xxIN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	Geonjung Ko, et al.	Attorney Docket No. 39843-0193IP1
U.S. Patent No.:	10,313,077	
Issue Date:	June 4, 2019	
Appl. Serial No.:	15/854,662	
Filing Date:	December 26, 2017	
Title:	WIRELESS COMMUNICATION METHOD AND WIRELESS COMMUNICATION TERMINAL FOR COEXISTENCE WITH LEGACY WIRELESS COMMUNICATION TERMINAL	

DECLARATION OF ZHI DING, Ph.D.

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.

Digitally signed by Zhi Ding
Date: 2025.06.03 14:49:46 -07'00'

Date: June 3, 2025

By: ______________________
Zhi Ding, Ph.D.

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I. ASSIGNMENT

1. I have been retained on behalf of Samsung Electronics Co., Ltd. ("Samsung" or "Petitioner") to offer technical opinions related to 10,313,077 ("the '077 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 '077 patent.

2. I have been asked to provide my independent analysis of the '077 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 '077 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 '077 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 declaration.

Appendix A 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.

6. I presently hold the title of Distinguished Professor in the Department of Electrical and Computer Engineering at the University of California, Davis, a position that I have held since my appointment on July 1, 2000. Since my appointment on July 1, 2000, I have held the position of professor for the past 25 years at the present university and have served as a faculty member at several US universities for over 30 years. I am also a private technical consultant on various technologies related to information systems. I have over three decades of teaching research experience on a wide range of topics related to communication systems and signal processing.

7. I earned my Bachelor of Engineering degree in 1982 in wireless engineering from the Nanjing Institute of Technology (later renamed as Southeast University) in Nanjing, China. I earned my Master of Applied Science degree in 1987 in electrical engineering from the University of Toronto in Toronto, Canada. I earned my Ph.D. in 1990 in electrical engineering from Cornell University in Ithaca, New York.

8. My responsibilities as a Professor at University of California, Davis,

include classroom instruction on various topics of communication systems and signal analysis, as well as mentoring undergraduate students and supervising graduate students in their research and development efforts on various topics related to digital communications. I have directly supervised such research and development works ranging from signal detection to wireless networking. As the chief academic advisor, I have also directly supervised the completion of over 30 Masters theses and 35 Ph.D. dissertations on various topics related to digital communications. I have served full time as a faculty member at three major research universities in the United States over the past 30 years, including Auburn University from 1990 to 1998, University of Iowa from 1999 to 2000, and University of California, Davis, from 2000 to present.

9. Since 1990, I have been selected as the principal investigator of multiple highly competitive federal and local research grants, including more than twenty major research projects supported by the National Science Foundation and two research projects funded by the U.S. Army Research Office. These competitive research projects focused on developing more efficient and effective digital communication transceivers, networks, and signal processing tools. I have also participated as co-principal investigator in several large-scale projects supported by the Defense Advanced Research Projects Agency (DARPA) with

teams of researchers. Additionally, I have applied for, and received support from, other federal, state, and industry sponsors.

10. I have published over 250 peer-reviewed research articles in premier international journals, in addition to over 250 refereed technical articles at top international conferences on communications and information technologies. According to Google Scholar, my published works have been cited by over 20,000 times by peers. In addition to these peer-reviewed technical works, I have also written two books on communications technologies. My most recent book, coauthored with B.P. Lathi, is entitled, "Modern Digital and Analog Communication Systems," 5th edition, and was published by the Oxford University Press in 2018. This edition and the 4th edition of this book (also coauthored with B.P. Lathi and published in 2009) had been widely adopted as an introductory textbook to communication systems.

11. In addition to the over 500 published technical papers that have been cited over 20,000 times according to Google Scholar, I am also co-inventor of 7 issued U.S. patents on communication technologies.

12. I am a member of the Institute of Electrical and Electronics Engineers (IEEE) and was elevated to the grade of Fellow in January 2003 for contributions made in signal processing for communication. The IEEE is the world's largest

professional society of engineers, with over 400,000 members in more than 160 countries. The IEEE has led the development of many standards for modern digital communications and networking, most notably, the IEEE 802 series of network standards. The IEEE Grade of Fellow is conferred by the Boards of Directors upon a person with an extraordinary record of accomplishments in any of the IEEE fields of interest. The total number selected in any one year does not exceed one-tenth of one percent of the total voting Institute membership.

13. I have served the IEEE in the following capacities:

- Chief Marketing Officer of the IEEE Communications Society from Jan. 2020 to present.
- Chief Information Officer of the IEEE Communications Society from Jan. 2018 to present.
- General Chair of the 2016 IEEE International Conference on Acoustics, Speech, and Signal Processing, the flagship conference of the IEEE Signal Processing Society.
- Chair of the Steering Committee for the IEEE Transactions on Wireless Communications from 2008 to 2010.
- Distinguished Lecturer of the IEEE Communications Society from January 2008 to December 2009.

- Technical Program Chair of the 2006 IEEE Globecom, one of two flagship annual IEEE Communication Society conferences.
- Distinguished Lecturer of the IEEE Circuits and Systems Society from 2004 to 2005.
- Associate Editor of the IEEE Transactions on Signal Processing from 1994 to 1997 and from 2001 to 2004.
- Member of the IEEE Statistical Signal and Array Processing for Communications Technical Committee from 1993 to 1998.
- Member of the IEEE Signal Processing for Communications Technical Committee from 1998 to 2004.

14. In 2012, I received the annual Wireless Communications Technical Committee Recognition Award from the IEEE Communications Society, an award given to a person with a high degree of visibility and contribution in the field of "Wireless and Mobile Communications Theory, Systems, and Networks." In 2020, I was the recipient of the annual Education Award from the IEEE Communications Society. According to the Society, this award "recognizes distinguished and significant contributions to education within the Society's technical scope."

15. I have also served as a technical consultant for the telecommunication industry. For example, in 1995 I consulted for Analog Devices, Inc., on the

development of the first generation DOCSIS cable modem systems. I have also consulted for other companies, including Nortel Networks and NEC US Laboratories. I worked as a visiting faculty research fellow at NASA Glenn Research Center in 1992 and at U.S. Air Force Wright Laboratory in 1993. I have served on multiple review panels of the National Science Foundation to evaluate competitive research proposals in the field of communication. I have also reviewed a large number of research proposals at the request of the National Science and Engineering Research Council (NSERC) of Canada as an expert panelist from 2010 to 2013, and also at the request of the Research Grant Council (RGC) of Hong Kong as an external reviewer.

16. I have served as an expert witness or consulting expert on a number of matters related to intellectual property, mostly in the area of telecommunications, including cellular communications, Wi-Fi technologies, Bluetooth, and optical communications. For example, since 2007, I have been engaged to assist in various litigations and legal disputes involving cellular, WiFi, and optical communication networks in terms of essentiality, infringement, and invalidity.

17. Based on my above-described near three decades of experience in communications technologies, and the acceptance of my publications and professional recognition by societies in my field, I believe that I am qualified to be

an expert in wireless communication systems, communication networks, and signal processing.

18. 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.

III. LEGAL STANDARDS

A. Terminology

19. I have been informed by Counsel (Fish & Richardson) 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 '077 patent was filed December 26, 2017, and claims priority to KR 10-2015-0092525 filed June 29, 2015, which I refer to as the earliest possible priority date in this proceeding. Because I do not know at what date the invention as claimed was

made, if ever, I have used the earliest possible priority date of the ’077 patent as the point in time for claim interpretation purposes. My opinion does not change if the invention date is earlier.

B. Legal Standards

20. I have been informed by Counsel and understand that patents or printed publications that qualify as prior art can be used to invalidate a patent claim as anticipated or as obvious.

21. 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.

1. Anticipation

22. 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.

23. 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).

2. Obviousness

24. 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 person of ordinary skill in the art.

25. 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.

26. 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.

27. 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."

28. 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.

29. 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.

30. 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.

31. 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.

32. 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.

33. 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.

34. 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.

35. 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).

IV. MATERIALS CONSIDERED

36. My analysis and conclusions set forth in this declaration are based on my educational background, professional knowledge, 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 earliest possible priority date, and I taught, participated in organizations, and worked closely with many such persons in the field during that time frame.

37. As part of my independent analysis for this declaration, I have considered the following: my own knowledge and experience, including my work experience in the field of wireless communications, the '077 patent, and related disciplines; my experience in teaching those subjects; my experience in working with others involved in this field and related disciplines; and the background knowledge/technologies that were commonly known to persons of ordinary skill in

this art during the time before the earliest possible priority date.

38. I have reviewed the ’077 patent (SAMSUNG-1001), relevant excerpts of the prosecution history (SAMSUNG-1002) of the ’077 patent, and Korean Application No. 10-2015-0092525, Certified English Translation and Original Korean Application (“the KR-525 Application”) (SAMSUNG-1005). Among various textbooks, documents, and publications, I have also reviewed and analyzed the following publications and materials, in addition to other materials I cite in my declaration:

- U.S. Patent Application Publication No. 2016/0345202 to Bharadwaj et al. (“Bharadwaj”) (SAMSUNG-1006)
- U.S. Provisional Application No. 62/170,059 (“Bharadwaj-Prov059”) (SAMSUNG-1007)
- IEEE Std. 802.11-2012 (SAMSUNG-1008)
- IEEE Std. 802.11ac-2013 (SAMSUNG-1009)
- U.S. Patent Application Publication No. 2015/0139205 to Kenney et al. (“Kenney”) (SAMSUNG-1010)
- U.S. Patent Application Publication No. 2012/0054587 to Van Nee et al. (SAMSUNG-1011)
- U.S. Patent Application Publication No. 2016/0285596 to Park et al.

(SAMSUNG-1012)

- U.S. Patent Application Publication No. 2015/0304077 to Cao et al. (SAMSUNG-1013)
- U.S. Patent Application Publication No. 2015/0139206 to Azizi et al. (SAMSUNG-1014)
- U.S. Patent Application Publication No. 2016/0127948 to Azizi et al. ("Azizi") (SAMSUNG-1015)
- L-LENGTH Equation Update, IEEE submission document IEEE 802.11-15/1372 (Nov. 2015) (SAMSUNG-1016)
- U.S. Provisional Application No. 62/165,848 ("Bharadwaj-Prov848") (SAMSUNG-1017)
- U.S. Patent Application Publication No. 2012/0177144 to Lee et al. ("Lee") (SAMSUNG-1018)
- U.S. Patent Application Publication No. 2016/0286012 to Yu et al. ("Yu") (SAMSUNG-1019)
- U.S. Provisional Application No. 62/145,428 ("Yu-Prov428") (SAMSUNG-1020)
- U.S. Provisional Application No. 62/138,294 ("Yu-Prov294) (SAMSUNG-1021)

- 802.11ax Preamble Design and Auto-detection, IEEE submission document IEEE 802.11-15/0579 (May 10, 2015) (SAMSUNG-1022)

39. Counsel has informed me that I should consider these materials through the lens of one of ordinary skill in the art related to the ’077 patent at the time of the earliest possible priority date of the ’077 patent, and I have done so during my review of these materials. I have been informed by Counsel to use the date of June 29, 2015 as the earliest possible priority date. However, as discussed below, the ’077 patent is not entitled to the filing date of Korean Application 10-2015-0092525 and, as such, the earliest effective filing date of the ’077 patent is no earlier than August 20, 2015.

V. OVERVIEW OF CONCLUSIONS FORMED

40. This declaration explains the conclusions that I have formed based on my analysis of all of the considered materials and my personal experience. My opinions, as explained below, are based on my education, experience, and expertise in the fields relating to the ’077 Patent. My analysis and conclusions set forth in this declaration are based on the perspective of a person of ordinary skill in the art. 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 ’077 Patent and the prior art discussed below. 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: Bharadwaj in view of Yu renders obvious claims 1-5 and 8-12.
- Ground 1B: Bharadwaj in view of Yu and Azizi renders obvious claims 4-5 and 11-12.
- Ground 1C: Bharadwaj in view of Yu and Kenney renders obvious claims 6-7 and 13-14.
- Ground 2A: Bharadwaj renders obvious claims 1-5 and 8-12.
- Ground 2B: Bharadwaj in view of Azizi renders obvious claims 4-5 and 11-12.
- Ground 2C: Bharadwaj in view of Kenney renders obvious claims 6-7 and 13-14.

41. In support of these conclusions, I provide an overview of the references in Section VIII and more detailed comments regarding the obviousness of claims 1-14 (“the Challenged Claims”) of the ’077 patent in Section IX.

VI. LEVEL OF ORDINARY SKILL IN THE ART

42. In my opinion, one of ordinary skill in the art relating to, and at the

time of, the earliest possible priority date would have been someone with (1) a Bachelor's degree in electrical engineering, computer engineering, computer science, or a related field, and (2) at least 3 years of experience in the research, design or development of wireless communication devices, systems, and/or networks, or the equivalent ("POSITA").

43. Further, all positions in this declaration are from the vantage point of a POSITA as of the earliest possible priority date of June 29, 2015.

44. 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.

VII. THE '077 PATENT

A. Overview of the '077 Patent

45. The '077 patent describes "a wireless communication environment in

which a legacy wireless communication terminal and a non-legacy wireless communication terminal coexist." SAMSUNG-1001, 1:21-25. The wireless communication environment can include a "wireless LAN system" "following a regulation of an IEEE 802.11 standard." SAMSUNG-1001, 7:41-8:24. The system includes a station that "transmits and receives a wireless signal such as a wireless LAN physical layer frame." SAMSUNG-1001, 8:43-50.

46. In the '077 patent, a "non-legacy wireless communication terminal may transmit signaling information decodable by a legacy wireless communication terminal through a physical layer frame. Signaling information decodable by a legacy wireless communication terminal, which is transmitted through a physical layer frame, is also referred to as L-SIG." SAMSUNG-1001, 11:25-31. The L-SIG includes "an L_LENGTH field indicating a length of a physical layer frame" after L-SIG. SAMSUNG-1001, 19:49-53, 28:48-51. "The non-legacy wireless communication terminal may set the value of L_LENGTH through the equation of FIG. 24" below.

$$L\_LENGTH = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3$$

SAMSUNG-1001, FIG. 24.

47. If a non-legacy physical layer frame includes a packet extension, "information that disambiguates ambiguity on whether or not the packet extension

of the non-legacy physical layer frame is included may be included in the non-legacy signaling field of the non-legacy physical layer frame." SAMSUNG-1001, 30:38-67. Information that "disambiguates ambiguity on whether a packet extension is included is referred to as a PE-Disambiguity field." *Id.* "The wireless communication terminal receiving the non-legacy physical layer frame may obtain the number of symbols N_{SYM} including data based on the value of the L_LENGTH field and the value $b_{PE\_Disambiguity}$ of the PE disambiguity field" according to the following equation.

$$N_{SYM} = \left\lfloor \left(\frac{L\_LENGTH + 3}{3} \times 4 - T_{HE\_PREAMBLE} \right) / T_{SYM} \right\rfloor - b_{PE\_Disambiguity}$$

SAMSUNG-1001, 31:65-32:22, FIG. 26.

48. "The legacy wireless communication terminal obtains the duration RXTIME of the non-legacy physical layer frame based on *L_LENGTH*" according to the following equation, where the operator $\lceil x \rceil$ denotes the "ceiling of *x*", i.e., the smallest integer not smaller than the value of *x*:

$$RXTIME = \left\lceil \frac{L\_LENGTH + 3}{3} \right\rceil \times 4 + 20$$

SAMSUNG-1001, 32:41-33:48, FIG. 27. Because "the legacy wireless communication terminal performs a ceiling operation…, the legacy wireless communication terminal may process *L_LENGTH* having different lengths… even if the value of the *L_LENGTH* changes from 31 to 32 or 33. With this feature, the non-legacy physical wireless communication terminal may signal information other than the duration of the non-legacy physical layer frame… through the remainder when the *L_LENGTH* is divided by 3." SAMSUNG-1001, 33:28-65, 36:43-37:11. "For this, when the non-legacy wireless communication terminal sets the length of the *L_LENGTH*, the non-legacy wireless communication terminal should add or subtract a positive integer less than the size of data transmittable by… the legacy physical layer frame in the length set based on the duration of the non-legacy physical layer frame." SAMSUNG-1001, 34:27-39.

49. The '077 patent describes an embodiment where a transmitting wireless communication terminal "subtracts a predetermined integer according to the format of a non-legacy signaling field while setting *L_LENGTH*." SAMSUNG-1001, 36:13-16, FIG. 30. The predetermined integer is "a positive integer *m* smaller than the size of data transmittable by one symbol of the legacy physical layer frame" and "may be 1 or 2" when "the data rate of the legacy physical layer frame is 6 Mbps" and "the size of data that one symbol of the legacy physical layer frame may transmit is 3 bytes." SAMSUNG-1001, 36:17-42. In other words, the predetermined integer *m* is smaller than 3. In this embodiment, a wireless communication terminal sets the value of *L_LENGTH* through the equation below.

$$L\_LENGTH_{fairness} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - m, \qquad m = 1\ or\ 2$$

SAMSUNG-1001, FIG. 30. The "wireless communication terminal receiving the non-legacy physical layer frame may obtain the number of symbols N_{SYM} including data based on the value of the L_LENGTH field and the value $b_{PE\_Disambiguity}$ of the PE disambiguity field" according to the equation below where the operator $\lfloor x \rfloor$ denotes the "floor" of the value *x* (the highest integer no larger than *x*).

$$N_{SYM} = \left\lfloor \left(\frac{L\_LENGTH + m + 3}{3} \times 4 - T_{HE\_PREAMBLE} \right) / T_{SYM} \right\rfloor - b_{PE\_Disambiguity}$$

SAMSUNG-1001, 37:12-51, FIG. 31.

B. Prosecution History of the '077 Patent

50. The application that issued as the '077 patent was allowed with no prior art rejections. As reasons for allowance, the examiner stated that no prior art discloses elements 1[d]/8[d] and 1[e]/8[e]. SAMSUNG-1002, 259-260. The examiner noted that some prior art was made of record but not relied upon in a rejection. *Id.* As demonstrated below in Grounds 1A-2C, however, the prior art and evidence cited in this Declaration would have rendered obvious the claim elements that the examiner apparently believed to be missing from the prior art.

C. Priority Date of the Challenged Claims

51. I understand that the '077 patent claims the benefit of priority to

Korean Application No. 10-2015-0092525 ("the KR-525 Application"). Based on my analysis of the '077 patent claims and the earlier-filed KR-525 Application, claims 1-14 are not entitled to the June 29, 2015 filing date of the earlier-filed KR-525 Application because claims 1-14 do not have written description support in the earlier-filed KR-525 Application. The KR-525 Application fails to disclose either expressly or inherently all elements of any Challenged Claim, and further fails to reasonably convey to a POSITA that the inventors were in possession of the claimed subject matter.

52. For example, each of the Challenged Claims requires a wireless communication terminal that obtains "information other than information on the duration of the non-legacy physical layer frame through a remaining value obtained by dividing the length information by a data size transmittable by a symbol of a legacy physical layer frame" (elements 1[d]/8[d]) and determines "the number of symbols of data of the non-legacy physical layer frame according to a following equation,

$$N_{SYM} = \left\lfloor \left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 - T_{HE\_PREAMBLE} \right) \Big/ T_{SYM} \right\rfloor - b_{PE\_Disambiguity}$$

," (elements 1[e]/8[e]). The KR-525 Application discloses no such wireless communication terminal that performs these functions.

53. For example, although KR-525 Application's paragraphs 48-50, 64, 69, and 88 mention length information and paragraphs 52, 54, 57, 60-61, 87, 89, 94 mention symbols, nothing in the KR-525 Application discloses or conveys possession of the specific features recited in elements 1[d], 1[e], 8[d], and 8[e] of the '077 patent. *See generally,* SAMSUNG-1005. Consequently, the KR-525 Application fails to provide written description support for the Challenged Claims.

54. Therefore, the KR-525 Application is not sufficient to demonstrate possession of elements 1[d], 1[e], 8[d], and 8[e] of the '077 patent. Consequently, the KR-525 Application neither actually nor inherently disclose each and every element of claims 1-14, and the '077 patent is not entitled to the benefit of the KR-525 Application filing date of June 29, 2015. As such, the Challenged Claims are, at most, entitled to an effective filing date no earlier than August 20, 2015. Therefore, I have applied a date of August 20, 2015, as the date of invention.

VIII. OVERVIEW AND COMBINATIONS OF PRIOR ART REFERENCES

A. Bharadwaj in view of Yu

1. Overview of Bharadwaj

55. Bharadwaj (SAMSUNG-1006) claims priority to a pair of provisional applications including U.S. Provisional Application 62/170,059 ("Bharadwaj-Prov059", SAMSUNG-1007), filed June 2, 2015. Bharadwaj-Prov059 fully

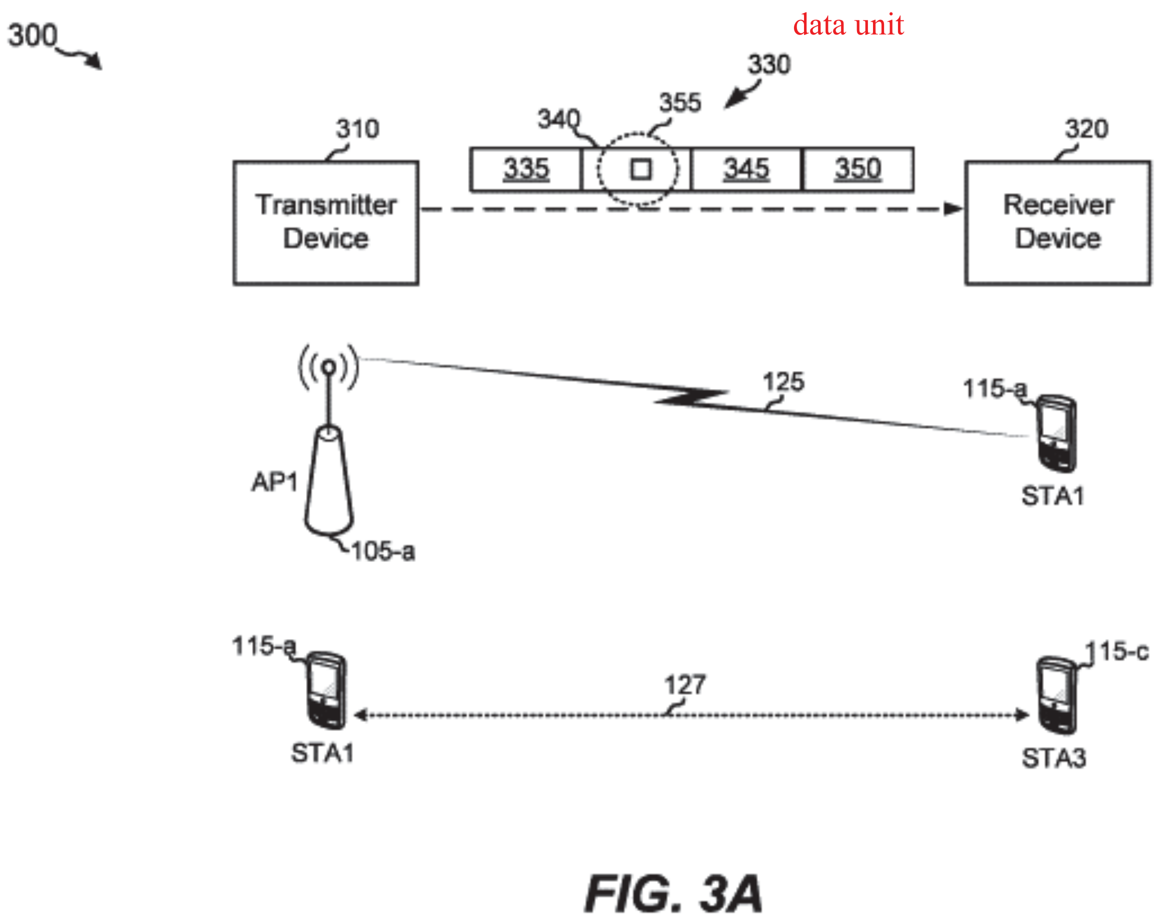
supports the disclosures of Bharadwaj relied upon in this Declaration. Bharadwaj-Prov059 also readily supports claims of Bharadwaj. In fact, the following claims of Bharadwaj-Prov059 were carried forward into Bharadwaj demonstrating direct claim-level support:

Bharadwaj-Prov059	Bharadwaj
Claim 1	Claim 1
Claim 12	Claim 9
Claim 13	Claim 17
Claim 14	Claim 25
Claim 7	Claim 33
Claim 16	Claim 39
Claim 17	Claim 45
Claim 18	Claim 51

56. Bharadwaj unambiguously incorporates the entire contents of Bharadwaj-Prov059, making Bharadwaj-Prov059 part of Bharadwaj's disclosure, because Bharadwaj claims priority to Bharadwaj-Prov059, which Bharadwaj "expressly incorporate[s] by reference herein for all purposes." SAMSUNG-1006, [0001].

57. Bharadwaj-Prov059, and thus Bharadwaj itself by virtue of its incorporation of Bharadwaj-Prov059, describes "techniques for signal extension

signaling." SAMSUNG-1007, [0001]. Bharadwaj-Prov059 illustrates in FIG. 3A "a conceptual diagram 300 illustrating an example of signal extension signaling from a transmitter device 310 to a receiver device 320" where "data unit 330 is shown to generally include a legacy preamble 335, a high efficiency (HE) preamble 340, which typically includes the single signaling bit 335 [sic] used for the single-bit signaling scheme, data portion 345, and signal extension 350." SAMSUNG-1007, [0043]-[0044].



SAMSUNG-1007, FIG. 3A

58. In Bharadwaj-Prov059, the "value of the duration of the data unit 330 in number of bytes is determined by the transmitter device 310 based on the time duration of the data unit 300 (*TXTIME*)" according to the following equation:

$$L_{LENGTH} = \left\lceil \frac{TXTIME-20}{4} \right\rceil \times 3 - 3 + m \text{ where } m = 1,2$$

(SAMSUNG-1007, [0051]), and the "time duration of the data unit 330 is determined by the receiver device 320 based on the duration of the data unit 330 in number of bytes ($L\_{_{LENGTH}}$). That is, at the receiver device 320, the duration RXTIME of the data unit 330 is computed from $L\_{_{LENGTH}}$ in the L-SIG as follows (Equation 5)." SAMSUNG-1007, [0055].

$$RXTIME = \left\lceil \frac{L_{LENGTH} - m + 3}{3} \right\rceil \times 4 + 20$$

SAMSUNG-1007, [0056]. Bharadwaj-Prov059 explains that once "the *RXTIME* is known, the number of data symbols, *Nsym*, is computed or determined by the receiver device 320 using the following expression (Equation 6):"

$$N_{sym} = \left\lfloor \frac{RXTIME - T_{L\_PREAMBLE} - T_{HE\_PREAMBLE}}{T_{SYM}} \right\rfloor - SE_{disambiguation\_bit}$$

SAMSUNG-1007, [0057]. Since $T_{L\_PREAMBLE}$ = 20 μs (SAMSUNG-1007, [0059]), Equation 6 can be written to incorporate Equation 5 as follows:

$$N_{sym} = \left\lfloor \frac{\left\lceil \frac{L_{LENGTH} - m + 3}{3} \right\rceil \times 4 - T_{HE\_PREAMBLE}}{T_{SYM}} \right\rfloor - SE_{disambiguation\_bit}$$

2. Overview of Yu

59. Yu (SAMSUNG-1019) claims priority to a pair of provisional applications including U.S. Provisional Application 62/138,294 ("Yu-Prov294", SAMSUNG-1021), filed March 25, 2015 and U.S. Provisional Application 62/145,428 ("Yu-Prov428" SAMSUNG-1020) filed Apr. 9, 2015. Yu-Prov428 fully supports the disclosures of Yu relied upon in this Declaration. Yu-Prov294 also readily supports claims of Yu. *Id.*. In fact, at least the following claims of Yu are supported by Yu-Prov294 demonstrating direct claim-level support:

Yu	Exemplary disclosure from Yu-Prov294
Claim 1	"To begin the UL transmission, any kind of a trigger frame from an AP should initiate the UL transmission of STAs. This trigger frame is sent by the AP and TXOP for UL transmission will start. With this trigger frame, each UL STA can estimate the carrier frequency offset with L-STF and L-LTF, and further track the frequency offset with pilots in each DATA OFDM symbols as shown in Fig. 1. This CFO estimate is calculated in PHY layer and this value can be used as a pre-compensation CFO without any aid of MAC layer when the next transmitted packet is sent to an AP, i.e. an UL MU packet. … To this end, the estimated CFO value should be included in RXVECTOR

	delivered by PHY layer to MAC layer. … Next, MAC layer delivers the CFO value to PHY layer for CFO and SFO precompensation. … When non-zero CFO value is delivered from MAC, PHY performs precompensation of CFO and SFO (sampling frequency offset) with the value in time and frequency domains, respectively, as shown in Fig. 3." SAMSUNG-1021, 25-26[1]. "CFO value should be defined in TXVECTOR and RXVECTOR." SAMSUNG-1021, 27. "In receiver operation, PHY layer calculates the CFO value to decode the received packet." SAMSUNG-1021, 28.
Claim 9	"Then CFO in TXVECTOR can be used both SFO precompensation block and CFO precompensation block. These two precompensation can be applied in time domain (after IDFT) and frequency domain (before IDFT). Because CFO is an incremental phase in time domain, it can be applied in time domain as in Fig. 3. SFO is an incremental phase in frequency domain if the accumulated offset does exceed the sample boundary, i.e., SFO is in fractional sample level. Therefore, SFO pre-compensation is done in frequency domain." SAMSUNG-1021, 26-29.

60. Further, at least the following claim of Yu is supported by Yu-

[1] Citations to SAMSUNG-1021 are to page numbers of the PDF document.

Prov428 demonstrating direct claim-level support:

Yu	Exemplary disclosure from Yu-Prov428
Claim 13	"The number of used data tones in the last OFDM symbol can be obtained by the payload size (the number of bytes)…. and then the waveforms of the IDFT output have the repetition property…. To save the transmission time, the transmitter sends the only one repeated waveform with CP for the last OFDM symbol." SAMSUNG-1020, 10-14[2].

61. Yu unambiguously incorporates the entire contents of Yu-Prov428, making Yu-Prov428 part of Yu's disclosure, because Yu claims priority to Yu-Prov428 (SAMSUNG-1020), "the entire contents of which are incorporated [into Yu] by reference." SAMSUNG-1019, [0001].

62. Yu-Prov428, and thus Yu by virtue of its incorporation of Yu-Prov428, describes a padding scheme for IEEE 802.11ax (also referred to as "HEW" or "High Efficiency WLAN"). SAMSUNG-1020, 5. Yu-Prov428 proposes "different OFDM subcarrier mapping and modulation methods depending on the payload size." SAMSUNG-1020, 10; SAMSUNG-1019, [0230]. Because

[2] Citations to SAMSUNG-1020 are to page numbers of the PDF document.

"the symbol structure can be changed depending on the payload size," Yu-Prov428 describes a "way to indicate the structure of the last symbol." SAMSUNG-1020, 16; SAMSUNG-1019, [0230]. Yu-Prov428 explains that "HE-SIG field can be used" and "dedicated bits can be assigned for the purpose." SAMSUNG-1020, 16; SAMSUNG-1019, [0231]. But if "the dedicated bits in HE-SIG is not available," "the L-LENGTH field, the LENGTH [field] in the legacy SIG, can be used" to indicate the structure of the last symbol by using "L-LENGTH information with *M* in the following equation." SAMSUNG-1020, 16; SAMSUNG-1019, [0232].

$$\text{Length} = \frac{\text{TXTIME-20}}{4} \times 3 - 3 - M, \; 0 \leq M \leq 2$$

Id. Yu-Prov428 discloses that this "L-LENGTH can imply three different states with the value of *M* without changing the operation of the legacy receiver" because "the legacy receiver [will] identify the same length (the same packet duration) because one OFDM symbol with the lowest rate includes 3 bytes data." *Id.* It was clear to a POSITA that Yu-Pro428 discloses that three states can be communicated by the three integer values of *M*=0, 1, 2, respectively.

3. Combination of Bharadwaj in view of Yu

63. While Bharadwaj-Prov059 explicitly discloses the following examples for calculating L_{LENGTH} and *Nsym* using the following equations,

$$L_{LENGTH} = \left\lceil \frac{TXTIME-20}{4} \right\rceil \times 3 - 3 + m \text{ where } m = 1,2$$

$$N_{sym} = \left\lfloor \frac{\left\lceil \frac{L_{LENGTH} - m + 3}{3} \right\rceil \times 4 - T_{HE\_PREAMBLE}}{T_{SYM}} \right\rfloor - SE_{disambiguation\_bit}$$

Bharadwaj-Prov059 also discloses that the value of *m* is merely used to "ensure that L_{LENGTH} is not exactly a multiple of 3 and is therefore used to distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions (e.g., auto-detections)." SAMSUNG-1007, [0051]-[0052]. From the above equation of L_{LENGTH}, a POSITA would have undersood that so long as *m* is not chosen as 0 or as a multiple of 3, then L_{LENGTH} is not exactly a multiple of 3. Noticeably, Bharadwaj-Prov059's transmitter device 310 signals whether the transmission is an 802.11ax or 802.11ac transmission by *adding* +m= 1 or 2 to the value of L_{LENGTH} communicated to the receiver device 320. *Id.* Because the addition of *m* in the L_{LENGTH} equation would potentially cause the receiver device 320 to miscalculate the number of data symbols N_{sym} as being greater than the actual number of data symbols in the transmission, the receiver device 320 compensates by determining *m* as the remaining value of the division L_{LENGTH} / 3 and then *subtracting m* from L_{LENGTH} via $\left\lceil \frac{L_{LENGTH}-m+3}{3} \right\rceil$ in the N_{sym} equation, thereby recovering the actual transmission length despite the use of *m*. *Id.*

64. The need identified by Bharadwaj-Prov059 to "distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions," as well as the use of a remaining value applied to the L_{LENGTH} equation to signal this distinction, was also recognized by others in the field before the '077 patent. SAMSUNG-1010, [0017] ("a technique to identify each transmission as either a HEW packet or a legacy packet is needed"), [0018]-[0020], [0024], [0036], [0038]-[0042], [0059]-[0060], [0063], [0065]; SAMSUNG-1012, [0057], [0068] ("a LENGTH field whose value is not divisible by 3 is a differentiating factor between for example, a WLAN 802.11ax and a WLAN 802.11ac frame"), [0073], [0080]-[0081]; SAMSUNG-1013, [0055]-[0056]; SAMSUNG-1014, [0039], [0077] ("determine whether a received frame is an HEW frame or a legacy frame based on whether a value in the length field of the L-SIG is divisible three"); SAMSUNG-1015, [0051]-[0052] ("The HEW device 104 needs a way to recognize HE packets and a way to indicate to legacy devices 106").

