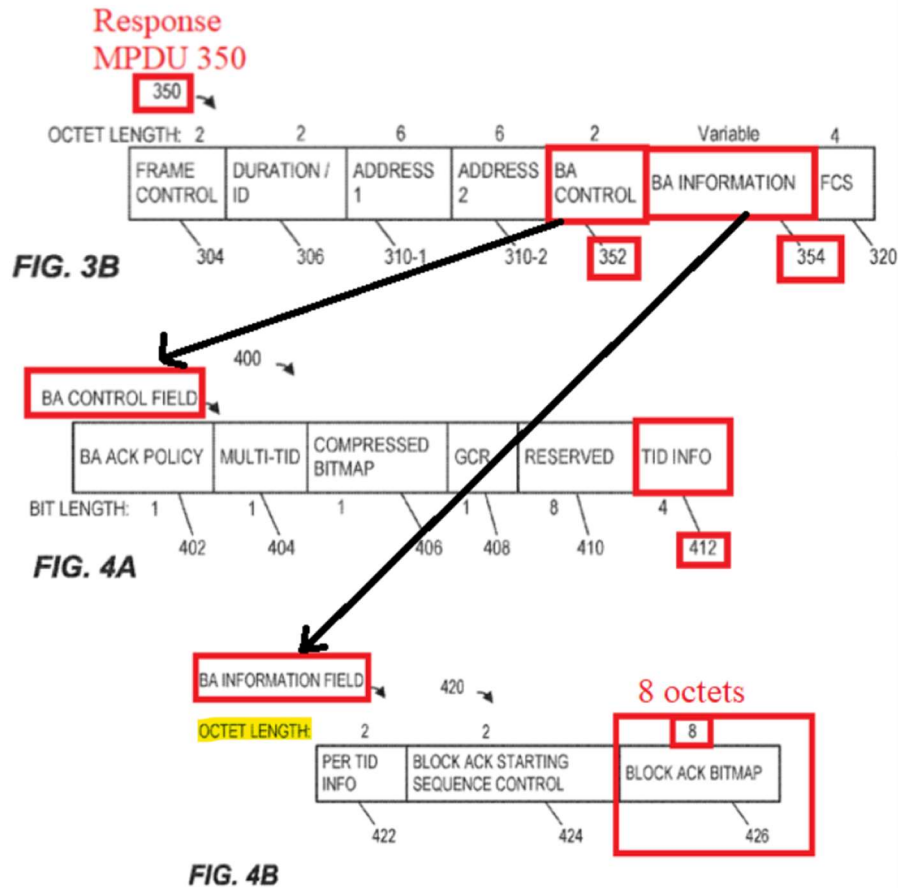
112. Further, Chu states that such block acknowledgment (e.g., BlockAck after a SIFS period (**compressed BlockAck frame**)) “indicates respective acknowledgments for multiple MPDUs belonging to a single TID [single-TID A-MPDU]” SAMSUNG-1004, [0081].

113. Second, Chu’s disclosure of a “BlockAck after a SIFS period” that acknowledges a single-TID A-MPDU corresponds to the **compressed BlockAck frame**, as defined in the 802.11 standards (2012, 2016) and 802.11ax standard. SAMSUNG-1009, 679-680 (678-679); SAMSUNG-1015, 509-510 (411-412);

SAMSUNG-1005, 61-62 (35-36). This is supported by Chu’s description and figures, which describe that the response frame (e.g., MPDU 350 or an acknowledgment unit thereof) includes **(1) a TID INFO subfield** (e.g., “TID INFO” 412, 614, 716) of BA Control field and **(2) a BA information field** (e.g., “BA information field” 420, 620, 720) **structured in the compressed format**, in which the BA information field has the **Block Ack bitmap subfield** (e.g., “Block Ack bitmap subfield” 426, 626, 726) **limited to 8 octets** (64 bits), consistent with the IEEE 802.11 definition of a Compressed BlockAck frame.<sup>2</sup> SAMSUNG-1004, FIGS. 3B & 4A-4B (reproduced below, annotated), 6A-6B, 7A-7B, [0060], [0064]-[0069], [0077]-[0085]); *see also supra* ¶63. Chu further confirms the functionality of a compressed BlockAck frame by disclosing that this block acknowledgment indicates “respective acknowledgments for multiple MPDUs belonging to a single TID,” and describes that such response frame can be generated and transmitted by AP or the client station. SAMSUNG-1004, [0081], [0060].

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<sup>2</sup> According to Chu, (1) BA control field including the TID INFO subfield of FIGS. 4A, 6A, and 7A and (2) BA information field of FIGS. 4B, 6B, and 7B can be applied to MPDU 350 of FIG. 3B or an acknowledgment data unit, which can correspond to the response frame. SAMSUNG-1004, [0060], [0064]-[0069], [0077]-[0085]; FIGS. 3B, 4A-4B, 6A-6B, 7A-7B.



SAMSUNG-1004, FIGS. 3B, 4A-4B.

114. Thus, as set forth above, Chu discloses that the **response frame** (e.g., MPDU 350) is determined as a **compressed BlockAck** response frame based on a combination of (1) the type of the MPDU (e.g., “block ack” MPDU(s), a sequence of MPDUs that belong to single TID within an A-MPDU) that is determined by EOF = 0 and the nonzero value of the MPDU length field, and (2) the policy bits (e.g., “00”) indicating normal acknowledgment or implicit block acknowledgment.

115. Determination of Response Frame Type – Mult-STA BlockAck (M-BA)  
– 1st Instance

116. Chu discloses determination of a “multi-TID block acknowledgment” response frame (corresponding to the Multi-STA BlockAck frame) based on a combination of (1) the type of the MPDU determined by EOF and length field, and (2) the policy information.

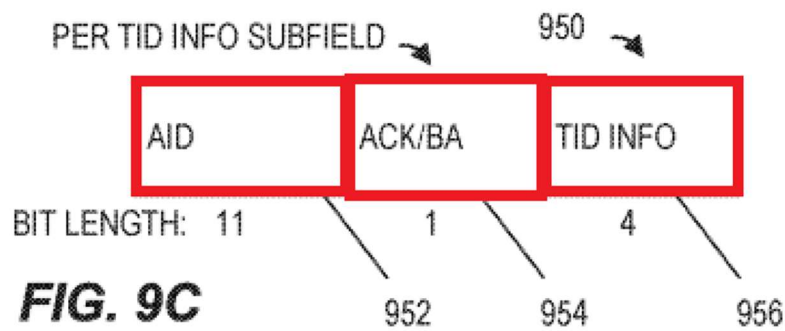
117. First, Chu discloses “multi-TID A-MPDU (e.g., an A-MPDU having A-MPDU subframes with at least some different TIDs)” and generation of “A-MPDU to include multiple normal ACK MPDUs,” where each normal ACK MPDU frame is associated with “each [different] TID.” SAMSUNG-1004, [0069], [0060], [0074]. Moreover, each “normal ACK MPDU” has (1) EOF = 1 and length  $\neq$  0 and (2) policy bits set to “a normal acknowledgment policy (e.g., a value of ‘00’). [policy information]” SAMSUNG-1004, [0074], [0161], [0159].

118. Second, Chu explains acknowledging such multi-TID A-MPDU using a multi-TID block acknowledgment response (e.g., multi-STA BlockAck frame). For instance, Chu explains that “[t]he AP 14 or client station 25 generates the MPDU 350,” which can be used as “a broadcast frame which includes a multi-TID block acknowledgment [e.g., which is “block acknowledgments for multiple TIDs” or “multi-TID A-MPDU”] for multiple stations or as a unicast frame which includes a multi-TID block acknowledgment for a single station.” SAMSUNG-1004, [0089], [0094], [0107], [0069].

119. Third, the structure of the response frame described in Chu

corresponds to the **multi-STA BlockAck frame** as defined in the IEEE 802.11ax standard. The 802.11ax standard explains that the M-BA format includes “Per STA Info subfields,” where each subfield includes an “AID [e.g., an association ID],” “Ack Type,” and “TID.” SAMSUNG-1013, 16-17; SAMSUNG-1005, 63-64 (37-38). The 802.11ax standard further provides that the presence or omission of a BlockAck bitmap may be governed by the “Ack Type” field: “If the Ack Type subfield is 1 . . . Block Ack Bitmap are not present.” SAMSUNG-1013, 16-17; SAMSUNG-1005, 64(38).

120. Consistent with this structure and shown at least in FIGs. 9C, 10C, and 12B of Chu, the response frame used for Chu’s “multi-TID block acknowledgment” corresponds to the **multi-STA BlockAck frame**. SAMSUNG-1004, FIGS. 9C, 10C, 12B, [0089]-[0099], [0106]-[0111]. For example, Chu’s FIG. 9C illustrates a “per TID information subfield 950” that includes three elements: an “AID” field 952 (11 bits), an “Ack/BA [Ack type]” subfield 954 (1 bit), and a “TID value” subfield 956 (4 bits). SAMSUNG-1004, [0091], FIG. 9C.



SAMSUNG-1004, FIG. 9C

121. Chu explains that “the device identifier 952 includes an identifier associated with the device or client station 25,” and that, in some cases, this “device identifier is an association ID (e.g., 11 bits),” or AID. SAMSUNG-1004, [0091]. Moreover, Chu explains that “the Ack/BA field 954 indicates whether the Block Ack starting sequence control subfield 924 and the Block Ack bitmap subfield 926 follow the per TID information subfield 922.” SAMSUNG-1004, [0090]. The conditional omission of bitmap fields may be governed by the “Ack/BA” subfield 954 (also referred to as “acknowledgment type subfield 954”), which indicates whether an Ack-type response or a full BlockAck is required, consistent with the IEEE 802.11ax standard. SAMSUNG-1004, [0092]; *see generally id.* [0090]-[0092].

122. This configuration, in which each acknowledgment entry may be indexed by an AID and TID combination and thus confirms that Chu’s response frame mirrors the structure defined for the Multi-STA BlockAck frame of IEEE 802.11ax standard at the time and maps to the **multi-STA BlockAck frame**. *See supra* ¶¶115-121.

123. Thus, as set forth above, Chu discloses that the response frame is determined as a “multi-TID block acknowledgment” response frame (**Multi-STA BlockAck frame**) based on a combination of (1) **the type of the MPDU** (e.g., a

standalone MPDU that is part of multi-TID A-MPDU, “multiple normal ACK MPDUs”) that is **determined by** EOF=1 and the non-zero MPDU length field, and (2) policy bits (e.g., “00”) indicating normal acknowledgment or implicit block acknowledgment. Based on my review of Chu, I prepared the following table summarizing representative examples of response frame types and the corresponding determination criteria as disclosed in Chu. *See supra, e.g., ¶¶99-122.*

| Response type<br>A-MPDU<br>Feature              | "Ack" response                                                                             | "BlockAck"<br>response "after a<br>SIFS period"<br>(e.g., C-BA<br>response) | Multi-TID block<br>acknowledgment<br>response<br>(e.g., M-BA<br>response)            |
|-------------------------------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| <b>A-MPDU Type</b>                              | VHT Single-MPDU                                                                            | Single TID A-MDPU<br>(Multiple MPDUs<br>associated with the<br>same TID)    | Multi-TID A-MPDU<br>(Multiple MPDUs,<br>each associated with<br>a different TID)     |
| <b>Policy</b>                                   | Single-MPDU having<br>“normal<br>acknowledgment”<br>policy (“e.g., which<br>asks for Ack”) | MPDUs having<br>“implicit block<br>acknowledgment”<br>policy                | MPDUs having<br>“normal<br>acknowledgment”<br>policy (“e.g., which<br>asks for Ack”) |
| <b>Delimiter<br/>information of<br/>MPDU(s)</b> | Single MPDU having                                                                         | MPDUs having<br>EOF=0, length≠0,<br>indicating a sequence<br>of MPDUs that  | MPDUs having<br>EOF=1, length≠0,<br>with each MPDU<br>having different TID           |

|  |                              |                      |  |
|--|------------------------------|----------------------|--|
|  | EOF=1, length≠0 <sup>3</sup> | belong to single TID |  |
|--|------------------------------|----------------------|--|

Table 2.

124. *Chu's Disclosure of Frame Responses Based on MPDU and TID*

*Relationships*

125. First, Chu discloses that each MPDU in an A-MPDU is associated with one or more traffic identifiers (TIDs). Specifically, Chu explains that, in some instances, an MPDU “is included in a plurality of data units of a plurality of uplink A-MPDUs” or “in a [one or plurality of data units of a] downlink or uplink single A-MPDU transmitted in a SU PPDU.” SAMSUNG-1004, [0056]-[0057]. “[T]he plurality of data units correspond to one, two, three, or more traffic classes (TC) or traffic specification identified by different traffic identifications (TIDs).” SAMSUNG-1004, [0056]-[0057].

126. Chu further explains that A-MPDUs may include multiple MPDUs each associated with different TIDs and each configured to request acknowledgment. For example, Chu explains that (1) an A-MPDU may “include multiple normal ACK MPDUs,” where each MPDU has “an acknowledgment policy corresponding to a Normal Ack Request,” and (2) an A-MPDU may

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<sup>3</sup> When the Declaration describes that an MPDU has a certain EOF and length, it refers to the MPDU delimiters having those values. This interpretation is applied consistently throughout the Declaration.

“include at most one frame from each TID corresponding to a normal acknowledgment (e.g., which asks for Ack).” SAMSUNG-1004, [0074]. These disclosures are reinforced elsewhere in Chu, including [0061], [0069], [0074], [0081], and [0125]-[0128], as well as in the claims (e.g., claims 16 and 21), which confirm that different TIDs can be present in a single A-MPDU.

127. Accordingly, Chu provides that an A-MPDU can include one or more TIDs corresponding to the one or more MPDUs. Moreover, it was well-known in the field that an A-MPDU includes one or more TIDs corresponding to the one or more MPDUs of the A-MPDU. SAMSUNG-1009, 649 (648) (“Table 9-6-QoS Control field” showing QoS control fields includes TID); SAMSUNG-1015, 487-488 (389-390) (“Table 8-4-QoS Control field” showing the same). As well-known and disclosed by prior art standards, each MPDU retains its QoS control field with a TID, which are compatible with Chu’s system, and thus, it would have been obvious to a POSITA that an A-MPDU in Chu’s system would have included TID(s) for the corresponding MPDU(s). SAMSUNG-1009, 649 (648) (“Table 9-6-QoS Control field”); SAMSUNG-1015, 487-488 (389-390) (“Table 8-4-QoS Control field”)); SAMSUNG-1004, [0035], [0058]-[0059].

128. Second, Chu distinguishes between different types of response frames based on the number of TIDs present in a received A-MPDU and the acknowledgment policy associated with each MPDU.

129. As an initial matter, I note that claim 3 of the '926 patent recites “a number of TIDs indicating an immediate response among the one or more TIDs.” With regards to this, a POSITA would have understood the “number of TIDs” to include “one or more TIDS,” as explicitly recited in the claim. Chu describes that an Ack frame is used when a single MPDU is present and requests an immediate acknowledgment (e.g., as indicated by policy bits of “00”). Because there is only one MPDU, it necessarily corresponds to a single TID. *See, e.g.*, SAMSUNG-1004, [0057], [0061], [0074], [0081], claim 16. Chu describes such a configuration as involving an MPDU with EOF = 1 and a policy indicating normal acknowledgment, prompting an Ack response “after a short interframe space (SIFS) period” (e.g., immediately). These are well corroborated by prior knowledge in the field. SAMSUNG-1004, [0053], [0072], [0074], [0146], [0159], [0161]; SAMSUNG-1009, 651 (650), 1319 (1318) (explaining that an “*Ack frame* might be sent in *immediate response* to a VHT single MPDU”), Table 9-9, 1371 (1370) (noting that for VHT single MPDU, “[d]ata frame could indicate an Ack Policy of ‘Normal Ack’, which solicits an Ack frame immediate response”; SAMSUNG-1020, 64 (34); *see supra* ¶¶99-107, 105.

130. Again, in the Ack frame context, the single MPDU is associated with only one TID, and “normal acknowledgment policy” solicits immediate response (e.g., response after “a short interframe space (SIFS) period”). Accordingly, it

would have been obvious to a POSITA that, when the context involves only one TID and a single MPDU requests immediate acknowledgment (with policy bits indicating such, e.g., “00”), resulting response frame would be the Ack frame. Thus, VHT single MPDU having one TID soliciting a normal acknowledgment (e.g., immediately after SIFS) distinguishes between different types of response frames. SAMSUNG-1004, [0074], [0159]; *see supra* ¶¶99-107. Moreover, for instance, because it was known in the art that (1) the policy information of VHT single MPDU (associated with one TID) corresponds to a policy value (e.g., “00”) that solicits “Normal Ack or Implicit Block Ack,” (2) such policy associated with one TID solicits immediate response (“after a short interframe space (SIFS) period”), and (3) “Ack frame might be sent in immediate response to a VHT single MPDU,” it would also have been obvious to a POSITA that, in the context of Chu’s single MPDU or VHT single MPDU (associated with a single TID), the policy value indicates a normal Ack and triggers an Ack frame.

131. Chu describes that an BlockAck after SIFS period (e.g., compressed BlockAck frame) is used when multiple MPDUs in the A-MPDU all share the same TID and request immediate acknowledgment. As described above, these MPDUs are typically block ack MPDUs each having EOF = 0, nonzero length, and policy bits set to a value that can indicate an implicit block acknowledgment (e.g., “00”). Chu confirms that such MPDUs are acknowledged collectively with a

BlockAck after a SIFS period. SAMSUNG-1004, [0075], [0081]; *see supra* ¶¶95-101. Moreover, Chu explains that each BlockAck response (e.g., “compressed BlockAck frame”) “indicates respective acknowledgments for multiple MPDUs belonging to a single [same] TID” when these multiple MPDUs having the “single TID” (“one TID”) are within the received A-MPDU of PPDU that may have “the plurality of data units correspond[ing] to one, two, three, or more . . . traffic specification identified by different traffic identifications (TIDs) [among one or more TIDs]” or that may have just the “single TID.” SAMSUNG-1004, [0056]-[0057], [0060]-[0061], [0081].

132. Further, this is consistent with industry conventions, in which a compressed BlockAck is used to acknowledge multiple frames from the same TID. SAMSUNG-1012, 11-12, Table 9-421 (explaining “block ack request for a [same] TID” for “HT-immediate BlockAck [compressed BlockAck]” vs. “block ack requests for multiple TIDs” for the “Multi-STA BlockAck frame”); SAMSUNG-1013, 27-28 (explaining a similar concept as presented in SAMSUNG-1012, 11-12, Table 9-421); SAMSUNG-1009, 1293 (1292), Table 9-425 (explaining a similar concept as presented in SAMSUNG-1012, 11-12, Table 9-421); SAMSUNG-1009, 153 (152); SAMSUNG-1015, 125 (27) (explaining that high-throughput immediate block acknowledgment is “[a]n Immediate Block Ack mechanism that requires the use of the compressed BlockAck frame”); *see also*

*supra* ¶63.

133. Chu describes that a multi-block acknowledgment (e.g, multi-STA BlockAck frame) is used when the A-MPDU contains MPDUs associated with multiple different TIDs (multi-TID A-MPDU). For example, Chu describes multi-TID A-MPDU as an “A-MPDU having A-MPDU subframes with at least some different TIDs,” confirming the association between this multi-TID structure and a multi-TID block acknowledgment response. SAMSUNG-1004, [0061], [0069]; *see supra* ¶¶102-110.

134. In this regard, a POSITA would have understood that the number of TIDs indicating an immediate response—among the one or more TIDs present in the A-MPDU—can serve as an additional criterion for determination of the type of the response frame. This distinction would have been obvious to a POSITA, as it was known in the art that the multi-STA BlockAck and compressed BlockAck contexts are determined based on whether multiple MPDUs within an A-MPDU share the same TID. SAMSUNG-1012, 11-12, Table 9-421 (illustrating Ack, HT-immediate BlockAck (e.g., compressed BlockAck), multi-STA BlockAck in immediate response context); SAMSUNG-1013, 27-28, Table 9-426a; SAMSUNG-1015, 913-914 (815-816), Table 8-284 (disclosing HT-immediate BlockAck (e.g., C-BA) context); SAMSUNG-1009, 1293 (1292), Table 9-425).

135. Moreover, when Chu’s teachings are considered in view of the

802.11ax standard (SAMSUNG-1005, SAMSUNG-1006), it would have been clear to a POSITA that Chu explains or suggests this TID association with response frame determination. Chu explains that the “IEEE Standard 802.11ax [was] in the process of being adopted” was “incorporated herein fully by reference.” SAMSUNG-1004, [0004].

136. For instance, the IEEE 802.11ax standard explains that multi-TID A-MPDU can contain (1) MPDU delimiters with the EOF subfield set to 1, one for each TID requesting an Ack frame, and/or (2) MPDU delimiters with the EOF subfield set to 0, one for each TID requesting a BlockAck frame. In such cases, the standard provides that “an HE STA that receives a multi-TID A-MPDU shall respond with a Multi-STA BlockAck frame.” SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1006, 4-5.

137. Accordingly, a POSITA would have understood that Chu discloses the number of TIDs indicating an immediate response as a relevant criterion in determining the response frame type.

## **B. REFERENCE 2 (“IEEE-D1”)**

138. The IEEE 802.11ax D1.0 draft (“IEEE-D1”) describes optimization of data transmission and acknowledgment processes, particularly through the use of A-MPDUs. SAMSUNG-1005, 135 (109), 131-137 (105-111), 144-149 (118-123), 160-163 (134-137), 183-193 (157-167), 218-221 (192-195).

139. IEEE-D1 describes the structure of multi-TID A-MPDUs, including the use of MPDU delimiter formats, examples of receiving such multi-TID A-MPDUs, and mechanisms for acknowledging the receipt of such multi-TID A-MPDUs with corresponding responses (e.g., Multi-STA BlockAck frame). SAMSUNG-1005, 219-220 (193-194).

140. IEEE-D1 explains that a “multi-TID A-MPDU may contain multiple noncontiguous nonzero length MPDU delimiters with EOF subfield equal to 1, one for each TID that solicits Ack and/or multiple noncontiguous nonzero length MPDU delimiters with EOF subfield equal to 0, one for each TID that solicits BlockAck.” SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1018, 179-180 (155-156) (corroborating described multi-TID A-MPDU structure).

141. Moreover, IEEE-D1 describes that when such a multi-TID A-MPDU is received, the device (e.g., High Efficiency Station (HE STA)) “shall respond with a Multi-STA BlockAck frame that contains”: 1) “One Per STA Info field indicating an Ack for each successfully received MPDU that solicits a response that is preceded by a nonzero length MPDU delimiter whose EOF is 1 (TID value equals that of the QoS Data/QoS Null frame or 15 for the Action frame)”; and 2) “One Per STA Info field indicating a BlockAck for each TID of a successfully received MPDU that solicits a response that is preceded by a nonzero length MPDU delimiter whose EOF is 0 (TID value equals that of the QoS Data frame).”

SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1018, 179-180 (155-156)

(corroborating the above).

142. Based on the above IEEE-D1 disclosure, I have summarized the multi-TID A-MPDU structures and corresponding response types disclosed in IEEE-D1 in Table 3 below.

| <div>Response type</div> <div>A-MPDU<br/>Feature</div> | <b>“Multi-STA block”<br/>acknowledgment response –<br/>1<sup>st</sup> instance<sup>4</sup></b> | <b>“Multi-STA block”<br/>acknowledgment response –<br/>2<sup>nd</sup> instance<sup>5</sup></b>                                                                        |
|--------------------------------------------------------|------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>A-MPDU Type</b>                                     | Multi-TID A-MPDU                                                                               | Multi-TID A-MPDU                                                                                                                                                      |
| <b>Policy</b>                                          | MPDUs having normal acknowledgment policy (“that solicits Ack”) within an A-MPDU               | MPDU(s) having normal acknowledgment policy (“that solicits Ack”) co-exists with MPDUs having block acknowledgment policy (“that solicits BlockAck”) within an A-MPDU |
| <b>Delimiter<br/>information of<br/>MPDU(s)</b>        | MPDUs having EOF=1, length≠0 within an A-MPDU, with each MPDU having                           | MPDU(s) having EOF=1, length≠0 co-exists with MPDUs having EOF=0,                                                                                                     |

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<sup>4</sup> SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1006, 4-5.

<sup>5</sup> SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1006, 4-5.

|  |               |                           |
|--|---------------|---------------------------|
|  | different TID | length≠0 within an A-MPDU |
|--|---------------|---------------------------|

Table 3.

143. As noted in Table 3, IEEE-D1 discloses a first instance of Multi-STA block acknowledgment response context that is the same or similar to Chu's Multi-STA block acknowledgment response context depicted in Table 2. *See supra*, Table 2. Moreover, as noted in Table 3, IEEE-D1 **additionally** discloses a second instance: when the combination (nonzero length delimiters with differing EOF values (e.g., EOFs of 1 and 0) and corresponding policies (e.g., Ack and BlockAck)) is present within an A-MPDU, such an A-MPDU can correspond to a multi-TID A-MPDU and can trigger a Multi-STA block acknowledgment response. SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1018, 179-180 (155-156).

144. The additional multi-TID A-MPDU structure disclosed in IEEE-D1 supports more flexible aggregation formats by allowing nonzero length MPDU delimiters with differing EOF values to coexist within a single A-MPDU. It is obvious that this added flexibility enables a wider range of A-MPDU types to be transmitted and received, while also allowing the receiving terminal to distinguish between acknowledgment types (e.g., compressed BlockAck, Multi-STA BlockAck). With regards to the distinguishment, for example, a BlockAck (e.g., compressed BlockAck) may be used when the received A-MPDU includes

multiple nonzero-length MPDUs associated with the same TID, each having EOF = 0 and a policy that solicits a BlockAck. SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1018, 179-180 (155-156) (“multiple noncontiguous nonzero length MPDU delimiters with EOF subfield equal to 0, one for each TID that solicits BlockAck”). In contrast, a Multi-STA BlockAck may be used [1] when the received A-MPDU includes multiple nonzero-length MPDUs associated with different TIDs, with mixed EOF values (e.g., EOF = 0 and EOF = 1), and where some MPDUs solicit an Ack while others solicit a BlockAck—or [2] when all MPDUs have EOF = 1 and solicit Acks across multiple TIDs. SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1018, 179-180 (155-156); *see* Table 3, Table 4.

### **C. REFERENCE 3 (“IEEE-D2”)**

145. The 802.11-16/1185r2 (“IEEE-D2”) discloses the same or similar subject matter found in IEEE-D1. SAMSUNG-1006, 4-5; SAMSUNG-1005, 219-220 (193-194). For example, both IEEE-D1 and IEEE-D2 **contain same or similar content under the “A-MPDU with multiple TIDs” section**, where the multi-TID A-MPDU structure and the corresponding response mechanism—namely, the Multi-STA BlockAck—are described, **as previously noted with respect to IEEE-D1 and reflected in Table 3**. SAMSUNG-1006, 4-5; SAMSUNG-1005, 219-220 (193-194); *see* Table 3. Therefore, this discussion will not be repeated here.