65. Based upon my knowledge and experience in this field and my review of the publications cited here, a POSITA would have understood that there were only a small number of candidate values for m that could be applied to $\mathrm{L}_{\mathrm{LENGTH}}$ by the transmitter and that could be uniquely recovered by the receiver through calculation of the remainder from the division L_{LENGTH} / 3—namely, a non-zero

remainder could only be either 1 or 2, which are the only values less than the divisor of 3. Any larger values of *m* added to L_{LENGTH} at the transmitter (e.g., m=4, 5, 7, or 8) would still produce the two remainder values of *m*=1 or 2 at the receiver. A POSITA likewise would have understood that the values of *m*=1 or 2 could only be applied as a constant offset by *addition* to the L_{LENGTH} equation at the transmitter (as disclosed in Bharadwaj-Prov059) or *subtraction* from the L_{LENGTH} equation at the transmitter (as disclosed in Yu-Prov428). *Id.* Indeed, Yu-Prov428, which also pre-dates the '077 patent, discloses the following Length equation that instead *subtracts* a value of *M* =0, 1, or 2 depending on the signaling state:

$$\text{Length} = \frac{TXTIME - 20}{4} \times 3 - 3 - M,\ 0 \leq M \leq 2$$

SAMSUNG-1020, 16; SAMSUNG-1019, [0232]. Yu-Prov428 explains that this "L-LENGTH can imply three different states with the value of *M* without changing the operation of the legacy receiver" because "the legacy receiver [will] identify the same length (the same packet duration) because one OFDM symbol with the lowest rate includes 3 bytes data." *Id.* In other words, Yu-Prov428 recognized a benefit to signaling additional information in the Length equation in a manner that involves *subtracting m* because it would not disturb the operation and outcome of legacy receivers that did not recognize *m* as additional signaling information and that were not configured to compensate for the transmitter's application of *m* before making use of the Length value (only non-legacy receivers would be capable of recognizing m or reversing its application when using the Length value at the receiver).[3]

66. Based on Yu-Prov428's teachings, a POSITA would have found it obvious and straightforward to implement Bharadwaj-Prov059's transmitter device such that it would signal information to distinguish "between IEEE 802.11ax and IEEE 802.11ac transmissions" by *subtracting m* in the L_{LENGTH} equation, rather than *adding* m as Bharadwaj-Prov059 originally proposed:

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - m$$

SAMSUNG-1020, 16; SAMSUNG-1019, [0232]; *see also* SAMSUNG-1007, [0051]. A POSITA would have been motivated to apply Yu-Prov428's suggestion in this regard to Bharadwaj-Prov059's receiver device to provide additional

[3] Yu-Prov428's concerns with legacy compatibility and coexistence are fundamentally the same concerns that later motivated the proposal to subtract "*m*" in the length equation of the '077 patent. SAMSUNG-1001, 35:56-36:42.

information (e.g., information distinguishing between 802.11ax and 802.11ac transmissions) through L_{LENGTH} "without changing the operation of the legacy receiver" and to allow legacy devices to correctly calculate *Nsym* and *RXTIME* so that the legacy devices need not defer transmissions for a longer duration than required. SAMSUNG-1020, 16; SAMSUNG-1019, [0232]; SAMSUNG-1008, 818-819; SAMSUNG-1010, [0017]-[0020], [0024]-[0025], [0036], [0041]; SAMSUNG-1015, [0048], [0051].

67. For example, for legacy devices that operate according to the 802.11ac standard like those described in Bharadwaj-Prov059 (SAMSUNG-1007, [0003], [0062])), the receiver calculates the duration of the transmitted data unit using the following equation:

$$RXTIME = \left\lceil \frac{LENGTH + 3}{3} \right\rceil \times 4 + 20$$

SAMSUNG-1009, 313-314. As an example, when *LENGTH* = 240, the desired RXTIME for legacy 802.11ac devices would be computed as follows:

$$RXTIME = \left\lceil \frac{240 + 3}{3} \right\rceil \times 4 + 20 = 344$$

For the L_{LENGTH} equation that uses m = +1 or +2 as disclosed in Bharadwaj-Prov059, $L\_{LENGTH} = LENGTH + m$, and the RXTIME calculated by the legacy 802.11ac devices would be:

$$RXTIME = \left\lceil \frac{(240 + m) + 3}{3} \right\rceil \times 4 + 20 = 348$$

SAMSUNG-1007, [0056]. As shown above, the RXTIME calculated by the legacy 802.11ac devices based on received $L_{\_LENGTH}$ is not the correct or desired RXTIME because legacy 802.11ac devices do not compensate for the *m* value added to the *LENGTH* by the transmitter. On the other hand, for the $L_{\_LENGTH}$ equation that uses *m* = −1 or −2 (*i.e.*, "−*m*" where *m*=1 or 2), the RXTIME calculated by the legacy 802.11ac devices would be as follows:

$$RXTIME = \left\lceil \frac{(240 - m) + 3}{3} \right\rceil \times 4 + 20 = 344$$

In this case, the *RXTIME* calculated by the legacy 802.11ac devices based on received $L_{\_LENGTH}$ would be the desired *RXTIME* because of the "ceiling" operator even though the legacy 802.11ac devices do not compensate for the *m* value subtracted from the *LENGTH* by the transmitter. *Id.* Thus, a POSITA would have been motivated to use *m* = −1 or −2 (*i.e.*, "−m" with *m*=1, or 2) to allow legacy 802.11ac devices to correctly calculate *RXTIME* and other parameters based on $L_{\_LENGTH}$, e.g., so that the legacy receiver devices would not defer channel access for a longer duration than required based on an incorrect *RXTIME* or other parameter incorrectly derived from an $L_{\_LENGTH}$ value to which m had been added at the transmitter. SAMSUNG-1008, 818-819; SAMSUNG-1010, [0017]-[0020], [0024]-[0025], [0036], [0041]; SAMSUNG-1015, [0048], [0051].

68. Similarly, for legacy devices that operate according to the 802.11n standard (*i.e.*, according to IEEE Std 802.11-2012), $L_{\_LENGTH}$ and N_{SYM} are calculated according to the following equations:[4]

$$L\_LENGTH = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3$$

$$N_{SYM} = \left\lceil \frac{16 + 8 \times LENGTH + 6}{N_{DBPS}} \right\rceil$$

SAMSUNG-1008, 925, 1597. With $N_{DBPS} = 24$ (SAMSUNG-1008, 1590) and substituting *LENGTH* with the $L_{\_LENGTH}$ equation, the desired Nsym value for 802.11n devices becomes as follows:

$$N_{SYM} = \left\lceil \frac{16 + 8 \times \left(\left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 \right) + 6}{24} \right\rceil = \left\lceil \frac{TXTIME - 20}{4} \right\rceil$$

[4] A POSITA would have understood 802.11n to be another legacy variant of the 802.11 standard. SAMSUNG-1007, [0003] (“earlier or legacy Wi-Fi standards”).

For the $L_{\_LENGTH}$ equation that adds m = +1 or +2 as disclosed in Bharadwaj-Prov059, the N_{SYM} value calculated by a legacy device would be incorrect and would exceed the desired Nsym value as indicated by the "+ 1" in the simplified equation:

$$N_{SYM} = \left\lceil \frac{8 \times \left(\left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 + m \right) + 22}{24} \right\rceil$$

$$= \left\lceil \left\lceil \frac{TXTIME - 20}{4} \right\rceil - 1 + \frac{m}{3} + \frac{22}{24} \right\rceil$$

$$= \left\lceil \left\lceil \frac{TXTIME - 20}{4} \right\rceil + \frac{m}{3} - 0.08 \right\rceil = \left\lceil \frac{TXTIME - 20}{4} \right\rceil + 1$$

Id. On the other hand, for the $L_{\_LENGTH}$ equation that sets $L_{\_LENGTH}$ with the addition of $m = -1$ or -2 (*i.e.*, subtracting m=+1 or +2), the calculated N_{SYM} value would yield the correct and desired N_{SYM} value:

$$N_{SYM} = \left\lceil \frac{8 \times \left(\left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - m \right) + 22}{24} \right\rceil$$

$$= \left\lceil \left\lceil \frac{TXTIME - 20}{4} \right\rceil - 1 - \frac{m}{3} + \frac{22}{24} \right\rceil$$

$$= \left\lceil \left\lceil \frac{TXTIME - 20}{4} \right\rceil - \frac{m}{3} - 0.08 \right\rceil = \left\lceil \frac{TXTIME - 20}{4} \right\rceil$$

Id. By performing these calculations of N_{SYM} for 802.11n devices, a POSITA would have recognized that an $L_{\_LENGTH}$ equation using $m = +1$ or $+2$ would result in an error in the calculation of Nsym whereas an $L_{\_LENGTH}$ equation using $m = -1$ or -2 (*i.e.*, "$-m$" with m=1 or 2) would result in the desired N_{SYM} value. *Id.* 802.11-2012 discloses that reception is "terminated after the reception of the final symbol of the last PSDU octet indicated by the PLCP header's LENGTH field." SAMSUNG-1008, 1494. The number of symbols is denoted by the N_{SYM} value. SAMSUNG-1008, 1596-1597. Thus, a POSITA would have been motivated to use $m = -1$ or -2 (*i.e.*, "$-m$" with m=1 or 2) to allow legacy 802.11n devices to correctly calculate N_{SYM} so that the legacy devices need not defer transmissions for a duration longer than required. SAMSUNG-1008, 818-819; SAMSUNG-1010, [0017]-[0020], [0024]-[0025], [0036], [0041]; SAMSUNG-1015, [0048], [0051].

69. Additional contemporaneous evidence also confirms that using $m = -1$ or -2 (i.e., *subtracting m* in the *L_LENGTH* equation) would have been within the knowledge and capability of a POSITA, and that a POSITA would have pursued this approach with a reasonable expectation of success. For example, Lee, which pre-dates the '077 patent, discloses yet another $L_{\_LENGTH}$ setting equation with a "$-n$" in which n is 0, 1, or 2, similar to Yu-Prov428:

$$L\_LENGTH = \left\lceil \frac{((TXTIME - \text{Signal Extension}) - 20))}{4} \right\rceil \times 3 - 3 - n$$

SAMSUNG-1018, [0078]-[0079].

70. As another example, IEEE submission document IEEE 802.11-15/1372, titled "L-LENGTH Equation Update" and dated Nov. 2015, proposed to change the L-LENGTH equation from

$$L\_LENGTH = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 + m,\ m = 1 \text{ or } 2$$

to

$$L\_LENGTH = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - \boldsymbol{m}, m = 1 \text{ or } 2$$

resulting in the N_{SYM} equation correspondingly changing to

$$N_{SYM} = \left\lfloor \frac{\left(\frac{L\_LENGTH + m + 3}{3} \times 4 - T_{HE\_PREAMBLE}\right)}{T_{SYM}} \right\rfloor - b_{PE\_Disambiguity}.$$

SAMSUNG-1016, 2, 4-5 (red text in original). 802.11-15/1372 indicates that this change provides the benefit of allowing legacy devices to correctly calculate the desired N_{SYM}. SAMSUNG-1016, 3-4.

71. Indeed, Bharadwaj, the non-provisional application of Bharadwaj-Prov059, implemented this change to the L_{LENGTH} equation, which also solves the need to "ensure that L_{LENGTH} is not exactly a multiple of 3 and therefore can be used

to distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions":

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - m,$$

where

$$m = 1, 2$$

.

SAMSUNG-1006, [0050]. From this updated L_{LENGTH} equation, Bharadwaj teaches that the receiver computes correspondingly $RXTIME$ and N_{sym} as follows:

$$RXTIME = \left\lceil \frac{L_{LENGTH} + m + 3}{3} \right\rceil \times 4 + 20$$

$$N_{sym} = \left\lfloor \frac{RXTIME - T_{L\_PREAMBLE} - T_{HE\_PREAMBLE}}{T_{SYM}} \right\rfloor - SE_{disambiguation\_bit}$$

$$= \left\lfloor \frac{\left\lceil \frac{L_{LENGTH} + m + 3}{3} \right\rceil \times 4 - T_{HE\_PREAMBLE}}{T_{SYM}} \right\rfloor - SE_{disambiguation\_bit}$$

SAMSUNG-1006, [0054]-[0055], [0060][5].

72. Bharadwaj's Nsym calculation is noticeably equivalent to the Nsym

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[5] Bharadwaj's equation for RXTIME includes a typographical error in which "−20" should be "+20" as evident by the calculation of RXTIME = 344 μs. SAMSUNG-1006, [0054]-[0055], [0060].

equation provided in claim 1 of the ’077 Patent. The only difference in expression of the Nsym equation as written above and the Nsym equation recited in claim 1 is that claim 1 lacks the ceiling operator around $\frac{L_{LENGTH}+m+3}{3}$. But this is immaterial because $\frac{L_{LENGTH}+m+3}{3}$ will always produce an integer for valid values of L_{LENGTH} and m in which L_{LENGTH} + m is a multiple of 3, thereby rendering the ceiling operator unnecessary. For example, a POSITA would have understood that because L_{LENGTH} is calculated by subtracting m=1 or 2 from a multiple of 3 as disclosed at paragraph [0050] of Bharadwaj, the natural consequence is that L_{LENGTH} + m +3 will also be a multiple of 3, and dividing L_{LENGTH} +m + 3 by 3 will produce an integer that makes the ceiling operator moot:

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - m$$

$$\frac{L_{LENGTH} + 3 + m}{3} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil$$

$$\left\lceil \frac{L_{LENGTH} + 3 + m}{3} \right\rceil = \left\lceil \left\lceil \frac{TXTIME - 20}{4} \right\rceil \right\rceil = \left\lceil \frac{TXTIME - 20}{4} \right\rceil$$

$$= \frac{L_{LENGTH} + 3 + m}{3}$$

and because $\lceil x \rceil$ is an integer, $\lceil \lceil x \rceil \rceil = \lceil x \rceil = \lceil \text{integer} \rceil = \text{integer}$. Using, for example, if m=1 and also

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - m = 239$$

a POSITA would have recognized that:

$$\left\lceil \frac{L_{LENGTH} + m + 3}{3} \right\rceil = \left\lceil \frac{239 + 1 + 3}{3} \right\rceil = \frac{239 + 1 + 3}{3} = \frac{L_{LENGTH} + m + 3}{3}$$

and therefore:

$$N_{sym} = \left\lfloor \frac{\left\lceil \frac{L_{LENGTH} + m + 3}{3} \right\rceil \times 4 - T_{HE\_PREAMBLE}}{T_{SYM}} \right\rfloor - SE_{disambiguation\_bit}$$

$$= \left\lfloor \frac{\frac{L_{LENGTH} + m + 3}{3} \times 4 - T_{HE\_PREAMBLE}}{T_{SYM}} \right\rfloor - SE_{disambiguation\_bit}$$

SEC-1006, [0057]-[0058].

73. Based upon my knowledge and experience in this field and my review of the publications cited here, it would have been obvious to try other predictable potential values for *m*, including *m* = −1 or −2, to address the need to "ensure that L_{LENGTH} is not exactly a multiple of 3… to distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions" and to ensure compatibility with legacy devices. SAMSUNG-1006, [0050]; SAMSUNG-1007, [0051]; SAMSUNG-1010, [0017]-[0020], [0024], [0036], [0038]-[0042], [0059]-[0060], [0063], [0065]; SAMSUNG-1012, [0057], [0068], [0073], [0080]-[0081]; SAMSUNG-1013, [0055]-[0056]; SAMSUNG-1014, [0039], [0077]; SAMSUNG-1015, [0051]-[0052]; SAMSUNG-

1016, 2, 4-5.

B. Bharadwaj in view of Yu and Azizi

1. Overview of Azizi

74. Azizi relates to "high efficiency (HE) wireless local area networks (WLANs) including networks operating in accordance with the Institute of Electronic and Electrical Engineers (IEEE) 802.11 family of standards, such as the IEEE 802.11a/g/n/ac standard or the IEEE 802.11ax standard" and describes "using different size preambles." SAMSUNG-1015, [0002]. In Azizi, HE packets can be configured to have either a short preamble format 200 or a long preamble format 300 as shown in FIGS. 2 and 3, respectively. SAMSUNG-1015, [0028]-[0043]. A "HEW device 104 and/or AP 102 may determine whether to use the short preamble format 200 or the long preamble format 300 based on characteristics of the wireless medium. For example a lot of errors may indicate that the long preamble format 300 should be used." SAMSUNG-1015, [0049], [0055], [0071]. The "length field of the L-SIG field 206 may indicate whether the preamble is the short preamble format 200 or the long preamble format 300. For example, a length field that has a length of 1 modulo 3 may indicate a short preamble format 200 and a length of 2 modulo 3 may indicate a long preamble format 300." SAMSUNG-1015, [0031], [0037], [0045], [0049], [0064], [0068]-

[0069], [0079]-[0080]. It would have been clear to a POSITA that a length of 1 modulo 3 and a length of 2 modulo 3 correspond to a length having a remaining value of 1 or a remaining value of 2, respectively, when dividing the length by 3, i.e., length / 3.

75. Azizi further explains that "legacy devices 106 and HEW devices 104 co-exist in the same WLAN." SAMSUNG-1015, [0051]. Therefore, the "HEW device 104 needs a way to recognize HE packets and a way to indicate to legacy devices 106 to defer if the packet is HE packet. The HEW device 104 may be able to determine based on the L-SIG whether or not the packet may be a HE packet. For example, a length 406 field may indicate that the packet may be an HE packet if the length 406 field is not equal to 0 modulo 3." *Id*. If "the L-SIG indicates that the packet is or may be an HE packet" then the HEW device determines "the preamble format. For example, the length 406 field of the L-SIG 400 may indicate based on the modulus 3 the preamble configuration." SAMSUNG-1015, [0053].

2. Combination of Bharadwaj and Yu in view of Azizi

76. Based upon my knowledge and experience in this field and my review of the publications cited here, a POSITA would have found it obvious and straightforward to implement Bharadwaj-Prov059's receiver device, as modified by Yu ("Bharadwaj-Yu"), such that the processor distinguishes between HE

packets and legacy packets, and also determines the preamble format based on the length field of the L-SIG, based on Azizi's teachings. SAMSUNG-1015, [0051], [0053]. A POSITA would have been motivated to apply Azizi's suggestion in this regard to Bharadwaj-Yu's receiver device because Azizi explicitly describes a receiver device that performs such functionality. *Id.* A POSITA would have also been motivated to apply Azizi's suggestion (e.g., using a short preamble format or a long preamble format and determining the preamble format based on the length field of the L-SIG) to Bharadwaj-Yu's receiver device in order to use the wireless medium more efficiently. SAMSUNG-1015, [0049], [0055], [0071]. For example, "the short preamble 200 has less overhead and may be used indoors" and "the long preamble 300 may be used in the outdoors and may have more overhead but may be more reliable in some environments." *Id.*

77. Based upon my knowledge and experience in this field and my review of the publications cited here, a POSITA would have applied Azizi's functionality in the same way to Bharadwaj-Yu's receiver device, would have achieved predictable results, and would have reasonably expected success in achieving the combination.

C. Bharadwaj in view of Yu and Kenney

1. Overview of Kenney

78. Kenney relates to "high-efficiency Wi-Fi (HEW) communications in accordance with the IEEE 802.11ax draft standard." SAMSUNG-1010, [0002]. In Kenney, "an HEW station" is "an IEEE 802.11ax configured station (STA) that is configured for HEW operation." SAMSUNG-1010, [0027]. "Legacy stations" include "non-HT stations 108 (e.g., IEEE 802.11 a/g stations), HT stations 110 (e.g., IEEE 802.11n stations), and VHT stations 112 (e.g., IEEE 802.11ac stations)." SAMSUNG-1010, [0024].

79. Kenney describes "methods for distinguishing high-efficiency Wi-Fi (HEW) packets from legacy packets." SAMSUNG-1010, Abstract, [0024], [0056], FIG. 4. Kenney discloses that an HEW device with a processor determines "whether a value for the length field is divisible by three" and identifies "the PPDU as an HEW PPDU when the value in the length field is not divisible three" and "the PPDU as a non-HEW PPDU (e.g., a VHT PPDU or HT PPDU) when the value in the length field is divisible three." SAMSUNG-1010, [0065], Abstract, [0024], [0036], [0038]-[0041], [0059]-[0060], FIG. 4 (406, 408), claims 1, 13, 17. Kenney discloses that the HEW device's processor also determines "whether the PPDU is a HT PPDU, a VHT PPDU or an HEW PPDU based on the phase rotation applied to the BPSK modulation of at least one of the first and second symbols of the subsequent signal field" following the L-SIG field. SAMSUNG-1010,

Abstract, [0066], [0024], [0062], FIG. 4 (412), claims 3, 15, 17.

80. Kenney discloses that a data unit (PPDU) is configured "to include a subsequent/additional signal field 210 (e.g., HT-SIG 212, VHT-SIG 222, or HEW-SIG 232) following the L-SIG 206" that has "first and second symbols that are BPSK modulated." SAMSUNG-1010, [0043], [0061], FIG. 4 (410). For "an HEW-PPDU, the first symbol 332A of the HEW-SIG 232 is rotated BPSK and the second symbol 332B is conventional (i.e., non-rotated) BPSK." SAMSUNG-1010, [0050]. For "a VHT-PPDU, the first symbol 322A of the VHT-SIG 222 is conventional BPSK and the second symbol 322B is rotated BPSK." SAMSUNG-1010, [0051]. For a HT PPDU, both symbols of the HT-SIG 222 are rotated BPSK. SAMSUNG-1010, [0052]. "The HT-SIG 212 uses rotated binary phase-shift keying (BPSK) in both symbols of the HT-SIG 212 so that IEEE 802.11n devices can distinguish it from non-rotated BPSK data 208 of an IEEE 802.11a/g transmission and allows those devices to detect the existence of an IEEE 802.11n packet" and this "modulation format may be used by an IEEE 802.11n device to detect those packets and identify them as IEEE 802.11n packets." SAMSUNG-1010, [0032], [0034].

2. Combination of Bharadwaj in view of Yu and Kenney

81. Based upon my knowledge and experience in this field and my review

of the publications cited here, a POSITA would have found it obvious and straightforward to implement Bharadwaj-Yu's receiver device such that the processor distinguishes "between IEEE 802.11ax and IEEE 802.11ac transmissions," "HEW PPDUs from non-HEW PPDUs," and "HT PPDUs, VHT PPDUs and HEW PPDUs" (SAMSUNG-1007, [0051]; SAMSUNG-1010, [0024], Abstract, [0036], [0038]-[0041], [0059]-[0060], [0062], [0064]-[0066]) based on whether a value for the length field is divisible by three and a phase rotation applied to the BPSK modulation of the first and second symbols of the HEW-SIG field following the L-SIG field, based on Kenney's teachings. SAMSUNG-1010, Abstract, [0024], [0036], [0038]-[0041], [0059]-[0060], [0062], [0064]-[0066], FIG. 4 (406, 408, 412), claims 1, 3, 13, 15, 17.

82. A POSITA would have been motivated to apply Kenney's suggestion in this regard to Bharadwaj-Prov059's receiver device because Kenney explicitly describes a receiver device that uses the determination of whether a value for the length field is divisible by 3 "to distinguish HEW PPDUs from non-HEW PPDUs" and determines a phase rotation applied to the BPSK modulation of the first and second symbols of the HEW-SIG field following the L-SIG field "to distinguish HT PPDUs, VHT PPDUs and HEW PPDUs." SAMSUNG-1010, [0024], Abstract, [0036], [0038]-[0041], [0059]-[0060], [0062], [0064]-[0066]. By determining both

(1) whether a value for the length field is divisible by 3 and (2) a phase rotation applied to the BPSK modulation of the first and second symbols of the HEW-SIG field, the HEW device is provided with a more robust and reliable determination that the PPDU is a HEW PPDU. *Id.*

83. Based upon my knowledge and experience in this field and my review of the publications cited here, a POSITA would have applied Kenney's functionality in the same way to Bharadwaj-Yu's receiver device, would have achieved predictable results, and would have reasonably expected success in achieving the combination.

IX. MANNER IN WHICH THE PRIOR ART REFERENCES RENDER THE '077 CLAIMS UNPATENTABLE

A. Ground 1A: Combination of Bharadwaj in view of Yu Renders Obvious Claims 1-5 and 8-12

1. Claims 1 and 8

1[pre]. A wireless communication terminal that communicates wirelessly, the terminal comprising:
8[pre]. An operation method of a wireless communication terminal that communicates wirelessly, the method comprising:

84. To the extent the preambles are limitations, the Bharadwaj-Yu combination renders obvious 1[pre] and 8[pre]. For example, Bharadwaj-Prov059 describes "a wireless local area network (WLAN)" that includes "one or more mobile stations (STAs)" in connection with "techniques for signal extension

signaling." SAMSUNG-1007, [0011], [0034], [0001]-[0002], [0005]-[0008], [0012]-[0026], [0029]-[0031], [0036]-[0038], [0046], FIGS. 1-13. The STAs "utilize the backhaul services of their respective AP to connect to a network, such as the Internet" and can be "a cellular phone, a smart phone, a laptop computer, a desktop computer, a personal digital assistant (PDA), a personal communication system (PCS) device, a personal information manager (PIM), personal navigation device (PND), a global positioning system, a multimedia device, a video device, an audio device, a device for the Internet-of-Things (IoT), or any other suitable wireless apparatus requiring the backhaul services of an AP." SAMSUNG-1007, [0035]. In Bharadwaj-Prov059, a receiver device, such as a STA, processes a received data unit and generates a response to the received data unit within a SIFS (short interframe space) duration in IEEE 802.11ax using signal extension signaling techniques. SAMSUNG-1007, [0029]-[0031], [0043], FIGS. 3A-3B. Each STA is **a wireless communication terminal that communicates wirelessly** using signal extension signaling techniques (**an operation method**).

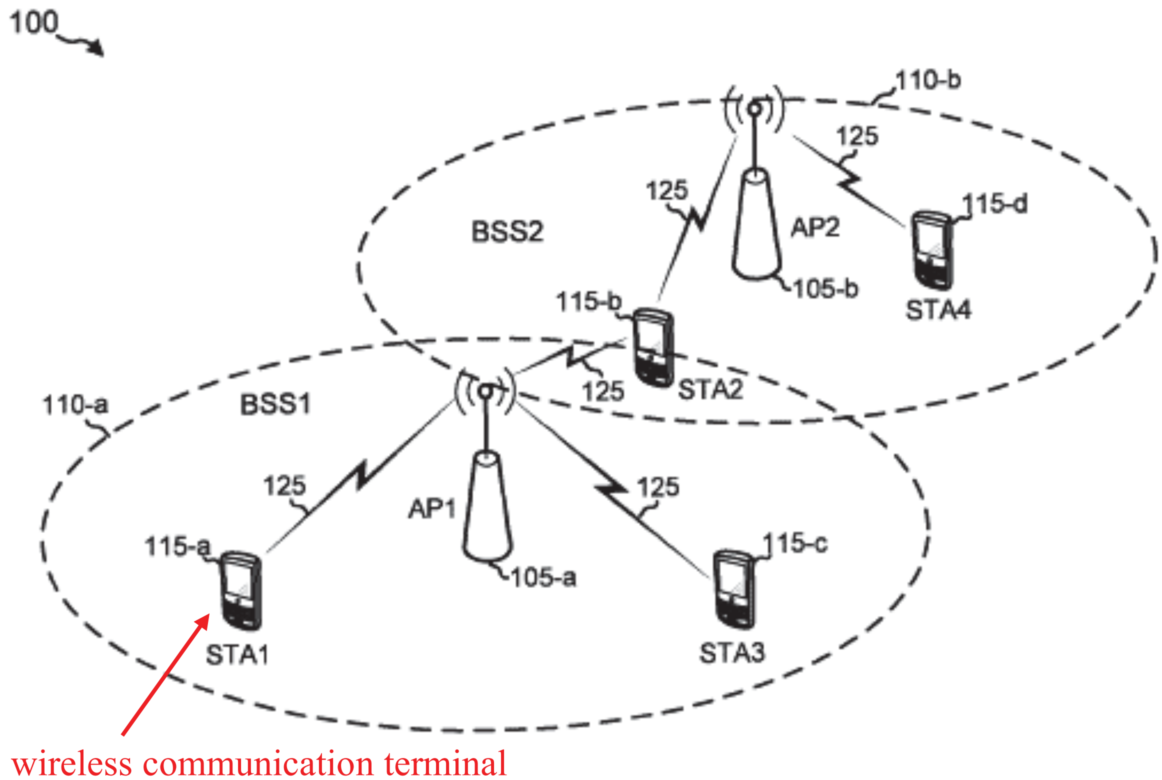


FIG. 1

SAMSUNG-1007, FIG. 1

85. Bharadwaj-Prov059 illustrates in FIG. 3A "signal extension signaling from a transmitter device 310 to a receiver device 320." SAMSUNG-1007, [0043]. In one example, the receiver device 320 is the STA1 115-a. *Id.*

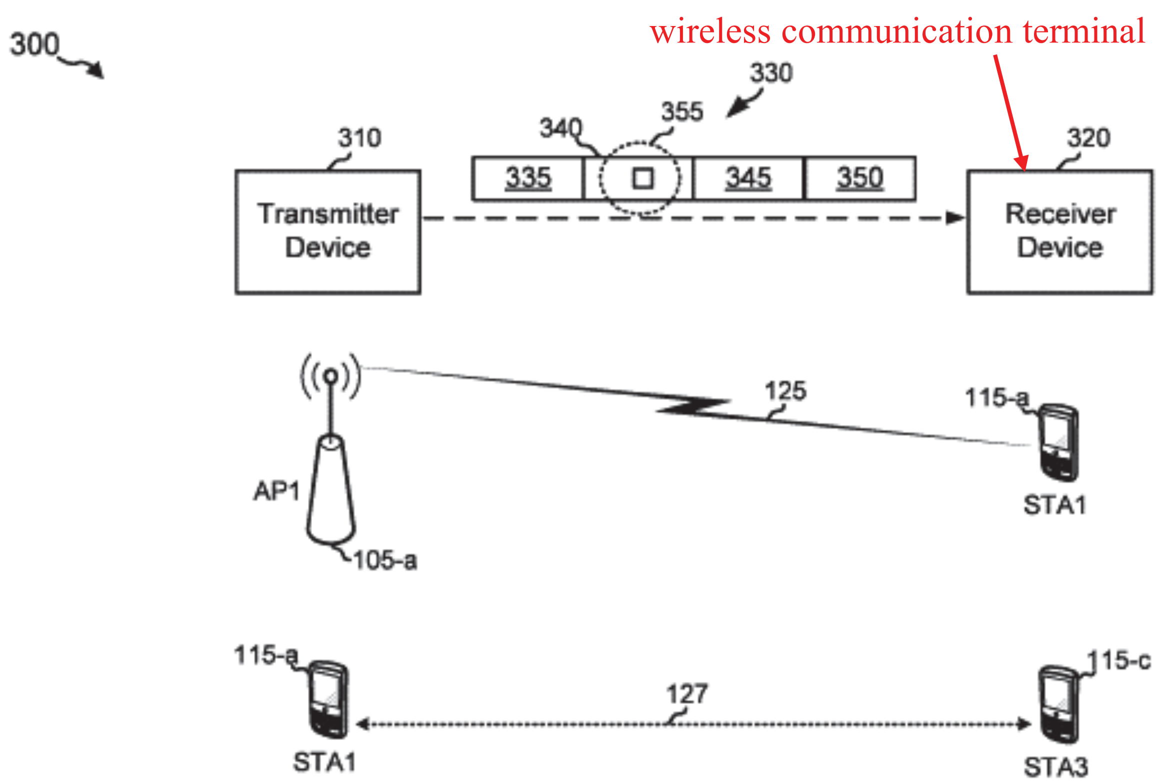


FIG. 3A

SAMSUNG-1007, FIG. 3A

1[1]. a transceiver; and a processor, wherein the processor is configured to

86. The Bharadwaj-Yu combination renders obvious 1[1]. For example, Bharadwaj-Prov059 discloses that the “various elements, components, or modules” of “the receiver device 320 in FIG. 8 may be implemented in hardware, software, or a combination of hardware and software” and “the functionality of each of the various elements, components, or modules” of “the receiver device 320 in FIG. 8

can be implemented or performed by a **processor** (see e.g., processor 1304 in FIG. 13) in connection with instructions or code… programmed to implement the **methods** shown in FIGS. 9-12… through use of the equations and functionality for signal extension signaling." SAMSUNG-1007, [0080]. Bharadwaj-Prov059 further illustrates in FIG. 13 "an example of a processing system 1314 that supports signal extension signaling operations." SAMSUNG-1007, [0027], [0099]. "The processing system 1314 may be coupled to a **transceiver** 1310." SAMSUNG-1007, [00100]. "The transceiver 1310 may receive a signal from the one or more antennas 1320, may extract information from the received signal, and may provide the extracted information to the processing system 1314, specifically the **processor** 1304." *Id.* "The processor 1304 is responsible for general processing, including the execution of software stored on the computer-readable medium/memory 1306. The software, when executed by the processor 1004, causes the processing system 1314 to perform the various functions described in the disclosure for signal extension signaling." *Id.*