**D. THE CHU-IEEE-D1 OR CHU-IEEE-D2 COMBINATIONS**

146. Chu describes a system for efficient transmission and acknowledgment of data units in wireless environments, utilizing A-MPDUs that include MPDUs, policy information, and delimiters with EOF and length fields. SAMSUNG-1004, [0058], [0059], [0070]-[0076], [0157]-[0161], FIGS. 5A-5C, 18. Chu's system supports normal acknowledgment, block acknowledgment, and multi-STA block acknowledgment responses. *See* Table 2; *see also, e.g.*, ¶¶99-123. Each of IEEE-D1 and IEEE-D2 describes the use of mixed EOF values (e.g., EOF=0 and EOF=1) and mixed policies (e.g., normal acknowledgment policy and implicit block acknowledgment policy) within a multi-TID A-MPDU, thereby introducing a new format of multi-TID A-MPDU, as well as a second instance of Multi-STA BlockAck response context. *See supra* ¶¶138-145. Moreover, at least based on (i) a new multi-TID A-MPDU format allowing mixed EOF values (e.g., EOF=0 and EOF=1) and mixed policies to co-exist within an A-MPDU and (ii) description that "nonzero length MPDU delimiters with EOF . . . equal to 1" indicates "each TID that solicits Ack" and "nonzero length MPDU delimiters with EOF . . . equal to 0" indicates "one for each TID that solicits BlockAck," each of IEEE-D1 and IEEE-D2 discloses a way to distinguish between BlockAck response and Multi-STA BlockAck response. *See supra* ¶¶138-145. For example, when an A-MPDU contains both (1) one or more "noncontiguous nonzero length MPDU

delimiters with EOF subfield equal to 1, one for each TID that solicits Ack” and

(2) “multiple noncontiguous nonzero length MPDU delimiters with EOF subfield equal to 0, one for each TID that solicits BlockAck,” the receiving terminal “shall respond with a Multi-STA BlockAck frame.” SAMSUNG-1006, 4-5;

SAMSUNG-1005, 219-220 (193-194). For example, when an A-MPDU contains only “multiple noncontiguous nonzero length MPDU delimiters with EOF subfield equal to 0, one for each TID that solicits BlockAck,” the receiving terminal that receives such A-MPDU would respond with BlockAck. SAMSUNG-1006, 4-5; SAMSUNG-1005, 219-220 (193-194).

147. The Chu-IEEE-D1 or Chu-IEEE-D2 combination would have enabled support for more flexible aggregation formats by allowing nonzero length MPDU delimiters with differing EOF values and policies thereof to coexist within a single A-MPDU. This allows an A-MPDU to include a sequence of MPDUs that solicit a BlockAck and one or more single MPDUs (e.g., standalone MPDUs) that solicit Ack at the same time. This added flexibility allows the receiving terminal to distinguish between acknowledgment types—such as BlockAck (e.g., C-BA) and Multi-STA BlockAck—even when the MPDUs share the same acknowledgment policy bits (e.g., a value indicating immediate Ack/BA)—by utilizing MPDU delimiter information (e.g., EOF and length fields) and/or TID context.

148. An example of the types of response frames and corresponding

determination criteria based on Chu, incorporating the teachings of IEEE-D1 or IEEE-D2, is illustrated in Table 4 below. Table 4 has been prepared by combining Table 2 (from Chu) and Table 3 (from IEEE-D1 or IEEE-D2).

| Response type<br>A-MPDU Feature | Ack response                                    | “BlockAck” response “after a SIFS period” (e.g., C-BA response) | Multi-TID block acknowledgment response (e.g., M-BA response) | M-BA response - 2 <sup>nd</sup> instance<br>( <i>newly added based on IEEE D-1 or IEEE D-2</i> ) <sup>6</sup>        |
|---------------------------------|-------------------------------------------------|-----------------------------------------------------------------|---------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| A-MPDU Type                     | VHT Single-MPDU                                 | Single TID A-MPDU                                               | Multi-TID A-MPDU                                              | Multi-TID A-MPDU                                                                                                     |
| Policy                          | Single MPDU having normal acknowledgment policy | MPDUs within having block acknowledgment policy                 | MPDUs having normal acknowledgment policy                     | MPDU(s) having normal acknowledgment policy co-exists with MPDUs having block acknowledgment policy within an A-MPDU |

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<sup>6</sup> This 2<sup>nd</sup> instance of Multi-STA BlockAck context has been added from Table 3. *See supra* Table 3.

|                                         |                                    |                                                                                                         |                                                                                    |                                                                                             |
|-----------------------------------------|------------------------------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| <b>Delimiter information of MPDU(s)</b> | Single MPDU having EOF=1, length≠0 | MPDUs having EOF=0, length≠0, indicating a sequence of MPDUs that belong to single TID within an A-MPDU | MPDUs having EOF=1, length≠0, with each MPDU having different TID within an A-MPDU | MPDU(s) having EOF=1, length≠0 co-exists with MPDUs having EOF=0, length≠0 within an A-MPDU |
|-----------------------------------------|------------------------------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|

Table 4.

149. In particular, as noted in Table 4’s “M-BA response - 2nd instance,” each of Chu-IEEE-D1 and Chu-IEEE-D2 combinations discloses that the response frame is determined as a **Multi-STA BlockAck frame** based on a combination of:

- (1) **type of the MPDU** (co-existence of (i) standalone MPDU(s) having a unique TID or normal ACK MPDU(s) and (ii) “block ack” MPDU(s) or a sequence of MPDUs that belong to single TID within an A-MPDU) that is **determined by** EOF=0 and 1 (**EOF field**), and the “non-zero value” of “MPDU length field” (**length field**), and
- (2) the policy bits set to “immediate Ack/BA” such as “a normal acknowledgment policy (e.g., a value of ‘00’)” or “implicit block acknowledgment request (e.g., a value of ‘00’)” [**the Ack policy information**].

*See supra, e.g., Table 4, ¶¶94-96.*

**E. REASONS FOR THE COMBINATIONS**

150. It is my opinion that a POSITA would have been motivated and found it obvious to combine Chu with either IEEE-D1 or IEEE-D2 as doing so would have merely involved combining prior art elements according to known methods to yield predictable results, as explained in more detail below. In particular, a POSITA would have been motivated to combine the protocol for transmitting and receiving a multi-TID A-MPDU (as described in each of IEEE-D1 and IEEE-D2) containing MPDUs with nonzero delimiters having differing EOF values and corresponding response mechanisms (e.g., Multi-STA BlockAck) into Chu's system, and would have found the combinations predictable with a reasonable expectation of success.

151. First, adopting IEEE-D1 or IEEE-D2 enhances alignment and interoperability of Chu's system with the evolving IEEE 802.11ax standards. Chu explicitly discloses that its system incorporates by reference various IEEE 802.11 standards and explicitly discloses its processors as communicating according to the IEEE 802.11ax communication protocol. SAMSUNG-1004, [0035]-[0036], [0004]. Thus, it would have been obvious and predictable for a POSITA to modify or update Chu's system based on features described in the evolving 802.11ax specifications, including those relating to A-MPDU and acknowledgment mechanisms, as described in IEEE-D1 and IEEE-D2. SAMSUNG-1004, [0035]-

[0036], [0004]; SAMSUNG-1005, 135, 137 (109, 111), 131-137 (105-111), 144-149 (118-123), 154-155 (128-129), 160-163 (134-137), 183-193 (157-167), 218-221 (192-195); SAMSUNG-1006, 4-5; SAMSUNG-1013, 15-17, 26-28, 49-50.

152. Further, it is my opinion that a POSITA would have found the combinations predictable not only because Chu operates according to the 802.11 ax protocol, but also because the other 802.11 protocols in Chu are compatible with the 802.11ax protocol. SAMSUNG-1004, [0004] (“Various wireless technologies is described in detail in the IEEE 802.11 Standards, including for example, the IEEE Standards 802.11a/b/g, 802.11n, and 802.11ac and their updates and amendments, as well as the IEEE Standard 802.11ax now in the process of being adopted, all of which are collectively incorporated herein fully by reference”), [0035]-[0036] (explaining that, for example, processors of the AP and STA are configured to operate according to “802.11ax,” “802.11ac,” “802.11a,” and/or 802.11n” protocols). For example, the 802.11ax protocol builds upon and maintains backward compatibility with earlier 802.11 protocols, allowing 802.11-based systems to be extended or adapted to newer features. SAMSUNG-1008, 2 (“IEEE 802.11 standards/amendments are released to be backwards compatible and thus pile atop of each other by adding and removing key technical aspects”), 4 (“[a]lthough IEEE 802.11ax is an evolution of the IEEE 802.11ac standard, it aims to adopt new technologies while being backward compatible”); SAMSUNG-1010,

6 (“Because WLANs implementing IEEE 802.11ax-2019 must also support devices using any previous IEEE 802.11 PHY/MAC amendments, mechanisms must also be implemented to make it backward compatible”).

153. Second, incorporating the IEEE 802.11ax protocol enables more flexible and efficient multi-TID A-MPDU aggregation. While Chu supports multi-TID A-MPDU aggregation, with each MPDU having EOF value of 1 and each soliciting an Ack response, IEEE-D1 and IEEE-D2 describe an enhanced multi-TID A-MPDU format that allows a mix of MPDUs with EOF values of 1 and 0 and enable a single A-MPDU to include MPDUs that solicit both Ack and BlockAck responses (e.g., mixed policies). SAMSUNG-1004, [0069], [0074] (“the AP 14 generates the A-MPDU to include multiple normal ACK MPDUs . . . for example, the AP 14 generates the A-MPDU to include at most one frame from each TID corresponding to a normal acknowledgment (e.g., which asks for Ack)”), SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1006, 4-5 (“A multi-TID A-MPDU may contain multiple . . . MPDU delimiters with EOF subfield equal to 1, one for each TID that solicits Ack and/or multiple noncontiguous nonzero length MPDU delimiters with EOF subfield equal to 0, one for each TID that solicits BlockAck”). Specifically, this new type of multi-TID A-MPDU in IEEE-D1 and IEEE-D2 aggregates MPDUs including (1) sequences of MPDUs that have EOF values of 0 and solicit BlockAck, and (2) standalone MPDUs that have EOF values

of 1 and solicit Ack, all within a single multi-TID A-MPDU. *See id.* This new and enhanced format of multi-TID A-MPDU improves efficiency by allowing diverse traffic types—one or more MPDU(s) requiring Ack, other MPDUs requiring Block Ack—within a single multi-TID A-MPDU, thereby reducing the number of data units (e.g., A-MPDUs and PPDUs) that need to be constructed and transmitted. *See* Table 4.

154. Moreover, it is my opinion that a POSITA would have found the combinations predictable based on instructions provided in each of IEEE-D1 and IEEE-D2, which Chu incorporates fully by reference. SAMSUNG-1004, [0004]. IEEE-D1 and IEEE-D2 provide instructions based on the mix of EOF values for determining when to use a Multi-STA BlockAck response. Specifically, when MPDUs with nonzero length delimiters having differing EOF values (EOF=1 and EOF=0) are aggregated, IEEE-D1 or IEEE-D2 teaches that a Multi-STA BlockAck is triggered. SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1006, 4-5. In addition, IEEE-D1 and IEEE-D2 further disclose instructions for responding with a Multi-STA BlockAck frame, including the use of “One Per STA Info field,” for example, to indicate an Ack for nonzero length MPDU (with EOF=1) and BlockAck for nonzero length MPDU (with EOF=0), which are compatible with Chu’s multi-TID block acknowledgment frame (e.g., Multi-STA BlockAck frame as discussed above) structure featuring per-TID information and acknowledgment

type subfields. SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1006, 4-5; *see supra* ¶¶115-123; *see e.g.*, SAMSUNG-1004, [0089]-[0092], FIGS. 9A-9C; *see e.g.*, SAMSUNG-1003, 16-17; *see e.g.*, SAMSUNG-1005, 63-65 (37-39). These rules also build upon the existing multi-STA blockAck frame and A-MPDU acknowledgment mechanism already disclosed in Chu, in which EOF and length fields are used to distinguish acknowledgment policy and response types. *See* Table 4; SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1006, 4-5; SAMSUNG-1004, [0073]-[0076].

155. Third, IEEE-D1 and IEEE-D2 disclose additional determination point for response frame determination beyond what Chu explicitly discloses. Particularly, Chu uses EOF and length fields to distinguish Ack from BlockAck, but does not distinguish Multi-STA BlockAck context if MPDUs having different EOFs (e.g., EOF=0 and EOF=1) are present. IEEE-D1 or IEEE-D2 cures this by disclosing an additional rule that makes such a distinction (e.g., by prompting the receiving terminal to interpret the presence of MPDUs (within an A-MPDU) with different EOF values and/or policies as an indication of a Multi-STA BlockAck context, rather than a BlockAck or Ack). *See* Table 4; SAMSUNG-1005, 219-220 (193-194); SAMSUNG-1006, 4-5; SAMSUNG-1004, [0073]-[0076].

156. Fourth, it is my opinion that a POSITA would have found the combinations obvious and predictable because the response frames disclosed in the

802.11ax framework are the same as, or similar to, those in Chu, which builds upon the established A-MPDU format and associated acknowledgment frame types, including Ack response, immediate BlockAck response (e.g., compressed BlockAck response), and multi-TID block acknowledgment response (e.g., Multi-STA BlockAck response). *See* Tables 2-4; *see* ¶¶99-107, 108-114, 115-223; *see, e.g.,* SAMSUNG-1004, [0069], [0072]-[0075], [0081], [0082], [0089]-[0092], [0159]; SAMSUNG-1005, 135, 137 (109, 111), 131-137 (105-111), 144-149 (118-123), 154-155 (128-129), 160-163 (134-137), 183-193 (157-167), 218-221 (192-195); SAMSUNG-1006, 4-5; SAMSUNG-1013, 15-17, 26-28, 49-50.

Accordingly, this compatibility would have allowed Chu to readily incorporate the acknowledgment mechanisms defined in IEEE-D1 or IEEE-D2 without requiring a system redesign.

157. Fifth, the combinations would have been obvious and predictable because Chu, IEEE-D1, and IEEE-D2 utilize similar systems and component. Because all three references adopt a high-efficiency (HE) wireless framework, using technologies such as Orthogonal Frequency Division Multiplexing (OFDM), Orthogonal Frequency Division Multiple Access (OFDMA), Multiple Input Multiple Output (MIMO), and Very High Throughput (VHT), incorporating the teachings of IEEE-D1 or IEEE-D2 into Chu would have been obvious and predictable and only involve routine skill of one in the art. SAMSUNG-1004,

[0004], [0035], [0045]-[0053]; SAMSUNG-1006, 3-5; SAMSUNG-1008, 4, 6; *see e.g.*, SAMSUNG-1005, 35 (9), 171 (145), 235-239 (209-213).

158. Sixth, it is my opinion that a POSITA would have pursued the combinations because doing so is merely the application of known techniques (e.g., identifying a multi-TID A-MPDU based on EOF, length, policy information, and/or number of TIDs) to a known structure (e.g., (1) the A-MPDU described in Chu, configured to further include nonzero MPDU delimiters with differing EOF values along with existing policy framework (e.g., Ack/BlockAck), and (2) Chu's receiving terminal (AP or client station) configured to receive the A-MPDU, process the A-MPDU, and determine response frames based on the received A-MPDU) to yield predictable results (e.g., determining a multi-STA block acknowledgment response frame).

## **X. [GROUND 2] – IEEE-D3**

### **A. REFERENCE (“IEEE-D3”)**

159. *Overview of IEEE-D3's System and Support for A-MPDUs*

160. The IEEE-D3 describes wireless communication protocols encompassing various Medium Access Control (MAC) and Physical Layer (PHY) enhancements, including mechanisms for aggregated frame transmissions (A-MPDUs) and various acknowledgment procedures. SAMSUNG-1009, 123 (122) (“The purpose of this standard is to provide wireless connectivity. . . This standard

also offers regulatory bodies a means of standardizing access to one or more frequency bands. . .”), 12 (11) (“this revision specifies technical corrections and clarifications to IEEE Std 802.11 as well as enhancements to the existing medium access control (MAC) and physical layer (PHY) functions”), 1288 (1287) (disclosing dedicated section for A-MPDU), 651 (650) (“The Ack Policy subfield... identifies the acknowledgment policy that is followed upon the delivery of the MPDU”), 1288-1295 (1287-1294).

161. Notably, the standard discloses multiple types of acknowledgment frames for MAC layer and PHY layer data units exchanged between wireless communication terminals —such as Ack, Compressed BlockAck, and Multi-TID BlockAck—and explicitly describes that various acknowledgment frames (including the **Ack frame**) can be selectively employed based on the characteristics of the transmitted MAC layer data units, including information derived from the EOF and length fields of MPDU delimiters, as well as the Ack Policy subfield. SAMSUNG-1009, 1319 (1318) (“An Ack frame might be sent in immediate response to a VHT single MPDU”), 1290 (1289) (disclosing that “MPDU delimiter of a VHT single MPDU” has “EOF” value “[s]et to 1” and “MPDU Length” of non-zero value), 153 (152) (explaining that high-throughput (HT) immediate block acknowledgement corresponds to “immediate block ack mechanism that requires the use of the compressed BlockAck frame”), 1295

(1294), Table 9-428 (disclosing “BlockAck frame with a TID that corresponds to an HT-immediate block ack agreement”), 676 (675), 1461 (1460) (disclosing transmission of Multi-TID Block Acknowledgment); *see also supra* ¶61.

162. As I will further explain in detail below, IEEE-D3 is highly relevant to the ’926 Patent because it provides specific details on (i) the structure of A-MPDUs, (ii) the use of MPDU delimiters (including EOF and length fields), (iii) acknowledgment policies, and (iv) the selection of appropriate acknowledgment response frame(s) depending on both the delimiter information of the MPDU(s) and associated policy settings.

163. To begin with, the IEEE-D3 describes that both AP (e.g., AP STA) and non-AP STA, as wireless communication terminals, operate per MAC/PHY specifications and are configured to receive and transmit PPDU. *See* SAMSUNG-1009, 123 (122) (“The scope of this standard is to define one medium access control (MAC) and several physical layer (PHY) specifications for wireless connectivity for fixed, portable, and moving stations (STAs) within a local area”), 129 (128) (explaining that AP “comprises a STA”), 187 (186) (“(AP) is any entity that has STA functionality and a distribution system access function (DSAF)”), 197-198 (196-197) (“An HT STA provides PHY and MAC features . . . HT STA . . . supports transmission and reception of frames . . . HT STA has MAC features that include frame aggregation, some block ack features,” e.g., “VHT STA is an HT

STA”).

164. Moreover, IEEE-D3 generally describes “one medium access control (MAC) and several physical layer (PHY) specifications for wireless connectivity for fixed, portable, and moving stations (STAs) within a local area.” *See* SAMSUNG-1009, 123 (122). It would have been obvious to a POSITA that the wireless station and/or access point described within the IEEE-D3 (IEEE 802.11 standard (2016)), which implements MAC layer and PHY layer functions for wireless connectivity, include **a processor**.

165. Specifically, IEEE-D3 describes numerous operations that require **a processor** to carry out protocol logic, decision-making, and computation. For example, the standard describes that the stations are responsible for generating, parsing, and acknowledging MAC frames (e.g., SAMSUNG-1009, 1288-1293 (1287-1292), 651 (650); *see generally id.*, section “Frame formats”), performing synchronization and association procedures (e.g., SAMSUNG-1009, 186 (185), 1598 (1597)), implementing acknowledgment policies regarding communication of MPDU(s) or A-MPDU(s) between AP and non-AP STA (e.g., SAMSUNG-1009, 651-652 (650-651)), and supporting various MAC-layer aggregation and control mechanisms (e.g., SAMSUNG-1009, 198 (197), 1288-1296 (1287-1295), 1368-1375 (1367-1374)). For example, IEEE-D3 specifies that various MAC and PHY layer functions (e.g., data generation, frame aggregation, transmission, reception,

and protocol management) are performed by stations (e.g., HT STA, VHT STA), each of which requires processor. SAMSUNG-1009, 197-199 (196-198), Sections “4.3.13 High-throughput (HT) STA” and “4.3.14 Very high throughput (VHT) STA”; *see generally* SAMSUNG-1009. Indeed, all of these functions require processing capabilities.

166. Further, it was well known in the art that the wireless station and/or access point that implements the IEEE-D3 (IEEE 802.11 standard) would include a processor. Indeed, various prior art references that implement IEEE 802.11 standard on STA such as AP and a non-AP STA require use of a processor. SAMSUNG-1016, [0037], [0041] (generally disclosing the “STA refers to both an AP and a non-AP STA” that implements “IEEE 802.11 standard”), claims 6, 8, 9 (reciting that the station, which can be an “(AP) station” or “non...(AP) station” includes “*a processor*”); SAMSUNG-1017, [0134], [0135] (describing that general wireless apparatus, which can be an AP or an STA, includes *a processor* and a transceiver, where the transceiver “implements a PHY layer of IEEE 802.11” and the *processor* “implements a MAC layer of IEEE 802.11 and a PHY layer for performing a method of transmitting a PPDU delivered from the MAC layer”); *see also* SAMSUNG-1004, [0034]-[0043]).

167. Moreover, it would have been obvious to a POSITA that the non-AP STA and/or AP described within the IEEE-D3, which implements MAC layer and

PHY layer functions for wireless connectivity, include a transceiver. For instance, the IEEE-D3 standard defines various physical layer (PHY) signaling techniques and interface functions that are controlled by the MAC layer, and specifies that stations transmit and receive wireless frames in compliance with these PHY specifications. *See* SAMSUNG-1009, 123 (122) (“The scope of this standard is to define one medium access control (MAC) and several physical layer (PHY) specifications for wireless connectivity for fixed, portable, and moving stations (STAs) within a local area”), 123-124 (122-123) (“this standard . . . [d]efines the PHY signaling, MAC, and beamforming procedures required for operation with directional antenna patterns”); 197-199 (196-198).

168. Moreover, it was well known in the art that the non-AP STA and/or AP that implements the IEEE 802.11 standard would include a transceiver. *See* SAMSUNG-1016, [0037], [0041] (generally disclosing the station (which can be AP or non-AP STA) that implements IEEE 802.11 standard), claims 6, 8, 9 (reciting that the station, which can be an “(AP) station” or “non...(AP) station” includes “a transceiver”); SAMSUNG-1017, [0134], [0135] (describing that general wireless apparatus, which can be an AP or an STA, includes a transceiver, where the transceiver “implements a PHY layer of IEEE 802.11”); *see also* SAMSUNG-1004, [0034]-[0043].

169. *Receiving A-MPDU within a PPDU, A-MPDU Structure, and Policy*

Information

170. The IEEE-D3 describes that station, such as an HT station and a VHT station—each of which can be a non-AP station or AP— includes a processor (as described above) that is configured to receive a PPDU that includes an A-MPDU, where the A-MPDU includes one or more MPDUs that are aggregated. As discussed above in ¶¶163-168, the processor included in such station (e.g., non-AP station or AP) is configured to perform MAC/PHY operations, including receiving PPDU and transmitting acknowledgment or response frames in response. *See supra*, ¶¶163-168; *see also* SAMSUNG-1004, [0034]-[0037], [0040]-[0043] (corroborating the same).

171. For example, the IEEE-D3 explains that “*A-MPDU* consists of a sequence of one or more [aggregate-MPDU] *A-MPDU subframes*” and that “an A-MPDU is . . . carried in a single *PPDU*.” SAMSUNG-1009, 1288-89 (1287-1288), (describing the structure of A-MPDU, including A-MPDU format of “HT PPDU” and “VHT PPDU”), 1292 (1291) (disclosing that, in VHT single PPDU context “[t]he A-MPDU is transmitted within a VHT PPDU and contains a VHT single MPDU”) and generally disclosing that an “A-MPDU” is contained in a VHT MU PPDU or an SU PPDU”), 1293 (1292).

172. Moreover, the IEEE-D3 describes the transmission of *PPDU* (containing *A-MPDU*) and solicitation of immediate response, indicating that the

recipient (e.g., non-AP STA or AP) receiving the **PPDU** should acknowledge with the response, thus confirming the reception of the **PPDU**. SAMSUNG-1009, 1292-1293 (1291-1292) (“A-MPDU is transmitted in one of the contexts specified in Table 9-424 as defined by the description in the ‘Definition of context’ column, independently of whether the A-MPDU is contained in a VHT MU PPDU or an SU PPDU” and “VHT MU PPDU does not carry more than one A-MPDU that contains one or more MPDUs soliciting an immediate response), 1292-95 (1291-1294), Tables 9-424-429 (describing acknowledgement response contexts for the recipient (e.g., non-AT STA or AP) including the HT and VHT contexts, thus indicating that the HT or VHT non-AP station or AP receives the PPDU (containing A-MPDU) and responds with corresponding response frames), 1318 (1317) (“[t]he acknowledgment procedure performed by a STA that receives MPDUs that were transmitted within a VHT MU PPDU is the same as the acknowledgment procedure for MPDUs that were not transmitted within a VHT MU PPDU” . . . NOTE—All MPDUs transmitted within a VHT MU PPDU are contained within A-MPDUs”).

173. Moreover, the IEEE-D3 discloses an Ack-policy subfield of a QoS control field within an A-MPDU, in which the Ack-policy subfield indicates the acknowledgment type. *See* SAMSUNG-1009, 1292 (1291) (“All QoS Data frames within an **A-MPDU** that have a TID for which an HT-immediate block ack

agreement exists have the same value for the **Ack Policy subfield of the QoS Control field**”), 1293 (1292) ([1] disclosing that in the HT-immediate BlockAck response context, the received (“preceding”) A-MPDU of PPDU contains “implicit . . . block ack request,” [2] disclosing the “[o]ne or more QoS Data frames [within an A-MPDU] with the **Ack Policy field equal to Implicit Block Ack Request**”), 651 (650) (“The **Ack Policy subfield** is 2 bits in length and **identifies the acknowledgment policy**”), Table 9-9 (disclosing that “00” bits that represent the **Normal Ack / Implicit Block Ack** policy, where the Table 9-9 is reproduced below and annotated).

**Table 9-9—Ack Policy subfield in QoS Control field of QoS Data frames**

| Bits in QoS Control field |       | Meaning                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bit 5                     | Bit 6 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 0                         | 0     | <b>Normal Ack or Implicit Block Ack Request.</b><br><br>In a frame that is a non-A-MPDU frame or VHT single MPDU:<br>The addressed recipient returns an Ack or QoS +CF-Ack frame after a short interframe space (SIFS) period, according to the procedures defined in 10.3.2.9 and 10.22.3.5. A non-DMG STA sets the Ack Policy subfield for individually addressed QoS Null (no data) frames to this value.<br><br>Otherwise:<br>The addressed recipient returns a BlockAck frame, either individually or as part of an A-MPDU starting a SIFS after the PPDU carrying the frame, according to the procedures defined in 10.3.2.9, 10.24.7.5, 10.24.8.3, 10.28.3, 10.28.4, and 10.32.3. |

SAMSUNG-1009, Table 9-9 (illustrating a portion of the table)

174. Moreover, the four different policy values in Table 9-9 of the IEEE-D3 are consistent with four different policy values disclosed in the '926 Patent. See SAMSUNG-1009, Table 9-9; SAMSUNG-1001, 14:37-65, 15:1-7. In

particular, the first value (“00” bits), representing “Normal Ack or Implicit Block Ack” policy in the standard, corresponds to the ’926 Patent’s “first value.” As will be further discussed below, this policy value allows for at least one of a Ack frame, a compressed BlockAck frame, or a multi-TID BlockAck frame to be transmitted.

175. An example A-MPDU format that can be included within the PPDU is shown below. *See* SAMSUNG-1009, FIG. 9-741 (reproduced below, annotated). IEEE-D3 discloses A-MPDU of HT PPDU and VHT PPDU and explains that HT PPDU and VHT PPDU use the same and similar A-MPDU format, except that “the final A-MPDU subframe is not padded” in HT PPDU. SAMSUNG-1009, 1288-1289 (1287-1288), FIG. 9-741 (illustrating A-MPDU; *see also* 1288-1295 (1287-1294). Accordingly, an A-MPDU of the PPDU (including HT *PPDU* and the VHT *PPDU*) includes *one or more subframes*.