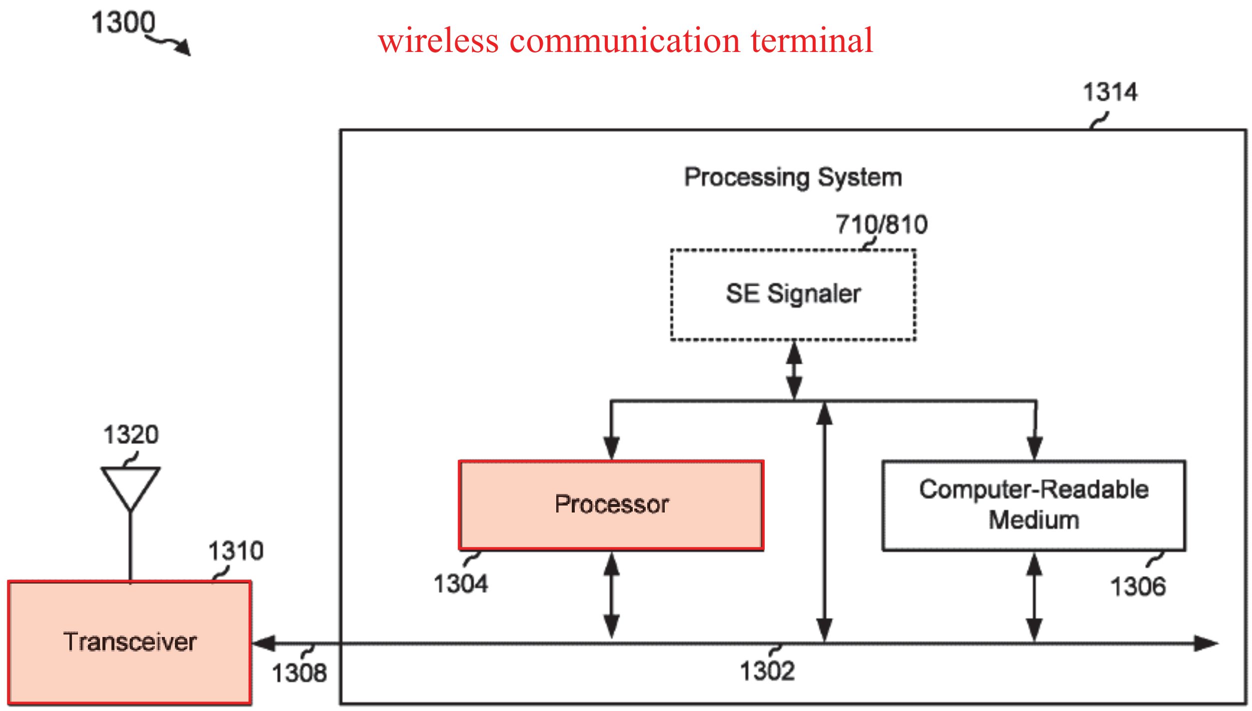


FIG. 10

SAMSUNG-1007, FIG. 13[6]

1[a]/8[a]. receive/receiving a non-legacy physical layer frame by using the transceiver,

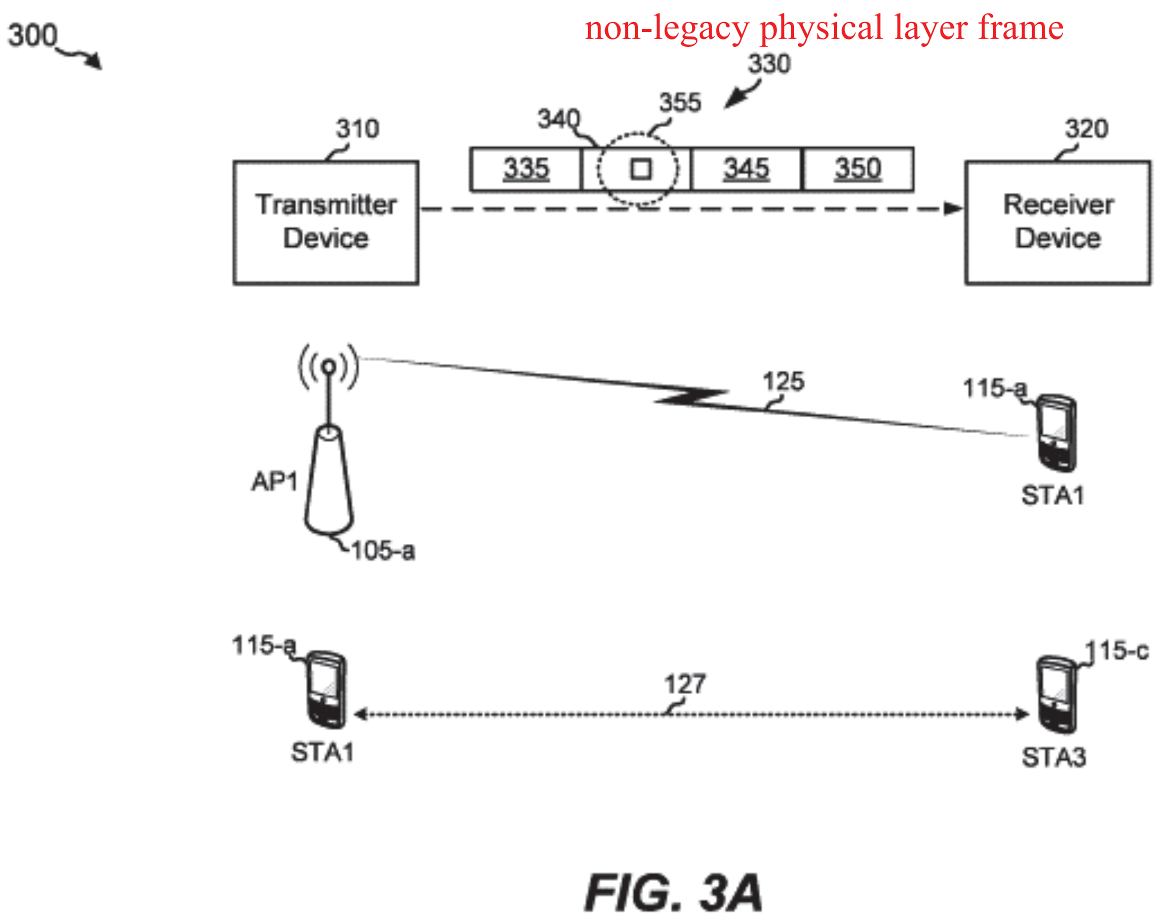
87. The Bharadwaj-Yu combination renders obvious 1[a] and 8[a]. For

[6] Bharadwaj-Prov059 label of FIG. 10 is a typographical error and should be FIG. 13 as evident from the accompanying description.

example, Bharadwaj-Prov059 describes IEEE 802.11ac as an "earlier or legacy" Wi-Fi standard prior to the IEEE 802.11ax Wi-Fi standard. SAMSUNG-1007, [0003], [0040]. Bharadwaj-Prov059 explains that the receiver device "has to process a received data unit and generate a response to the received data unit under IEEE 802.11ax in the same amount of time as it would have under the legacy IEEE 802.11ac… even though it now has to process four times the number of tones." SAMSUNG-1007, [0029]. In Bharadwaj-Prov059, a receiver device, such as a STA, processes a received data unit and generates a response to the received data unit within a SIFS (short interframe space) duration in IEEE 802.11ax using signal extension signaling techniques. SAMSUNG-1007, [0029]-[0031], [0043], FIGS. 3A-3B. The IEEE 802.11ax data unit, such as data unit 330 depicted in FIG. 3A, is **a non-legacy physical layer frame**. SAMSUNG-1007, [0043], FIG. 3A; *see also id.*, FIGS. 4A-4B, 6A-6C.

88. Bharadwaj-Prov059 illustrates in FIG. 3A "a conceptual diagram 300 illustrating an example of signal extension signaling from a transmitter device 310 to a receiver device 320." SAMSUNG-1007, [0043]. In one example, the transmitter device 310 is AP1 105-a, and the receiver device 320 is the STA1 115-a. *Id.* The "AP1 105-a determines that signal extension is to be applied to a data unit (e.g., data unit 330) and the duration of the signal extension to be applied. The

AP1 105-a then signals (e.g., using a communications link 125) the signal extension to the STA1 115-a using the single-bit signaling scheme." *Id.* "The data unit 330 is shown to generally include a legacy preamble 335, a high efficiency (HE) preamble 340, which typically includes the single signaling bit 335 used for the single-bit signaling scheme, data portion 345, and signal extension 350." SAMSUNG-1007, [0044]. FIG. 3A shows the receiver device 320 receiving a data unit 330.



SAMSUNG-1007, FIG. 3A

89. Bharadwaj-Prov059's "FIG. 8 is a block diagram 800 illustrating an example of an SE signaler 810 in the receiver device 320. The SE signaler 810 may include a frame/data unit communicator 820 configured to receive a data unit (e.g., the data unit 330 in FIG. 3A) from a transmitter device (e.g., the transmitter device 310 in FIG. 3A)." SAMSUNG-1007, [0076]. Bharadwaj-Prov059's "FIG. 10 is a flow diagram illustrating an example of a method 1000 for signal extension signaling by a receiver device (e.g., the receiver device 320 in FIGS. 3A and 8). At 1011, a data unit is received from a transmitter device. In an example, the frame/data unit communicator 820 in the SE signaler 810 receives a data unit from a transmitter device (e.g., the transmitter device 310 in FIGS. 3A and 7)." SAMSUNG-1007, [0086].

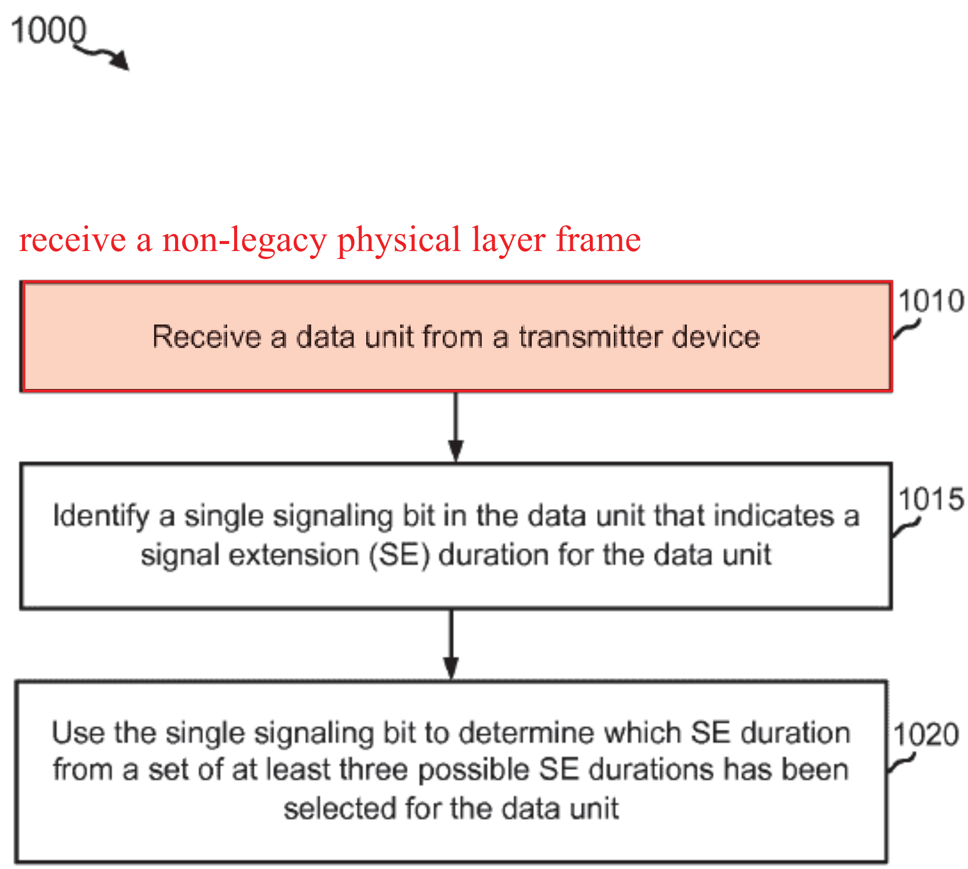


FIG. 10

SAMSUNG-1007, FIG. 10

90. As discussed above in 1[1], the receiver device 320 includes a "transceiver 1310" that "receive[s] a signal from the one or more antennas 1320." SAMSUNG-1007, [00100]. In Bharadwaj-Prov059, the receiver device 320 would receive the data unit from the transmitter device using the transceiver 1310. *Id.*

1[b]/8[b]. obtain/obtaining a legacy signaling field including information decodable by a legacy wireless communication terminal from the non-legacy physical layer frame,

91. The Bharadwaj-Yu combination renders obvious 1[b] and 8[b]. As discussed above in 1[a]/8[a], Bharadwaj-Prov059's data unit 330 (**non-legacy physical layer frame**) includes a legacy preamble 335. SAMSUNG-1007, [0044], FIG. 3A. Bharadwaj-Prov059 discloses that "signaling bits are included in a preamble of the data unit and the preamble is not transmitted at a high data rate in part to maintain compatibility with legacy devices." SAMSUNG-1007, [0033]. "In IEEE 802.11ac, the reason that the transmitter device 310 provides L_{LENGTH} and *TXTIME* is for the receiver device 320 to know the number of data symbols (*Nsym*) that need to be decoded. In IEEE 802.11ax, for the receiver device 320 to know the number of data symbols (*Nsym*) to be decoded, the transmitter device 310 may provide $L_{\_LENGTH}$, TXTIME, and T_{SE}." SAMSUNG-1007, [0052], [0048] ("In IEEE 802.11ax, the Length field ($L_{\_LENGTH}$) transmitted through the legacy signal (L-SIG) field in the legacy preamble can be used to indicate[] both the data unit (e.g., data unit 330) duration (TXTIME) and the signal extension."), [0051]. The legacy signal (L-SIG) field including the Length field ($L_{\_LENGTH}$) is a **legacy signaling field including information decodable by a legacy wireless communication terminal**.

92. Bharadwaj-Prov059 discloses the "time duration of the data unit 330 is determined by the receiver device 320 based on the duration of the data unit 330 in number of bytes ($L_{\_LENGTH}$). That is, at the receiver device 320, the duration RXTIME of the data unit 330 is computed from $L_{\_LENGTH}$ in the L-SIG." SAMSUNG-1007, [0055]. Accordingly, the receiver device 320 obtains the L-SIG (**legacy signaling field**) including $L_{\_LENGTH}$ (**information decodable by a legacy wireless communication terminal**) from the data unit 330 (**non-legacy physical layer frame**) to compute the RXTIME of the data unit 330.

1[c]. obtain length information indicating information on a duration of the non-legacy physical layer frame, from the legacy signaling field,
8[c]. obtaining length information indicating information on a duration of the non-legacy physical layer frame after a legacy signaling field, from the legacy signaling field,

93. The Bharadwaj-Yu combination renders obvious 1[c] and 8[c]. For example, Bharadwaj-Prov059 discloses that in "IEEE 802.11ax, the Length field ($L_{\_LENGTH}$) transmitted through the legacy signal (L-SIG) field in the legacy preamble can be used to indicate[] both the data unit (e.g., data unit 330) duration (TXTIME) and the signal extension." SAMSUNG-1007, [0048]. "The duration of the data unit 330, in number of bytes, is determined by the following expression (Equation 2):

$$L_{LENGTH} = \left\lceil \frac{TXTIME-20}{4} \right\rceil \times 3 - 3 + m \text{ where } m = 1,2$$

where TXTIME = $T_{L\_PREAMBLE}$ + $T_{HE\_PREAMBLE}$ + T_{DATA} + T_{SE}. $T_{L\_PREAMBLE}$ is the duration of the legacy preamble 335 of the data unit 330…. $T_{HE\_PREAMBLE}$ is the duration of the high efficiency (HE) or IEEE 802.11ax preamble 340 of the data unit 330…. The value of T_{DATA} is the duration of the data portion 345 of the data unit 330 and can be determined by the transmitter device 310 based on the following expression (Equation 3):

$$T_{DATA} = N_{sym} \times T_{sym} = N_{sym} \times (12.8 + T_{GI})$$

where N_{sym} is the number of data symbols, T_{sym} is the duration of a data symbol, and T_{GI} is the guard time of a data symbol…. Finally, T_{SE} is the duration of the… signal extension 350….” SAMSUNG-1007, [0051].

94. In Bharadwaj-Prov059, the “time duration of the data unit 330 is determined by the receiver device 320 based on the duration of the data unit 330 in number of bytes ($L_{\_LENGTH}$). That is, at the receiver device 320, the duration RXTIME of the data unit 330 is computed from $L_{\_LENGTH}$ in the L-SIG as follows (Equation 5).” SAMSUNG-1007, [0055].

$$RXTIME = \left\lceil \frac{L_{LENGTH} - m + 3}{3} \right\rceil \times 4 + 20$$

SAMSUNG-1007, [0056]. Accordingly, the receiver device 320 obtains, from the L-SIG (**legacy signaling field**), $L_{\_LENGTH}$, which is based on TXTIME = $T_{L\_PREAMBLE}$ + $T_{HE\_PREAMBLE}$ + T_{DATA} + T_{SE}, and which indicates a duration of the data unit 330 in number of bytes (**length information indicating information on a duration of the non-legacy physical layer frame**) to compute the RXTIME of the data unit 330. Moreover, because the receiver device 320 knows that the length of the legacy preamble ($T_{L\_PREAMBLE}$) that includes the legacy signaling field (L-SIG) is 20 µs (SAMSUNG-1007, [0059]), the value of $L_{\_LENGTH}$ that the receiver device 320 obtains from the legacy signaling field is indicative of information on a duration of the non-legacy physical layer frame **after the legacy signaling field** at least because $L_{\_LENGTH}$ is further set based on the duration of a portion of the frame after the legacy signaling field including $T_{HE\_PREAMBLE}$ + T_{DATA} + T_{SE} (i.e., TXTIME – 20 µs), which is a **duration of the non-legacy physical layer frame after a legacy signaling field**. The receiver device 320 also calculates a time duration of the frame after the preamble(s), for example, by determining RXTIME – $T_{L,PREAMBLE}$ – $T_{HE,PREAMBLE}$ to calculate the number of data symbols N_{sym}. SAMSUNG-1007, [0057]; *see also id.*, [0058]-[0063].

95. As discussed above in Section VIII.A.3, the Bharadwaj-Yu combination renders obvious an $L_{\_LENGTH}$ equation with a "– m" instead of a "+m"

with m=1 or 2:

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - m$$

SAMSUNG-1020, 16; SAMSUNG-1019, [0232]; SAMSUNG-1007, [0051]-[0052]. From this updated L_{LENGTH} equation, the receiver would also have correspondingly changed the sign of the "*m*" value to correctly compute RXTIME as follows:

$$RXTIME = \left\lceil \frac{L_{LENGTH} + m + 3}{3} \right\rceil \times 4 + 20$$

SAMSUNG-1006, [0054]-[0055], [0060][7].

1[d]/8[d]. obtain/obtaining information other than information on the duration of the non-legacy physical layer frame through a remaining value obtained by dividing the length information by a data size transmittable by a symbol of a legacy physical layer frame, wherein the data size transmittable by a symbol of the legacy physical layer frame is 3 octets when a data rate of the legacy physical layer frame is 6 Mbps, and

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[7] Bharadwaj's equation for RXTIME includes a typographical error in which "−20" should be "+20" as evident by the calculation of RXTIME = 344 μs. SAMSUNG-1006, [0054]-[0055], [0060].

96. The Bharadwaj-Yu combination renders obvious 1[d] and 8[d]. For example, Bharadwaj-Prov059 discloses that the "duration of the data unit 330, in number of bytes, is determined by the following expression (Equation 2):

$$L_{LENGTH} = \left\lceil \frac{TXTIME-20}{4} \right\rceil \times 3 - 3 + m \text{ where } m = 1, 2$$

where TXTIME = $T_{L\_PREAMBLE} + T_{HE\_PREAMBLE} + T_{DATA} + T_{SE}$… The value *m* shown above has been added in IEEE 802.11ax to ensure that L_{LENGTH} is not exactly a multiple of 3 and is therefore used to distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions (e.g., auto-detections)." SAMSUNG-1007, [0051]. Based on Bharadwaj-Prov059's explanation that the value *m* "has been added in IEEE 802.11ax" so as to "distinguish" IEEE 802.11ax from IEEE 802.11ac transmissions based on whether $L_{\_LENGTH}$ is "a multiple of 3," a POSITA would have understood and found obvious that the receiver device 320 would determine whether a received physical layer frame (e.g., data unit 33) is a non-legacy frame (e.g., 11ax frame) or a legacy frame (e.g., 11ac frame) based on whether the division $L_{\_LENGTH}$ / 3 yields a remaining value (*i.e.*, a non-zero remainder). Based upon my knowledge and experience in this field and my review of the publications cited here, a POSITA also would have understood from general knowledge of the legacy 802.11 standards that L_{LENGTH} in 802.11ac is determined by the expression:

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3$$.

See, e.g., SAMSUNG-1008, 925; SAMSUNG-1009, 256; SAMSUNG-1010, [0039]; SAMSUNG-1011, [0067]. A POSITA would have understood from general knowledge of the legacy 802.11 standards referenced in Bharadwaj that the above 802.11ac L_{LENGTH} equation is a simplified version of the following equation:

$$\text{L\_LENGTH} = \left\lceil \frac{((\text{TXTIME} - \text{Signal Extension}) - (\text{aPreambleLength} + \text{aPLCPHeaderLength}))}{\text{aSymbolLength}} \right\rceil \times N_{OPS} - \left\lceil \frac{\text{aPLCPServiceLength} + \text{aPLCPConvolutionalTailLength}}{8} \right\rceil$$

where "N_{OPS} is the number of octets transmitted during a period of aSymbolLength at the rate specified by L_DATARATE" "set to the value of 6 Mb/s." SAMSUNG-1008, 925; SAMSUNG-1009, 236, 256. As evident from the above L_{LENGTH} and L_LENGTH equations, N_{OPS} (**data size transmittable by a symbol of the legacy physical layer frame) is 3 octets when the data rate of the legacy physical layer frame is 6 Mb/s**. *Id.*

$$L\_LENGTH = \left\lceil \frac{((TXTIME - Signal\ Extension) - (aPreambleLength + aPLCPHeaderLength))}{aSymbolLength} \right\rceil \times N_{OPS} - \left\lceil \frac{aPLCPServiceLength + aPLCPConvolutionalTailLength}{8} \right\rceil$$

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3$$

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 + m \text{ where } m = 1, 2$$

Yu-Prov428 also discloses that "one OFDM symbol with the lowest rate includes 3 bytes of data" (**data size… is 3 octets**). SAMSUNG-1020, 16.

97. In Bharadwaj-Prov059, the "value *m* shown above has been added in IEEE 802.11ax to ensure that L_{LENGTH} is not exactly a multiple of 3 and is therefore used to distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions (e.g., auto-detections)." SAMSUNG-1007, [0051]. Based on Bharadwaj-Prov059's disclosure and a POSITA's general knowledge, a POSITA would have understood and found it obvious that the receiver device 320 divides the L_{LENGTH} by 3 (**dividing the length information by a data size transmittable by a symbol of a legacy physical layer frame**) to "distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions" (**obtain information other than information on the duration of the non-legacy physical layer frame**) **through a remaining value** was well known as of the earliest possible priority date of the '077 patent. *Id.*;

SAMSUNG-1010, [0017]-[0020], [0024], [0036], [0038]-[0042], [0059]-[0060], [0063], [0065]; SAMSUNG-1012, [0057], [0068], [0073], [0080]-[0081]; SAMSUNG-1013, [0029], [0032], [0035], [0055]-[0056], [0085]; SAMSUNG-1014, [0039], [0077]; SAMSUNG-1015, [0051]-[0052]. A remaining value of 0 would indicate an 802.11ac transmission, and a remaining value of either 1 or 2 would indicate an 802.11ax transmission. *Id.* A POSITA also would have sought to obtain a remaining value that results from dividing L_{LENGTH} by 3 to implement the auto-detection feature and thereby distinguish 801.11ac from 802.11ax transmissions as expressly contemplated in Bharadwaj-Prov059. Based upon my knowledge and experience in this field and my review of the publications cited here, a POSITA would reasonably expected success because the use of such operations for this purpose well established in the prior art before the earliest possible priority date. *Id.*

98. As discussed above in Section VIII.A.3, the Bharadwaj-Yu combination renders obvious an L_{LENGTH} equation with a "– m" instead of a "+m" where m=1 or 2:

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - m$$

SAMSUNG-1020, 16; SAMSUNG-1019, [0232]; SAMSUNG-1007, [0051]-[0052]. This L_{LENGTH} equation with a "– m" (m=1 or 2) would likewise "distinguish" IEEE 802.11ax from IEEE 802.11ac transmissions based on whether L_LENGTH is "a multiple of 3" (an example of **information other than information on the duration**). *Id.* As discussed, a POSITA would have understood and found obvious that the receiver device 320 would determine whether a received physical layer frame (e.g., data unit 33) is a non-legacy frame (e.g., 11ax frame) or a legacy frame (e.g., 11ac frame) based on whether the division $L_{LENGTH} / 3$ yields a zero or non-zero remaining value. *Supra*, §VIII.A.3. Yu-Prov428 also describes using the remaining value "to indicate the structure of the last symbol" (another example of **information other than information on the duration**). SAMSUNG-1020, 16; SAMSUNG-1019, [0230].

1[e]/8[e]. determine/determining the number of symbols of data of the non-legacy physical layer frame according to a following equation,

$$N_{SYM} = \left\lfloor \left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 - T_{HE\_PREAMBLE} \right) \Big/ T_{SYM} \right\rfloor - b_{PE\_Disambiguity}$$

where ⌊x⌋ denotes a largest integer less than or equal to x,
L_LENGTH denotes the length information,
m denotes a value obtained by subtracting the remaining value from the data size transmittable by a symbol of the legacy physical layer frame,
$b_{PE\_Disambiguity}$ denotes a value of PE Disambiguity field,
$T_{HE\_PREAMBLE}$ denotes a duration of non-legacy preamble of the non-legacy physical layer frame,
T_{SYM} denotes a duration of a symbol of the data of the non-legacy physical layer frame,

wherein the PE Disambiguity field is set based on the duration of a symbol of the data of the non-legacy physical layer frame and an increment of duration to set a value of the length information based on a duration of a symbol of the legacy physical layer frame.

99. The Bharadwaj-Yu combination renders obvious 1[e] and 8[e]. For example, Bharadwaj-Prov059 explains that once the "RXTIME is known, the number of data symbols, *Nsym*, is computed or determined by the receiver device 320 using the following expression (Equation 6):

$$N_{sym} = \left\lfloor \frac{RXTIME - T_{L\_PREAMBLE} - T_{HE\_PREAMBLE}}{T_{sym}} \right\rfloor - SE_{disambiguation\_bit}.$$

SAMSUNG-1007, [0057]. As discussed above in 1[c]/8[c],

$$RXTIME = \left\lceil \frac{L_{LENGTH} - m + 3}{3} \right\rceil \times 4 + 20$$

SAMSUNG-1007, [0056]. Because $T_{L\_PREAMBLE}$ = 20 μs (SAMSUNG-1007, [0059]), Equation 6 can be expressed as reduced to:

$$N_{sym} = \left\lfloor \frac{\left\lceil \frac{L_{LENGTH} - m + 3}{3} \right\rceil \times 4 - T_{HE\_PREAMBLE}}{T_{SYM}} \right\rfloor - SE_{disambiguation\_bit}$$

which uses "a <u>flooring</u> function to obtain *Nsym*. In an example, if a number is 3.4, the flooring function rounds the number down to 3." SAMSUNG-1007, [0048]. In the above *Nsym* equation, L_{LENGTH} denotes the "duration of the data unit 330, in number of bytes" (**length information**), "$T_{HE\_PREAMBLE}$ is the duration of the high efficiency (HE) or IEEE 802.11ax preamble 340 of the data unit 330" (**duration of non-legacy preamble of the non-legacy physical layer frame**), and "Tsym is the duration of a data symbol" (**duration of a symbol of the data of the non-legacy physical layer frame**). SAMSUNG-1007, [0051]-[0052].

100. In Bharadwaj-Prov059, when "signal extension is applied to the end of the data unit,… there may be a rounding error 'Δ' caused by L_{LENGTH} quantization…. Because of the rounding error 'Δ' caused by L_{LENGTH} quantization, an ambiguity as to the signal extension duration occurs when $T_{SE} + \Delta > Tsym$ (data symbol duration)." SAMSUNG-1007, [0049]. The "SE disambiguation bit is introduced into IEEE 802.11ax to resolve the ambiguities in the *N*sym and T_{SE} computation. As Equation 6 above illustrates, when SE disambiguation bit = 1, the number of data symbols according to the IEEE 802.11ax computation is reduced by one (1)." SAMSUNG-1007, [0057], [0030]-[0031], [0033], [0041]-[0043], [0047]. "The transmitter 310 may be configured to set or determine the SE disambiguation bit (e.g., the single signaling bit 355) as follows. In an example, if the condition in expression shown below (Equation 4) is TRUE, then the SE disambiguation bit is set to 'l,' else it is set to '0.'"

$$T_{SE} + \underbrace{4 \times \left(\left\lceil \frac{TXTIME - 20}{4} \right\rceil - \left(\frac{TXTIME - 20}{4} \right) \right)}_{\text{Computes rounding error } \Delta} \geq T_{sym}$$

SAMSUNG-1007, [0054], [0072], [0078], [0082]. Accordingly, the location/field (**PE Disambiguity field)** provided for the SE disambiguation bit 355 (**a value of PE Disambiguity field**) is set based on Tsym (**duration of a symbol of the data of the non-legacy physical layer frame**) and an **increment of duration**, which can include the rounding error Δ. SAMSUNG-1007, [0049], [0051]-[0052], [0054].

101. Bharadwaj-Prov059's FIGS. 4A and 4B show that the "Total TXTIME reported through L-SIG" includes the "Rounding error 'Δ' due to L-SIG Quantization" (**increment of duration**):

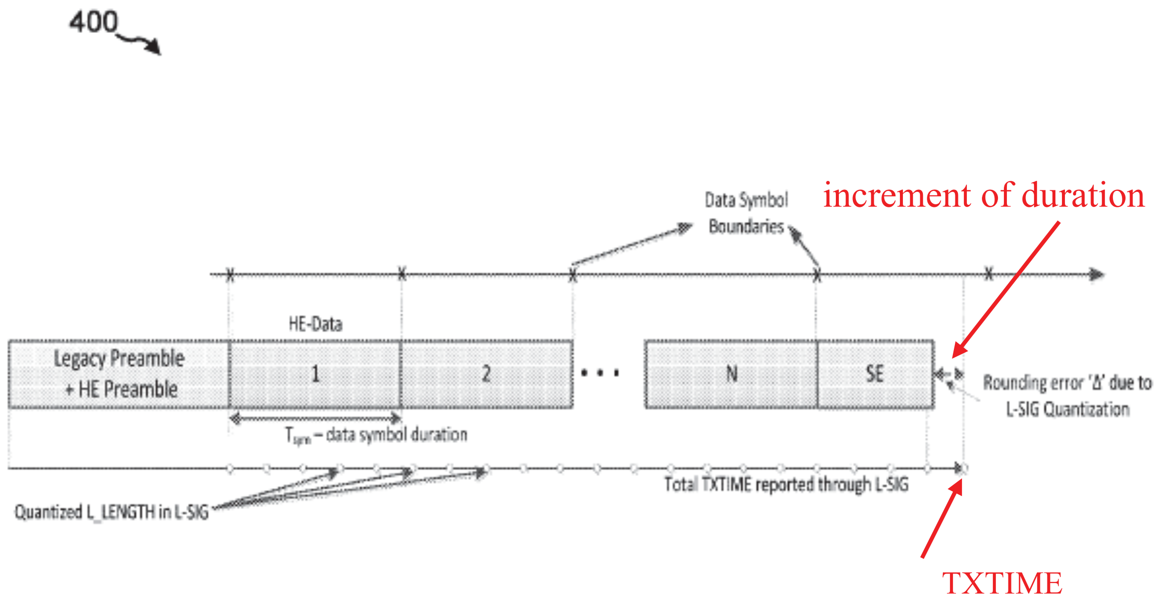

FIG. 4A

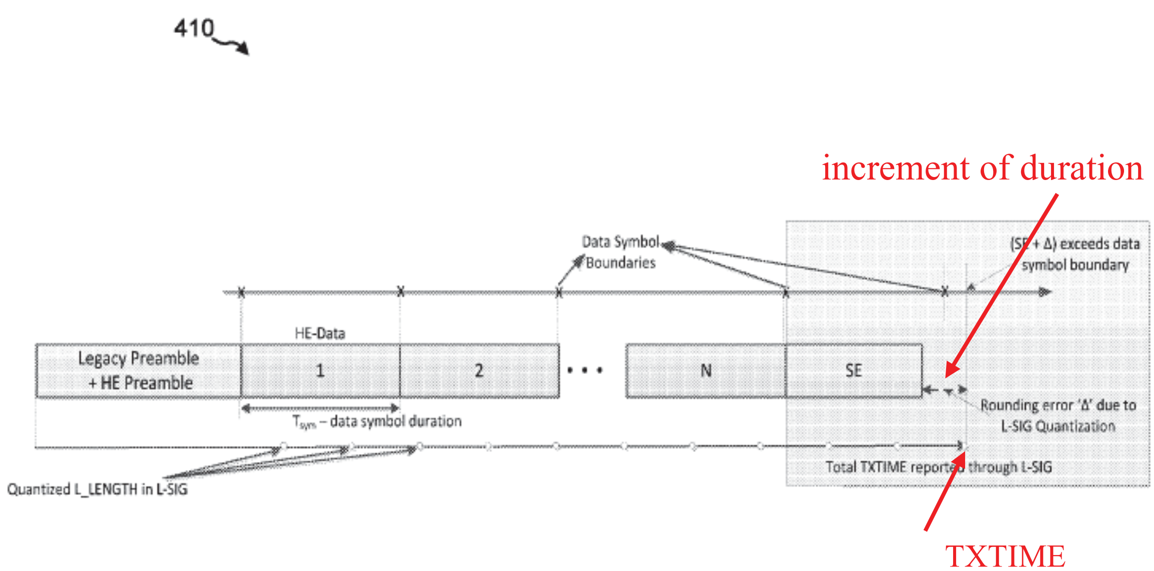

FIG. 4B

SAMSUNG-1007, FIGS. 4A, 4B

102. As discussed above in 1[d]/8[d], a POSITA would have understood from general knowledge of the legacy 802.11 standards referenced in Bharadwaj that the above 802.11ac L_{LENGTH} equation is a simplified form of the following L_LENGTH equation:

$$\text{L\_LENGTH} = \left\lceil \frac{((\text{TXTIME} - \text{Signal Extension}) - (\text{aPreambleLength} + \text{aPLCPHeaderLength}))}{\text{aSymbolLength}} \right\rceil \times N_{OPS} - \left\lceil \frac{\text{aPLCPServiceLength} + \text{aPLCPConvolutionalTailLength}}{8} \right\rceil$$

where "aSymbolLength is the duration of a symbol (in microseconds)" of the 802.11ac frame. SAMSUNG-1008, 925, 363. As evident from the above L_LENGTH equation and the IEEE 802.11ac/802.11ax L_{LENGTH} equations, aSymbolLength is 4 μs (**a duration of a symbol of the legacy physical layer frame**). *Id.*

$$\text{L\_LENGTH} = \left\lceil \frac{((\text{TXTIME} - \text{Signal Extension}) - (\text{aPreambleLength} + \text{aPLCPHeaderLength}))}{\text{aSymbolLength}} \right\rceil \times N_{OPS} - \left\lceil \frac{\text{aPLCPServiceLength} + \text{aPLCPConvolutionalTailLength}}{8} \right\rceil$$

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3$$

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 + m \text{ where } m = 1, 2$$

103. Also discussed above, in Bharadwaj-Prov059, the "duration of the data unit 330, in number of bytes, is determined by the following expression

(Equation 2):

$$L_{LENGTH} = \left\lceil \frac{TXTIME-20}{4} \right\rceil \times 3 - 3 + m \text{ where } m = 1,2$$

where TXTIME = $T_{L\_PREAMBLE}$ + $T_{HE\_PREAMBLE}$ + T_{DATA} + T_{SE}.… The value of T_{DATA} is the duration of the data portion 345 of the data unit 330 and can be determined by the transmitter device 310 based on the following expression (Equation 3):

$$T_{DATA} = N_{sym} \times T_{sym} = N_{sym} \times (12.8 + T_{GI})$$

where… T_{sym} is the duration of a data symbol….” SAMSUNG-1007, [0051]. Accordingly, T_{sym} (**duration of a symbol of the data of the non-legacy physical layer frame**) and the rounding error Δ (**increment of duration**) are also used to set TXTIME reported through L_{LENGTH} (**a value of the length information**) based on aSymbolLength (**duration of a symbol of the legacy physical layer frame**).

104. As discussed above in Section VIII.A.3, while Bharadwaj-Prov059 explicitly discloses the following examples for calculating L_{LENGTH} and N_{sym} using the following equations,

$$L_{LENGTH} = \left\lceil \frac{TXTIME-20}{4} \right\rceil \times 3 - 3 + m \text{ where } m = 1,2$$

$$N_{sym} = \left\lfloor \frac{\left\lceil \frac{L_{LENGTH} - m + 3}{3} \right\rceil \times 4 - T_{HE\_PREAMBLE}}{T_{SYM}} \right\rfloor - SE_{disambiguation\_bit}$$

a POSITA would have found it obvious in the alternative to *subtract* rather than add m in the L_{LENGTH} equation for reasons discussed in detail above in the overview of the Bharadwaj-Yu combination, including, to address the need to "ensure that L_{LENGTH} is not exactly a multiple of 3… to distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions" and to ensure that application of m in the L_{LENGTH} equation does not disturb the operation of legacy receivers. *Supra*, §VIII.A.3; SAMSUNG-1006, [0050]; SAMSUNG-1007, [0051]; SAMSUNG-1010, [0017]-[0020], [0024], [0036], [0038]-[0042], [0059]-[0060], [0063], [0065]; SAMSUNG-1012, [0057], [0068], [0073], [0080]-[0081]; SAMSUNG-1013, [0055]-[0056]; SAMSUNG-1014, [0039], [0077]; SAMSUNG-1015, [0051]-[0052]; SAMSUNG-1016, 2, 4-5. Indeed, Yu-Prov428, which also pre-dates the '077 patent and is incorporated by reference in Yu, discloses the following Length equation that *subtracts* a value of M=0, 1, or 2 depending on the signaling state:

$$\text{Length} = \frac{TXTIME - 20}{4} \times 3 - 3 - M, \; 0 \le M \le 2$$

SAMSUNG-1020, 16; SAMSUNG-1019, [0001], [0232].

105. By applying Yu-Prov428's suggestion to *subtract* m, a POSITA would have found it obvious for Bharadwaj's transmitter to set L_{LENGTH} according to the equation,

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - m$$

which also solves the need to "ensure that L_{LENGTH} is not exactly a multiple of 3 and therefore can be used to distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions." SAMSUNG-1020, 16; SAMSUNG-1019, [0232]; SAMSUNG-1007, [0051]-[0052]; SAMSUNG-1006, [0050]. From this updated L_{LENGTH} equation, the receiver computes *RXTIME* and N_{sym} as follows:

$$RXTIME = \left\lceil \frac{L_{LENGTH} + m + 3}{3} \right\rceil \times 4 + 20$$

$$N_{sym} = \left\lfloor \frac{\left\lceil \frac{L_{LENGTH} + m + 3}{3} \right\rceil \times 4 - T_{HE\_PREAMBLE}}{T_{SYM}} \right\rfloor - SE_{disambiguation\_bit}$$

SAMSUNG-1006, [0054]-[0055], [0060][8]. As discussed above in Section VIII.A.3, the above Nsym equation is equivalent to:

$$N_{sym} = \left\lfloor \frac{\frac{L_{LENGTH} + m + 3}{3} \times 4 - T_{HE\_PREAMBLE}}{T_{SYM}} \right\rfloor - SE_{disambiguation\_bit}$$

where ***m*** **denotes a value obtained by subtracting the remaining value from** 3 (**the data size transmittable by a symbol of the legacy physical layer frame** (per 1[d]/8[d])), as shown below using, for example, $m = 1$ and $L_{LENGTH} = 240 – m = 240 – 1 = 239$:

$$m = 3 - L_{LENGTH} \bmod 3 = 3 - 239 \bmod 3 = 3 - 2 = 1$$

where L_{LENGTH} mod 3 denotes the remaining value of dividing L_{LENGTH} by 3. As demonstrated by the prior art equations, a POSITA would have understood and found obvious that it would be necessary for the receiver to subtract L_{LENGTH} mod 3 from 3 to recover the value of *m* that the transmitter applied by substraction in the L_{LENGTH} equation as taught in Yu-Prov248. *Id.* By contrast, in the case where the

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[8] Bharadwaj's equation for RXTIME includes a typographical error in which "−20" should be "+20" as evident by the calculation of RXTIME = 344 µs. SAMSUNG-1006, [0054]-[0055], [0060].

transmitter adds m=1 or 2 in the L_{LENGTH} equation, the receiver can recover m by taking L_{LENGTH} mod 3 without subtracting from 3. *Id.* The receiver's method of deriving m to recover the same value of m that the transmitter used to set L_{LENGTH} is a straightforward mathematical calculation that would have been readily recognized by a POSITA since it flows directly from the transmitter's method of either adding or subtracting m in the L_{LENGTH} equation. *Id.*

2. Claims 2 and 9

2. The wireless communication terminal of claim 1, wherein the processor is configured to obtain …
9. The method of claim 8, the method further comprises obtaining
a duration of a packet extension which is a padding of the non-legacy physical layer frame, according to a following equation,

$$T_{PE} = \left\lfloor \frac{\left(\frac{\text{L\_LENGTH} + m + 3}{3} \times 4 - T_{HE\_PREAMBLE}\right) - N_{SYM} \times T_{SYM}}{4} \right\rfloor \times 4$$

where $\lfloor x \rfloor$ denotes a largest integer less than or equal to x,
L_LENGTH denotes the length information,
***m* denotes the value obtained by subtracting the remaining value from the data size transmittable by a symbol of the legacy physical layer frame,**
$T_{HE\_PREAMBLE}$ denotes the duration of non-legacy preamble of the non-legacy physical layer frame,
T_{SYM} denotes the duration of a symbol of the data of the non-legacy physical layer frame.

106. The Bharadwaj-Yu combination renders obvious claims 2 and 9. For example, Bharadwaj-Prov059 discloses that "[a]fter the value of N_{sym} is obtained,

the duration of the signal extension 350 (e.g., T_{SE}) applied to the data unit 330 is determined or computed by the receiver device 320 based on the following expression (Equation 7):"

$$T_{SE} = \left\lfloor \frac{RXTIME - T_{L\_PREAMBLE} - T_{HE\_PREAMBLE} - (N_{sym} \times T_{sym})}{4} \right\rfloor \times 4$$.

SAMSUNG-1007, [0058]. Further, as discussed above in 1[c]/8[c], Bharadwaj-Prov059 teaches that the receiver calculates *RXTIME* as follows (Equation 5):

$$RXTIME = \left\lceil \frac{L_{LENGTH} - m + 3}{3} \right\rceil \times 4 + 20$$

SAMSUNG-1007, [0056]; *see also id.*, FIGS. 2, 4, 6 (depicting durations of a packet extension as a padding of the 802.11ax non-legacy physical layer frame), [0047], [0064].

107. As discussed above in Section VIII.A.3, it would have been obvious to use $+m = -1$ or -2 to "ensure that L_{LENGTH} is not exactly a multiple of 3… to distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions." SAMSUNG-1006, [0050]; SAMSUNG-1007, [0051]; SAMSUNG-1010, [0017]-[0020], [0024], [0036], [0038]-[0042], [0059]-[0060], [0063], [0065]; SAMSUNG-1012, [0057], [0068], [0073], [0080]-[0081]; SAMSUNG-1013, [0055]-[0056]; SAMSUNG-1014, [0039], [0077]; SAMSUNG-1015, [0051]-[0052]; SAMSUNG-

1016, 2, 4-5. Applying Equation 5 for RXTIME with +m = −1 or −2 to Equation 7, and cancelling out terms of +/- 20 µs (since $T_{L\_PREAMBLE}$ = 20 µs (SAMSUNG-1007, [0059])), Equation 7 can be expressed as follows:

$$T_{SE} = \left\lfloor \frac{\left\lceil \frac{L_{LENGTH} + m + 3}{3} \right\rceil \times 4 - T_{HE\_PREAMBLE} - (N_{sym} \times T_{sym})}{4} \right\rfloor \times 4$$

SAMSUNG-1016, 4-5; SAMSUNG-1006, [0056], [0061].

108. A POSITA would have understood that for valid values of L_{LENGTH} and *m* where L_{LENGTH} +*m* is a multiple of 3 (*see supra*, §VIII.A.3), $\left\lceil \frac{L_{LENGTH}+3+m}{3} \right\rceil = \frac{L_{LENGTH}+3+m}{3}$. For example:

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - m$$

$$\frac{L_{LENGTH} + 3 + m}{3} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil$$

$$\left\lceil \frac{L_{LENGTH} + 3 + m}{3} \right\rceil = \left\lceil \left\lceil \frac{TXTIME - 20}{4} \right\rceil \right\rceil = \left\lceil \frac{TXTIME - 20}{4} \right\rceil$$

$$= \frac{L_{LENGTH} + 3 + m}{3}$$

and because $\lceil x \rceil$ is an integer, $\lceil \lceil x \rceil \rceil = \lceil x \rceil = \lceil \text{integer} \rceil = \text{integer}$. Using, for example, *m*=1 and

$$L_{LENGTH} = \left\lceil \frac{TXTIME - 20}{4} \right\rceil \times 3 - 3 - m = 239$$

a POSITA would have recognized that:

$$\left\lceil \frac{L_{LENGTH} + m + 3}{3} \right\rceil = \left\lceil \frac{239 + 1 + 3}{3} \right\rceil = \frac{239 + 1 + 3}{3} = \frac{L_{LENGTH} + m + 3}{3}$$

and therefore:

$$T_{SE} = \left\lfloor \frac{\left\lceil \frac{L_{LENGTH} + m + 3}{3} \right\rceil \times 4 - T_{HE\_PREAMBLE} - (N_{sym} \times T_{sym})}{4} \right\rfloor \times 4$$

$$= \left\lfloor \frac{\frac{L_{LENGTH} + m + 3}{3} \times 4 - T_{HE\_PREAMBLE} - (N_{sym} \times T_{sym})}{4} \right\rfloor \times 4$$

SEC-1006, [0057]-[0058].

3. Claims 3 and 10

3. The wireless communication terminal of claim 1,
10. The method of claim 8,
wherein the increment of duration is a value obtained by multiplying a difference between a value obtained by performing a ceiling operation on a value obtained by dividing the duration of the non-legacy physical layer frame after the legacy signaling field by the duration of a symbol of the legacy physical layer frame and the value obtained by dividing the duration of the non-legacy physical layer frame after the legacy signaling field by the duration of a symbol of the legacy physical layer frame by the duration of a symbol of the legacy physical layer frame.

109. The Bharadwaj-Yu combination renders obvious claims 3 and 10. As discussed above in 1[e]/8[e], the SE disambiguation bit (**a value of PE Disambiguity field**) is set based on T_{sym} (**duration of a symbol of the data of the**

non-legacy physical layer frame) and the T_{SE} in connection with the rounding error Δ (**increment of duration**). SAMSUNG-1007, [0049], [0054]. "The transmitter 310 may be configured to set or determine the SE disambiguation bit (e.g., the single signaling bit 355) as follows" using Equation 4:

$$T_{SE} + \underbrace{4 \times \left(\left\lceil \frac{TXTIME - 20}{4} \right\rceil - \left(\frac{TXTIME - 20}{4} \right) \right)}_{\text{Computes rounding error } \Delta} \geq T_{sym}$$

SAMSUNG-1007, [0054], [0072], [0078], [0082]. In Equation 4, the subtraction of TXTIME − 20 gives **the duration of the non-legacy physical layer frame after the legacy signaling field** (per 1[c]/8[c]) and 4 μs is **the duration of a symbol of the legacy physical layer frame** (per 1[e]/8[e]), and therefore the rounding error Δ of Bharadwaj-Prov059's **increment of duration** is a value obtained by the claimed mathematical operations.

4. Claims 4-5 and 11-12

4. The wireless communication terminal of claim 1, wherein the processor is configured to determine …
11. The method of claim 8, the method further comprises determining a format of a non-legacy signaling field included in the non-legacy physical layer frame based on the length information.
5. The wireless communication terminal of claim 4, wherein the processor is configured to determine …

12. The method of claim 11, wherein determining the format of a non-legacy signaling field included in the non-legacy physical layer frame comprises determining whether the non-legacy physical layer frame comprises a predetermined signaling field based on the length information.

110. The Bharadwaj-Yu combination renders obvious claims 4-5 and 11-12. As discussed above in 1[d]/8[d], in Bharadwaj-Prov059, the "value *m* shown above has been added in IEEE 802.11ax to ensure that L_{LENGTH} is not exactly a multiple of 3 and is therefore used to distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions (e.g., auto-detections)." SAMSUNG-1007, [0051]. Based on Bharadwaj-Prov059's disclosure and a POSITA's general knowledge, a POSITA would have found it obvious that the receiver device 320 divides the L_{LENGTH} by 3 to "distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions" through a remaining value, as it was well known as of the earliest possible priority date of the '077 patent. *Id.*; SAMSUNG-1010, [0017]-[0020], [0024], [0036], [0038]-[0042], [0059]-[0060], [0063], [0065]; SAMSUNG-1012, [0057], [0068], [0073], [0080]-[0081]; SAMSUNG-1013, [0029], [0032], [0035], [0055]-[0056], [0085]; SAMSUNG-1014, [0039], [0077]; SAMSUNG-1015, [0051]-[0052]. A remaining value of 0 would indicate that the transmission is an 802.11ac transmission, and a remaining value of either 1 or 2 would instead indicate that the transmission is an 802.11ax transmission. From the remaining value of dividing L_{LENGTH} by 3 and thus the length information L_{LENGTH}, the receiver

device determines the format of the signaling field included in the frame. For example, from the remaining value of either 1 or 2, the receiver determines that the format of the frame is an 802.11ax frame (**non-legacy physical layer frame**) including a legacy preamble 335, a high efficiency (HE) preamble 340, data portion 345, and signal extension 350. SAMSUNG-1007, [0044], [0051], [0053]-[0054], [0085], [0090]. The HE preamble that includes an RL-SIG, an HE-SIG-A, an HE-SIG-B, an HE-STF, an HE-LTF, and a single signaling bit 355 used for the single-bit signaling scheme 340 includes a **non-legacy signaling field/predetermined signaling field**. *Id.*

B. Ground 1B: Combination of Bharadwaj in view of Yu and Azizi Renders Obvious Claims 4-5 and 11-12

4. The wireless communication terminal of claim 1, wherein the processor is configured to determine …
11. The method of claim 8, the method further comprises determining a format of a non-legacy signaling field included in the non-legacy physical layer frame based on the length information.
5. The wireless communication terminal of claim 4, wherein the processor is configured to determine …
12. The method of claim 11, wherein determining the format of a non-legacy signaling field included in the non-legacy physical layer frame comprises determining whether the non-legacy physical layer frame comprises a predetermined signaling field based on the length information.

111. The Bharadwaj-Yu-Azizi combination renders obvious claims 4-5 and 11-12. As explained above in Section VIII.B.2, the processor of Bharadwaj-Yu-

Azizi's device distinguishes between an HE packet and a legacy packet and determines the preamble format (e.g., a short preamble format or long preamble format) of an HE packet based on the length field of the L-SIG (**determine a format of a non-legacy signaling field included in the non-legacy physical layer frame based on the length information**). SAMSUNG-1007, [0051]-[0052]; SAMSUNG-1020, 16; SAMSUNG-1019, [0232]; SAMSUNG-1015, [0051], [0053]. By determining whether the preamble format is a short preamble format or a long preamble format based on the length field of the L-SIG, the processor of Bharadwaj-Yu-Azizi's device determines whether the HE packet includes the predetermined signaling fields of the short preamble as shown in FIG. 2 or the predetermined signaling fields of the long preamble as shown in FIG. 3 (**determine whether the non-legacy physical layer frame comprises a predetermined signaling field**). SAMSUNG-1015, [0028]-[0043].

C. Ground 1C: Combination of Bharadwaj in view of Yu and Kenney Renders Obvious Claims 6-7 and 13-14

6. The wireless communication terminal of claim 1, wherein the processor is configured to obtain…
13. The method of claim 8, wherein the obtaining the information other than the information on the duration of the non-legacy physical layer frame comprises obtaining the information other than the information on the duration of the non-legacy physical layer frame based on the remaining value and a modulation method of a third symbol after the legacy signaling field.

7. The wireless communication terminal of claim 6,…
14. The method of claim 13, wherein the modulation method is Binary Phase Shift Keying (BPSK) or Quadrature Binary Phase Shift Keying (QBPSK).

112. The Bharadwaj-Yu-Kenney combination renders obvious claims 6-7 and 13-14. For example, in Bharadwaj-Prov059, the "data unit 330 is shown to generally include a legacy preamble 335, a high efficiency (HE) preamble 340, which typically includes the single signaling bit 335 used for the single-bit signaling scheme, data portion 345, and signal extension 350." SAMSUNG-1007, [0044]. The "legacy preamble 335 of the data unit 330… includes a legacy short training field (L-STF), a legacy long training field (L-LTF), and L-SIG." SAMSUNG-1007, [0051]. The "high efficiency (HE) or IEEE 802.11ax preamble 340 of the data unit 330… includes an RL-SIG, an HE-SIG-A, an HE-SIG-B, an HE-STF, and an HE-LTF." *Id.* As such, in Bharadwaj-Prov059, after L-SIG (**legacy signaling field**), RL-SIG is the first symbol, and HE-SIG includes a second and a third symbol (e.g., HE-SIG-A including two symbols, or HE-SIG-A having one symbol and HE-SIG-B having one symbol). SAMSUNG-1022, 11 (describing R-LSIG as a "symbol repeating the LSIG content"); SAMSUNG-1015, [0032] ("HE-SIG-A field 208 may be K1 number of symbols long" where "K1 may be one or more. The HE-SIG-B field 210 may be K2 symbols long" where "K2 may be one or more."), [0038] ("HE-SIG-A 310 may be one or more

symbols.).

113. Kenney discloses that a data unit (PPDU) is configured "to include a subsequent/additional signal field 210 (e.g., HT-SIG 212, VHT-SIG 222, or HEW-SIG 232) following the L-SIG 206" that has "first and second symbols that are BPSK modulated." SAMSUNG-1010, [0043], [0061], FIG. 4 (410). For "an HEW-PPDU, the first symbol 332A of the HEW-SIG 232 is rotated BPSK and the second symbol 332B is conventional (i.e., non-rotated) BPSK." SAMSUNG-1010, [0050].

114. As discussed above in Section VIII.C.2, the processor of Bharadwaj-Yu-Kenny's receiver device distinguishes "between IEEE 802.11ax and IEEE 802.11ac transmissions," "HEW PPDUs from non-HEW PPDUs," and "HT PPDUs, VHT PPDUs and HEW PPDUs" (SAMSUNG-1007, [0051]; SAMSUNG-1010, [0024], Abstract, [0036], [0038]-[0041], [0059]-[0060], [0062], [0064]-[0066]) (**obtain information other than information on the duration of the non-legacy physical layer frame**) **based on a remaining value** (per 1[d]/8[d]) and a phase rotation applied to the **BPSK modulation** (**modulation method**) of the first and second symbols of the HE-SIG field after the L-SIG field (**legacy signaling field**) and the RL-SIG field. SAMSUNG-1010, Abstract, [0024], [0036], [0038]-[0041], [0059]-[0060], [0062], [0064]-[0066], FIG. 4 (406, 408, 412),

claims 1, 3, 13, 15, 17. Here, the second symbol of the HE-SIG field is the **third symbol after the legacy signaling field** in Bharadwaj-Yu-Kenny's data unit.

D. GROUND 2A: Bharadwaj Renders Obvious Claims 1-5 and 8-12; GROUND 2B: Bharadwaj in view of Azizi Renders Obvious Claims 4-5 and 11-12; GROUND 2C: Bharadwaj in view of Kenney Renders Obvious Claims 6-7 and 13-14

115. As articulated in Ground 1A in light of Yu's teaching of a Length equation with a "−*M*" value of 0, 1, or 2, a POSITA would have found it obvious for the processor of Bharadwaj-Prov059's receiver device to distinguish "between IEEE 802.11ax and IEEE 802.11ac transmissions" using the L_LENGTH equation with "−*m*" where *m* = 1 or 2. SAMSUNG-1020, 16; SAMSUNG-1019, [0232]. Bharadwaj and Yu is a combination in which Yu is offered to demonstrate a broader concept that is well understood by a POSITA, namely that the L_LENGTH equation with "−*m*" where *m* = 1 or 2 also serves to distinguish between IEEE 802.11ax and IEEE 802.11ac transmissions. *Id.* This concept is well known to a POSITA, and thus, for Grounds 2A-2C, the application of Bharadwaj alone reveals to a POSITA, based on their general knowledge and ordinary level of skill, that it would have been obvious to use the L_LENGTH equation with "−*m*" where *m* = 1 or 2 to distinguish between IEEE 802.11ax and

IEEE 802.11ac transmissions. *Id.*

X. CONCLUSION

116. For all the reasons I have noted in the foregoing paragraphs, claims 1-14 of the ’077 Patent are obvious in view of the references discussed above.

117. 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

Expert/Consultant Curriculum Vitae

Professor Zhi Ding

Ph.D. and Fellow of IEEE

Expertise

- Wireless Communication Systems
- Cellular Wireless (2G, 3G, 4G, 5G)
- Communication Network Protocols
- Multi-Antenna Technologies
- WLAN (WiFi, Bluetooth)
- xDSL Internet Services
- DOCSIS Modems
- Optical Networks

Professional Summary

- Professor of major US universities for 35 years.
- *Consulted for multiple major technology companies*
- Worked as expert on multiple patent infringement cases.
- Conducted research works on Communications and Signal Processing for over 30 years.
- Supervised over 30 PhD students.
- Author of more than 200 journal papers and 2 books on communication technologies.

Dr. Zhi Ding has been a professor of electrical engineering at major US universities for 32 years. Since 1995, he has consulted for both engineering companies such as Nortel, Analog Devices, Intel, and worked as expert for major law firms from US, UK, China, and Canada including Kirkland & Ellis, WilmerHale, Quinn Emanuel, Fish & Richardson, Sheppard Mullin, Sidley Austin, Mayer Brown, Venable, and Finnegan, on multiple technical and patent infringement cases. He has been conducting research works on wireless communications and signal processing since 1984. He has supervised over 30 PhD students. He is an author of 500 peer-reviewed papers and 2 technical books on communication technologies. He has taught classes that cover the fundamentals of signal detection, communications, and systems.

Dr. Ding currently holds the position of Distinguished Professor at the University of California, where he was also the Child Family Professor of Engineering and Entrepreneurship in 2009-2014. He served as the steering committee chair of the IEEE Transactions on Wireless Communications. He was elevated to Fellow of IEEE in 2002 by the IEEE Signal Processing Society. He also served as the Technical Program Chair of the IEEE Globecom 2006 (the flagship conference of the IEEE Communications Society), Dr. Ding is an eminent scholar and expert of wireless technologies AND signal processing. He received the IEEE Communications Society's 2012 TC Recognition Award and the 2020 Education Award.

Intellectual Property Dispute Consulting:

Past Client	Past Engagement
Kirkland & Ellis LLP	2007 (Intel v. WiLAN)
	2008 (Cisco, Motorola, etc., v. R.),
	2008 (Apple v. N.)
	2009 (Cisco v. WiAV)
	2009 (Apple v. P.)
	2009 (Cisco v. M.)
	2010 (Netgear v. R.)
	2011 (Intel v. E.)
	2011 (Cisco v. M.)
	2011 (Cisco, Motorola v. I.)
	2011 (Netgear v. E.)
	2013 (Alcatel Lucent matter)
	2015 (Intel "project Impala")
	2020 (Xiaomi Global)
	2021 (Samsung v. E.)
	2023 (TP v. N.)
Wilmer Cutler Pickering Hale, & Dorr, LLP	2009 (Apple v. N.)
	2011 (Apple v. S.)
	2013 (Apple v. A.)
	2015 (Apple v. E.)
	2018 (Unified matter)
	2019 (Apple v. O.)
	2023 (Z. v. N.)
	2023 (Apple v. Lionra)
Fish and Richardson, LLP	2014 (Marvell v. I.)
	2018 (NEC v. X.)
	2020 (DISH v. T.)
	2020 (Huawei SEP)
	2020 (Samsung v. E.)
	2021 (LG Electronics, Dell v. N.)
	2021 (Quectel v. P.)
	2021 (Apple v. E.)
	2022 (Apple v. S.)
	2022 (LG Electronics v. C.)
	2023 (Dish v. E.)
	2023 (G Project)
	2024 (A. vs. V.H.)
	2024 (A. vs. A. B.)
	2025 (S. vs. W.)
Kaye Scholer LLP	2012 (Timer Warner+Ceres+Atlanta Broadband Finance v. K.)

Bridges and Mavrakakis, LLP	2011(Apple matter)
	2014 (Apple v. C.)
	2015 (Marvell "IP evaluation matter")
Sterne, Kessler, Goldstein & Fox, LLC	2014 (Marvell, MediaTek v. B.)
	2019 (Volkswagen v. C.)
	2020 (Apple v. S.)
Bramson, Plutzik, Mahler & Birkhaeuser	2013 (Karim v. H.)
Gibson, Dunn & Crutcher, LLP	2014 (AT&T v. I)
Desmarias	2024 (C. v. OptiMorphix)
Quinn Emanuel	2014 (Canon v. I.)
	2023 (Z. v. E.)
	2024 (ASSA v. Charter)
Norton Rose Fulbright US LLP	2015 (Qualcomm v. B.)
	2018 (Qualcomm v. A.)
	2021 (NXP v. Me.)
	2023 (NXP v MI.)
Sheppard, Mullin, Richter, and Hampton, LLP	2015 (TLC v. E.)
	2017 (ZTE v. H.)
	2018 (HTC v. I.)
	2019 (Motorola v. U.)
	2019 (U-Blox AG v. I.)
	2019 (Continental v. A.)
	2019 (Toyota matter)
	2020 (Oppo v. S.)
	2021 (HTC v. S.)
Duane Morris	2015 (Comcast, Cox, Time Warner, Verizon v. T.)
Rothwell, Figg, Ernest, & Manbeck, P.C.	2016 (LG Electronics v. O.)
Mayer Brown LLP	2016 (LG Electronics v. N.)
Sidley Austin, LLP	2016 (Huawei v. S.)
	2018 (Huawei v. O.)
Irell & Manella, LLP	2016 (Juniper v. M.)
	2021 (NXP v. M.)
Finnegan, Henderson, Farabow, Garrett & Dunner, L.L.P	2017 (LGE v. BLU)
	2017 (Sol IP)
Arnold, Porter, Kaye, and Scholer	2017 (Charter v. S.)
	2021 (Samsung v. X.)
Venable, LLP	2017 (Verizon v. S.)
Pillsbury LLP	2017 (ZTE v. H.)
Alston, Bird, LLP	2018 (ASUSTeK v. H.)
Gibson, Dunn & Crutcher, LLP	2019 (AT&T v. S.)
Allen & Overy, LLP, UK	2019 (Huawei v. Conversant.)
Erise IP	2019 (Apple v. I.) 2022 (Apple v. L.)
Xiaomi (China)	2020 (Siemens)

Munger Tolles & Olson, LLP (Tesla)	2021 (Tesla v. O.)
	2023 (G. v. U.)
Orrick, Herrington, & Sutcliffe, LLP	2021 (Canon v. W.)
Saikrishna & Associates (India)	2019 (Xiaomi v. Ericsson)
	2020 (OPPO v. NOKIA)
	2022 (OPPO v. Phillips) (OPPO v. IDC)
	2023 (OPPO v. Voiceage)
	2022 (vivo v. Nokia)
	2024 (vivo v. Phillips)
Anand & Anand (India)	2025 (SEC in India)
Dannemann Siemsen (Brazil)	2023 (OPPO v. NOKIA)
Continental	2022 (Continental v. N.)
Kelley Dryer	2022 (Keep Truckin v. F.)
Haynes Boone	2022 (Apple v. T.)
	2024 (T. v. IV)
Quinsumbing Torres (Philippines)	2022 (vivo v. N.)
Biro Oktroi Roosseno (Indonesia)	2022 (vivo v. N.)
Paul Hastings	2022 (Samsung v. G.)
Cabello Hall Zinda, PLLC	2023 (K. v. E.)
DLA Piper	2023 (D. & M. v. Ozmo)
King and Spalding	2024 (DGS v. D)
Kilpatrick Townsend & Stockton LLP	2024 (IV et al. v. Lenovo) (Iv et al. v. Zebra)
Warren Kash Warren LLP	2024 (Viasat)
Bookoff	2024 (L.v. I.V.)

Expert Testifying and Depositions (13 Trials and 18 Depositions)

Clients	**Deposition/Testifying Experience**
Bramson, Plutzik, Mahler & Birkhaeuser LLP	2013: ***Deposition*** on Case No. CV 12-05240 PJH Nad Karim v. Hewlett Packard, Co. UNITED STATES NORTHERN DISTRICT COURT OF CALIFORNIA. Settlement ordered Jan. 18, 2017.
Fish and Richardson	2015 (Feb): ***Deposition*** for Marvell. US PTAB *Inter Partes* Review IPR2014-00548 Marvell Semiconductor, Inc. v. Intellectual Ventures I LLC
	2015 (August): ***Deposition*** for Marvell. US PTAB *Inter Partes* Review IPR2014-00548 Marvell Semiconductor, Inc. v. Intellectual Ventures I LLC
Norton, Rose, Fulbright, US, LLP	2016 (April): ***Deposition*** for Qualcomm. US PTAB *Inter Partes* Review cases IPR2015-10577, IPR2015-10580, IPR2015-10581 Qualcomm Inc. v Bandspeed Inc.