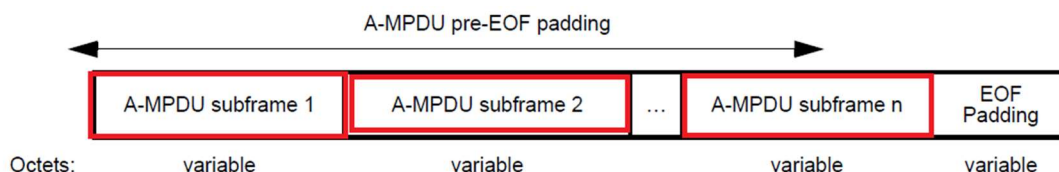


Figure 9-741—A-MPDU format

SAMSUNG-1009, FIG. 9-741.

176. As illustrated in FIGS. 9-743 and 9-744 below, the IEEE-D3 discloses that each of one or more subframes of an A-MPDU includes (1) an *MPDU delimiter* containing identifier fields: an *EOF field* and a *length field* specifying the size of the MPDU, and (2) an *MPDU*. *See* SAMSUNG-1009, 1288-1289

(1287-1288), FIGS. 9-741, 9-743, 9-744 (reproduced below, annotated).

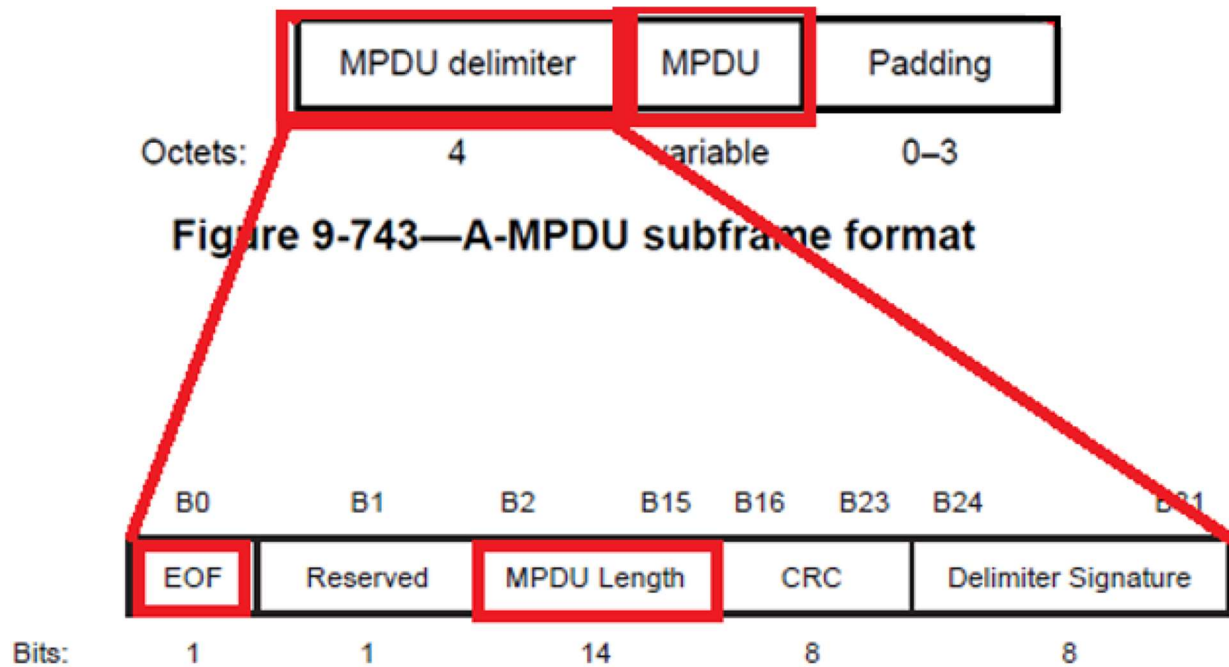


**Figure 9-744—MPDU delimiter (non-DMG)**

SAMSUNG-1009, FIGS. 9-743, 9-744.

177. The IEEE-D3 describes and/or suggests that, in response to the PPDU (including the HT PPDU or the VHT PPDU), the non-AP STA or AP—processor thereof— generates and *transmits* a response frame. For instance, as described above, the IEEE-D3 describes different acknowledgement response contexts for the recipient (e.g., non-AP STA or AP) in the HT or VHT context, which indicates that the non-AP STA or AP receives the PPDU (containing A-MPDU) and responds with corresponding response frames. *See* SAMSUNG-1009, 1292-1295 (1291-1294), Tables 9-424-429; *see also supra* ¶¶163-168, 170.

178. The IEEE-D3 explains that, in some cases, (1) the STA (which can be

AP STA or non-AP STA) “also needs to transmit one of the following immediate response frames: Ack, BlockAck frame with a TID for which an HT-immediate block ack agreement exists,” (2) “Ack frame is transmitted in response to an MPDU [within A-MPDU of PPDU] that requires an Ack frame” and (3) in the context of VHT single MPDUs (which “VHT single MPDU [VHT S-MPDU],” is defined as an “MPDU that is the only MPDU in an A-MPDU and that is carried in an A-MPDU subframe” as described above at, e.g., paragraphs ¶¶88, 182), “[t]he addressed recipient returns an Ack . . . after a short interframe space (SIFS) period.” See SAMSUNG-1009, 1292 (1291), 1295 (1294) (disclosing Tables 9-424, 9-428), 651-652 (650-651), Table 9-9 (disclosing policy bits “00” and explaining (i) VHT single MPDU context, where Ack frame is sent immediately (e.g., after SIFS) when VHT single MPDU is received by the receiving STA) and (ii) BlockAck frame context); see also *id.*, 1319 (1318) (“NOTE1 . . . An Ack frame might be sent in immediate response to a VHT single MPDU in the VHT MU PPDU”).

179. According, IEEE-D3 describes transmitting a response frame in response to the PPDU.

180. Determination of Response Frame Type – Ack Frame

181. The IEEE-D3 describes the Ack context in which, for example, the received S-MPDU or VHT S-MPDU has EOF = 1 and length  $\neq$  0, with Ack policy

bits set to “00” that indicates Normal Ack or Implicit Block Ack request. Under these conditions, the corresponding response frame is an Ack frame. SAMSUNG-1009, 1319 (1318), 1290 (1289), Table 9-422, 1371 (1370).

182. In particular, the IEEE-D3 defines “VHT single MPDU” as an “MPDU that is the only MPDU in an *A-MPDU* and that is carried in an *A-MPDU subframe* with 1 in the *EOF field*.” SAMSUNG-1009, 170 (169), 1371 (1370). Moreover, the IEEE-D3 explains that, in the context of VHT single MPDU (having EOF = 1 and length  $\neq 0$ ), corresponding policy value is set to “00” (*the Ack policy information*), and the resulting response frame is an “*Ack frame*.” See SAMSUNG-1009, 1371 (1370) (noting that for VHT single MPDU, “[d]ata frame could indicate an Ack Policy of ‘Normal Ack’, which solicits an Ack frame immediate response”), 651 (650), Table 9-9 (disclosing that policy bits of “00” indicate either “Normal Ack or Implicit Block Ack Request” and in the context of VHT single MPDU, “Ack [response] frame” is triggered), 1319 (1318) (explaining that an “*Ack frame* might be sent in immediate response to a VHT single MPDU”), 1290 (1289), Table 9-422 (describing that length is non-zero when there is MPDU present and that EOF is “[s]et to 1 in the MPDU delimiter of a VHT single MPDU”); see SAMSUNG-1012, 9-10 (corroborating the definition of VHT single MPDU).

183. Accordingly, the IEEE-D3 discloses or suggests that the “*Ack frame*”

is determined as a response frame when the A-MPDU corresponds to the VHT S-MPDU (e.g., A-MPDU containing single MPDU), which is (1) a single standalone MPDU (“*a type of the MPDU* with EOF = 1 (“*EOF field*”) and length  $\neq$  0 (“*length field*”), and (2) has corresponding policy value or bits [“*the policy information*”] of “00,” that solicits Ack or Implicit BlockAck.

184. Thus, IEEE-D3 discloses that a type of the response frame is determined as one of an Ack frame, a compressed BlockAck frame, and a multi-STA BlockAck frame according to a combination of a type of the MPDU determined by the EOF field and the length field, and the Ack policy information.

185. *Use of Compressed BlockAck for Single-TID A-MPDU*

186. The IEEE-D3 explains that when multiple QoS Data frames—each of which corresponds to an MPDU—share the same TID under an HT-immediate block acknowledgment agreement, they are acknowledged using a compressed BlockAck frame. SAMSUNG-1009, 153 (152), 1292-1293 (1291-1292), 651(650), 679-680 (678-679).

187. As an initial matter, the HT-immediate block acknowledgment response corresponds to the claimed “*compressed BlockAck frame*.” For instance, the IEEE-D3 defines HT-immediate block acknowledgment as “[a]n immediate block ack mechanism that requires the use of the *compressed BlockAck frame* and an implicit block ack request.” SAMSUNG-1009, 153 (152).

188. Moreover, the IEEE-D3 explains that HT-immediate block acknowledgment mechanism applies “if the preceding PPDU [received PPDU] contains an implicit or explicit block ack request for a **TID** for which an **HT-immediate block ack agreement** exists,” and that in such cases, “at most one BlockAck frame [**compressed BlockAck frame**] for **this TID**” is transmitted. SAMSUNG-1009, 1293-1295 (1292-1294), Table 9-425, Table 9-428.

189. Additionally, the IEEE-D3 confirms that under this **HT-immediate block ack agreement**, “QoS Data frames [**MPDUs**] with the same TID are acknowledged.” SAMSUNG-1009, 1293-1295 (1292-1294), Table 9-425, Table 9-428.

190. Accordingly, IEEE-D3 makes clear that a compressed BlockAck frame is the designated acknowledgment response when multiple MPDUs corresponding to the same TID are received. The IEEE-D3 establishes that such MPDUs corresponding to the one TID are collectively acknowledged by a single BlockAck frame, corresponding to the compressed BlockAck frame. SAMSUNG-1009, 153 (152), 1292-1295 (1291-1294), Table 9-425, Table 9-428.

## **XI. CONCLUSION**

191. For all the reasons I have noted in the foregoing paragraphs, claims 1-14 of the '926 Patent are obvious in view of the references discussed above.

192. 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 A**

**Mark P. Mahon, Ph.D.**  
Teaching Professor  
Pennsylvania State University  
School of Electrical Engineering and Computer Science  
W209A Westgate Bldg.  
University Park, PA

## Highlights

Teaching faculty experienced in research and systems development in cellular and mobile wireless networks, wireless local area networks, wireless network security, mobility management, mobile data systems including networks, protocols, and applications, wideband signal processing, modulation theory, algorithms, mathematical/analytical modeling, communication, detection and estimation, and control systems. Pursues funding for and conducts advanced research in computer and mobile networks, theoretical and experimental analysis of communication systems, cellular, wireless, and mobile systems, wideband signal processing, sensors, tracking, localization, and data fusion. Experienced in hardware/software development, data acquisition, integration, and testing, field test planning, preparation, and execution. Extensive programming experience including UI, analysis tools, real-time object-oriented programming, and embedded systems code development in C, C++, python, java, Verilog, RTL, VHDL, HDL, and assembly.

## Education

PhD. Acoustics, The Pennsylvania State University, University Park, PA 16802, 2001  
M.S. Electrical Engineering, The Pennsylvania State University, University Park, PA, 16802, 1991  
B. S. Electronics Engineering, The University of Scranton, Scranton, PA, 18510, 1987

## Employment

**July 2021 – Present:** *Teaching Professor, School of Electrical Engineering and Computer Science, The Pennsylvania State University, University Park, PA 16801*

**June 2018 – June 2021:** *Associate Teaching Professor*

**Aug. 2015 – June 2018:** *Assistant Teaching Professor*

Teach graduate and undergraduate courses in computer science and electrical engineering such as communication networks, mobile networks, neural networks, programming, mathematics, and wireless security. Advise and direct graduate students' MS and PhD research in the areas of wireless and computer networks, data pipelining, network resource allocation and optimization techniques, ultrawide band systems, multiple antenna applications, and wireless security. Guide Schreyer Honors College students' honors theses. HackPSU, BlockChain@PSU, and ML@PSU faculty adviser, member of graduate advising committees, member of Computer Science Undergraduate Curriculum Committee, member of School of EECS Management Committee, advise undergraduate electrical engineering, computer science, computer engineering, and data science students.

**2003 – Aug. 2015:** *Associate Research Professor, Applied Research Laboratory, Communications, Information, and Navigation Office, The Applied Research Laboratory, The Pennsylvania State University, State College, PA* Principal Investigator, Co-Principal Investigator, Technical lead conducting research on multi-Int data fusion and UI design to support intelligence analysts in Combat Operation Centers, cellular and mobile networks, computer network security, mobile communication systems, and wideband signals and image processing with total funding over \$12M.

**2002 – 2003:** *Sr. Systems Engineer, Klein & Stump, Inc., 2120 Washington Blvd. #400, Arlington, VA 22204* Researcher and technical consultant working on wireless communications projects for US Special Operations Command (SOCOM) and Naval Information Warfare Activity (NIWA). Awarded \$150k SBIR for SOCOM advanced signal simulator.

**1991 – 2002:** *Assistant Research Professor, Applied Research Laboratory, Communication Sciences and Technology Division, The Applied Research Laboratory, The Pennsylvania State University, State College, PA 16804* Principal Investigator and researcher conducting research on cellular and mobile networks, wideband signals, tracking and localization, adaptive signal processing, acoustic propagation, sensor systems, remote sensing, and active noise control. Awarded \$750k for development of novel wavelet based wideband signal detection for high altitude sensors.

**1988 – 1989:** *Program Engineer, Central Intelligence Agency, Langley, VA 22101* Assisted in the development of algorithms and signal processing systems for novel applications in the areas of RF communications and signal modulation techniques.