Sheppard, Mullin, Richter, and Hampton, LLP	2016 (May): ***Deposition*** for in *TCL Communication Technology Holdings, LTD., et al. v. Ericsson, et al.,* Case No. 8:14-cv-341 (C. D. CA).
	2017 (Feb): **Testified at C.D. California** bench trial.
Sidley Austin, LLP	2016 (December): **Testified at** trial involving Huawei Technologies, Co. Ltd v. Samsung regarding FRAND licensing disputes in Shenzhen Court, P.R. China.
	2018 (June): ***Deposition*** for N.D. CA on IP matter concerning Huawei Technologies, Co. Ltd v. Samsung.
	2018 (December): **Testified at** trial involving Huawei Technologies, Co. Ltd v. Samsung regarding FRAND licensing disputes in Beijing Court of Intellectual Properties, P.R. China.
Mayer Brown LLP	2017 (January): **Testified during tribunal proceeding** for LG Electronics, Inc. in standard essential patent (SEP) licensing dispute of Nokia Technologies, Ltd. *v*. LG Electronics, Inc. During arbitration hearing in Paris, France.
Venable LLP	2017 (October): ***Deposition*** as expert witness for Verizon Services Corp. in Case No. 2:16-CV-588-WCB (E. D. TX) on US Patent disputes.
Pillsbury LLP	2018 (Feb): ***Deposition*** (E. D. Texas Case No. 5:16-cv-00179-RWS)
	2018 (June): **Testified at E. D. Texas** (Texarkana) jury trial (Case No. 5:16-cv-00179-RWS).
Allen & Overy LLP UK	2019 (April) **Testified at** trial involving Huawei Technologies, Co. Ltd v. Conversant regarding FRAND licensing disputes in Nanjing Intermediate Court, P.R. China.
Sidley Austin LLP, US	2019 (Sept.) **Testified at** trial involving Huawei Technologies, Co. Ltd v. PanOptics, regarding FRAND licensing disputes in Shenzhen Intermediate Court, P.R. China.
Sheppard, Mullin, Richter, and Hampton, LLP	2019 (Dec. 3rd): ***Deposition*** for HTC and Apple in *HTC Corporation, HTC America, Inc., and Apple Inc. v. INVT SPE LLC,* Case Nos. IPR2018-01555 and IPR2018-01581.
Sterne, Kessler, Goldstein & Fox, LLC	2020 (Feb.): ***Deposition*** for Volkswagen Group of America, In. v. Carucel Investments, L.P. Case Nos. IPR2019-01573 and IPR2019-01101.
Jincheng Tongda & Neal, LLP	2021 (June) **Testified at** trial involving TCL. v. Ericsoon, regarding FRAND licensing disputes in Shenzhen Intermediate Court, P.R. China.
Orrick, Herrington, & Sutcliffe, LLP	2021 (October): ***Deposition*** for Canon, Inc, in Canon, v. WSOU Investments, LLC d/b/a/ Brazos Licensing, W.D. Texas, Case No. 6:20-cv-980.
Fish & Richardson, P.C.	2021 (November) 1st ***Deposition*** for Petitioner IPR 2021-00560 in Quectel v. Koninklijke Philips N.V.
	2021 (December) 1st ***Deposition*** for Petitioner on IPR 2021-00563 Proceeding in Quectel v. Koninklijke Philips N.V.
	2022 (March 31) 2nd ***Deposition*** for Petitioner IPR 2021-00560

	in Quectel v. Koninklijke Philips N.V. (028) (-)
	2022 (April 1) 2nd ***Deposition*** for Petitioner on IPR 2021-00563 Proceeding in Quectel v. Koninklijke Philips N.V. (+)
	2022 (Oct. 28) ***Deposition*** for Petitioner on IPR 2022-00339 in Apple v. Ericsson.
	2023 (Nov. 18) ***Deposition*** for Petitioner on IPR 2023-00496 Proceeding (Apple).
Jauar Jahja and Partners (Indonesia)	2022 (April 25) **Testified** at trial involving OPPO v. Nokia regarding one patent disputes at Court in Jakarta, Indonesia. ***Successful denial of temporary injunction.*** 2022 (April 26) **Testified** at trial involving OPPO v. Nokia regarding another patent dispute at Court in Jakarta, Indonesia. ***Successful denial of temporary injunction.***
Quinsambing & Torres (Philippines)	2022 (September) **Testified** on site at trial involving vivo v. Nokia regarding patent disputes in Regional Trial Court in Manila, the Philippines. ***Successful denial of temporary injunction.***
Orrick, Herrington, & Sutcliffe, LLP	2021 (Oct. 12) ***Deposition*** Western D. of Texas cas: 6:20-cv-00980-ADA (Canon**)**
Arnold, Porter, Kaye, and Scholer	2022 (Dec. 30) ***Deposition*** for Petitioner on IPR 2022-00613 Proceeding (Samsung)
Biro Oktroi Roosseno (Indonesia)	2023 (Jan. 4) **Testified** online at trial involving vivo v. Nokia regarding patent disputes at Court in Jakarta, Indonesia. ***Successful denial of temporary injunction.*** 2023 (Feb. 1) **Testified** on site at trial involving vivo v. Nokia regarding patent disputes at Court in Jakarta, Indonesia. ***Successful denial of temporary injunction.***
Paul Hastings	2023 (June 22) ***Deposition*** for Petitioner on IPR 2022-01598 Proceeding (Samsung)
	2023 (Sept. 23) ***Deposition*** for Petitioner on IPR 2023-00171 Proceeding (Samsung)
Kirkland & Ellis LLP	2024 (May 31) ***Deposition*** for Petitioner on IPR 2023-01469 Proceeding (TP Link)

IPR Opinions 70+	**Expert Opinions (Excluding links before 2019 for brevity):**
Older IPR Cases	IPR2014-00547 IPR2014-00548 IPR2014-01562 IPR2015-00237 IPR2015-00314 IPR2015-00315 IPR2015-00316 IPR2015-00531 IPR2015-01577 IPR2015-01580 IPR2015-01581

	IPR2015-01582 IPR2016-00620 IPR2016-00623 IPR2018-00237 IPR2018-01160 IPR2018-01190 IPR2018-01555 IPR2018-01581 IPR2019-00070
Recent IPR Declarations	IPR2019-01573 Expert Declaration to the Patent Trial and Appeal Board. Instituted (2020-01-22); Final Decision: Unpatentable (2020-11-20) IPR2019-01105 Expert Declaration to the Patent Trial and Appeal Board. Instituted (2019-12-02); Final Decision: Unpatentable (2020-11-20) IPR2019-01101 Expert Declaration to the Patent Trial and Appeal Board. Instituted (2019-12-02); Final Decision: Unpatentable (2020-11-20) IPR2020-00038 Expert Declaration to the Patent Trial and Appeal Board (Filed 2019-10-11); Institution Decision: (2020-04-13). IPR2021-00560 Expert Declaration to the Patent Trial and Appeal Board. Instituted (2021-09-13); Final Decision: (2022-09-09) IPR2021-00563 Expert Declaration to the Patent Trial and Appeal Board. Instituted (2021-09-15); Final Decision: Unpatentable (2022-9-13) IPR2021-00587 Expert Declaration to the Patent Trial and Appeal Board. Filed (2021-02-26); Withdrawn. IPR2021-00644 Expert Declaration to the Patent Trial and Appeal Board. Filed (2021-03-12); Settled. IPR2021-00683 Expert Declaration to the Patent Trial and Appeal Board. Filed (2021-03-19); Withdrawn. IPR2021-01468 Expert Declaration to the Patent Trial and Appeal Board. Filed (2021-09-01). IPR2021-01486 Expert Declaration to the Patent Trial and Appeal Board. Filed (2021-09-16).

	IPR2022-00339 Expert Declaration to the Patent Trial and Appeal Board. Instituted (2022-08-22); Settlement (2022-12-20). IPR2022-00348 Expert Declaration to the Patent Trial and Appeal Board, Filed (2022-02-15). IPR2022-00349 Expert Declaration to the Patent Trial and Appeal Board, Filed (2022-02-15), Settled. IPR2022-00616 Expert Declaration to the Patent Trial and Appeal Board, Filed (2022-02-18), Withdrawn. IPR2022-00619 Expert Declaration to the Patent Trial and Appeal Board, Filed (2022-02-25). IPR2022-00613 Expert Declaration to the Patent Trial and Appeal Board. Instituted (2022-10-20); Settled. IPR2022-01512 Expert Declaration to the Patent Trial and Appeal Board. Filed (2022-09-09); Instituted (2023-05-15). IPR2022-01598 Expert Declaration to the Patent Trial and Appeal Board. Filed (2022-10-04); Instituted (2023-04-04). IPR2023-00136 Expert Declaration to the Patent Trial and Appeal Board. Filed (2022-11-30); Instituted (2023-05-22). IPR2023-00151 Expert Declaration to the Patent Trial and Appeal Board; Filed (2022-11-30); Instituted (2023-06-09). IPR2023-00174 Expert Declaration to the Patent Trial and Appeal Board, Filed (2022-11-30); Instituted (2023-05-19). IPR2023-00171 Expert Declaration to the Patent Trial and Appeal Board. Filed (2022-11-08); Instituted (2023-05-31). IPR2023-00441 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-01-05); Instituted (2023-08-03). IPR2023-00496 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-01-20); Institute (2023-08-21). IPR2023-00525 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-07-10); Institute (2023-10-02).

	IPR2023-00644 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-03-07); Institute (2023-10-11). IPR2023-00645 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-03-22); Institute (2023-10-11). IPR2023-00665 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-03-22) IPR2023-00720 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-03-16). IPR2023-00721 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-03-16); Institute (2023-10-11). IPR2023-00796 IPR2023-01393 Expert Declaration to the Patent Trial and Appeal Board. Instituted (2023-11-13). IPR2023-01060 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-09-07); Instituted (2024-01-16). IPR2023-01393 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-09-07). IPR2023-01400 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-09-07); Instituted (2024-03-08). IPR2023-01403 Expert Declaration to the Patent Trial and Appeal Board; Instituted (2024-03-06). IPR2023-01429 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-09-18). IPR2023-01469 Expert Declaration to the Patent Trial and Appeal Board, Instituted (2024-04-02). Settled. IPR2024-00125 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-10-30). Settled. IPR2024-00148 Expert Declaration to the Patent Trial and Appeal Board, Filed (2023-11-10). IPR2024-00883 Expert Declaration to the Patent Trial and Appeal Board, Filed (2024-05-01). IPR2024-01224 Expert Declaration to the Patent Trial and Appeal Board, Filed (2024-08-02).

	IPR2024-01358 Expert Declaration to the Patent Trial and Appeal Board, Filed (2024-08-28). IPR2024-01362 Expert Declaration to the Patent Trial and Appeal Board, Filed (2024-08-30). Instituted (2025-03-11). IPR2024-01363 Expert Declaration to the Patent Trial and Appeal Board, Filed (2024-08-30). Instituted (2025-03-11). IPR2024-01364 Expert Declaration to the Patent Trial and Appeal Board, Filed (2024-08-30). Instituted (2025-03-11). IPR2025-00049 Expert Declaration to the Patent Trial and Appeal Board, Filed (2024-10-14). IPR2025-00194 Expert Declaration to the Patent Trial and Appeal Board, Filed (2024-11-19). IPR2025-00218 Expert Declaration to the Patent Trial and Appeal Board, Filed (2024-11-21). IPR2025-00220 Expert Declaration to the Patent Trial and Appeal Board, Filed (2024-11-25). IPR2025-00343 Expert declaration to the Patent Trial and Appeal Board, Filed (2024-12-31).

Employment History

From: 2000 **University of California at Davis**
To: Present Davis, CA
Position: *Professor* (2000-2020) and *Distinguished Professor* (2020-), *Department of Electrical and Computer Engineering*

From: 01/1999 **University of Iowa**
To: 09/2000 Iowa City, IA
Position: *Assoc. Professor, Department of Electrical and Computer Engineering*

From: 01/1997 **Hong Kong University of Science and Technology**
To: 12/1997 Hong Kong

Position: *Visiting Associate Professor, Department of Electrical and Electronic Engineering*

From: 09/1995 **Auburn University**
To: 12/1998 Auburn, AL
Position: *09/1995-12/1998: Associate Professor, Department of Electrical and Computer Engineering*
09/1990-08/1995: Assistant Professor, Department of Electrical and Computer Engineering

From: 08/1993 **Australian National University**
To: 09/1993 Canberra, Australia
Position: *Visiting Research Fellow, Faculty of Information Technology and Engineering*

From: 06/1993 **US Air Force Wright Laboratory**
To: 08/1993 Eglin AFB, Florida
Position: *Faculty Research Associate, Armament Directorate*

From: 06/1992 **NASA Lewis Research Center**
To: 08/1992 Cleveland, OH
Position: *Visiting Faculty Research Fellow*

From: 08/1987 **Cornell University**
To: 08/1990 Ithaca, NY
Position: *Research Assistant*

From: 09/1984 **University of Toroto**
To: 08/1987 Toronto, Ontario, Canada
Position: *Research Assistant*

Technical Consulting

Consulted for multiple major technology companies, aside from IP litigation related matters.

Patents (Granted and/or Licensed)

Patent Number	Date Issued	Title

US 6,396,885	Mar.28, 2002	Co-channel interference reduction in wireless communications systems
US 6,463,099	Oct.8, 2002	Blind channel equalizers and methods of blind channel equalization (Licensed)
US 7,379,513	Mar. 20, 2008	Channel estimation in CDMA communications systems using both lower power pilot channel and higher power date channel
US 9,554,388	Jan. 24, 2017	Method and apparatus of resource sharing for device-to-device and cellular communications
US 10,623,230	Apr. 14, 2020	Trans-layer robust header-compression technique
US 11,019,530	May 25, 2021	Trans-layer bidirectional robust header compression system
US 11,368,940	June 21, 2022	Systems and Methods for Data transmission over Wi-Fi and LTE-U coexistence framework

Education

1990	Cornell University, Ithaca, NY	Ph.D., Electrical Engineering
1987	University of Toronto, Toronto, Canada	MS, Electrical Engineering
1982	Nanjing Institute of Technology, Nanjing, China	BS, Wireless Engineering

Publications

Books & Book Chapters

[1] B. P. Lathi and Z. Ding, *Modern Digital and Analog Communication Systems,* 5th edition, Oxford University Press, 2018.

[2] Zhi Ding and Ye Li, *Blind Equalization and Identification*, Marcel Dekker, New York, 2001.

[3] Z. Ding, "Chapter 7: Linear Predictive Algorithms for Blind Multichannel Identification," in *Signal Processing Advances in Wireless and Mobile Communications*, Vol. I: Trends in Channel Estimation and Equalization, G. B. Giannakis, Y. Hua, P. Stoica, and L. Tong (Editors), Prentice Hall, 2000.

[4] Z. Ding, "Blind Channel Identification and Equalization using Spectral Correlation Measurements: Frequency Domain Analysis," in *Cyclostationarity in Communications and Signal Processing*, William A. Gardner, Ed., pp.417-436, IEEE Press, 1993.

[5] Z. Ding, C. R. Johnson, Jr., and R. A. Kennedy, "Chapter 3: Global Convergence Issues with Linear Blind Adaptive Equalizers," in *Blind Deconvolution*, Simon Haykin, Ed., pp.60-120, Prentice-Hall, 1994.

[6] Z. Ding, "Adaptive Filters for Blind Equalization," in *IEEE DSP Handbook*, Douglas B. Williams, Ed., pp.24.1-24.17, IEEE Press, 1998.

Journal Papers

[1] K. Wang, Z. Ding, D. K. C. So and Z. Ding, ``Exploring Age-of-Information Weighting in Federated Learning under Data Heterogeneity'', in IEEE Transactions on Wireless Communications, doi: 10.1109/TWC.2025.3545456, 2025.

[2] Zhang, Songyang, Brian Choi, Feng Ouyang, and Zhi Ding, ``Physics-inspired machine learning for radiomap estimation: Integration of radio propagation models and artificial intelligence. IEEE Communications Magazine, 62, no. 8, pp. 155-161, 2024. doi: 10.1109/MCOM.001.2300782.

[3] Wang, Kaidi, Yi Ma, Mahdi Boloursaz Mashhadi, Chuan Heng Foh, Rahim Tafazolli, and Zhi Ding, ``Convergence Acceleration in Wireless Federated Learning: A Stackelberg Game Approach." IEEE Transactions on Vehicular Technology, 2024. doi: 10.1109/TVT.2024.3452933

[4] Q. Deng, Y. Zhang, M. Li, S. Zhang and Z. Ding, ``Efficient Eigen-Decomposition for Low-Rank Symmetric Matrices in Graph Signal Processing: An Incremental Approach," IEEE Transactions on Signal Processing, 2024 doi: 10.1109/TSP.2024.3438676.

[5] Q. Deng, S. Zhang and Z. Ding, ``Body Motion Segmentation via Multilayer Graph Processing for Wearable Sensor Signals," IEEE Open Journal of Signal Processing, Volume 5, pp. 934-947, 2024 doi: 10.1109/OJSP.2024.3407662.

[6] S. Jing, S. Zhang and Z. Ding, ``Reinforcement Learning for Robust Header Compression (ROHC) Under Model Uncertainty," IEEE Transactions on Machine Learning in Communications and Networking, vol. 2, pp. 1033-1044, 2024, doi: 10.1109/TMLCN.2024.3409200.

[7] A. Wijesinghe, S. Zhang and Z. Ding, ``PS-FedGAN: An Efficient Federated Learning Framework With Strong Data Privacy," IEEE Internet of Things Journal, vol. 11, no. 16, pp. 27584-27596, 15 Aug.15, 2024, doi: 10.1109/JIOT.2024.3399226.

[8] Z. Liu, L. Wang, L. Xu and Z. Ding, ``Deep Learning for Efficient CSI Feedback in Massive MIMO: Adapting to New Environments and Small Datasets," IEEE Transactions on Wireless Communications, 2024. doi: 10.1109/TWC.2024.3390583.

[9] C. -H. Hsu and Z. Ding, ``Unsupervised Learning for Resource Allocation and User Scheduling in Wideband MU-MIMO Systems," IEEE Open Journal of the Communications Society, vol. 5, pp. 2240-2256, 2024, doi: 10.1109/OJCOMS.2024.3384110.

[10] S. Zhang, T. Yu, B. Choi, F. Ouyang and Z. Ding, ``Radiomap Inpainting for Restricted Areas based on Propagation Priority and Depth Map," *IEEE Transactions on Wireless Communications,* 23(8): 9330-9344, August 2024. doi: 10.1109/TWC.2024.3360872.

[11] K. Wang, Z. Ding, D. K. C. So and Z. Ding, ``Age-of-Information Minimization in Federated Learning based Networks with Non-IID Dataset," *IEEE Transactions on Wireless Communications,* 23(8): 8939-8953, August 2024. doi: 10.1109/TWC.2024.3357208.

[12] C. Feres, B. C. Levy and Z. Ding, ``Over-the-Air Multisensor Collaboration for Resource Efficient Joint Detection," *IEEE Transactions on Signal Processing,* vol. 72, pp. 384-399, 2024, doi: 10.1109/TSP.2023.3310895.

[13] Y. -C. Lin, T. -S. Lee and Z. Ding, ``A Scalable Deep Learning Framework for Dynamic CSI Feedback With Variable Antenna Port Numbers," *IEEE Transactions on Wireless Communications,* vol. 23, no. 4, pp. 3102-3116, April 2024, doi: 10.1109/TWC.2023.3305546.

[14]

[15] Y. -C. Lin, T. -S. Lee and Z. Ding, ``Exploiting Partial FDD Reciprocity for Beam Based Pilot Precoding and CSI Feedback in Deep Learning," IEEE Transactions on Wireless Communications, doi: 10.1109/TWC.2023.3289929.

[16] S. Zhang, Q. Deng and Z. Ding, ``Signal Processing Over Multilayer Graphs: Theoretical Foundations and Practical Applications," IEEE Internet of Things Journal, vol. 11, no. 2, pp. 2453-2471, 15 Jan.15, 2024, doi: 10.1109/JIOT.2023.3294470.

[17] W. Cao, X. Ling, J. Wang, Z. Ding and X. Gao, ``A Framework for QoS-Guaranteed Fast Access Services in Blockchain Radio Access Network," IEEE Transactions on Wireless Communications, vol. 23, no. 4, pp. 2711-2725, April 2024, doi: 10.1109/TWC.2023.3302415

[18] Q. Deng, Y. Ge and Z. Ding, ``Jamming Suppression via Resource Hopping in High-Mobility OTFS-SCMA Systems," IEEE Wireless Communications Letters, vol. 12, no. 12, pp. 2138-2142, Dec. 2023, doi: 10.1109/LWC.2023.3309787.

[19] X. Liang, W. Fang, J. Wang, Z. Ding, X. Gao and C. Zhao, ``Robust Transceiver Design for RIS-Aided Spatially Correlated MIMO Channels With Uncertainty," IEEE Wireless Communications Letters, vol. 12, no. 12, pp. 2013-2017, Dec. 2023, doi: 10.1109/LWC.2023.3304335.

[20] Qi S, He M, Hoang R, Zhou Y, Namadi P, Tom B, Sandhu P, Bai Z, Chung F, Ding Z, Anderson J. ``Salinity Modeling Using Deep Learning with Data Augmentation and Transfer Learning" .*Water,* 15(13):2482, 6 July, 2023.

[21] S. Zhang, A. Wijesinghe and Z. Ding, ``RME-GAN: A Learning Framework for Radio Map Estimation based on Conditional Generative Adversarial Network" *IEEE Internet of Things Journal* 2023. doi:10.1109/JIOT.2023.3278235.

[22] Y. Ge, Q. Deng, D. Gonzalez G., Y. L. Guan and Z. Ding, ``OTFS Signaling for SCMA With Coordinated Multi-Point Vehicle Communications," *IEEE Transactions on Vehicular Technology*, doi: 10.1109/TVT.2023.3248119.

[23] H. Ma, X. Yuan, Z. Ding, D. Fan and J. Fang, "Over-the-Air Federated Multi-Task Learning via Model Sparsification, Random Compression, and Turbo Compressed Sensing," *IEEE Transactions on Wireless Communications,* doi: 10.1109/TWC.2022.3231088.

[24] Siyu Qi, Minxue He, Zhaojun Bai, Zhi Ding, Prabhjot Sandhu, Francis Chung, Peyman Namadi, Yu Zhou, Raymond Hoang, Bradley Tom, Jamie Anderson, and Dong Min Roh, "Novel Salinity Modeling Using Deep Learning for the Sacramento-San Joaquin Delta of California" in *Water* , 2022, 14(22), 3628; https://doi.org/10.3390/w14223628

[25] M. Del Rosario and Z. Ding, ``Learning-Based MIMO Channel Estimation under Practical Pilot Sparsity and Feedback Compression," in IEEE Transactions on Wireless Communications, 2022, doi: 10.1109/TWC.2022.3202750.

[26] C. Sun, X. Gao and Z. Ding, ``Optimization of Workload Balancing and Power Allocation for Wireless Distributed Computing," in IEEE Transactions on Wireless Communications, vol. 21, no. 9, pp. 7682-7695, Sept. 2022, doi: 10.1109/TWC.2022.3160493.

[27] C. -H. Hsu, C. Feres and Z. Ding, ``Wirtinger Flow for Nonconvex Blind Demixing with Optimal Step Size," in IEEE Wireless Communications Letters, 2022, doi: 10.1109/LWC.2022.3203313.

[28] Zhang, S., Deng, Q. & Ding, Z., ``Multilayer graph spectral analysis for hyperspectral images," EURASIP Journal of Adv. Signal Process, 2022, 92 (2022). doi: https://doi.org/10.1186/s13634-022-00926-8;

[29] C. Feres and Z. Ding, ``An Unsupervised Learning Paradigm for User Scheduling in Large Scale Multi-Antenna Systems," in IEEE Transactions on Wireless Communications, 2022, doi: 10.1109/TWC.2022.3215471.

[30] L. D. Chamain, S. Qi, and Z. Ding, ``End-to-End Image Classification and COmpression with variational autoencoder" IEEE Internet of Things Journal, vol. 70, 2022, doi: 10.1109/JIOT.2022.3182313.

[31] C. Feres and Z. Ding, ``A Riemannian Geometric Approach to Blind Signal Recovery for Grant-Free Radio Network Access," IEEE Transactions on Signal Processing, vol. 70, pp. 1734-1748, 2022, doi: 10.1109/TSP.2022.3159988.

[32] Q. Deng, S. Zhang and Z. Ding, ``An Efficient Hypergraph Approach to Robust Point Cloud Resampling," IEEE Transactions on Image Processing, vol. 31, pp. 1924-1937, 2022, doi: 10.1109/TIP.2022.3149225.

[33] X. Ling, B. Zhang, H. Xie, J. Wang, Z. Ding, Hash Access in Blockchain Radio Access Networks: Characterization and Optimization IEEE Internet of Things Journal, 9(11): 8053-8066, 1 June 2022 doi: 10.1109/JIOT.2021.3111915.

[34] Qi, S.; He, M.; Bai, Z.; Ding, Z.; Sandhu, P.; Zhou, Y.; Namadi, P.; Tom, B.; Hoang, R.; Anderson, J. ``Multi-Location Emulation of a Process-Based Salinity MOdel Using Machine Learning',' Water , 14(13):2030, 2022, doi: 10.3390/w14132030.

[35] C. Wang, A. -A. Lu, X. Gao and Z. Ding, ``Robust Precoding for 3D Massive MIMO Configuration With Matrix Manifold Optimization," IEEE Transactions on Wireless Communications, vol. 21, no. 5, pp. 3423-3437, May 2022, doi: 10.1109/TWC.2021.3121734.

[36] Z. Liu, M. Del Rosario, and Z. Ding, ``A Markovian Model-Driven Deep Learning Framework for Massive MIMO CSI Feedback," in IEEE Transactions on Wireless Communications,, vol. 21, no. 2, pp. 1214-1228, Feb. 2022, doi: 10.1109/TWC.2021.3103120.

[37] L. Teng, G. Zhai, Y. Wu, X. Min, W. Zhang, Z. Ding, and C Xiao, ``QoE Driven VR 360Â° Video Massive MIMO Transmission," IEEE Transactions on Wireless Communications, vol. 21, no. 1, pp. 18-33, Jan. 2022, doi: 10.1109/TWC.2021.3093305.

[38] Q. Deng, S. Zhang and Z. Ding, ``Point Cloud Resampling via Hypergraph Signal Processing," IEEE Signal Processing Letters, vol. 28, pp. 2117-2121, 2021, doi: 10.1109/LSP.2021.3119257.

[39] X. Ling, P. Chen, J. Wang and Z. Ding, ``Data Broker: Dynamic Multi-Hop Routing Protocol in Blockchain Radio Access Network," in IEEE Communications Letters, vol. 25, no. 12, pp. 4000-4004, Dec. 2021, doi: 10.1109/LCOMM.2021.3114218.

[40] Qi, Siyu, Zhaojun Bai, Zhi Ding, Nimal Jayasundara, Minxue He, Prabhjot Sandhu, Sanjaya Seneviratne, and Tariq Kadir, ``Enhanced Artificial Neural Networks for Salinity Estimation and Forecasting in the Sacramento-San Joaquin Delta of California." Journal of Water Resources Planning and Management 147, no. 10 (2021): 04021069.

[41] Y. -C. Lin, Z. Liu, T. -S. Lee and Z. Ding, ``Deep Learning Phase Compression for MIMO CSI Feedback by Exploiting FDD Channel Reciprocity," in IEEE Wireless Communications Letters, vol. 10, no. 10, pp. 2200-2204, Oct. 2021, doi: 10.1109/LWC.2021.3096808.

[42] C. J. Feres and Z. Ding, ``Wirtinger Flow Meets Constant Modulus Algorithm: Revisiting Signal Recovery for Grant-Free Access," in IEEE Transactions on Signal Processing, vol 69, pp. 6515-6529, Aug. 2021. doi: 10.1109/TSP.2021.3103038.

[43] Q. Hu, Y. Liu, Y. Cai, G. Yu and Z. Ding, ``Joint Deep Reinforcement Learning and Unfolding: Beam Selection and Precoding for mmWave Multiuser MIMO With Lens Arrays," in IEEE Journal on Selected Areas in Communications, vol. 39, no. 8, pp. 2289-2304, Aug. 2021, doi: 10.1109/JSAC.2021.3087233.

[44] C. Sun, J. Wang, X. Gao, Z. Ding and X. Zheng, ``Fiber-Enabled Optical Wireless Communications With Full Beam Coverage," in IEEE Transactions on Communications, vol. 69, no. 5, pp. 3207-3221, May 2021, doi: 10.1109/TCOMM.2021.3059458.

[45] Y. Ge, Q. Deng, P.C. Ching, Z. Ding ``OTFS Signaling for Uplink NOMA of Heterogeneous Mobility Users," in IEEE Transactions on Communications, 2021, doi: 10.1109/TCOMM.2021.3059456.

[46] Y. Ge, Q. Deng, P.C. Ching, Z. Ding ``Receiver design for OTFS with fractionally spaced sampling approach", in IEEE Transactions on Wireless Communications, 2021, doi: 10.1109/TWC.2021.3055585.

[47] S. Zhang, S. Cui and Z. Ding, ``Hypergraph Spectral Analysis and Processing in 3D Point Cloud," in IEEE Transactions on Image Processing, vol. 30, pp. 1193-1206, 2021, doi: 10.1109/TIP.2020.3042088.

[48] S. Zhang, S. Cui and Z. Ding, ``Hypergraph Spectral Clustering for Point Cloud Segmentation," in IEEE Signal Processing Letters, vol. 27, pp. 1655-1659, 2020, doi: 10.1109/LSP.2020.3023587.

[49] X. Ling, Y. Le, J. Wang and Z. Ding, ``Hash Access: Trustworthy Grant-Free IoT Access Enabled by Blockchain Radio Access Networks," in IEEE Network, vol. 34, no. 1, pp. 54-61, January/February 2020, doi: 10.1109/MNET.001.1900159.

[50] Ling, X.; Gao, Z.; Le, Y.; You, L.; Wang, J.; Ding, Z.; Gao, X. ``Satellite-Aided Consensus Protocol for Scalable Blockchains", Sensors Vol. 20, Issue 19, 2020.

[51] Z. Jiang, X. Shen, H. Wang and Z. Ding, ``Joint PSK Data Detection and Channel Estimation Under Frequency Selective Sparse Multipath Channels," in IEEE Transactions on Communications, vol. 68, no. 5, pp. 2726-2739, May 2020, doi: 10.1109/TCOMM.2020.2975172.

[52] Z. Liu, L. Zhang and Z. Ding, ``An Efficient Deep Learning Framework for Low Rate Massive MIMO CSI Reporting," in IEEE Transactions on Communications, vol. 68, no. 8, pp. 4761-4772, Aug. 2020, doi: 10.1109/TCOMM.2020.2993626.

[53] Q. Chen and Z. Ding, ``Accommodating LAA Within IEEE 802.11ax WiFi Networks for Enhanced Coexistence," in IEEE Transactions on Wireless Communications, vol. 19, no. 11, pp. 7621-7636, Nov. 2020, doi: 10.1109/TWC.2020.3014425.

[54] C. Sun, J. Wang, X. Gao and Z. Ding, ``Networked Optical Massive MIMO Communications," in IEEE Transactions on Wireless Communications, vol. 19, no. 8, pp. 5575-5588, Aug. 2020, doi: 10.1109/TWC.2020.2994545.

[55] Q. Liu, J. Xu, Z. Ding and H. C. So, ``Target Localization With Jammer Removal Using Frequency Diverse Array," in IEEE Transactions on Vehicular Technology, vol. 69, no. 10, pp. 11685-11696, Oct. 2020, doi: 10.1109/TVT.2020.3016948.

[56] T. Bouchoucha and Z. Ding, ``Anchor selection for topology inference and routing in wireless sensor networks," in Journal of Communications and Information Networks, vol. 5, no. 3, pp. 318-323, Sept. 2020, doi: 10.23919/JCIN.2020.9200895.

[57] X. Ling, Y. Le, J. Wang, Z. Ding and X. Gao, ``Practical Modeling and Analysis of Blockchain Radio Access Network," in IEEE Transactions on Communications, 2020 doi: 10.1109/TCOMM.2020.3029779.

[58] Z. Liu, L. Zhang and Z. Ding, ``Overcoming the Channel Estimation Barrier in Massive MIMO Communication via Deep Learning," in IEEE Wireless Communications, vol. 27, no. 5, pp. 104-111, October 2020, doi: 10.1109/MWC.001.1900413

[59] Q. Hu, Y. Cai, Q. Shi, K. Xu, G. Yu and Z. Ding, ``Iterative Algorithm Induced Deep-Unfolding Neural Networks: Precoding Design for Multiuser MIMO Systems," in IEEE Transactions on Wireless Communications, 2020. doi: 10.1109/TWC.2020.3033334.

[60] X. Ling, J. Wang, Y. Le, Z. Ding and X. Gao, ``Blockchain Radio Access Network Beyond 5G," in IEEE Transactions on Wireless Communications, in IEEE Wireless Communications, 2020. doi: 10.1109/MWC.001.2000172.

[61] A. Jalali and Z. Ding, ``Joint Detection and Decoding of Polar Coded 5G Control Channels", *IEEE Transactions on Wireless Communications,* 19(3), pp. 2066-2078, Mar. 2020.

[62] Yang, Kai, Yuanming Shi, Wei Yu, and Zhi Ding, ``Energy-efficient processing and robust wireless cooperative transmission for edge inference," *IEEE Internet of Things Journal*, accepted, 2020. DOI: 10.1109/JIOT.2020.2979523

[63] J. Dong, Y. Shi, and Z. Ding, ``Blind Over-the-Air Computation and Data Fusion via Provable Wirtinger Flow", *IEEE Transactions on Signal Processing* vol. 68, pp. 1136-1151, 2020. DOI: 10.1109/TSP.2020.2970338.

[64] Y. Ma, Z. Quan, D. Li, S. Zhang, X. Li, Z. Feng, and Z. Ding, Optimal Linear Cooperation for Signal Classification via M-ary Hypothesis Testing in Cognitive Communication Networks, *IEEE Transactions on Wireless Communications,* 19(5), pp. 3144-3155, May 2020.

[65] S. Zhang, Z. Ding and S. Cui, ``Introducing Hypergraph Signal Processing: Theoretical Foundation and Practical Applications," *IEEE Internet of Things Journal,* , vol.7, no.1, pp. 639-660, Jan. 2020. doi: 10.1109/JIOT.2019.2950213

[66] Z. Jiang, X. Shen, H. Wang and Z. Ding, ``Joint PSK Data Detection and Channel Estimation under Frequency Selective Sparse Multipath Channels," in *IEEE Transactions on Communications*, doi: 10.1109/TCOMM.2020.2975172.

[67] R. Liu, Q. Chen, G. Yu, G. Y. Li and Z. Ding, ``Resource Management in LTE-U Systems: Past, Present, and Future," *IEEE Open Journal of Vehicular Technology,* vol. 1, pp. 1-17, 2020 DOI: 10.1109/OJVT.2019.2949020

[68] Li, Pei-Rong, Zhi Ding, and Kai-Ten Feng, ``Enhanced Receiver Based on FEC Code Constraints for Uplink NOMA With Imperfect CSI." *IEEE Transactions on Wireless Communications* vol. 18, no. 10, pp. 4790-4802, 2019.

[69] Z. Liu, L. Zhang, and Z. Ding, ``Exploiting Bi-Directional Channel Reciprocity in Deep Learning for Low Rate Massive MIMO CSI Feedback", *IEEE Wireless Communications Letters*, Feb. 2019. doi:10.1109/LWC.2019.2898662

[70] K. Yang, Y. Shi and Z. Ding, ``Generalized Low-Rank Optimization for Topological Cooperation in Ultra-Dense Networks," *IEEE Transactions on Wireless Communications,* vol. 18, no. 5, pp. 2539-2552, May 2019. doi: 10.1109/TWC.2019.2904570

[71] K. Yang, Y. Shi and Z. Ding, ``Data Shuffling in Wireless Distributed Computing via Low-Rank Optimization," *IEEE Transactions on Signal Processing,* vol. 67, no. 12, pp. 3087-3099, 15 June, 2019. doi: 10.1109/TSP.2019.2912139

[72] S. Bi, J. Lyu, Z. Ding, and R. Zhang, R., ``Engineering Radio Maps for Wireless Resource Management," *IEEE Wireless Communications,* 26(2), pp.133-141, Feb. 2019. doi:10.1109/MWC.2019.1800146

[73] Z. Zhang, Z. Zhu, B. Bazor, S. Lee, Z. Ding and T. Pan, ``FeetBeat: A Flexible Iontronic Sensing Wearable Detects Pedal Pulses and Muscular Activities," *IEEE Transactions on Biomedical Engineering,* 2019. doi: 10.1109/TBME.2019.2900224

[74] L. Jing, H. Wang, C. He and Z. Ding, ``A Novel Spatial CCK Modulation Design for Underwater Acoustic Communications," *IEEE Transactions on Vehicular Technology,* vol. 68, no. 6, pp. 6192-6196, June 2019. doi: 10.1109/TVT.2019.2912583

[75] T. Bouchoucha, C. N. Chuah, and Z. Ding, ``Topology Inference of Unknown Networks Based on Robust Virtual Coordinate Systems", *IEEE/ACM Transactions on Netorking*, vol. 27, no. 1, pp. 405-418, Jan. 2019. doi:10.1109/TNET.2018.2888600

[76] W. Wu and Z. Ding, ``A Markovian Design of Bi-Directional Robust Header Compression for Efficient Packet Delivery in Wireless Networks" *IEEE Transactions on Wireless Communications*, vol.18, no.1, pp. 20-33, Jan. 2019. doi:10.1109/TWC.2018.2875448

[77] X. Ling, J. Wang. T. Bouchoucha, B. C. Levy, and Z. Ding, ``Blockchain Radio Access Network (B-RAN): Towards Decentralized Secure Radio Access Paradigm," IEEE Access, vol. 7, pp. 9714-9723, Jan. 2019. doi: 10.1109/ACCESS.2018.2890557

[78] H. Wang, L. Jing, C. He, and Z. Ding, `` High Rate CCK Modulation Design for Bandwidth Efficient Link Adaptation," IEEE Wireless Communications Letters, , pp. 4960499, 8(2), April 2019.

[79] Q. Chen, G. Yu, and Z. Ding, ``Enhanced LAA for Unlicensed LTE Deployment Based on TXOP Contention," IEEE Transactions on Communications, vol. 67, no. 1, pp. 417-429, Jan. 2019. doi: 10.1109/TCOMM.2018.2868694

[80] Hema K. Achanta, Soura Dasgupta, Raghuraman Mudumbai, Weiyu Xu, and Zhi Ding, ``Optimum sensor placement for localization of a hazardous source under log normal shadowing," Numerical Algebra, Control & Optimization, no. 3, pp. 361-382, 2019. doi: 10.3934/naco.2019024

[81] C. Sun, X. Gao, J. Wang, Z. Ding and X. Xia, "Beam Domain Massive MIMO for Optical Wireless Communications With Transmit Lens," IEEE Transactions on Communications, vol. 67, no. 3, pp. 2188-2202, March 2019. doi: 10.1109/TCOMM.2018.2883622

[82] P. Ge, X. Liang, J. Wang, C. Zhao, X. Gao and Z. Ding, "Optical Filter Designs for Multi-Color Visible Light Communication", IEEE Transactions on Communications, vol. 67, no. 3, pp. 2173-2187, March 2019. doi: 10.1109/TCOMM.2018.2883422

[83] Y. Wu, C. Xiao, Z. Ding, X. Gao, and S. Jin A Survey on MIMO Transmission With Finite Input Signals: Technical Challenges, Advances, and Future Trends," Proceedings of the IEEE, vol. 106, No. 10, 1779-1833, October, 2018.

[84] Q. Wu, C. Feres, D. Kuzmenko, Z. Ding, Z. Yu, X. Liu, and Xiaoguang Liu, ``Deep learning based RF fingerprinting for device identification and wireless security," Electronics Letters, vol. 54, no. 24, pp. 1405-1407, 2018. doi: 10.1049/el.2018.6404

[85] L. Liang, S. Xie, G. Y. Li, Z. Ding and X. Yu, ``Graph-Based Resource Sharing in Vehicular Communication," IEEE Transactions on Wireless Communications, vol. 17, no. 7, pp. 4579-4592, July 2018. doi: 10.1109/TWC.2018.2827958

[86] Q. Ji, Z. Ding, N. Wang, M. Pan and G. Song, ``A Novel Waveform Optimization Scheme for Piezoelectric Sensors Wire-Free Charging in the Tightly Insulated Environment,"> IEEE Internet of Things Journal, vol. 5, no. 3, pp. 1936-1946, June 2018. doi: 10.1109/JIOT.2018.2817601

[87] X. Ling, J. Wang, Z. Ding, C. Zhao and X. Gao, ``Efficient OFDMA for LiFi Downlink," *Journal of Lightwave Technology,* vol. 36, no. 10, pp. 1928-1943, 15 May 2018. doi: 10.1109/JLT.2018.2796120

[88] C. Jiang, W. Wu, and Z. Ding, ``LTE Multimedia Broadcast Multicast Service Provisioning Based on Robust Header Compression," *IEEE Transactions on Wireless Communications,* vol. 17, no. 2, pp. 1161-1172, Feb. 2018. doi: 10.1109/TWC.2017.2776906

[89] X. Ling, J. Wang, X. Liang, Z. Ding, C. Zhao, and X. Gao ``Biased Multi-LED Beamforming for Multicarrier Visible Light Communications," IEEE Journal on Selected Areas in Communications, vol. 36, no. 1, pp.106-120, Jan. 2018. doi: 10.1109/JSAC.2017.2774539

[90] X. Liang, Z. Ding and C. Xiao, ``On Linear Precoding of Non-Regenerative MIMO Relay Networks For Finite-Alphabet Source," *IEEE Transactions on Vehicular Technology,* vol. 66, no. 11, pp. 9761-9775, Nov. 2017. doi: 10.1109/TVT.2017.2717925

[91] X. Liang; M. Yuan; J. Wang; Z. Ding; M. Jiang; C. Zhao, ``Constellation Design Enhancement for Color-Shift Keying Modulation of Quadrichromatic LEDs in Visible Light Communications," *Journal of Lightwave Technology,* vol.15, no.17, pp.3650-3663, September 2017. doi: 10.1109/JLT.2017.2720579

[92] L. Jing, C. He, J. Huang and Z. Ding, ``Energy Management and Power Allocation for Underwater Acoustic Sensor Network,"*IEEE Sensors Journal,* vol. 11, no. 11, pp. 1789-1796, August 2017. doi: 10.1109/JSEN.2017.2737229

[93] W. Wu and Z. Ding, ``On Efficient Packet-Switched Wireless Networking: A Markovian Approach to Trans-layer Design and Optimization of ROHC," in IEEE Transactions on Wireless Communications , vol.16, no.7, pp.4232-4245, July 2017. doi: 10.1109/TWC.2017.2694840

[94] W. Wu, H. Mittelmann, and Z. Ding, ``Modulation Design for MIMO-CoMP HARQ," IEEE Communications Letters, vol.21, no.2, pp.290-293, Feb. 2017. doi: 10.1109/LCOMM.2016.2618796

[95] Lianyou Jing, C. He, Jian-guo Huang, and Z. Ding, ``Joint Channel Estimation and Detection Using MCMC Method over Sparse Underwater Acoustic Channels". *IET Communications,* May 2017. doi: 10.1049/iet-com.2016.1339

[96] L. Jing, H. Wang, C. He and Z. Ding, ``Spatial CCK Modulation and Iterative Detection over Frequency-Selective Fading Channels," *IEEE Wireless Communications Letters,* vol.6, no.4, pp.506-509, June 2017. doi: 10.1109/LWC.2017.2709315

[97] Hesham Elmaghraby and Zhi Ding, ``Scheduling and Power Allocation for Hybrid Access Cognitive Femtocells," *IEEE Transactions on Wireless Communications* vol.16, No.4, pp. 2520-2533, April 2017.

[98] Chen Sun, Xiqi Gao, and Zhi Ding. ``BDMA in Multi-Cell Massive MIMO Communications: Power Allocation Algorithms", *IEEE Transactions on Signal Processing,* vol. 65, No. 11, pp. 2962-74, June 2017.

[99] Dongrun Qin and Zhi Ding, ``Transport capacity analysis of wireless in-band full duplex ad hoc networks." *IEEE Transactions on Communications,* vol. 65, no. 3, pp.1303-18, March 2017. doi: 10.1109/TCOMM.2016.2640278

[100] Qimei Chen, Guanding Yu, Hesham M. Elmaghraby, Jyri Hamalainen, Zhi Ding, ``Embedding LTE-U within Wi-Fi Bands for Spectrum Efficiency Improvement", *IEEE Network*, Vol.31, No. 2, pp. 72-79, March 2017.

[101] K. Wang; Z. Ding, ``FEC Code Anchored Robust Design of Massive MIMO Receivers," in *IEEE Transactions on Wireless Communications,* vol.15, no.12, pp.8223-8235, 2016, doi: 10.1109/TWC.2016.2613516

[102] Q. Chen, G. Yu and Z. Ding, ``Optimizing Unlicensed Spectrum Sharing for LTE-U and WiFi Network Coexistence," in *IEEE Journal on Selected Areas in Communications,* vol. 34, no. 10, pp. 2562-2574, Oct. 2016. doi: 10.1109/JSAC.2016.2604998

[103] Z. Zheng; J. Hamalainen; Z. Ding, ``On the sum rate of fair resource allocation with selective feedback," in *IEEE Transactions on Wireless Communications*, vol.15, no.8, pp.5193 - 5205, doi: 10.1109/TWC.2016.2554579

[104] D. Qin and Z. Ding, ``Exploiting Multi-Antenna Non-Reciprocal Channels for Shared Secret Key Generation,"in *IEEE Transactions on Information Forensics and Security,* vol. 11, no. 12, pp. 2693-2705, Dec. 2016. doi: 10.1109/TIFS.2016.2594143

[105] Han, Huy-Dung, Zhi Ding, and Muhammad Zia. ``A Convex Relaxation Approach to Higher-Order Statistical Approaches to Signal Recovery." *IEEE Transactions on Vehicular Technology*, vol.PP, no.99, pp.1-1 doi: 10.1109/TVT.2016.2542108

[106] H. Wang; C. Zhu; Z. Ding, ``Femtocell Power Control for Interference Management Based on Macro-Layer Feedback," IEEE Transactions on Vehicular Technology, vol.64, no.6, pp.5222-5236 July 2016. doi: 10.1109/TVT.2015.2463718

[107] W. Wu, H. Mittelmann, and Z. Ding, ``Modulation Design for Two-Way Amplify-and-Forward Relay HARQ," IEEE Wireless Communications Letters, vol.5, no.3, pp.244-247, June 2016. doi: 10.1109/LWC.2016.2530659

[108] K. Wang; Z. Ding, ``Diversity Integration in Hybrid-ARQ with Chase Combining under Partial CSI," in IEEE Transactions on Communications, vol.64, no.6, pp.2647-2659, June 2016. doi: 10.1109/TCOMM.2016.2553664

[109] Xintong Ling, J. Wang, X. Liang, Z. Ding, C. Zhao, Offset and power optimization for DCO-OFDM in visible light communication systems," *IEEE Transactions on Signal Processing,* 64(2), 349-363, 2016.

[110] H. Tang and Z. Ding, ``Mixed Mode Transmission and Resource Allocation for D2D Communication," IEEE Transactions on Wireless Communications, vol. 15, no. 1, pp. 162-175, Jan. 2016. doi: 10.1109/TWC.2015.2468725

[111] X. Ling, J. Wang, X. Liang, Z. Ding and C. Zhao, ``Offset and Power Optimization for DCO-OFDM in Visible Light Communication Systems," IEEE Transactions on Signal Processing, vol. 64, no. 2, pp. 349-363, Jan.15, 2016. doi: 10.1109/TSP.2015.2477799

[112] H. Wang, J. Wang and Z. Ding, ``Distributed Power Control in a Two-Tier Heterogeneous Network," IEEE Transactions on Wireless Communications, vol. 14, no. 12, pp. 6509-6523, Dec. 2015. doi: 10.1109/TWC.2015.2456055

[113] Bi, Suzhi, Rui Zhang, Zhi Ding, and Shuguang Cui. ``Wireless communications in the era of big data." IEEE Communications Magazine, vol. 53, no. 10, pp. 190-199, October 2015. doi: 10.1109/MCOM.2015.7295483

[114] Michal Cierny, Zhi Ding, and Risto Wichman. ``Higher Rank Interference Effect on Weak Beamforming or OSTBC Terminals." IEEE Transactions on Wireless Communications, vol. 14, no. 9, pp. 4948-4957, Sept. 2015. doi: 10.1109/TWC.2015.2429648

[115] Haile, B.B.; Dowhuszko, A.A.; Hamalainen, J.; Wichman, R.; Ding, Z., ``On Performance Loss of Some CoMP Techniques Under Channel Power Imbalance and Limited Feedback,", IEEE Transactions on Wireless Communications, vol.14, no.8, pp.4469-4481, Aug. 2015. doi: 10.1109/TWC.2015.2421898

[116] Kun Wang, Hong Shen, Wenhao Wu, and Zhi Ding, Joint Detection and Decoding in LDPC-Based Space-Time Coded MIMO-OFDM Systems via Linear Programming" IEEE Transactions on Signal Processing, 63. 3411-3424. 2015. doi: 10.1109/TSP.2015.2422681

[117] Elsherif, A.R.; Wei-Peng Chen; Ito, A.; Zhi Ding, ``Resource Allocation and Inter-Cell Interference Management for Dual-Access Small Cells," *IEEE Journal on Selected Areas in Communications,* vol.33, no.6, pp.1082-1096, June 2015. doi: 10.1109/JSAC.2015.2416990

[118] Elsherif, A.R.; Chen, Wei-Peng; Ito, A.; Z. Ding, ``Adaptive resource allocation for interference management in small cell networks," IEEE Transactions on Communications, vol.63, no.6, pp.2107-2125, June 2015. doi: 10.1109/TCOMM.2015.2420676

[119] Sun, C.; Gao, X.; Jin, S.; Matthaiou, M.; Ding, Z.; Xiao, C., ``Beam Division Multiple Access Transmission for Massive MIMO Communications," IEEE Transactions on Communications," vol.63, no.6, pp.2170-2184, 2015. doi: 10.1109/TCOMM.2015.2425882

[120] Sam Siu, Qing Ji, Wenhao Wu, Gangbing Song, and Zhi Ding, ``Stress wave communication in concrete: I. Characterization of a smart aggregate based concrete channel," *Smart Materials and Structures,* 23(12): 125030, Dec. 2014.

[121] Sam Siu, Qing Ji, Wenhao Wu, Gangbing Song, and Zhi Ding. ``Stress wave communication in concrete: II. Evaluation of low voltage concrete stress wave communications utilizing spectrally efficient modulation schemes with PZT transducers," *Smart Materials and Structures,* 23(12): 125031, Dec. 2014.

[122] Wang, Haining, and Zhi Ding, ``Power Control and Resource Allocation for Outage Balancing in Femtocell Networks," *IEEE Transactions on Wireless Communications,* 14, no. 4 (2015): 2043-2057. doi: 10.1109/TWC.2014.2379282

[123] Wu, Wenhao, Kun Wang, Weiliang Zeng, Zhi Ding, and Chengshan Xiao, ``"Cooperative Multi-Cell MIMO Downlink Precoding With Finite-Alphabet Inputs," *IEEE Transactions on Communications,* vol. 63, no. 3 (2015): 766-779. doi: 10.1109/TCOMM.2015.2388584

[124] Huan Tang, Zhi Ding, and B. C. Levy, ``Enabling D2D Communications Through Neighbor Discovery in LTE Cellular Networks," IEEE Transactions on Signal Processing, vol.62, no.19, pp.5157-5170, Oct.1, 2014. doi: 10.1109/TSP.2014.2348950

[125] Haining Wang; Zhi Ding, ``Macrocell-Queue-Stabilization-Based Power Control of Femtocell Networks," *IEEE Transactions on Wireless Communications*, vol.13, no.9, pp.5223-5236, Sept. 2014

[126] Zia, M.; Ding, Z., ``Bandwidth Efficient Variable Rate HARQ Under Orthogonal Space-Time Block Codes," IEEE Transactions on Signal Processing, vol.62, no.13, pp.3360-3370, July 2014 doi: 10.1109/TSP.2014.2327580

[127] Binbin Guan; Djordjevic, S.S.; Fontaine, N.K.; Linjie Zhou; Ibrahim, S.; Scott, R.P.; Geisler, D.J.; Zhi Ding; Ben Yoo, S.J., "CMOS Compatible Reconfigurable Silicon Photonic Lattice Filters Using Cascaded Unit Cells for RF-Photonic Processing," IEEE Journal of Selected Topics in Quantum Electronics, vol.20, no.4, pp.1,10, July-Aug. 2014 doi: 10.1109/JSTQE.2013.2296233

[128] Hong Shen; Zhi Ding; Dasgupta, S.; Chunming Zhao, "Multiple Source Localization in Wireless Sensor Networks Based on Time of Arrival Measurement,"IEEE Transactions on Signal Processing, vol.62, no.8, pp.1938-1949, April 15, 2014 doi: 10.1109/TSP.2014.2304433

[129] Dongrun Qin; Zhi Ding; Dasgupta, S., "On Forward Channel Estimation for MIMO Precoding in Cooperative Relay Wireless Transmission Systems," IEEE Transactions on Signal Processing, vol.62, no.5, pp.1265-1278, March 2014 doi: 10.1109/TSP.2013.2296880

[130] Elsherif, A.R.; Zhi Ding; Xin Liu, "Dynamic MIMO Precoding for Femtocell Interference Mitigation," IEEE Transactions on Communications, vol.62, no.2, pp.648-666, February 2014 doi: 10.1109/TCOMM.2013.122913.130062

[131] Tseng, Po-Hsuan, Zhi Ding, and Kai-Ten Feng. "Cooperative Self-Navigation in a Mixed LOS and NLOS Environment", IEEE Transactions on Mobile Computing, 13, no. 2 (2014): 350-363. doi: 10.1109/TMC.2013.6

[132] Ahmed R. Elsherif, Zhi Ding, Xin Liu, and Jyri Hamalainen, ``Resource Allocation in Two-Tier Heterogeneous Networks through Enhanced Shadow Chasing," IEEE Transactions on Wireless Communications, vol. 12, no.12, pp. 6439-6453, Dec. 2013. doi:10.1109/TWC.2013.101813.130732

[133] Enyang Xu, Z.Ding, and S. Dasgupta, ``Target tracking and mobile sensor navigation in wireless sensor networks". IEEE Transactions on Mobile Computing, 12(1):177-186. 2013. doi: 10.1109/TMC.2011.262

[134] Jacklin, Neil, and Zhi Ding. "A linear programming based tone injection algorithm for papr reduction of OFDM and linearly precoded systems", IEEE Transactions on Circuits and Systems I: Regular Papers, vol. 60, no. 7 (2013): 1937-1945. doi: 10.1109/TCSI.2012.2230505

[135] M. Cierny, Haining Wang, R. Wichman, Zhi Ding, and C. Wijting, ``On Number of Almost Blank Subframes in Heterogeneous Cellular Networks," IEEE Transactions on Wireless Communications, vol.12, no.10, pp.5061-5073, October 2013.

[136] Zhe Jiang; Haiyan Wang; Zhi Ding, ``A Bayesian Algorithm for Joint Symbol Timing Synchronization and Channel Estimation in Two-Way Relay Networks,"IEEE Transactions on Communications, vol.61, no.10, pp.4271-4283, October 2013. doi:10.1109/TCOMM.2013.082813.110691

[137] Yongpeng Wu; Chengshan Xiao; Xiqi Gao; Matyjas, J.D.; Zhi Ding, "Linear Precoder Design for MIMO Interference Channels with Finite-Alphabet Signaling," IEEE Transactions on Communications, vol.61, no.9, pp.3766-3780, September 2013. doi: 10.1109/TCOMM.2013.072213.130132

[138] Xiao Liang; Chun-Ming Zhao; Zhi Ding, ""Piggyback Retransmissions over Wireless MIMO Channels: Shared Hybrid-ARQ (SHARQ) for Bandwidth Efficiency," IEEE Transactions on Wireless Communications, vol.12, no.8, pp.3770,3782, August 2013. doi: 10.1109/TWC.2013.051313.121098

[139] Kun-Yu Wang, Neil Jacklin, Zhi Ding, and Chong-Yung Chi, ``Robust MISO Transmit Optimization under Outage-Based QoS Constraints in Two-Tier Heterogeneous Networks," IEEE Transactions on Wireless Communications, 12 (4):1883-1897, April 2013. doi: 10.1109/TWC.2013.022013.121111

[140] Enyang Xu, Zhi Ding, and S. Dasgupta, ``Target Tracking and Mobile Sensor Navigation in Wireless Sensor Networks", IEEE Transactions on Mobile Computing, 12(1):177 - 186, Jan. 2013.

[141] F. E. Lapiccirella, X. Liu, and Z. Ding, ``Distributed Control of Multiple Cognitive Radio Overlay for Primary Queue Stability", IEEE Transactions on Wireless Communications, 12(1):112-122, January 2013. doi:10.1109/TWC.2012.121112.111783

[142] Shafi, A. Bashar, Zhi Ding, and Chengshan Xiao, ``On Secrecy Rate Analysis of MIMO Wiretap Channels Driven by Finite-Alphabet Input," IEEE TRANSACTIONS ON COMMUNICATIONS, 60 (12):3816-3825, Dec. 2012.

[143] Huy-Dung Han and Z. Ding, ``Steepest descent algorithm implementation for multichannel blind signal recovery", IET Communications, 6(18):3196-3203, December 2012.

[144] Y. Wu, C. Xiao and Z. Ding, X. Gao, and S. Jin, ``LINEAR PRECODING FOR FINITE-ALPHABET SIGNALING OVER MIMOME WIRETAP CHANNELS," IEEE Transactions on Vehicular Technology, 61(6): 2599-2612, 2012

[145] Y. Wu, M. Wang, C. Xiao, Z. Ding, X.-Q. Gao ``Linear Precoding for MIMO Broadcast Channels With Finite-Alphabet Constraints'', IEEE Transactions on Wireless Communications, 11(8): 2906 - 2920, August 2012

[146] Neil Jacklin, Zhi Ding, Wei Chen, Chunqi Chang, ``Noniterative Convex Optimization Methods for Network Component Analysis'' IEEE/ACM Transactions on Computational Biology and Bioinformatics, 9(5):1472-1481, Sept.-Oct. 2012

[147] F.~E. Lapiccirella, Z. Ding, and X. Liu, ``Cognitive Spectrum Access Control Based on Intrinsic Primary ARQ Information'', IET Communications, 6(8):900-908, August 2012.

[148] X. Liang, Z. Ding and C. Xiao, ``OPTIMIZED POWER ALLOCATION FOR PACKET RETRANSMISSIONS OF NON-GAUSSIAN INPUTS THROUGH SEQUENTIAL AWGN CHANNELS'', IEEE Transactions on Communications, 60(7): 1889-1902, 2012.

[149] T. Miyajima and Zhi Ding, ``Subcarrier Nulling Algorithms for Channel Shortening in Uplink OFDMA Systems,'' IEEE Transactions on Signal Processing, vol.60, no.5, pp.2374-2385, May 2012.

[150] C. Xiao, Y. R. Zheng, and Z. Ding, ``Globally optimal linear precoders for finite alphabet signals over complex vector Gaussian channels,'' IEEE Trans. Signal Process., vol.59, pp.3301-3314, July 2011.

[151] Li Zhang, Shu Lin, K. Abdel-Ghaffar, Zhi Ding, and Bo Zhou, ``Quasi-Cyclic LDPC Codes on Cyclic Subgroups of Finite Fields'' , IEEE Transactions on Communications, 59(9):2330-2336, Sept. 2011

[152] Z. Muhammad, and Z. Ding, ``Blind Multiuser Detection for Synchronous High Rate Space-Time Block Coded Transmission'', IEEE Transactions on Wireless Communications, Issue: 99, July 2011, Page(s): 2171 - 2185.

[153] S. Bashar, Z. Ding, C. Xiao, ``On the Secrecy Rate of Multi-Antenna Wiretap Channel under Finite-Alphabet Input'', IEEE Communications Letters, Vol. 15, No. 5, 2011, Page(s): 527-529.

[154] Xiao Liang, Chunming Zhao, and Zhi Ding, ``Sequential Linear MIMO Precoder Optimization for Hybrid ARQ Retransmission of QAM Signals'', IEEE Communications Letters, 15(9): 913 - 915, September 2011.

[155] Enyang Xu; Zhi Ding; Dasgupta, S.; ``Source Localization in Wireless Sensor Networks From Signal Time-of-Arrival Measurements'', IEEE Transactions on Signal Processing, Volume: 59 , Issue: 6, June 2011, Page(s): 2887 - 2897

[156] S. Bashar, Z. Ding, and (G.) Y. Li, `` On Secrecy of Codebook-Based Transmission Beamforming under Receiver Limited Feedback,'' IEEE Transactions on Wireless Communications, Volume: 10 , Issue: 4, April 2011 , Page(s): 1212 - 1223

[157] Senhua Huang, Xin Liu, and Zhi Ding; ``Decentralized Cognitive Radio Control Based on Inference from Primary Link Control Information'', IEEE Journal on Selected Areas in Communications, Volume: 29 Issue:2, February 2011; page(s): 394 - 406.

[158] Enyang Xu, Zhi Ding, Soura Dasgupta, ``Reduced Complexity Semidefinite Relaxation Algorithms for Source Localization based on Time Difference of Arrival,'' IEEE Transactions on Mobile Computing, vol. 99, no. 9, 2011.

[159] Djordjevic, S.S.; Luo, L.W.; Ibrahim, S.; Fontaine, N.K.; Poitras, C.B.; Guan, B.; Zhou, L.; Okamoto, K.; Ding, Z.; Lipson, M.; Yoo, S.J.B.; ``Fully Reconfigurable Silicon Photonic Lattice Filters With Four Cascaded Unit Cells,'' IEEE Photonics Technology Letters, vol.23, no.1, pp.42-44, Jan.1, 2011

[160] Z. Shi, W. Xu, S. Jin, C. Zhao, and Z. Ding, ``On Wireless Downlink Scheduling of MIMO Systems With Homogeneous Users" IEEE Transactions on Information Theory, Volume 56, July 2010. page(s): 3367 - 3378.

[161] S. Song, S. Lin, K. Abdel-Ghaffar, Z. Ding, W.H. Fong, M.P.C. Fossorier, ``Burst Decoding of Cyclic Codes Based on Circulant Parity-Check Matrices," IEEE Transactions on Information Theory, Volume 56, March 2010. page(s): 1038 - 1047.

[162] M. Muhammad and Z. Ding, ``A Linear Programming Receiver for Blind Detection of Full Rate Space-Time Block Codes" IEEE Transactions on Signal Processing, Volume: Issue: 99, Nov. 2010.

[163] S. Huang, X. Liu, and Z. Ding, ``Optimal Transmission Strategies for Dynamic Spectrum Access in Cognitive Radio Networks," IEEE Transactions on Mobile Computing, Volume 8, No. 12, December 2009. Page(s):1636 - 1648

[164] C. He, J. Huang, and Z. Ding, ``A Variable-Rate Spread-Spectrum System for Underwater Acoustic Communications" IEEE Journal of Oceanic Engineering, 34(4): 624-633, Oct. 2009.

[165] W. Xu, C. Zhao, and Z. Ding, ``Optimisation of limited feedback design for heterogeneous users in multi-antenna downlinks" , Institution of Engineering and Technology Communications, Volume 3, Issue 11, Page(s):1724 - 1735, November 2009

[166] S. Bashar and Zhi Ding, ``Admission control and resource allocation in a heterogeneous OFDMA wireless network" IEEE Transactions on Wireless Communications, Volume 8, Issue 8, Page(s):4200 - 4210, August 2009

[167] Wei Xu, Chunming Zhao, and Zhi Ding, ``Limited Feedback Multiuser Scheduling of Spatially Correlated Broadcast Channels" , IEEE Transactions on Vehicular Technology, Volume 58, Issue 8, Page(s):4406 - 4418, Oct. 2009.

[168] C. Meng, J. Tuqan, and Z. Ding, `` A Quadratic Programming Approach to Blind Equalization and Signal Separation" IEEE Transactions on Signal Processing, 57(6): 2232-2244, June 2009.

[169] Wei Xu, Chunming Zhao, and Zhi Ding, ``Limited feedback design for MIMO broadcast channels with ARQ mechanism" IEEE Transactions on Wireless Communications, Volume 8, Issue 4, Page(s):2132 - 2141, April 2009.

[170] Xiaofei Dong and Z. Ding, ``Wireless Channel Estimation for Linear MIMO Transmission Precoding" IEEE Transactions on Communications, Volume 57, Issue 4, April 2009 Page(s):1151 - 1161

[171] Bo Zhou, Jingyu Kang, Ying Tai, Shu Lin, and Zhi Ding, ``High Performance Non-Binary Quasi-Cyclic LDPC Codes on Euclidean Geometries LDPC Codes on Euclidean Geometries," IEEE Transactions on Communications, Volume 57, Issue 5, May 2009, Page(s):1298 - 1311.

[172] S. D. Chitte, S. Dasgupta, and Zhi Ding, ``Distance Estimation From Received Signal Strength Under Log-Normal Shadowing: Bias and Variance", IEEE Signal Processing Letters, 16(3): 216 - 218, March 2009.

[173] X. Dong, Z. Ding, and S. Dasgupta, ``Performance Analysis of a Forward Link Channel Estimation Method for Wireless Multicarrier Systems," IEEE Transactions on Wireless Communications,, 7(8): 3026-3035, August 2008.

[174] Chunqi Chang, Zhi Ding, Yeung Sam Hung, and Peter Chin Wan Fung, ``Fast Network Component Analysis (FastNCA) for Gene Regulatory Network Reconstruction from Microarray Data", Bioinformatics 2008 24(11):1349-1358.

[175] H. Sun, Z. Shi, C. Zhao, J. H. Manton, and Z. Ding, ``Progressive Linear Precoder Optimization for MIMO Packet Retransmissions Exploiting Channel Covariance Information", IEEE Transactions on Communications, Volume: 55, Issue: 5, page(s): 818-827, May 2008.

[176] H. Kameyama, T. Miyajima, and Z. Ding, ``Perfect Blind Channel Shortening for Multicarrier Systems", IEEE Transactions on Circuits and Systems, Volume: 55, Issue: 3, page(s): 851-860, April 2008.

[177] C. Meng, Z. Ding, and S. Dasgupta, ``A Semidefinite Programming Approach to Source Localization in Wireless Sensor Networks", IEEE Signal Processing Letters, Volume 15, 2008, Page(s):253 - 256

[178] Zhihua Shi, Haitong Sun, Chunming Zhao, and Z. Ding, ``Linear precoder optimization for ARQ packet retransmissions in centralized multiuser MIMO uplinks", IEEE Transactions on Wireless Communications, vol. 7, no. 2, February 2008, page(s): 736-745.

[179] Peter M. Hahn, Bum-Jin Kim, Thomas Stutzle, Sebastian Kanthak, William L. Hightower, Harvind Samra, Zhi Ding, and Monique Guignard, The Quadratic Three-dimensional Assignment Problem: Exact and Approximate Solution Methods, European Journal of Operational Research Volume 184, Issue 2, Pages 416-428, 16 January 2008.

[180] Y. Du, F.Xue, S. J. B. Yoo, and Z. Ding, "Security Enhancement of SPECTS O-CDMA Through Concealment Against Upstream DPSK Eavesdropping", Journal of Lightwave Technology, Volume 25, Issue 9, Sept. 2007 Page(s):2799 - 2806

[181] H. Sun and Z. Ding, Iterative Transceiver Design for MIMO ARQ Retransmissions With Decision Feedback Detection" IEEE Transactions on Signal Processing, vol. 55, pp. 3405-3416, July 2007.

[182] C. Yang, N. K. Fontaine, R. P. Scott, V. J. Hernandez, W. Cong, D. L. Harris, K. Okamoto, B. H. Kolner, Z. Ding, J. P. Heritage, and S. J. B. Yoo, ``Two-User 150-km Field Fiber Security Enhanced SPECTS O-CDMA Transmission", IEEE Photonics Technology Letters, Volume 19, Issue 11, June 1, 2007, Page(s):852 - 854.