### **Detailed Research Experience:**

#### *Current ongoing research:*

Resource allocation and scheduling improvements in NG networks and edge computing; Multiple Input Multiple Output antenna techniques for increased capacity in NG systems; Fast handover techniques using blockchains to reduce mobility interruption times in 5G networks; AI/NN techniques applied to network scheduling and optimization, and mobile robotics for localization and mapping; Automated object detection and 3D mapping using sonar array data. Security vulnerabilities in UWB ranging.

#### *2015 – Present*

Lead graduate and undergraduate student research in wireless communication networks, distributed video processing in cellular systems, UWB ranging, communication systems and security, software defined network security, application of game theory to cyber resiliency, wireless, machine learning, big data analytics, and artificial intelligence for mobile and computer network security and automated detection in acoustic and sonar systems.

#### *2014 – 2015*

Leading internal research and development effort on deep packet inspection for zero day and predictive detection for data networks. Technical performer developing novel deformable wavelet-based contour matching technique for automated object detection in satellite images. Acoustic tracking and identification of drones for area defense system.

#### *2014*

Developed real-time scanner for 802.15.4 (LR-WPAN) protocol deployed on software defined radio platform.

#### *2013-2014*

Technical lead on developing novel mathematical model for analyzing torpedo acoustic threat surrogate systems for US Navy. Experimental lead on disposable, adaptive, high bandwidth fiber-optic undersea communication system for US Navy.

#### *2013*

Implemented a novel matched filter receiver for a unique OFDM signal of interest to facilitate signal detection in a high co-channel interference environment of a wide field of view high altitude

receiver and wideband signal set design in highly complex propagation environments for Department of Defense (DoD).

*2012-2013*

Technical lead for design and implementation of a real-time transmitter/receiver on a software defined radio platform for maritime communication systems (Automatic Information System/Maritime Security).

*2012*

Communications/signal processing technical consultant on Maritime Domain Operations and Unmanned Surface Ship Interdiction study effort for US Navy.

*2011-2012*

Principal Investigator, technical and experimental lead on fiber optic undersea communication system for Advanced Submarine System Development effort for US Navy.

*2011*

Technical lead on mathematical analysis, algorithm development, and implementation of pattern of life signal to noise ratio analysis in high co-channel interference environment for DoD.

Trusted agent for Army Research Lab to review and critically analyze work associated with wideband signaling and passive emissions collection from cell phones. Reviewed contractor data analysis and technical briefings for scientific accuracy and rigor. Advised the sponsor on contractor testing methodologies, procedures, and analysis techniques. Technical lead implementing unique wideband acoustic communication system and specialized signal processing hardware for an acoustic system being utilized in a complex maritime environment for the DoD.

*2009 – 2010*

Tiger team lead for large unmanned undersea vehicle (UUV) assigned to identify platform induced electromagnetic interference with electronic payload system in the HF and acoustic regimes for the US Navy.

Developed and implemented a novel algorithm to calculate the effective force charge based on muzzle sensor data utilizing MEMS transducers and PIC controller on a portable howitzer for the US Army.

Conducted study and authored Intelligence, Surveillance, and Reconnaissance (ISR) for Unmanned/Minimally Manned Undersea Vehicle (UMUV) report presented to Defense Advanced Research Projects Agency (DARPA).

*2006 – 2009*

Principal Investigator for a multi-year research and FPGA-based engineering prototype development effort in the area of 3G/4G (UMTS/LTE) cellular and wireless (IEEE 802.16 and 802.11) communication systems; Effort consisted of three phases: theoretical and analytical study, proof-of-concept development, and testing, and prototype development for DoD.

*2005-2006*

Technical lead on Information Fusion engine integration into a sandbox enclave at Joint Interagency Task Force South (JIATF-S) to support multi-int data fusion.

*2003 – 2006*

Principal Investigator for multi-year Office of Secretary of Defense sponsored research program in the area of multi-intelligence data fusion (fusion engine and UI interface) as part of the overall initiative of Force Transformation; worked extensively with NGA, DIA, DISA, OSD, all military services, and some coalition components. Led team of software engineers to develop scalable user-facing application and backend data fusion engines.

*2002 – 2003*

Pursued funding for research interests in the areas of wireless/wideband communications, wideband systems, source detection/localization, intelligent system of systems design, and data fusion; Awarded Phase I, Small Business Innovative Research contract for Portable Signal Training System by SOCOM (02-013); Technical consultant for Naval Information Warfare Center on Common for High Performance Computing Software Support Initiative's (CHSSI) Electronic Battlefield Environment (EBE) portfolio (Electromagnetic Environmental Effects Toolkit), SBIR, MERIT/TENCAP, TST programs

*1998 – 2002*

Researcher and principal investigator performed research in large time-bandwidth product (wavelets) source detection and localization – theoretical, analytical, and field testing; CDMA IS-95A/3G cellular communications; Developed mathematical analytical models and included code development of the CDMA air interface physical layer implementing major aspects of the CDMA protocol for test and analysis purposes; Built real-time hardware platform for deploying developed CDMA physical layer code.

*1996 – 1998*

Principal Investigator in charge of signal processing algorithm and code development, image acquisition and compression, telephony, and user interface design for an experimental remote, autonomous, acoustic rockslide detection for Conrail. Work included algorithm and code development utilizing embedded digital signal processing (DSP) board and development of unique algorithms for real-time monitoring of transducers to create an event detection system.

*1991 – 1997*

Performed fundamental research in the areas of signal processing algorithm development, acoustic atmospheric propagation, detection, source localization, beamforming, system identification, and active control; Main responsibilities include real-time code development (C, Visual C++, assembly) for signal processing systems, adaptive beamforming, and embedded processing for eight major projects during this time. Multiple DSP platform development; Active Noise Control, feature extraction, data logging and fusion, passive acoustic tracking, beamforming, and analysis for these projects

*1988-1989*

Assisted in the development of algorithms and signal processing systems for novel applications in the areas of RF communications and signal modulation techniques.

## **Case History:**

*October 2024 – March 2025, Carmichael, IP*

*Aylo Freesites LTD v. Wellcomemat LLC IPR2024-00710 (IPR)*

Consulting for respondent Wellcomemat. Technology related to remote editing of video content. Filed declaration 2/12/25. Deposed 3/13/25.

*May 2024 – Present, McKool Smith*

*AT&T Services, Inc, Cellco Partnership D/B/A Verizon Wireless, Ericsson, Inc., and Nokia Corporation v. ASUS Technology Licensing, Inc. (IPR)*

Consulting for petitioners. Technology related to control signaling in 5G networks. Filed declarations on 6/4/24 and 10/16/24.

*May 2024 – July 2024, Merchant & Gould*

*Apex Beam Technologies LLC v. TCT Mobile International Ltd. Case No. 2:21-cv-438 (EDTX)*

Consulting for defendant TCT. Technology related to signaling in 5G cellular networks. Wrote submitted claim construction declaration filed on 7/17/24. Deposed 7/31/24 on claim construction declaration.

*March 2024 – February 2025, Duane Morris*

*Ericsson and Nokia v. Active Wireless IPR2024-00886, -00951, -00985, -00986*

*Active Wireless v. T-Mobile, Ericsson, and Nokia Case No. 2:23-cv-00261 (EDTX)*

Consulted for petitioners Ericsson and Nokia. Technology related to signaling in 4G and 5G cellular networks. Wrote four declarations for IPR. Consulted for defendants T-Mobile and intervenors. Submitted invalidity report for defendant and intervenors; deposed 12/4/24.

*March 2024 – May 2024, Quinn Emanuel, LLP*

*Samsung Electronics Co., Ltd. v. Datang Mobile Communications Equipment Co., Ltd.*

Consulted for petitioner Samsung. Technology related to random access in 4G/5G cellular networks. Wrote declaration in support of claim construction. Case stayed.

*January 2024 – Present, McKool Smith*

*Headwater Research, LLC v. AT&T Corp. et al, Case No. 2:23-cv-00398*

Consulting for defendant. Technology related to control of battery and data usage in 4G/5G user devices. Filed a rebuttal report 3/13/25. Deposed 3/19/25.

*December 2023 – Present, Duane Morris*

*Ericsson, Inc. and Nokia of America v. XR Communications, LLC, IPR2024-00613 (IPR); Case No. 2:23-CV-00202-JRG-RSP (EDTX).* Consulted for petitioners and defendants. Technology related to MIMO in cellular networks. Filed declarations on 3/6/24. Deposed 1/7/25.

*October 2023 – April 2024, Erise IP; Finnegan, DLA Piper, Husch Blackwell*

*BNR v. ASUSTek/Media Tek/Laird/NXP Inc. Inv. No. 337-TA-1367 (USITC).* Consulting for defendant ASUS on ASUS (Qualcomm-based products) non-infringement and JDG (ASUS/Media Tek/ Laird/ NXP) on Tech DI non-infringement on WiFi wireless devices and semiconductor chips with wireless capabilities related to wireless transmission technologies. Wrote rebuttal report. BNR settled with ASUS and Media Tek; BNR withdrew complaint for NXP.

*September 2023 – April 2024, McKool Smith*

*Daingean Technologies Ltd. v. AT&T, et al, Case No. IPR2024-00309.* Consulting for petitioner AT&T. Technology related to 5G wireless transmissions. Wrote declarations. Case settled.

*August 2023 – December 2023, Greenberg Traurig*

*Atlas Global Technologies, LLC v. Acer Incorporated, No. 2:22-cv-00259 WDTX.* Consulting for defendant Acer. Technology related to wireless transmissions in WiFi networks. No reports. Settled.

*August 2023 – February 2025, McKool Smith*

*Ericsson v. Lenovo/Motorola, In the Matter of Certain Mobile Phones, Components Thereof, and Products Containing Same, Inv. No. 337-TA-1375 (USITC); IPR204-00702 (IPR)*

Consulting for Complainant Ericsson on technology related to 5G cellular signaling technology. Infringement and invalidity rebuttal. Testified at the ITC. Filed Decl 12/6/24. Deposed IPR 2/12/25.

*August 2023 – Present, Caldwell, Cassady and Curry*

*Neo Wireless, LLC v. Ford, et al., Case No. 2:22-MD-03034.* Consulting for plaintiff on technology related to 4G cellular radio access. Wrote infringement and invalidity rebuttal reports.

*June 2023 – November 2023, Duane Morris*

*Ericsson, Inc., and Cellco Partnership D/B/A Verizon Wireless v. Woodbury Wireless LLC., IPR 2023-01364.* Consulted for petitioner Verizon. IPR. Technology related to MIMO and minimization of interference. Declaration filed 10/10/23. Case settled.

*January 2023 – April 2023, McKool Smith*

*Ericsson v. Koninklijke KPN N.V., Case No. IPR2023-00582.* Consulting for Petitioner Ericsson. IPR. Technology related to neighbor cell lists in wireless systems. Declaration filed 2/17/23.

*November 2022 – April 2023, Finnegan, Henderson, Farabow, Garrett & Dunner, LLP*

*Qualcomm, Inc. vs. FedEx, Inc., IPR 2022-00585.* Consulting for patent owner FedEx. Wrote IPR declaration. Deposed 4/19/23. Technology related to sensor information collected by tracking devices.

*October 2022 – November 2023, BC Law Group, P.C.*

*Lionra Technologies Limited v. Apple, Inc. Case No. 6:22-cv-00351-ADA, WDTX*

Consulting for patent owner Lionra. Case dismissed 11/18/23.

*September 2022 – June 2023, Quinn Emanuel, LLP*

*Google LLC v. Sonos, Inc., Inv. No. 337-TA-1330 (USITC)*

Consulting for patent owner Google. Wrote infringement and validity rebuttal reports.

Technology related to voice assistants and smart devices. Deposed 4/14/23. Testified at trial 6/20/23 and 6/23/23.

*September 2022 – August 2023, BC Law Group, P.C.*

*Apple, Inc. vs. Speir Technologies Limited, IPR2022-01512 and -00151*

Consulted for patent owner Speir on UWB localization technology. Wrote IPR declarations. Deposed 10/25/23. Case dismissed 11/18/23.

*August 2022 – July 2024, Venable, LLP*

*VoIP-Pal.com, Inc. v. Verizon Communications Inc. Case No. 6:21-cv-00672, WDTX*

Consulting for defendant Verizon. Wrote non-infringement report. Deposed 5/17/23.

Technology relates to VoIP in cellular networks. Summary judgement of non-infringement.

*July 2022 – November 2023, Quinn Emanuel Urquhart & Sullivan, LLP*

*Evolved Wireless LLC v. Samsung Electronics Co., Ltd., and Samsung Electronics America, Inc., Case No. 2:21-cv-00033, EDTX.* Technology related to handovers in 4G networks.

Consulting for defendant Samsung. Wrote non-infringement and validity rebuttal report. Deposed 7/5/23; Testified at trial 11/14/23.

*March 2022 – Dec. 2022, Knobbe, Martens, Olson & Bear, LLP*

*Jawbone Innovations, LLC v. Amazon.com, Inc., et al.*

Consulting for petitioner Amazon (IPR). Technology related to tracking using acoustic arrays. Case stayed. No reports.

*May 2022 – Dec. 2022, McKool Smith; Alston Bird*

*Ericsson Inc. and Telefonaktiebolaget LM Ericsson vs. Apple Inc., Case No. 2:21-cv-376, EDTX*

Consulted for plaintiff and counter-defendant Ericsson.

Report on Essentiality and Rebuttal report (FRAND). Deposed 10/4/2022. Testified 12/7/2022. Case settled during trial.

Broad spectrum of technology related to cellular networks (core network and mobile device)

*March 2022 – Dec. 2022, McKool Smith*

*Ericsson Inc. and Telefonaktiebolaget LM Ericsson vs. Apple Inc., Inv. No. 337-TA-1299, ITC*  
Consulted for Ericsson. Opening and Rebuttal report. Deposed 10/7/2022. Case settled.  
Technology related to security in cellular systems.