[183] S. J. Yoo, J. P. Heritage, V. J. Hernandez, R. P. Scott, W. Cong, N. K. Fontaine, R. G. Broeke, J. Cao, S.-W. Seo, J.-H. Baek, F. M. Soares, Y. Du, C. Yang, W. Jiang, K. Aihara, Z. Ding, B. H. Kolner, Anh-Vu Pham, Shu Lin, F. Olsson, S. Lourdudoss, K. Y. Liou, S. N. Chu, R. A. Hamm, B. Patel, W. S. Hobson, J. R. Lothian, S. Vatanapradit, L. A. Gruezke, W. T. Tsang, M. Shearn, and A. Scherer, ``Spectral phase encoded time spread optical code division multiple access technology for next generation communication networks [Invited]", Journal of Optical Networking,, Volume 6, Issue 10, Pages 1210-1227, September 2007.

[184] Tongtong Li, Qi Ling, and Zhi Ding ``Transmit Delay Structure Design for Blind Channel Estimation over Multipath Channels," EURASIP Journal onWireless Communications and Networking, February 2007, Page(s)

[185] V.J. Hernandez, Wei Cong; Junqiang Hu; Chunxin Yang; Fontaine, N.K.; Scott, R.P.; Zhi Ding; Kolner, B.H.; Heritage, J.P.; Yoo, S.J.B.; ``A 320-Gb/s Capacity (32-User X 10 Gb/s) SPECTS O-CDMA Network Testbed With Enhanced Spectral Efficiency Through Forward Error Correction" IEEE Journal of Lightwave Technology, Volume 25, Issue 1, Jan. 2007 Page(s):79 - 86

[186] J. Roberson, X. Dong, and Z. Ding, ``Channel Estimation and Equalization Techniques in Downsampled ARQ Systems" , IEEE Transactions on Signal Processing, Volume 55, Issue 5, Page(s):2251 - 2262, May 2007.

[187] N. Ammar and Z. Ding, ``Blind Channel Identifiability for Generic Linear Space-Time Block Codes", , IEEE Transactions on Signal Processing, Volume 55, Issue 1, Jan. 2007, Page(s):202 - 217.

[188] Y. Du, S. J. B. Yoo, and Z. Ding, ``Nonuniform Spectral Phase Encoding in Optical CDMA Networks'' IEEE Photonics Technology Letters, Volume 18, Issue 23, Dec.1, 2006, Page(s):2505 - 2507.

[189] H. Sun, J. Manton, and Z. Ding, ``Progressive Linear Precoder Optimization for MIMO Packet Retransmissions Exploiting Channel Covariance Information'', IEEE Journal on Selected Areas in Communications, Vol. 24, no.3, pp. 448-456, March 2006.

[190] H. Samra and Z. Ding, ``Retransmission Diversity Schemes for Multicarrier Modulations'', IEEE Transactions on Wireless Communications. Vol. 5, no. 5, pp. 1142-1147, May 2006.

[191] N. Ammar and Z. Ding, ``Channel Identifiability under Space-Time Coded Modulations without Training'' , IEEE Transactions on Wireless Communications. Vol. 5, no. 5, pp. 1003-1013, May 2006.

[192] T. A. Drumright and Z. Ding, ``QAM Constellation Classification based on Statistical Sampling for Distortive Channels'', IEEE Trans. on Signal Processing. Vol.54, No.5, pp. 1575-1586, May 2006.

[193] H. Samra and Z. Ding, ``New MIMO ARQ Protocols and Joint Detection via Sphere Decoding,'' IEEE Transactions on Signal Processing, vol. 54, no.2, pp. 473-482, Feb. 2006.

[194] B. Parr, B. L. Cho, K. Wallace, and Z. Ding, ``Performance Analysis of a spectrally compliant ultra-wideband pulse design,'' IEEE Transactions on Wireless Communications, vol.4, No.5, pp. 2172-2181, September 2005.

[195] X. Tang and Z. Ding, ``Low-Complexity Iterative Equalization for EDGE with Bidirectional Processing,'' IEEE Transactions on Wireless Communications, vol. 4, No.5, pp.1963-1968, September, 2005.

[196] H. Samra and Z. Ding, ``A Hybrid ARQ Protocol using Integrated Channel Equalization,'' IEEE Transactions on Communications, vol. 53, No. 12, pp. 1996-2001, Dec. 2005.

[197] X. Dong, Z. Ding, and S. Dasgupta, ``Forward link channel estimation and precoding based on decimated feedback,'' IEEE Signal Processing Letters. Vol. 12, Issue 6, pp.445-448, Dec. 2005.

[198] H. Samra, Z. Ding, and P.M. Hahn, ``Symbol Mapping Diversity Design for Multiple Packet Transmissions,'' IEEE Transactions on Communications, Vol. 53, No.5, pp. 810-817, May 2005.

[199] S. Cui, M. Kisialiou, Z.-Q. Luo, and Z. Ding, ``Robust Blind Multiuser Detection Against Signature Waveform Mismatch base on second order cone programming,'' IEEE Transactions on Wireless Communications, Vol. 4, No. 4, pp. 1285-1291, July 2005.

[200] T. Li, W. Liang, Z. Ding, and J. K. Tugnait, ``Blind Multiuser Detection for Long-code CDMA Systems with Transmission-induced Cyclostationarity,'' EURASIP Journal on Wireless Communications and Networking, vol.2, pp.206-215, 2005

[201] T. Miyajima and Zhi Ding, ``Second-order statistical approaches to channel shortening in multicarrier systems'', IEEE Transactions on Signal Processing, pp.3253 - 3264, vol.52, Nov. 2004.

[202] V. J. Hernandez, Y. Du, W. Cong, R. P. Scott, K. Li, J. P. Heritage, Z. Ding, B. H. Kolner, and S. J. B. Yoo, ``Spectral phase-encoded time-spreading (SPECTS) optical code-division multiple access for terbit optical access networks,'' IEEE Journal of Lightwave Technology, Vol.22, No. 11, pp. 2671-2678, 2004.

[203] H. Xu, S. Dasgupta, and Z. Ding, ``A Novel Channel-identification Method for Wireless Communication Systems", IEEE Transactions on Communications, vol.52, pp.1767-1776, Oct. 2004.

[204] Wing-Kin Ma, Pak-Chung Ching, and Zhi Ding, ``Semidefinite relaxation based multiuser detection for M-ary PSK multiuser systems", IEEE Transactions on Signal Processing, vol.52 pp.2862-2872, Oct. 2004.

[205] J. Liang and Z. Ding, ``FIR Channel Estimation through Generalized Cumulant Slice Weighting," IEEE Trans. Signal Processing, pp.657-667, Mar. 2004.

[206] J. Liang and Z. Ding, ``Nonminimum Phase FIR Channel Estimation Using Cumulant Matrix Pencils", IEEE Trans. Signal Processing, pp.2310-2320, Sept. 2003.

[207] J. Liang and Z. Ding, ``Blind MIMO System Identification Based on Cumulant Subspace Decomposition", IEEE Trans. Signal Processing, vol.51, pp.1457-1468, June 2003.

[208] Z. Ding and L. Qiu, ``Blind MIMO Channel Identification from Second Order Statistics using Rank Deficient Channel Convolution Matrix," IEEE Trans. on Signal Processing, pp.535-544, Feb. 2003.

[209] Q. Li, E.-W. Bai, and Z. Ding, ``Blind Source Separation of Signals with Known Alphabets using E-Approximation Algorithms", IEEE Trans. on Signal Processing, pp.1-10, Jan. 2003.

[210] B. Parr, B. Cho, K. Wallace, and Z. Ding, ``A Novel Ultra-Wideband Pulse Design Algorithm", IEEE Communications Letters, vol.7, pp. 219-222, Dec. 2002.

[211] J. Liang and Z. Ding, ``Multiuser Channel Estimation from Higher Order Statistical Matrix Pencil", EURASIP Journal on Applied Signal Processing, , vol. 49, no. 2, pp. 1417-1426, Dec. 2002.

[212] X. Tang and Zhi Ding, ``Error Propagation in Blind Sequence Estimation", IEEE Communications Letters, vol.6, pp. 265-267, June 2002.

[213] J. E. Mooney, Z. Ding, and L. S. Riggs, ``Performance Analysis of a GLRT Automated Target Discrimination Scheme," IEEE Transactions on Antenna and Propagation, 49(12):1827-1835, Dec. 2001.

[214] R. Lopez-Valcarce, Zhi Ding, and Soura Dasgupta ``Equalization and Interference Cancellation in Linear Multi-User Systems Based on Second Order Statistics" , IEEE Transactions on Signal Processing , vol. 49, no.9, pp. 2042-2049, 2001.

[215] Erwei Bai and Zhi Ding, ``Blind Decision Feedback Equalization of Time-Varying Channels with DPSK Inputs", IEEE Transactions on Signal Processing, vol.49, no.7, pp. 1533-1542, July, 2001.

[216] Junqiang Shen and Zhi Ding, ``Zero-Forcing Blind Equalization Based on Channel Subspace Estimates for Multiuser Systems", IEEE Transactions on Communications, pp.262-271, Feb. 2001.

[217] Zhi Ding and Jing Liang, ``A Cumulant Matrix Subspace Algorithm for Blind Single FIR Channel Identification", IEEE Transactions on Signal Processing, vol. 49, no. 2, pp. 325-333, Feb. 2001

[218] Ge Li and Zhi Ding, ``Semi-blind Channel Identification for Individual Data Bursts in GSM Wireless Systems", Signal Processing, 80(10):2017-2031, Oct. 2000.

[219] Zhi Ding and Zhi-Quan Luo, ``A Fast Linear Programming Algorithm for Blind Equalization", IEEE Transactions on Communications, COM-48(9):1432-1436, September 2000.

[220] Chor Tin Ma, Zhi Ding, and Sze Fong Yau, ``A Two Stage Algorithm for MIMO Blind Deconvolution of Colored Input Signals", IEEE Transactions on Signal Processing, SP-48(4):1187-1192, April 2000.

[221] Chunqi Chang, Zhi Ding, Sze Fong Yau, and Francis H Y Chan, ``A Matrix-Pencil Approach to Blind Separation of Colored Nonstationary Signals", IEEE Transactions on Signal Processing, SP-48(3):900-907, March 2000.

[222] J.E. Mooney, Z. Ding, and L.S. Riggs, "Performance Analysis of an Automated E-pulse Target Discrimination Scheme," IEEE Trans. Antenna Propagation, vol. 48, pp. 619-628, Apr. 2000.

[223] Zhi Ding and Tuan Nguyen, ``Convergence Study of A Kurtosis Maximization Algorithm for Blind Signal Separation and Antenna Beamforming", IEEE Transactions on Signal Processing, 48(6):1587 -1596, June 2000.

[224] Junqiang Shen and Zhi Ding, ``Direct Blind MMSE Channel Equalization Based on Second Order Statistics", IEEE Transactions on Signal Processing, SP-48(4): 1015-1022, April 2000.

[225] Erwei Bai and Zhi Ding, ``Zero-Forcing Equalizability of FIR and IIR Multi-Channel Systems with and without Perfect Measurements", IEEE Transactions on Communications, vol.48, pp.~17-22, Jan. 2000.

[226] Erwei Bai and Zhi Ding, ``Invertibility of Sampled Data Systems", IEEE Transactions on Circuits and Systems, pp.~279-289, March 2000.

[227] Erwei Bai and Zhi Ding, ``Zero of Sampled Data Systems Represented by FIR Models", Automatica, vol.36, No.1, pp.121-123, , Jan. 2000.

[228] K. K. Borah, R. A. Kennedy, Z. Ding, and I. Fijalkow, ``Sampling and Profiltering Effects on Blind Equalizer Design", IEEE Transactions on Signal Processing, SP-49(1):209-218, Jan. 2000.

[229] J. K. Tugnait, L. Tong and Z. Ding, ``Single-User Channel Estimation and Equalization," IEEE Signal Processing Magazine, vol. 17, no. 3, pp. 17-28, 2000.

[230] J.K. Tugnait and Z. Ding, ``Channel Estimation, Equalization and Synchronization," pp. 14-16 in Highlights of Signal Processing for Communications, G.B. Giannakis (Ed.), IEEE Signal Processing Magazine, vol. 16, no. 3, pp. 14-50, 1999.

[231] J.E. Mooney, Z. Ding, and L.S. Riggs, `` Performance Analysis of a GLRT in Late-Time Radar Target Detection," Journal of Electromagnetic Waves and Applications vol. 13, pp. 1339-1341, 1999; also in Progress in Electromagnetic Research, vol. 24, pp. 77-96, 1999.

[232] Tongtong Li and Zhi Ding, ``Joint Transmitter-Receiver Optimization for Non-maximally Decimated Filterbank Precoding Systems", IEEE Transactions on Signal Processing, vol. 47, pp.2407-2414, Sept. 1999.

[233] Jie Zhu, X.-R. Cao and Z. Ding, ``An Algebraic Principle for Blind Separation of White Non-gaussian Sources", Signal Processing, vol.76, pp.105-115, 1999.

[234] Z. Mao and Zhi Ding, ``A Non-parametric Phase Estimation Method for SIMO Systems based on Second Order and Higher Order Statistics," IEEE Trans. on Signal Processing, pp. 843-847, March 1999.

[235] Jie Zhu, Zhi Ding and Xi-Ren Cao, ``Column-anchored Zeroforcing Blind Equalization for Multiuser Wireless FIR Channels", IEEE Journal on Selected Areas in Communications, pp.411-423, March 1999.

[236] Jon E. Mooney, Z. Ding, and L.S. Riggs, ``Robust Target Identification in White Gaussian Noise for Ultra-Wideband Radar Systems," IEEE Trans. Antenna and Propagation, vol.46, pp.1817-1823, Dec. 1998.

[237] Junqiang Shen and Zhi Ding, ``Edge Decision Assisted Decorrelators for Asynchronous CDMA Channels", IEEE Transactions on Communications, pp. 438-445, March 1998.

[238] Zhi Ding and Ge Li, ``Single Channel Blind Equalization for GSM Cellular Systems", IEEE Journal on Selected Areas of Communications, vol.16, pp.1493-1505, October 1998.

[239] Raul A. Casas, C. Richard Johnson Jr., Rodney A. Kennedy, Zhi Ding, and Roberto Malamut, ``Blind Adaptive Decision Feedback Equalization: A Class of Channels Resulting in Ill-convergence from A Zero Initialization", Int. Journal of Adaptive Control and Signal Processing, vol.12, pp.~173-193, March 1998.

[240] Tuan Nguyen and Zhi Ding, ``Blind CMA Beamforming For Narrowband Signals with Multipath Arrivals", Int. Journal of Adaptive Control and Signal Processing, vol.12, pp.~157-172, March 1998.

[241] Darren B. Ward, Zhi Ding, and Rodney A. Kennedy, ``DOA Estimation for Broadband Signals Using Frequency Invariant Beamforming", IEEE Transactions on Signal Processing, 46(3), pp.~1463-1469, May 1998.

[242] Zhi Ding, ``Matrix Outer-product Decomposition Method for Blind Multiple Channel Identification," IEEE Trans. on Signal Processing, 45(12), pp.~3053-3061, 1997.

[243] Z. Ding, ``On Convergence Analysis of Fractionally Spaced Adaptive Blind Equalizers," IEEE Transactions on Signal Processing, pp.~650-657, March 1997.

[244] Z. Ding, ``Multipath Channel Identification Based on Partial System Information", IEEE Transactions on Signal Processing, pp.~235-240, Jan. 1997.

[245] Z. Ding, ``Characteristics of Band-limited Channels Un-identifiable from Second Order Cyclostationary Statistics" IEEE Signal Processing Letters, 3(5):150-152, May 1996.

[246] Y. Li, K. J. R. Liu, and Z. Ding, ``Length-and Cost-dependent Local Minima of Unconstrained Blind Channel Equalizers," IEEE Transactions on Signal Processing, 44(11):2726-2735, 1996.

[247] Y. Li and Z. Ding, ``Global Convergence of Fractionally Spaced Godard Adaptive Equalizers," IEEE Transactions on Signal Processing, SP-44:818-826, April 1996.

[248] Y. Li and Z. Ding, ``Convergence Analysis of Finite Length Blind Adaptive Equalizers," IEEE Transactions on Signal Processing, pp. 2120-2129, September 1995.

[249] Y. Li and Z. Ding, ``A Simplified Approach to Optimum Diversity Combining and Equalization in Digital Data Transmission," IEEE Transactions on Communications, pp. 2285-2288, August 1995.

[250] Y. Li and Z. Ding, ``ARMA System Identification Based on Second Order Cyclostationarity", IEEE Transactions on Signal Processing, pp. 34983-3493, December 1994.

[251] Y. Li and Z. Ding, ``A New Nonparametric Method for Linear System Phase Recovery from Bispectrum", vol. 41, pp. 415-419, IEEE Transactions on Circuits and Systems II, May 1994.

[252] Z. Ding and Y. Li, ``On Channel Identification Based on Second Order Cyclic Spectra", IEEE Transactions on Signal Processing, vol.42, pp. 1260-1264, May 1994.

[253] Z. Ding, ``Blind Equalization Based on Joint Minimum Mean Square Error Criterion," IEEE Transactions on Communications, vol.42, pp. 648-654, Feb/March/April 1994.

[254] J. Y. Hung and Z. Ding, ``Design of Currents to Reduce Torque Ripple in Brushless DC Motors," IEE Proceedings-B, vol.140, pp. 260-266, July 1993.

[255] Z. Ding and C. R. Johnson, Jr., ``On the non-vanishing stability of undesirable equilibria for FIR Godard blind equalizers," IEEE Transactions on Signal Processing, vol.41, pp. 1940-1944, May 1993.

[256] Z. Ding, R. A. Kennedy, B. D. O. Anderson, and C. R. Johnson, Jr., ``Local Convergence of the Sato Blind Equalizer and Generalizations Under Practical Constraints", IEEE Transactions on Information Theory, vol.39, pp. 129-144, Jan. 1993.

[257] R. A. Kennedy and Z. Ding, ``Blind Adaptive Equalizers for QAM Communication Systems Based on Convex Cost Functions," Optical Engineering, vol.31, pp. 1189-1199, June 1992.

[258] Z. Ding, C. R. Johnson, Jr., and R. A. Kennedy, ``On the (Non)Existence of Local Equilibria of Godard Blind Equalizers," IEEE Transactions on Signal Processing, vol.40, pp. 2425-2432, 1992.

[259] Z. Ding and R. A. Kennedy, ``On the Whereabouts of Local Minima For Blind Adaptive Equalizers," IEEE Transactions on Circuit and Systems II, vol.39, pp. 119-223, Feb. 1992.

[260] Z. Ding, R. A. Kennedy, B. D. O. Anderson, and C. R. Johnson, Jr., ``Ill-Convergence of Godard Blind Equalizers in Data Communications," IEEE Transactions on Communications, vol. COM-39, pp. 1313-1327, 1991.

[261] Z. Ding, C. R. Johnson, Jr., and W. A. Sethares, ``Frequency-dependent Bursting in Adaptive Echo Cancellation and its Prevention using Double-talk Detectors," Int. Journal of Adaptive Control and Signal Processing, pp. 219-236, May 1990.

Conference Publications

[1] S A. Wijesinghe, S. Zhang, S. Qi and Z. Ding, ``UFed-GAN: Secure Federated Learning over Wireless Sensor Networks with Unlabeled Data," *2024 IEEE International Conference on Communications Workshops (ICC Workshops)*, Denver, CO, USA, 2024, pp. 1048-1053, doi: 10.1109/ICCWorkshops59551.2024.10615691.

[2] A. Wijesinghe, S. Zhang, S. Wanninayaka, W. Wang and Z. Ding, ``Diff-GO: Diffusion Goal-Oriented Communications with Ultra-High Spectrum Efficiency," *2024 IEEE International Conference on Communications Workshops (ICC Workshops)*, Denver, CO, USA, 2024, pp. 1079-1084, doi: 10.1109/ICCWorkshops59551.2024.10615283. keyw

[3] K. Wang, Z. Ding, D. K. C. So and Z. Ding, ``Energy Efficient Federated Learning with Age-Weighted FedSGD," *2024 IEEE International Conference on Communications Workshops (ICC Workshops)*, Denver, CO, USA, 2024, pp. 457-462, doi: 10.1109/ICCWorkshops59551.2024.10615715.

[4] Y. -C. Lin, T. -S. Lee and Z. Ding, ``Training-Free Cost-Efficient Compression for Massive MIMO Channel State Feedback," *2023 IEEE Global Communications Conference*, Kuala Lumpur, Malaysia, 2023, pp. 3391-3396, doi: 10.1109/GLOBECOM54140.2023.10436746.

[5] C. Feres, B. C. Levy and Z. Ding, ``Bayesian Decision Making Via Over-the-Air Soft Information Aggregation," *IEEE International Conference on Communications*, Rome, Italy, 2023, pp. 3193-3198, doi: 10.1109/ICC45041.2023.10278705.

[6] C. -H. Hsu, C. Feres and Z. Ding, ``Spectral Clustering Aided User Grouping and Scheduling in Wideband MU-MIMO Systems," *IEEE International Conference on Communications*, Rome, Italy, 2023, pp. 4292-4297, doi: 10.1109/ICC45041.2023.10279388

[7] Y. Ge, L. Liu, S. Huang, D. G. G., Y. L. Guan and Z. Ding, ``Low-Complexity Memory AMP Detector for High-Mobility MIMO-OTFS SCMA Systems," *2023 IEEE International Conference on Communications Workshops (ICC Workshops)*, Rome, Italy, 2023, pp. 807-812, doi: 10.1109/ICCWorkshops57953.2023.10283752.

[8] S. Zhang, T. Yu, J. Tivald, B. Choi, F. Ouyang and Z. Ding, ``Exemplar-Based Radio Map Reconstruction of Missing Areas Using Propagation Priority," *2022 IEEE Global Communications Conference*, Rio de Janeiro, Brazil, 2022, pp. 1217-1222, doi: 10.1109/GLOBECOM48099.2022.10001269.

[9] C. Feres, B.C. Levy, and Z. Ding, ``Over-the-Air Collaborative Learning in Joint Decision Making," *IEEE Global Communications Conference* pp. 3581-3586, Dec. 2022. doi: 10.1109/GLOBECOM48099.2022.10001286.

[10] S. Qi, L. D. Chamain and Z. Ding, ``Hierarchical Training for Distributed Deep Learning Based on Multimedia Data over Band-Limited Networks," IEEE International Conference on Image Processing (ICIP), 2022, pp. 2871-2875, doi: 10.1109/ICIP46576.2022.9897383.

[11] A. Jalali, Y. Shi and Z. Ding, ``Robust Wirtinger Flow Algorithm for Channel Coded Blind Demixing," ICC 2022 - IEEE International Conference on Communications, 2022, pp. 4498-4503, doi: 10.1109/ICC45855.2022.9838429.

[12] Z. Wang, W. Cao, X. Ling, Y. Le, J. Wang, and Z. Ding, ``Analysis of Pooling Principle in Blockchain Radio Access Network" 2022 IEEE Int. Conf. on Communications Workshop, pp. 13-18, doi: 10.1109/ICCWorkshops53468.2022.9814583.

[13] L. D. Chamain, M. C. Ilter, J. Hämäläinen and Z. Ding, Interplay between vertical sectorization and user distribution for urban NB-IoT networks," IEEE Wireless Communications and Networking Conference (WCNC), 2022, pp. 1401-1406, doi: 10.1109/WCNC51071.2022.9771892.

[14] C. Wang, A. -A. Lu, X. Gao and Z. Ding, ``Robust Precoding for 3D Massive MIMO with Riemannian Manifold Optimization," IEEE Wireless Communications and Networking Conference (WCNC), 2022, pp. 1341-1346, doi: 10.1109/WCNC51071.2022.9771720.

[15] L. D. Chamain, S. Qi and Z. Ding, ``An End-to-End Learning Architecture for Efficient Image Encoding and Deep Learning," 29th European Signal Processing Conference (EUSIPCO), 2021, pp. 691-695, doi: 10.23919/EUSIPCO54536.2021.9616312.

[16] Y. -C. Lin, T. -S. Lee and Z. Ding, ``Deep Learning for Partial MIMO CSI Feedback by Exploiting Channel Temporal Correlation," 55th Asilomar Conference on Signals, Systems, and Computers, 2021, pp. 345-350, doi: 10.1109/IEEECONF53345.2021.9723211.

[17] Yihan Zou, Kwang Taik Kim, Xiaojun Lin, Mung Chiang, Zhi Ding, Risto Wichman and Jyri Hamalainen, ``Low-Overhead Joint Beam-Selection and Random-Access Schemes for Massive Internet-of-Things with Non-Uniform Channel and Load" IEEE International Conference on Computer Communications (INFOCOM), Toronto, Canada, 6-9 July 2020.

[18] Zou, Yihan, Kwang Taik Kim, Zhi Ding, Risto Wichman, Jyri Hamalainen, Xiaojun Lin, and Mung Chiang, ``Low-overhead multi-antenna-enabled random access for machine-type communications with low mobility," In 2019 IEEE Global Communications Conference (GLOBECOM), pp. 1-6, Kona, Hawaii, USA, December 2019.

[19] L. D. Chamain and Z. Ding, ``Improving Deep Learning Classification of JPEG2000 Images Over Bandlimited Networks", Proc. 2020 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Barcelona, Spain, 2020, pp. 4062-4066, doi: 10.1109/ICASSP40776.2020.9053778.

[20] Z. Liu, M. del Rosario, X. Liang, L. Zhang and Z. Ding, ``Spherical Normalization for Learned Compressive Feedback in Massive MIMO CSI Acquisition," 2020 IEEE International Conference on Communications Workshops (ICC Workshops), Dublin, Ireland, 2020, pp. 1-6, doi: 10.1109/ICCWorkshops49005.2020.9145171.

[21] L. D. Chamain, S.C.S. Cheung, and Z. Ding, ``Quannet: Joint Image Compression and Classification Over Channels with Limited Bandwidth," Proc. IEEE International Conference on Multimedia and Expo (ICME) pp. 338-343, Shanghai, July 2019.

[22] Z. Zhang, Z. Zhu, B. Bazor, S. Lee, Z. Ding and T. Pan, ``PIS: Wearable Pedal Iontronic Sensing for Arterial Pulses and Muscular Activities," Proc. 20th International Conference on Solid-State Sensors, Actuators and Microsystems & Eurosensors XXXIII (TRANSDUCERS &

EUROSENSORS XXXIII), pp. 2492-2495, Berlin, Germany, 2019, doi: 10.1109/TRANSDUCERS.2019.8808440.

[23] Le, Y., Ling X., Wang J., Ding Z., ``Prototype design and test of blockchain radio access network," Proc. IEEE International Conference on Communications Workshops (ICC Workshops), May 20 (pp. 1-6), 2019. DOI: 10.1109/ICCW.2019.8757042

[24] C. Feres and Z. Ding, ``Low Complexity Header Compression with Lower-Layer Awareness for Wireless Networks," 2019 IEEE International Conference on Communications (ICC), Shanghai, China, 2019, pp. 1-7. doi: 10.1109/ICC.2019.8761888

[25] T. Bouchoucha and Z. Ding, ``Robust Online Social Network Inference," 2019 IEEE International Conference on Communications (ICC), Shanghai, China, 2019, pp. 1-6. doi: 10.1109/ICC.2019.8761335

[26] Q. Chen and Z. Ding, ``On Non-Intrusive Coexistence of eLAA and Legacy WiFi Networks," 2019 IEEE International Conference on Communications (ICC), Shanghai, China, 2019, pp. 1-6. doi: 10.1109/ICC.2019.8761765

[27] K. Yang, T. Jiang, Y. Shi and Z. Ding, ``Federated Learning Based on Over-the-Air Computation," 2019 IEEE International Conference on Communications (ICC), Shanghai, China, 2019, pp. 1-6. doi: 10.1109/ICC.2019.8761429

[28] J. Dong, Y. Shi and Z. Ding, ``Sparse Blind Demixing for Low-latency Signal Recovery in Massive Iot Connectivity," 2019 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Brighton, United Kingdom, 2019, pp. 4764-4768. doi: 10.1109/ICASSP.2019.8683324

[29] C. Jiang, W. Wu, and Zhi Ding ``The Design of Transport Block-Based ROHC U-Mode for LTE Multicast"> IEEE Global Communications Conference (GLOBECOM) Abu Dhabi, United Arab Emirates, 9-13 Dec. 2018. doi: 10.1109/GLOCOM.2018.8648067

[30] K. Wang and Zhi Ding ``Joint Tourbo Receiver for LDPC-coded MIMO Systems based on Semi-Definite Relaxation" *IEEE 88th Vehicular Technology Conference* Chicago, IL, August 27-30, 2018. doi:10.1109/VTCFall.2018.8690886.

[31] A. Jalali and Zhi Ding ``A Joint Detection and Decoding Receiver Design for Polar Coded MIMO Wireless Transmissions" IEEE International Symposium on Information Theory Val, CO, USA, 17-22 June 2018. doi: 10.1109/ISIT.2018.8437879

[32] K. Yang, Y. Shi, and Z. Ding. ``Low-Rank Optimization for Data Shuffling in Wireless Distributed Computing", In 2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), pp. 6343-6347. IEEE, 2018.

[33] C. Feres, W. Wu and Z. Ding, ``A Markovian ROHC Control Mechanism Based on Transport Block Link Model in LTE Networks," IEEE International Conference on Communications (ICC), Kansas City, MO, USA, 2018, pp. 1-7. doi: 10.1109/ICC.2018.8422165

[34] H. M. Elmaghraby, K. Liu and Z. Ding, ``Femtocell Scheduling as a Restless Multiarmed Bandit Problem Using Partial Channel State Observation," IEEE International Conference on Communications (ICC), Kansas City, MO, USA, 2018, pp. 1-6. doi: 10.1109/ICC.2018.8422619

[35] L. Liang, S. Xie, G. Y. Li, Z. Ding and X. Yu, ``Graph-Based Radio Resource Management for Vehicular Networks", IEEE International Conference on Communications (ICC), Kansas City, MO, USA, 2018, pp. 1-6. doi: 10.1109/ICC.2018.8422585

[36] H. Lu, G.Liu, R. Proietti, V. Squitieri, K. Zhang, A. Castro, Q. J. Gu, Z. Ding, and S. B. Yoo, ``mmWave beamforming using photonic signal processing for future 5G mobile systems," Proc. Optical Fiber Communication Conference , pp. M4J-3, Optical Society of America, March 2018.

[37] G. Liu, K. Zhang, R. Proietti, H. Lu, Z. Ding, and S. B. Yoo, ``First Demonstration of FPGA-based Hitless Flexible Receiver with Blind Modulation Format Identification", Proc. Optical Society of America Optical Fiber Communication Conference, pp. W2A-45, Mar. 2018.

[38] Q. Wei, L. Wang, Z. Feng and Z. Ding, ``Cooperative coexistence and resource allocation for V2X communications in LTE-unlicensed," Proc. 15th IEEE Annual Consumer Communications & Networking Conference (CCNC), Las Vegas, NV, 2018. doi: 10.1109/CCNC.2018.8319219

[39] H. Wang, P. Shetty and Z. Ding, ``Low Complexity Node Clustering in Cloud-RAN for Service Provisioning and Resource Allocation," *GLOBECOM - 2017 IEEE Global Communications Conference,* Singapore, 2017, pp. 1-6. doi: 10.1109/GLOCOM.2017.8254979

[40] T. Bouchoucha, C. N. Chuah and Z. Ding, ``Finding Link Topology of Large Scale Networks from Anchored Hop Count Reports," *GLOBECOM - 2017 IEEE Global Communications Conference,* Singapore, 2017, pp. 1-6. doi: 10.1109/GLOCOM.2017.8253952

[41] X. Ling, J. Wang, X. Liang, Z. Ding, C. Zhao and X. Gao, ``Biased Beamforming for Multi-LED OFDM in Visible Light Communications," *GLOBECOM - 2017 IEEE Global Communications Conference,* Singapore, 2017, pp. 1-6. doi: 10.1109/GLOCOM.2017.8254777

[42] K. Yang, Y. Shi and Z. Ding, ``Generalized matrix completion for low complexity transceiver processing in cache-aided Fog-RAN via the Burer-Monteiro approach," 2017 IEEE Global Conference on Signal and Information Processing (GlobalSIP), Montreal, QC, 2017, pp. 863-867. doi: 10.1109/GlobalSIP.2017.8309083

[43] L. Jing, H. Wang, C. He, and Z. Ding, ``Joint Channel Estimation and Detection of High Rate CCK Signaling in Underwater Communications", Proc. IEEE Wireless Communications and Networking Conference (WCNC), San Francisco, USA, Mar. 2017.

[44] Chen Jiang, Wenhao Wu, and Z. Ding, ``LTE Multimedia Broadcast Multicast Service Provisioning Based on Robust Header Compression." IEEE Wireless Communications and Networking Conference (WCNC), San Francisco, CA, USA, May 2017.

[45] Chen Jiang, Wenhao Wu, and Z. Ding, ``IP packet header compression and user grouping for LTE Multimedia Broadcast Multicast Services, " Proc. 2017 International Conference on Computing, Networking and Communications (ICNC), pp. 52-57, January 2017.

[46] K. Yang, Y. Shi, J. Zhang, Z. Ding and K. B. Letaief, ``A low-rank approach for interference management in dense wireless networks," 2016 IEEE Global Conference on Signal and Information Processing (GlobalSIP), Washington, DC, 2016, pp. 708-712. doi: 10.1109/GlobalSIP.2016.7905934

[47] Yang, Kai, Yuanming Shi, and Zhi Ding, ``Low-rank matrix completion for mobile edge caching in fog-RAN via riemannian optimization." IEEE Global Communications Conference (GLOBECOM), pp. 1-6, Dec. 2016.

[48] Huan Tang, Zhi Ding, and Bernard C. Levy, ``D2D Neighbor Discovery and Resource Scheduling through Demodulation Reference Signal." IEEE 84th Vehicular Technology Conference (VTC-Fall), September 2016.