*January 2022 – March 2023, Duane Morris*

*Telecom Network Solutions v. AT&T Inc., et al, Case No. 2:21-cv-415 and Verizon Communications Inc., et al, Case No 2:21-cv-416, EDTX*  
Consulted for defendants AT&T and Verizon on Invalidity. Case settled; no reports filed.  
Technology related to QoS in cellular networks.

*September 2021 – December 2021, Duane Morris, LLP*

*KAIFI LLC v. Verizon Wireless, Case No. 2:20-cv-280-JRG, EDTX*  
Consulted for defendant Verizon. Wrote Non-Infringing Alternatives and Non-Infringement reports.  
Deposed 12/15/21. Case settled. Technology related to cellular and WiFi enablement cellular systems.  
*September 2021 – December 2021, Quinn Emanuel, LLP*

*L2 Mobile Technologies, LLC v. Google, Case No. 6:21-cv-358, WDTX*

Consulted for defendant Google. Wrote reply Claim Construction brief. Case settled.  
Technology related to control signaling in cellular systems.

*August 2021 – May 2022, McKool Smith*

*Godo Kaisha IP Bridge 1 v. Ericsson, Case No. 2:21-cv-00213-JRG, EDTX*  
Consulted for defendant Ericsson. IPR and Claim Construction declarations.  
Technology related to signaling in OFDM systems.

*July 2021 – August 2021, Quinn Emanuel, LLP*

*Finesse Wireless, LLC v. Nokia, et al., Case No. 2:21-CV-00063-JRG, EDTX*  
Consulted for defendant Nokia on claim construction. Wrote declaration and deposed on 8/17/21.  
Technology related to coding techniques in wireless systems.

*June 2021 – Dec 2021, Knobbe, Martens, Olson & Bear, LLP*

*Vocalife LLC v. Amazon.com, Inc., et al., Case No. 2:20-cv-00401-JRG-RSP, EDTX*  
Consulted for defendant Amazon on claim construction. Stayed pending sister case outcome.  
Technology related to echo cancelation and signal enhancement in acoustic systems.

*March 2021 – Sept 2021, Wilson Sonsini*

*Lenovo Holding Co, Inc., et al. v. InterDigital Technology Corp.*  
IPR. Consulted for InterDigital. Wrote three declarations. Deposed 7/27/21.  
Technology related to control signaling in cellular systems.

*January 2021 – May 2021, Winston & Strawn, LLP*

*Ericsson, Inc. v. Samsung Electronics, Ltd., ITC*  
Consulted for plaintiff. Settled May 2021. No deposition. No declaration filed.  
Patents dealt with antenna arrays for 5G/4G base stations, access point signaling, bearer handling.

*November 2020 – June 2021, Sheppard Mullin*

*Hong Kong uCloudlink v. SIMO Holdings, Inc. and Skyroam, Inc., Case No. 18-cv-05031-EMC, NDCA.* Consulted for plaintiff uCloudlink on infringement and validity. Deposed (3/26/21). Case settled. Virtual SIM technology.

*August 2019 – August 2020; June 2021 – Sept 2021 McKool Smith/Irell & Manella  
Optis Wireless Technology, LLC et al. v. Apple, Inc., EDTX, Civ No. 2:19-cv-66*  
Consulted for plaintiff Optis. Infringement and validity analysis/reports, IPR. Deposed 06/01/20 and testified at trial 8/3/20 – 8/9/20. Re-trial for damages 8/10/21 – 8/16/21.

*March 2019 – May 2020 Gibson, Dunn, & Crutcher, LLP  
Sol IP v. AT&T, Ericsson, Nokia, Verizon, and Sprint, EDTX, Case No. 2:18-cv-526*  
Consulted for defendants on patents involving LTE downlink cell search and synchronization signaling. Invalidity, non-infringement analysis/reports, claim construction. No deposition, case settled.

*2016 – March 2019 Sidley Austin, LLP  
Huawei v. Samsung, NDCA  
Case No. 3:16-cv-02787-WHO*  
Consulted for plaintiff Huawei on original complaint and for defendant Huawei on counterclaims on patents involving control channel signaling, network access, and security. Assisted claim construction, IPR petition and preliminary response, wrote validity and non-infringement reports. Deposed 6/20/18, 7/19/18. Case settled.

*2016 Russ, August & Kabat  
Core Wireless v. Apple, Court of Northern California, Case No. 6:14-cv-752-JDL*  
Consulted for plaintiff on patents associated with core network signaling. Wrote infringement and validity reports and rebuttals. Performed source code review and conformance testing. Deposed (8/12/2016). Patent was dropped during down-select before trial.

*2015 - 2016 Hueston & Hennigan  
Core Wireless v. LG Electronics, Court of Eastern Texas, Case No. 2:14-cv-911-JRG-RSP (lead case),  
Case No. 2:14-cv-912-JRG-RSP (consolidated)*  
Consulted for plaintiff on patents on cellular user interface. Present at jury trial (3/2016) and participated in mock jury trial (2/10/2016). Wrote rebuttal expert report on validity and deposed (12/11/2015). Wrote infringement report regarding cellular protocols. Performed source code review and conformance testing. Core Wireless prevailed.

*2015 Bunsow De Mory Smith & Allison  
Core Wireless v. LG Electronics, Court of Eastern Texas, Case No. 2:14-cv-911-JRG-RSP (lead case),  
Case No. 2:14-cv-912-JRG-RSP (consolidated) and Core Wireless v. Apple, Case No. 6:14-cv-752-JDL*  
Consulted for plaintiff on patents associated with core network signaling. Wrote declarations on claim construction. Prepared tutorial to be presented to court. Case handed off to Hueston & Hennigan.

## **Case Testimony History:**

*October 2024 – Present, Carmichael, IP  
Aylo Freesites LTD v. Wellcomemat LLC IPR2024-00710 (IPR)*  
Consulting for respondent Wellcomemat. Technology related to remote editing of video content. Filed declaration 2/12/25. Deposed 3/13/25.

*May 2024 – July 2024, Merchant & Gould  
Apex Beam Technologies LLC v. TCT Mobile International Ltd. Case No. 2:21-cv-438-JRG (EDTX);  
Case Filed 04/22/24. Consulting for defendant TCT. Technology related to signaling in 5G cellular networks. Submitted claim construction declaration 7/17/24. Deposed 7/31/24 on claim construction declaration.*

*March 2024 – February 2024, Duane Morris*

*Ericsson and Nokia v. Active Wireless IPR2024-00886, -00951, -00985, -00986*

Consulted for petitioners Ericsson and Nokia. Technology related to signaling in 4G and 5G cellular networks. Wrote four declarations for IPR. Deposed 12/4/24.

*January 2024 – Present, McKool Smith*

*Headwater Research, LLC v. AT&T Corp. et al, Case No. 2:23-cv-00398*

Consulting for defendant. Technology related to control of battery and data usage in 4G/5G user devices. Filed a rebuttal report 3/13/25. Deposed 3/19/25.

*December 2023 – Present, Duane Morris*

*Ericsson, Inc. and Nokia of America v. XR Communications, LLC, IPR2024-00613 (IPR); Case No. 2:23-CV-00202-JRG-RSP (EDTX).* Consulted for petitioners and defendants. Technology related to MIMO in cellular networks. Filed declarations on 3/6/24. Deposed 1/7/25.

*October 2023 – April 2024, Erise IP; Finnegan, DLA Piper, Husch Blackwell*

*BNR v. ASUSTek/Media Tek/Laird/NXP Inc. Inv. No. 337-TA-1367 (USITC).* Consulting for defendant ASUS on ASUS (Qualcomm-based products) non-infringement and JDG (ASUS/Media Tek/ Laird/ NXP) on Tech DI non-infringement. Wrote on WiFi wireless devices and semiconductor chips with wireless capabilities related to wireless transmission technologies. Wrote rebuttal report. Deposed 2/8/24. BNR settled with ASUS and Media Tek; BNR withdrew complaint before hearing.

*September 2023 – June 2023, Quinn Emanuel, LLP*

*Google LLC v. Sonos, Inc., Inv. No. 337-TA-1330 (USITC)*

Consulting for patent owner Google. Wrote infringement and validity rebuttal reports. Technology related to voice assistants and smart devices. Deposed 4/14/23. Testified 6/20-23/23.

*August 2023 – July 2024, McKool Smith*

*Ericsson v. Lenovo/Motorola, In the Matter of Certain Mobile Phones, Components Thereof, and Products Containing Same, Inv. No. 337-TA-1375 (USITC); IPR204-00702 (IPR)*

Consulting for complainant Ericsson on technology related to 5G cellular signaling technology. Wrote infringement and invalidity rebuttal. Deposed 5/23/24. Testified 7/16/24. Wrote IPR declaration filed on 12/6/24. Deposed for IPR 2/12/25.

*August 2023 – Present, Caldwell, Cassady and Curry*

*Neo Wireless, LLC v. Ford, et al., Case No. 2:22-MD-03034.* Consulting for plaintiff on technology related to 4G cellular radio access. Wrote infringement and invalidity rebuttal reports. Deposed 5/16/24 and 5/17/24.

*November 2022 – April 2023, Finnegan, Henderson, Farabow, Garrett & Dunner, LLP*

*Qualcomm, Inc. vs. FedEx, Inc., IPR 2022-00585*

Consulting for patent owner FedEx. Wrote IPR declaration. Deposed 4/19/23. Technology related to sensor information collected by tracking devices.

*September 2022 – November 2023, BC Law Group, P.C.*

*Apple, Inc., vs. Speir Technologies Limited, IPR2022-01512 and -00151*

Consulted for patent owner Speir on UWB localization technology. Wrote IPR declarations. Deposed 10/25/23. Case dismissed 11/18/23.

*August 2022 – July 2024, Venable, LLP*

*VoIP-Pal.com, Inc. v. Verizon Communications Inc. Case No. 6:21-cv-00672, WDTX*

Consulting for defendant Verizon. Wrote non-infringement report. Deposed 5/17/23. Technology relates to VoIP in cellular networks. Summary judgement of non-infringement.

*July 2022 – November 2023, Quinn Emanuel Urquhart & Sullivan, LLP*  
*Evolved Wireless LLC v. Samsung Electronics Co., Ltd., and Samsung Electronics America, Inc., Case No. 2:21-cv-00033, EDTX.* Technology related to handovers in 4G networks.  
Consulting for defendant Samsung. Wrote non-infringement and validity rebuttal report. Deposed 7/5/23; Testified at trial 11/14/23. Jury found for defendant on all counts.

*March 2022 – December 2022, McKool Smith*  
*Ericsson Inc. and Telefonaktiebolaget LM Ericsson vs. Apple Inc., Inv. No. 337-TA-1299, ITC*  
Consulting for Ericsson. Opening and Rebuttal report. Deposed 10/7/2022. Testified 12/7/2022. Case settled during trial.

*May 2022 – December 2022, McKool Smith; Alston Bird*  
*Ericsson Inc. and Telefonaktiebolaget LM Ericsson vs. Apple Inc., Case No. 2:21-cv-376, EDTX*  
Consulting for plaintiff and counter-defendant Ericsson.  
Report on Essentiality and Rebuttal report. Deposed 10/4/2022. Case settled.

*September 2021 – December 2021, Duane Morris, LLP*  
*KAIFI LLC v. Verizon Wireless, Case No. 2:20-cv-280-JRG, EDTX*  
Consulted for defendant Verizon. Wrote Non-Infringing Alternatives and Non-Infringement reports. Deposed 12/15/21. Case settled.

*July 2021 – August 2021, Quinn Emanuel, LLP*  
*Finesse Wireless, LLC v. Nokia, et al., Case No. 2:21-CV-00063-JRG, EDTX*  
Consulted for defendant Nokia on claim construction. Technology related to noise in the front-end of receiver. Deposed on 8/17/21.

*March 2021 – Sept 2021, Wilson Sonsini*  
*Lenovo Holding Co, Inc., et al. v. InterDigital Technology Corp.*  
IPR. Consulted for InterDigital. Technology related to control signaling in cellular systems. Wrote three declarations. Deposed 7/27/21.

*November 2020 – June 2021, Sheppard Mullin*  
*Hong Kong uCloudlink v. SIMO Holdings, Inc. and Skyroam, Inc., Case No. 18-cv-05031-EMC, NDCA.* Consulted for plaintiff uCloudlink on infringement and validity. Technology related to virtual SIM. Deposed 3/26/21.

*August 2019 – August 2020; June 2021 – Sept 2021 McKool Smith/Irell & Manella*  
*Optis Wireless Technology, LLC et al. v. Apple, Inc., EDTX, Civ No. 2:19-cv-66*  
SEPs – Consulted for plaintiff Optis on control channel MIMO switching, control channel information fields. Infringement and validity analysis/reports, IPR. Deposed 06/01/20 and testified at trial 8/3/20 – 8/9/20. Testified at re-trial for damages 8/10/21 – 8/16/21.

*2016 – March 2019 Sidley Austin, LLP*  
*Huawei v. Samsung, NDCA*  
*Case No. 3:16-cv-02787-WHO*  
Consulted for plaintiff Huawei on original complaint and for defendant Huawei. Assisted claim construction, IPR petition and preliminary response, wrote validity and non-infringement reports. Deposed 6/20/18, and 7/19/18.

*2016 Russ, August & Kabat*  
*Core Wireless v. Apple, Court of Northern California, Case No. 6:14-cv-752-JDL*  
Consulted for plaintiff on patents associated with core network signaling. Wrote infringement and validity reports and rebuttals. Performed source code review and conformance testing. Deposed (8/12/2016). Patent was dropped during down-select before trial.

2015 - 2016 Hueston & Hennigan

*Core Wireless v. LG Electronics, Court of Eastern Texas, Case No. 2:14-cv-911-JRG-RSP (lead case), Case No. 2:14-cv-912-JRG-RSP (consolidated)*

Consulted for plaintiff on patents on cellular user interface. Present at jury trial (3/2016) and participated in mock jury trial (2/10/2016). Wrote rebuttal expert report on validity and deposed (12/11/2015). Wrote infringement report regarding cellular protocols. Performed source code review and conformance testing. Core Wireless prevailed.

## Teaching:

### Courses:

- CSE 516 (Mobile Networks): Redesigned the course to integrate latest developments in mobile network architecture design. The course now includes signaling, control, and protocol issues unique to 4G/5G architectures addressing eMBB, mMTC, and URLLC use cases critical to IoT and future wireless network development and future NG networks.
- CSE 514 (Communication Networks)
- CSE 590 (Colloquium)
- CMPEN 462 (Wireless Communication Systems and Security): Created and designed this course to address a gap in the wireless communications area focusing on security. This course is included in the cybersecurity computational foundations minor.
- EE 466 (Introduction to Software-Defined Radio: Overview of the principles of software-defined radio systems with laboratory components.
- EE 456 (Introduction to Neural Networks): This course is intended to address the need for EE and CMPEN students to be exposed to the principles associated with artificial intelligence.
- CMPEN/EE 362 (Communication Networks)
- CMPSC 263 (Blockchains and Modern Web Development): This course is ‘module’ driven and designed to provide students with a broad range of academic backgrounds an opportunity to learn about blockchains and cryptography. Under supervision, students in the Distributed Ledger Society teach the modules including theory and practice in the areas of programming, math, and cryptography.
- ACS 505 (Experimental Techniques in Acoustics)
- MATH 141 (Calculus with Analytical Geometry II)
- CMPSC 101 (Programming in C++)

## Publications:

Rublein, Mehmeti, Mahon, and LaPorta, “Impact of Client Choice on Distributed Resource Allocation in Edge Computing”, *The 33<sup>rd</sup> International Conference on Computer Communications and Networks (ICCCN 2024)*, IEEE and IEEE Communication Society, July 29 – 31, 2024, Big Island, Hawaii, USA.

Rublein, Mehmeti, Mahon, and LaPorta, “Improved Methods of Task Assignment and Resource Allocation with Preemption in Edge Computing Systems”, *IEEE Transactions on Parallel and Distributed Computing*. Submitted July 2023.

Sorensen, Mahon, Mehmeti, and LaPorta, QoE-Analysis of 5G Network Resource Allocation Schemes for Competitive Multi-User Video Streaming Applications, *IEEE Conference on Vehicular Technology*, Florence, Italy, June 2023.

Sorensen, Mehmeti, Mahon, LaPorta, and Cao, “EQMS: An Improved Energy-Aware and QOE-aware Video Streaming Policy across Multiple Competitive Mobile Devices”, *Wireless Networks: The Journal of Mobile Communication, Computation and Information*, Dec. 2022.

- Sorensen, Mehmeti, Mahon, Qui, Chan, Qui, and LaPorta, "Optimal Resource Allocation for Crowdsourced Image Processing", *IEEE Transactions on Mobile Computing*. June 2022.
- Sorensen, Mehmeti, Mahon, La Porta, Cao, "Mutli-User Competitive Energy-Aware and QoE-Aware Video Streaming on Mobile Devices", *ACM Proceedings of the QoS and Security for Wireless and Mobile Networks (Q2SWinet) Symposium collocated with Modeling, Analysis, and Simulation of Wireless and Mobile Systems (MSWIM 2020)*, Alicante, Spain, Nov. 2020.
- Sorensen, Mehmeti, Mahon, Qui, Chan, and LaPorta, "Optimal Resource Allocation for Crowdsourced Image Processing", *IEEE International Conference on Sensing and Networking (IEEE SECON 2020)*, Como, Italy, June 2020.
- Swanson, Mahon, Norris, and Mast, "Atmospheric Multipath Resolution Using Spread Spectrum Acoustic Signals", *Proceedings of Meetings on Acoustics*, September 2017.
- Aquaviva, Mahon, Einfalt, and LaPorta, "Optimal Cyber-Defense Strategies for Advanced Persistent Threats: A Game Theoretic Approach," *2017 International Symposium on Reliable and Distributed Systems*, Hong Kong, China, September 27 – 29, 2017
- Young, Mahon, and Wyckoff, "Automated Information Management," Chap. 12, *Mathematical Techniques in Multisensor Data Fusion*, Hall, David L., Artech House Inc., Mar 2004
- Mahon, Sonsteby, and Wenchel, "Application of Non-Orthogonal Waveletes for Geolocation," *Radiolocation and Direction Finding Symposium*, Southwest Research Institute, San Antonio, Texas, 2-4 Nov. 1999.
- Myers, Lovette, Kilgus, Giannini, Swanson, Reichard, Mahon, Mast, "A Java-based Information System for Wayside Sensing and Control," *Proc. of the 1998 ASME/IEEE Joint Railroad Conference*, 1998, pp. 135-147.
- Swanson, Mast, Mahon, "Atmospheric Multipath Resolution Using Spread Spectrum Acoustic Signals," *Proceedings of the 133<sup>rd</sup> Meeting of the ASA*, June 15-20, 1997.
- Mahon, Swanson, "Acoustic Holography as an Active Control Measurement Tool," *Proceedings of Active 95, The 1995 International Symposium on Active Control of Sound and Vibration*, Newport Beach, CA, July 1995, pp. 673-684.
- Mahon, Sibul, Valenzuela, "A Sliding Window Update for the Basis Matrix of the QR Decomposition," *IEEE Transactions on Signal Processing*, May 1993, pp. 1951-1953.
- Mahon, Sibul, Valenzuela, "An Alternative Updating Scheme for the QR Algorithm as Applied to Adaptive Beamforming," *Proc. 25<sup>th</sup> Annual Conf. on Info. Sciences and Systems*, Johns Hopkins University, Baltimore, MD, March 1991, pp. 193-199.

#### **Awards/Honors:**

Senior Member IEEE

2001 Formal citation letter from National Reconnaissance Office (NRO) for experimental work with mobile wireless systems

2001 Formal citation letter for excellence in software development from the NRO for work associated with mobile wireless systems.

2000 Formal citation letter from NRO for development of wavelet course presented at NRO Technology Symposium

1997 Invited session chair of “Signal Processing in Acoustics: General Signal Processing,” Noise-Con ’97, 133rd meeting of the ASA.

1996 Simowitz Citation Acoustics Department PSU for outstanding publication by a graduate student

1995 Invited co-chair of “Transducers for Active Control of Sound and Vibration,” Active 95, Active Noise Control Conference

1993 Simowitz Award Acoustics Department PSU for outstanding publication by a graduate student

1987 Dr. A. J. Cawley Award for Excellence in Electronics Engineering by Physics/EE Department University of Scranton

## **APPENDIX B**

## APPENDIX B

### CLAIM LISTING

| Claim 1 |                                                                                                                                                                                                                                                                               |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1pre]  | A wireless communication terminal, the terminal comprising:                                                                                                                                                                                                                   |
| [1a]    | a processor; and                                                                                                                                                                                                                                                              |
| [1b]    | a communication unit,                                                                                                                                                                                                                                                         |
| [1c]    | wherein the processor is configured to: receive a PPDU (physical layer protocol data unit) including an A-MPDU (Aggregate-MAC Protocol Data Unit) in which one or more MPDUs (MAC Protocol Data Units) are aggregated,                                                        |
| [1d]    | wherein the A-MPDU includes Ack policy information related to a block Ack for the one or more MPDUs, and one or more subframes,                                                                                                                                               |
| [1e]    | wherein each of the one or more subframes includes MPDU identifier information and an MPDU of the one or more MPDUs, and                                                                                                                                                      |
| [1f]    | wherein the MPDU identifier information includes an end of frame (EOF) field and a length field, and                                                                                                                                                                          |
| [1g]    | transmit a response frame in response to the PPDU,                                                                                                                                                                                                                            |
| [1h]    | wherein a type of the response frame is determined as one of an Ack frame, a compressed BlockAck frame, and a multi-STA BlockAck frame according to a combination of a type of the MPDU determined by the EOF field and the length field, and the Ack policy information, and |
| [1i]    | wherein the compressed BlockAck frame is used to transmit a response to the one or more MPDUs corresponding to one TID, when the one or more MPDUs correspond to the one TID among an one or more TIDs (traffic IDs).                                                         |
| Claim 2 |                                                                                                                                                                                                                                                                               |
| [2]     | The wireless communication terminal of claim 1, wherein the A-MPDU further includes the one or more TIDs corresponding to the one or more MPDUs.                                                                                                                              |

| Claim 3 |                                                                                                                                                                                                                                                                                                                            |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3]     | The wireless communication terminal of claim 2, wherein the type of the response frame is determined by further considering a number of TIDs indicating an immediate response among the one or more TIDs.                                                                                                                  |
| Claim 4 |                                                                                                                                                                                                                                                                                                                            |
| [4]     | The wireless communication terminal of claim 3, wherein the type of the response frame is the Ack frame when the A-MPDU includes only one TID indicating the immediate response and the Ack policy information indicates a normal Ack.                                                                                     |
| Claim 5 |                                                                                                                                                                                                                                                                                                                            |
| [5]     | The wireless communication terminal of claim 3, wherein the type of the response frame is the compressed BlockAck frame when a number of the TIDs indicating the immediate response is one or more and the one or more TIDs are the same.                                                                                  |
| Claim 6 |                                                                                                                                                                                                                                                                                                                            |
| [6]     | The wireless communication terminal of claim 3, wherein the MPDU delimiter information is first MPDU delimiter information in which a value of the EOF field is 1 and a value of the length field is non-zero, or second MPDU delimiter information in which the EOF field value is 0.                                     |
| Claim 7 |                                                                                                                                                                                                                                                                                                                            |
| [7]     | The wireless communication terminal of claim 6, wherein the type of the response frame is determined by further considering whether the A-MPDU includes a subframe including the first MPDU delimiter information, and whether the A-MPDU includes at least one subframe including the second MPDU identifier information. |
| Claim 8 |                                                                                                                                                                                                                                                                                                                            |
| [8pre]  | A wireless communication method of a wireless communication terminal, the method comprising:                                                                                                                                                                                                                               |
| [8a]    | receiving a PPDU (physical layer protocol data unit) including an A-MPDU (Aggregate-MAC Protocol Data Unit) in which one or more MPDUs (MAC Protocol Data Units) are aggregated,                                                                                                                                           |

|                 |                                                                                                                                                                                                                                                                               |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8b]            | wherein the A-MPDU includes Ack policy information related to a block Ack for the one or more MPDUs, and one or more subframes,                                                                                                                                               |
| [8c]            | wherein each of the one or more subframes includes MPDU identifier information and an MPDU of the one or more MPDUs, and                                                                                                                                                      |
| [8d]            | wherein the MPDU identifier information includes an end of frame (EOF) field and a length field; and                                                                                                                                                                          |
| [8e]            | transmitting a response frame in response to the PPDU,                                                                                                                                                                                                                        |
| [8f]            | wherein a type of the response frame is determined as one of an Ack frame, a compressed BlockAck frame, and a multi-STA BlockAck frame according to a combination of a type of the MPDU determined by the EOF field and the length field, and the Ack policy information, and |
| [8g]            | wherein the compressed BlockAck frame is used to transmit a response to the one or more MPDUs corresponding to one TID, when the one or more MPDUs correspond to the one TID among an one or more TIDs (traffic IDs).                                                         |
| <b>Claim 9</b>  |                                                                                                                                                                                                                                                                               |
| [9]             | The wireless communication method of claim 8, wherein the A-MPDU further includes the one or more TIDs corresponding to the one or more MPDUs.                                                                                                                                |
| <b>Claim 10</b> |                                                                                                                                                                                                                                                                               |
| [10]            | The wireless communication method of claim 9, wherein the type of the response frame is determined by further considering a number of TIDs indicating an immediate response among the one or more TIDs.                                                                       |
| <b>Claim 11</b> |                                                                                                                                                                                                                                                                               |
| [11]            | The wireless communication method of claim 10, wherein the type of the response frame is the Ack frame when the A-MPDU includes only one TID indicating the immediate response and the Ack policy information indicates a normal Ack.                                         |
| <b>Claim 12</b> |                                                                                                                                                                                                                                                                               |

|                 |                                                                                                                                                                                                                                                                                                                           |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [12]            | The wireless communication method of claim 10, wherein the type of the response frame is the compressed BlockAck frame when a number of the TIDs indicating the immediate response is one or more and the one or more TIDs are the same.                                                                                  |
| <b>Claim 13</b> |                                                                                                                                                                                                                                                                                                                           |
| [13]            | The wireless communication method of claim 8, wherein the MPDU delimiter information is first MPDU delimiter information in which a value of the EOF field is 1 and a value of the length field is non-zero, or second MPDU delimiter information in which the EOF field value is 0.                                      |
| <b>Claim 14</b> |                                                                                                                                                                                                                                                                                                                           |
| [14]            | The wireless communication method of claim 13, wherein the type of the response frame is determined by further considering whether the A-MPDU includes a subframe including the first MPDU delimiter information, and whether the A-MPDU includes at least one subframe including the second MPDU identifier information. |

# **APPENDIX C**

## APPENDIX C

| List of Abbreviations |                                                  |
|-----------------------|--------------------------------------------------|
| A-MPDU                | Aggregate MAC Protocol Data Unit                 |
| AP                    | Access Point                                     |
| C-BA                  | Compressed BlockAck                              |
| EOF                   | End of Frame                                     |
| HT                    | High Throughput                                  |
| MAC                   | Medium Access Control                            |
| M-BA                  | Multi-STA BlockAck                               |
| MIMO                  | Multiple Input Multiple Output                   |
| MPDU                  | MAC Protocol Data Unit                           |
| OFDM                  | Orthogonal Frequency Division<br>Multiplexing    |
| OFDMA                 | Orthogonal Frequency Division<br>Multiple Access |
| PHY                   | Physical Layer                                   |
| PPDU                  | PHY Protocol Data Unit                           |
| QoS                   | Quality of Service                               |
| SIFS                  | Short Interframe Space                           |
| STA                   | Station                                          |
| TID                   | Traffic Identifier                               |
| VHT                   | Very High Throughput                             |