[49] H. Tang and Z. Ding, "Monotone optimization for power control of D2D underlay with partial CSI," 2016 IEEE International Conference on Communications (ICC), Kuala Lumpur, 2016, pp. 1-6. doi: 10.1109/ICC.2016.7511619

[50] H. Wang and Z. Ding, "Joint power and rate optimization for co-channel small cells using Frank-Wolfe algorithm," 2016 IEEE International Conference on Communications (ICC), Kuala Lumpur, 2016, pp. 1-6. doi: 10.1109/ICC.2016.7511345

[51] Kun Wang and Zhi Ding, ``Robust receiver design based on FEC code diversity in pilot-contaminated multi-user massive MIMO systems", Proc. 2016 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Shanghai, China, 2016. Pages: 3426 - 3430.

[52] Zhi Quan; Muyang Ye; Zhi Ding; Shuguang Cui ``Optimal linear cooperation for signal classification", Proc. 2016 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Shanghai, China, 2016. Pages: 3631 - 3635.

[53] H. M. Elmaghraby and Z. Ding, ``Cognitive Femtocell Scheduling and Power Allocation Based on Channel Quality Report," 2015 IEEE Global Communications Conference (GLOBECOM), San Diego, CA, 2015, pp. 1-6. doi: 10.1109/GLOCOM.2015.7417849

[54] Xintong Ling; Jiaheng Wang; Xiao Liang; Zhi Ding; Chunming Zhao ``Joint Offset and Power Optimization for Visible Light DCO-OFDM Systems," IEEE Global Communications Conference (GLOBECOM) San Diego, CA, 2015.

[55] Dongrun Qin; Zhi Ding ``On Transport Capacity of Full Duplex Ad Hoc Networks," IEEE Global Communications Conference (GLOBECOM) San Diego, CA, 2015.

[56] Chen Sun; Xiqi Gao; Shi Jin; Matthaiou, M.; Zhi Ding; Chengshan Xiao, ``Beam division multiple access for massive MIMO downlink transmission", 2015 IEEE International Conference on Communications (ICC), pp. 1970 - 1975, London, UK, 2015. DOI: 10.1109/ICC.2015.7248614

[57] Huan Tang and Zhi Ding ``Resource allocation in mixed mode Device-to-Device communications", 2015 IEEE International Conference on Communications (ICC), pp. 2554-2559, London, UK, 2015. DOI: 10.1109/ICC.2015.7248709

[58] Wang, Kun, Wenhao Wu, and Zhi Ding. ``Diversity combining in wireless relay networks with partial channel state information." 2015 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), pp. 3138-3142, Brisbane, Australia, May 2015.

[59] Elmaghraby, Hesham M., Dongrun Qin, and Zhi Ding, ``Downlink Scheduling and Power Allocation in Cognitive Femtocell Networks," In Cognitive Radio Oriented Wireless Networks [Proc. 10th Intl. Conf. Cognitive Radio Oriented Wireless Networks (CROWNCOM)], pp. 92-105. Springer International Publishing, Oct. 2015.

[60] Haining Wang and Zhi Ding, ``Power control and rate allocation for outage balancing in femtocell networks," IEEE Global Communications Conference (GLOBECOM), Austin, TX, December 2014.

[61] Alexis Dowhuszko, Jyri Hamalainen, and Zhi Ding, ``Opportunistic interference avoidance scheduling for underlay cognitive radio networks", 9th International Conference on Cognitive Radio Oriented Wireless Networks (CROWNCOM), July 2014.

[62] Ahmed R. Elsherif, Zhi Ding, Xin Liu, ``A Resource Allocation Scheme for Heterogeneous Networks Using Dynamic Programming Approach ," in IEEE 79th Vehicular Technology Conference, VTC-Spring 2014, May 2014, pp. 1-6.

[63] W. Wu, K. Wang, Z. Ding, and C. Xiao, ``Cooperative multi-cell MIMO downlink precoding for finite-alphabet inputs", in Proc. IEEE Int. Conf. Acoust., Speech, Signal Process. (ICASSP), pp. 464-468, Florence, Italy, May 2014, doi:10.1109/ICASSP.2014.6853639

[64] K. Wang, W. Wu, and Z. Ding, ``Joint detection and decoding of LDPC coded distributed space-time signaling in wireless relay networks via linear programming," in Proc. IEEE Int. Conf. Acoust., Speech, Signal Process. (ICASSP), pp. 1906-1910, Florence, Italy, May 2014, DOI: 10.1109/ICASSP.2014.6853930

[65] Ahmedin, A.; Elsherif, A.R.; Xin Liu; Hamalainen, J.; Wichman, R., ``Macrocell resource adaptation for improved femtocell deployment and interference management," 2014 World Congress on Computer Applications and Information Systems (WCCAIS), pp.1-6, 17-19 Jan. 2014, Tunisia.

[66] Huan Tang, Zhi Ding, S. J. B. Yoo, and Jyri Hamalainen. "Outage constrained joint precoding for D2D underlay cellular networks." In Global Communications Conference (GLOBECOM), 2013 IEEE, pp. 3540-3545. IEEE, 2013.

[67] Elsherif, Ahmed R.; Chen, Wei-Peng; Ito, Akira; Ding, Zhi, ``Design of dual-access-technology femtocells in enterprise environments," IEEE 24th International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC), pp.2774-2779, 8-11 Sept. 2013. doi: 10.1109/PIMRC.2013.6666619

[68] Kun-Yu Wang, Haining Wang, Zhi Ding and Chong-Yung Chi, ``A Low-Complexity Algorithm for Worst-Case Utility Maximization in Multiuser MISO Downlink," in 2013 IEEE 78th Vehicular Technology Conference (VTC Fall), pp.1-5, 2-5 Sept. 2013.

[69] A. R. Elsherif, Wei-Peng Chen, A. Ito, Zhi Ding, "Adaptive small cell access of licensed and unlicensed bands," IEEE International Conference on Communications (ICC), pp.6327,6332, 9-13 June 2013. doi: 10.1109/ICC.2013.6655621

[70] H. Wang, Z. Ding, M. Cierny, and R. Wichman, IEEE International Conference on Communications (ICC), pp.5183-5187, Budapest 9-13 June 2013. doi: 10.1109/ICC.2013.6655407

[71] Qing Ji, Michael Ho, Rong Zheng, Zhi Ding and Gangbing Song, ``An exploratory study of stress wave communication in concrete structures" SMART STRUCTURES AND SYSTEMS (Proc. 6th Int. Conf. on Structural Health Monitoring of Intelligent Infrastructure, vol. 15, no. 1, pp. 135-150, 2015, Hong Kong.

[72] Huan Tang; Chenxi Zhu; Zhi Ding, "Cooperative MIMO precoding for D2D underlay in cellular networks," IEEE International Conference on Communications (ICC), pp.5517-5521, 9-13 June 2013.

[73] Dowhuszko, A.A.; Hamalainen, J.; Elsherif, A.R.; Zhi Ding ``Performance of transmit beamforming for interference mitigation with random codebooks," 8th International Conference on Cognitive Radio Oriented Wireless Networks (CROWNCOM), pp. 190-195, 2013.

[74] A. Elsherif, Z. Ding, X. Liu, J. Hamalainen, and R. Wichman, ``Inference Driven Dynamic Access Scheme for Interference Management in Heterogeneous Networks", 8th International Conference on Cognitive Radio Oriented Wireless Networks (CROWNCOM), pp. 178-183, 2013.

[75] A. R. Elsherif, Zhi Ding, Xin Liu, J. Hamalainen, ``Shadow chasing enhancement in resource allocation for heterogeneous networks", IEEE Global Communications Conference (GLOBECOM), Page(s): 5531 - 5536, Anaheim, CA, 2012.

[76] Yong Li ; Lin Wang ; Zhi Ding ``Linear programming based joint detection of LDPC coded MIMO systems," IEEE Global Communications Conference (GLOBECOM), Page(s): 4043-48, Anaheim, CA, 2012.

[77] A.R. Elsherif, A. Ahmedin, Zhi Ding, and Xin Liu `` Adaptive precoding for femtocell interference mitigation", Proc.IEEE International Conference on Communications (ICC), Page(s): 4315 - 4320, 10-15 June 2012.

[78] Xiao Liang, Zhi Ding, and Chengshan Xiao, ``On linear precoding of non-regenerative MIMO relays for QAM inputs"Proc. IEEE International Conference on Communications (ICC), Page(s): 2439 - 2444, 10-15 June 2012

[79] Yongpeng Wu, Chengshan Xiao, Zhi Ding, Xiqi Gao, and Shi Jin ``Linear MIMO precoding in multi-antenna wiretap channels for finite-alphabet data", Proc. IEEE International Conference on Communications (ICC), Page(s): 2156 - 2160, 10-15 June 2012

[80] Yongpeng Wu, Mingxi Wang, Chengshan Xiao, Zhi Ding, and Xiqi Gao ``Linear precoding of finite alphabet signals in multi-antenna broadcast channels", Proc. IEEE International Conference on Communications (ICC), Page(s): 4257 - 4261, 10-15 June 2012.

[81] Huy-Dung Han, Chenxi Zhu, Yueqiao Xu, Yi Wang, and Zhi Ding Joint transmission using global codeword and codebook design for coordinated multipoint processing (CoMP) , Proc. 2012 IEEE Globecom Workshops (GC Wkshps), Page(s): 1118 - 1122, Anaheim, CA, USA, Dec. 2012.

[82] Enyang Xu, Zhi Ding, Soura Dasgupta, ``Urban source localization based on time of arrival measurement and street information" Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) Page(s): 2621 - 2624, Kyoto, Japan, 25-30 March 2012.

[83] Hema Kumari Achanta, Soura Dasgupta, Zhi Ding, ``Optimum sensor placement for localization in three dimensional under log normal shadowing", 5th International Congress on Image and Signal Processing (CISP) , pp.~1898-1901, 16-18 Oct. 2012

[84] Zhe Jiang, Hai-yan Wang, Wang, Zhi Ding, ``Joint Symbol Timing and Channel Estimation in Two-Way Multiple Antenna Relay Networks", Proc. IEEE Vehicular Technology Conference (VTC Fall), 3-6 Sept. 2012

[85] Yang Zhang, Jiandong Li, Lihua Pang, and Zhi Ding ``Maximizing lifetime in multi-source multi-relay non-regenerative OFDM networks", Prof. IEEE 23rd International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC), Page(s): 2259 - 2262, 9-12 Sept. 2012.

[86] Jacklin, N.; Zhi Ding `` A Convex Optimization Approach to Reducing Peak-to-Average-Power Ratio in OFDM", 2011 IEEE International Symposium on Circuits and Systems (ISCAS), 2011, Page(s): 973 - 976.

[87] Chengshan Xiao; Zheng, Y.R.; Zhi Ding, ``Design optimization of linear precoders for complex vector gaussian channelswith finite alphabet inputs", 2011 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2011, Page(s): 3272 - 3275.

[88] Binbin Guan; Fontaine, N.K.; Scott, R.P.; Geisler, D.J.; Djordjevic, S.S.; Ibrahim, S.; Cheung, S.; Tiehui Su; Pomerene, A.T.; Seaford, L.L.; Danziger, S.; Zhi Ding; Yoo, S.J.B., ``Dynamic sub-20 ns reconfiguration of a silicon CMOS photonic filter and filter shape measurement", 2011 Conference on Lasers and Electro-Optics (CLEO), 2011, Page(s): 1 - 2

[89] Lapiccirella, F.E.; Keqin Liu; Zhi Ding, ``Multi-Channel Opportunistic Access Based on Primary ARQ Messages Overhearing" Communications (ICC), 2011 IEEE International Conference on Publication Year: 2011 , Page(s): 1 - 5

[90] Yang Zhang; Jiandong Li; Lihua Pang; Zhi Ding, ``On Precoder Design for Amplify-and-Forward MIMO Relay Systems", 2011 IEEE Vehicular Technology Conference (VTC Fall), 2011, Page(s): 1 - 6

[91] Meng Shen; Chunming Zhao; Xiao Liang; Zhi Ding, ``Best-Effort Interference Alignment in OFDM Systems with Finite SNR", 2011 IEEE International Conference on Communications (ICC), 2011, Page(s): 1 - 6.

[92] Yang Zhang, Jiandong Li, Lihua Pang, Zhi Ding, ``Iterative InterCarrier Interference mitigation for mobile MIMO-OFDM systems", 2011 IEEE 22nd International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC), 2011, Page(s): 959 - 963.

[93] Huy-Dung Han; Zhi Ding; Junqiang Hu; Dayou Qian, ``On Steepest Descent Adaptation: A Novel Batch Implementation of Blind Equalization Algorithms," 2010 IEEE Global Telecommunications Conference , Miami, FL, 2010, Page(s): 1 - 6.

[94] Senhua Huang, Xin Liu, and Zhi Ding, ``Distributed Power Control for Cognitive User Access based on Primary Link Control Feedback", Proc. Conference on Computer Communications (INFOCOM 2010), 14-19 March 2010, Page(s): 1-9, San Diego, USA.

[95] Enyang Xu, Zhi Ding, and Soura Dasgupta, ``Robust and Low Complexity Source Localization in Wireless Sensor Networks Using Time Difference of Arrival Measurement",, Proceedings of the IEEE Wireless Communications and Networking Conference (WCNC), April 2010, Sydney, Australia, Page(s): 18-21.

[96] Dasgupta, S.; Ibeawuchi, S.C.; Zhi Ding; ``Optimum sensor placement for localization under log-normal shadowing", 2010 International Symposium on Communications and Information Technologies (ISCIT), 2010; Page(s): 204 - 208.

[97] Huy-Dung Han and Zhi Ding, ``A blind channel shortening criterion based on high-order cumulants" IEEE International Conf. on Acoustics, Speech and Signal Processing, 14-19 March 2010, Page(s):3210 - 3213.

[98] Enyang Xu, Zhi Ding, Soura Dasgupta, ``Wireless source localization based on time of arrival measurement" IEEE International Conf. on Acoustics, Speech and Signal Processing, 14-19 March 2010, Page(s):2842 - 2845.

[99] Ibrahim, S.; Luo, L.W.; Djordjevic, S.S.; Poitras, C.B.; Zhou, L.; Fontaine, N.K.; Guan, B.; Cheung, S.; Ding, Z.; Okamoto, K.; Lipson, M.; Yoo, S.J.B.; ``Fully reconfigurable silicon photonic lattice filters with four cascaded unit cells," Optical Fiber Communication (OFC), 21-25 Mar. 2010, Page(s):1 - 3.

[100] S. Bashar and Z Ding, ``Optimum Power Allocation against Information Leakage in Wireless Network" IEEE Global Telecommunications Conference, Nov. 30 2009-Dec. 4, 2009, Page(s):1-6.

[101] Huy-Dung Han and Zhi Ding, ``A Convex Optimization Approach to Blind Channel Shortening in Multicarrier Modulations," IEEE Global Telecommunications Conference, Nov. 30 2009-Dec. 4, 2009.

[102] Huy-Dung Han, Junqiang Hu, and Zhi Ding, ``A bandwidth efficient design of IM/DD optical OFDM," Conference on Lasers and Electro-Optics and Conference on Quantum electronics and Laser Science Conf. (CLEO/QELS 2009), 2-4 June 2009 Page(s): 1 - 2

[103] Senhua Huang, Xin Liu, and Zhi Ding, ``Optimal Sensing-Transmission Structure for Dynamic Spectrum Access", Proc. 28th IEEE Conference on Computer Communications (INFOCOM 2009), 19-25 April 2009, Page(s):2295 - 2303, Rio de Janeiro, Brazil.

[104] Linjie Zhou; Djordjevic, S.S.; Fontaine, N.K.; Zhi Ding; Okamoto, K.; Yoo, S.J.B., ``Silicon microring resonator-based reconfigurable optical lattice filter for on-chip optical signal processing" IEEE LEOS Annual Meeting Conference Proceedings (LEOS), 2009, Page(s): 501 - 502.

[105] Lapiccirella, Fabio E.; Huang, Senhua; Liu, Xin; Ding, Zhi; ``Feedback-based access and power control for distributed multiuser cognitive networks" Information Theory and Applications Workshop, 2009 8-13 Feb. 2009 Page(s):85 - 89

[106] Muhammad, Zia; Chen Meng, Zhi Ding, ``Blind detection of high rate orthogonal space-time block codes IEEE International Conference on Acoustics, Speech and Signal Processing, 19-24 April 2009 Page(s):2745 - 2748

[107] Huang, River; Zhi Ding, ``Precoder design for MIMO broadcast channels with power leakage constraints," IEEE International Conference on Acoustics, Speech and Signal Processing, 19-24 April 2009 Page(s):2385 - 2388

[108] Chang, Chunqi; Zhi Ding; Hung, Yeung Sam; ``Nonnegative Network Component Analysis by Linear Programming for Gene Regulatory Network Reconstruction" Proceedings of the 8th International Conference on Independent Component Analysis and Signal Separation, 2009. Pages: 395 - 402

[109] S. Bashar and Z. Ding, "Optimum routing protection against cumulative eavesdropping in multihop wireless networks", Proceedings of 2009 MILCOM, October 2009.

[110] S. Dasgupta, S.-R.C. Ibeawuchi, and Zhi Ding; ``Source localization using a maximum likelihood/semidefinite programming hybrid " 9th Int. Symp. on Communications and Information Technology, 28 - 30 Sept. 2009, Page(s):376 - 381

[111] S.D. Chitte, S. Dasgupta, and Zhi Ding, ``Source Localization from Received Signal Strength Under Log-Normal Shadowing: Bias and Variance" 2nd International Congress on Image and Signal Processing, 2009.

[112] Chang, Chunqi; Hung, Yeung Sam; Ding, Zhi; ``A new optimization algorithm for network component analysis based on convex programming" IEEE International Conf. on Acoustics, Speech and Signal Processing, 19-24 April 2009 Page(s):509 - 512

[113] Senhua Huang, Xin Liu, and Zhi Ding, ``Opportunistic Spectrum Access in Cognitive Radio Networks", INFOCOM 2008: IEEE 27th Conference on Computer Communications, 13-18 April. 2008, Page(s): 1427-1435.

[114] Jingyu Kang, Bo Zhou, Zhi Ding, and Shu Lin, ``LDPC coding schemes for error control in a multicast network", IEEE International Symposium on Information Theory, page(s): 822-826, 6-11 July 2008.

[115] S Bashar and Z Ding, ``Efficient Algorithms for Resource Allocation in Heterogeneous OFDMA Networks", 2008 IEEE Global Telecommunications Conference, Nov. 30 2008-Dec. 4 2008.

[116] M. Zia and Z Ding, ``Joint ARQ Receiver Design for Bandwidth Efficient MIMO Systems", 2008 IEEE Global Telecommunications Conference, Nov. 30 2008-Dec. 4 2008.

[117] J Kang, L Zhang, Z Ding, and S Lin, ``A Two-Stage Iterative Decoding of LDPC Codes for Lowering Error Floors", 2008 IEEE Global Telecommunications Conference, Nov. 30 2008-Dec. 4 2008.

[118] S.-R.C. Ibeawuchi, S. Dasgupta, Cheng Meng, and Zhi Ding, ``Source localization using a maximum likelihood/semidefinite programming hybrid " Proc. 3rd International Conference on Sensing Technology, Nov. 30 2008-Dec. 3 2008 Page(s):585 - 588.

[119] S Huang, X Liu, Z Ding, ``On Optimal Sensing and Transmission Strategies for Dynamic Spectrum Access," DySPAN 2008: New Frontiers in Dynamic Spectrum Access Networks, 14-17 October 2008.

[120] S Bashar, Z Ding, and Y. Li ``QOS aware resource allocation for heterogeneous multiuser OFDM wireless networks" , IEEE Workshop on Signal Processing Advances in Wireless Communications, page(s): 535-539, 6-9 July 2008.
[121] Z. Shi, C. Zhao, and Z. Ding, ``Low Complexity Eigenmode Selection for MIMO Broadcast Systems with Block Diagonalization" IEEE International Conference on Communications, 19-23 May 2008 Page(s):3976 - 3981.
[122] W. Xu, C. Zhao, and Z. Ding, ``Efficient user Scheduling under Low Rate Feedback for Correlated MIMO Broadcast Channels" IEEE International Conference on Communications, 19-23 May 2008 Page(s):3976 - 3981.
[123] He Huang and Zhi Ding, ``Ergodic capacity maximizing MIMO ARQ precoder design based on channel mean information", Information Theory and Applications Workshop, 2008, Jan. 27 2008-Feb. 1 2008 Page(s):58 - 62
[124] Huang, Senhua; Ding, Zhi; Liu, Xin; ``Non-Intrusive Cognitive Radio Networks Based on Smart Antenna Technology", IEEE Global Telecommunications Conference, 26-30 Nov. 2007, Page(s):4862 - 4867.
[125] T. Kazemi and Z. Ding, ``Scalable MIMO ARQ Retransmission using Differential Space-Time Block Codes," Military Communications Conference, 29-31 October 2007.
[126] Ye, Xiaohui; Liu, Xin; Yoo, S. J. Ben; Ding, Zhi; Priority Collision Resolution - Distributed Coordination Function for Distributed Wireless Networks," IEEE Global Telecommunications Conference, 26-30 Nov. 2007 Page(s):4708 - 4713
[127] C. Chang, Z. Ding, Y.S. Hung, P.C.W. Fung, ``Fast Network Component Analysis for Gene Regulation Networks," 2007 IEEE Workshop Machine Learning for Signal Processing, page(s): 21-26, 27-29 August 2007
[128] Q. Ling, T. Li, and Z. Ding, ``A Novel Concept: Message Driven Frequency Hopping (MDFH)", 2007 IEEE International Conference on Communications, Glasgow, Scotland, 24-28 June 2007 Page(s):5496 – 5501.
[129] Ohara, K.; Hernandez, V.J.; Du, Y.; Ding, Z.; Yoo, S.J.B.; Horiuchi, Y.; ``Resiliency of OCDM-PON against near-far problem", Proc. 2007 Optical Fiber Communication and the National Fiber Optic Engineers Conference (OFC/NFOEC 2007), 25-29 March 2007, Anaheim, CA, pp. 1-3,
[130] Fontaine, N.K. Yang, C. Scott, R.P. Hernandez, V.J. Soares, F. Broeke, R. Perry, K. Nowak, G. Cong, W. Okamoto, K. Kolner, B.H. Ding, Z. Heritage, J.P. Yoo, S.J.B. ``SPECTS O-CDMA field trials using subpicosecond pulses and integrated encoders/decoders across 80.8-km and 150-km links", Proc. Photonics in Switching Conference, pp. 95-96, 19-22 August 2007.
[131] Xin Liu and Zhi Ding, ``ESCAPE: A Channel Evacuation Protocol for Spectrum-Agile Networks," 2nd IEEE International Symposium on New Frontiers in Dynamic Spectrum Access Networks (DySPAN), Dublin, Ireland, 17-20 April 2007, Page(s):292 - 302.
[132] Du, Y.; Yoo, S.J.B.; Ding, Z. ``Non-uniform spectral encoding of measured mode-locked laser pulses for performance enhancement of optical CDMA networks," 2006 Optical Fiber Communication Conference (OFC), 5-10 March 2006, Anaheim, CA.
[133] Haitong Sun, and Zhi Ding, ``Optimal Linear Transceiver Design for Mimo Flat Fading Channels Exploiting Channel Mean Feedback", IEEE Global Telecommunications Conference, Nov., 2006.
[134] Song, Shumei; Lin, Shu; Abdel-Ghaffar, Khaled; Ding, Zhi; Fossorier, Marc, "Cyclic Codes for Correcting Bursts of Errors or Erasures With Iterative Decoding" IEEE Global Telecommunications Conference, Nov., 2006.
[135] Dong, Xiaofei; Ding, Zhi; ``Downlink MIMO Channel Estimation for Transmission Precoding" IEEE Global Telecommunications Conference, Nov., 2006. .
[136] Evans, Ashley A.; Ben Yoo, S. J.; Ding, Zhi; ``Space-Time Coded Modulation and Detection in Coherent Freespace Optical Communications", IEEE Global Telecommunications Conference, Nov., 2006.
[137] Yang, C. ; Cong, W. ; Xue, F. ; Hernandez, V. J. ; Scott, R. P. ; Heritage, J. P. ; Kolner, B. H. ; Ding, Z. ; Yoo, S. J. B. ; ``Experimental Investigation on Using Phase Mask in Spectral-Phase-

Encoded O-CDMA for Security Enhancement", European Conference on Optical Communications (ECOC), 24-28 Sept. 2006, Cannes, France, Page(s): 1 - 2.

[138] Chang, C.Q.; Hung, Y.S.; Fung, P.C.W.; Ding, Z.; Network Component Analysis for Blind Source Separation 2006 International Conference on Communications, Circuits and Systems Proceedings, Volume 1, 25-28 June 2006, Page(s):323 - 326.

[139] N. Ammar and Zhi Ding, ``Semi-Coherent Detection for Differential Space-Time Codes", Proceedings of 2006 IEEE International Conference on Communications, Istabul, Turkey, 2006.

[140] H. Sun and Z. Ding, ``Robust Precoder Design for MIMO Packet Retransmission over Imperfectly Known Flat Fading Channels", Proceedings of 2006 IEEE International Conference on Communications, Istabul, Turkey, 2006.

[141] Haitong Sun, Zhi Ding, and Chunming Zhao, ``Iterative Design of MIMO ARQ Transceiver for Decision Feedback Detection", IEEE 7th Workshop on Signal Processing Advances in Wireless Communications, 2-5 July 2006.

[142] X. Dong and Z. Ding, ``Channel Estimation and Bit-loading in Wireless Multicarrier Systems based on Decimated Signal Feedback" , Proceedings of 2006 IEEE International Conference on Communications, Istabul, Turkey, 2006.

[143] J. Roberson and Zhi Ding, ``A BICM Approach to Type-II Hybrid ARQ", Proceedings of 2006 IEEE International Conference on Acoustics, Speech and Signal Processing, Volume 4, 2006 Page(s):IV-273 - IV-276, 2006, Toulouse, France.

[144] J. Roberson and Z. Ding, ``Integration of Hybrid ARQ and Space-Time Coding through Embebded Quasi-Orthogonal Space-Time Block Codes," Proc. 40th Annual Conference on Informaiton Sciences and Systems, pp. 547-551. 22-24 March 2206.

[145] F. Xue, Y. Du, S. J. B Yoo, and Z. Ding, `` Security issues on spectral-phase-encoded optical CDMA with phase-masking scheme", Proc. 2006 Optical Fiber Communication Conference, March 5-10, 2006.

[146] X. Dong and Z. Ding, ``MIMO Channel Estimation Based on Ambiguity Resistant Filtering and Decimated Feedback", Proc. IEEE Globecom Conference, Vol. 5, pp.2958-2963, St. Louis, MO, 28 Nov.-2 Dec. 2005.

[147] F. Xue, Z. Ding, and S. J. B. Yoo, ``Design and Analysis of Coordinated Access Schemes for Code-Limited Optical-CDMA Networks", Proc. IEEE Globecom Conference, vol. 4, pp.1930-1935, St. Louis, MO, 2005.

[148] J. Roberson, X. Dong, Z. Ding, ``Joint Data Detection for Punctured ARQ Diversity Systems", Proc. International Conference on Acoustics, Speech, and Signal Processing, pp. III-1145-1148, 2005.

[149] T. Li, Q. Ling, and Z. Ding, ``Space-Time Design for Blind Estimation and Equalization over Frequency Selective Channels", Proc. Int. Conference on Acoustics, Speech, and Signal Processing, pp. III-441-444, 2005.

[150] H. Sun, H. Samra, Z. Ding, and J. Manton, ``Constrained Capacity of Linear Precoded ARQ in MIMO Wireless Systems", Proc. Int. Conference on Acoustics, Speech, and Signal Processing, pp. III-425-428, 2005.

[151] A. A. Farid, Z.-Q. Luo, and Z. Ding, ``Blind Channel Equalization based on Second Order Statistics", Proc. Int. Conference on Acoustics, Speech, and Signal Processing, pp. III-557-560, 2005.

[152] F. Xue, Z. Ding, and S. J. B. Yoo, ``Performance Evaluation of Optical CDMA Networks with Random Media Access Schemes", Proc. 2005 Optical Fiber Communication Conference, vol. 4, 6-11 March 2005.

[153] Fei Xue, Zhi Ding, S.J.B. Yoo, ``Performance analysis for optical CDMA networks with random access schemes", Proc. IEEE Global Telecommunications Conf., Volume 3, pp.1883-1887, Nov-Dec., 2004.

[154] J. Roberson, and Z. Ding, ``Joint channel estimation and detection of partial ARQ in OFDM", Conference Record of the Thirty-Eighth Asilomar Conference on Signals, Systems and Computers, Volume 1, Page(s):662 - 666, 7-10 Nov. 2004

[155] Haitong Sun; Mihaela van der Schaar, and Zhi Ding, `` ``Joint data compression and error protection for collaborative transmission," 2004 International Conference on Image Processing, 2004, Volume 1, 24-27 Oct. 2004 Page(s):533 - 536.

[156] Larcher, Aymeric, Haitong Sun, M. van der Schaar, and Zhi Ding. ``Decentralized transmission strategy for delay-sensitive applications over spectrum agile network", Proc. 13h Intl. Packet Video Workshop, Dec. 2004.

[157] H. Sun, M. van der Schaar, and Zhi Ding, ``Joint data compression and error protection over wireless fading channels using LDPC codes" Proc. 38th Asilomar Conf. on Signals, Systems and Computers, Pacific Grove, CA, 2004, Page(s): 978 - 982 Vol.1

[158] S. Neugebauer and Z. Ding, ``A Turbo-Driven Known-modulus Blind Equalization Method", Proceedings of the 5th Workshop on Signal Processing Advances in Wireless Communications, pp. 36-40, Lisbon, Portugal, July 2004.

[159] N. Ammar and Z. Ding, ``Flat Fading Channel Estimation Under Generic Linear Space-Time Block Coded Transmissions", Proceedings of the IEEE International Communications Conference, pp.2616-2620, 2004.

[160] T. Li, Z. Ding, J. K. Tugnait, and W. Liang, ``Channel Identification and Signal Separation for Long-code CDMA Systems using Mulitple Linear Prediction Method", Proceedings of the IEEE Int. Communications Conference, pp. 2437-2441, 2004.

[161] N. Ammar and Z. Ding, ``Frequency Selective Channel Estimation in Time-Reversed Space-Time Coding",, Proceedings of the IEEE Wireless Communications and Networking Conference (WCNC), pp. 1838-1843, March 2004.

[162] T. A. Drumright and Z. Ding, ``Monte-Carlo Equalization and Estimation of Frequency Selective Channels under System Nonlinearity," Proceedings of the IEEE WCNC Conference, pp. 2432-2437, 2004.

[163] X. Dong, Z. Ding and S. Dasgupta, ``Fractional spaced dual channel estimation based on decimated feedback", Proceedings of the IEEE WCNC Conference, pp. 489-494, 2004.

[164] J. Roberson and Z. Ding, ``Joint Channel Identification in Punctured Hybrid ARQ Retransmissions", Proceedings of the IEEE WCNC Conference, pp. 2099-2104, 2004.

[165] Y. Du, S. J.B. Yoo, and Z. Ding, ``Non-uniform Spectrual Encoding for Enhanced Multi-user Performacne in Optical CDMA Networks", Proc. Conference on Lasers and Electro-Optics. Vol. 1, 2 pp. 2004.

[166] W. Cong, V. J. Hernandez, R. P. Scott, K. Li, J. P. Heritage, B. H. Kolner, Z. Ding, and S. J. B. Yoo, ``PERFORMANCE OF A 10GB/S OPTICAL CODE DIVISION MULTPLE ACCESS CHANNEL IN THE PRESENCE OF AN INTERFERER", Proceedings of the Conference on Lasers and Electro-Optics, Vol. 1, 3 pp., 2004.

[167] S. P. Neugebauer and Z. Ding, ``Blind SIMO Channel Estimation for CPM Using the Laurent Approximation", Proceedings of the IEEE Int. Symposium on Circuits and Systems (ISCAS)}, pp.676-679, 2004.

[168] J. Roberson and Zhi Ding, ``Joint semi-blind channel identification in punctured ARQ retransmissions", Proc. IEEE Int. Conf. on Acoustics, Speech, and Signal Processing, pp.II.421-4, May 2004.

[169] H. Samra, and Z. Ding, ``Sphere decoding for retransmission diversity in MIMO flat-fading channels," Proc. IEEE Int. Conf. on Acoustics, Speech, and Signal Processing, pp.IV.585-588, May 2004.

[170] H. Samra, Zhi Ding, and P. M. Hahn, ``Symbol mapping diversity design for packet retransmissions through fading channels", Proc. IEEE Global Telecommunications Conf., vol.4, pp.1989-1993, 1-5 Dec. 2003.

[171] T. A. Drumright, A. A. Tabarrok, and Zhi Ding, ``Array beamforming for long code CDMA under carrier drift", Proc. IEEE Globecom, vol.4, pp.2156-2160, 1-5 Dec. 2003.
[172] Wing-Kin Ma; Ching, P.C.; Ding, Z.; ``Efficient relaxed maximum-likelihood MPSK multiuser detection using semidefinite programming", 4th IEEE Workshop on Signal Processing Advances in Wireless Communications (SPAWC), 15-18 June 2003 Page(s):522 - 526
[173] T. Miyajima and Z. Ding, ``Multicarrier channel shortening based on second order output statistics", 4th IEEE Workshop on Signal Processing Advances in Wireless Communications (SPAWC), 15-18 June 2003 Page(s):145 - 149.
[174] Honghui Xu, Dasgupta, S. Zhi Ding ``A novel channel identification method for fast wireless communication systems with transmitter and receiver diversity," Proceedings of the 2003 International Symposium on Circuits and Systems, pp. II:9-12, 25-28 May 2003.
[175] H. Samra and Zhi Ding, ``Symbol mapping diversity in iterative decoding/demodulation of ARQ systems," IEEE International Conf. on Communications, vol.5, pp.3585-3589, May 2003.
[176] T. Li, J. K. Tugnait, and Zhi Ding, ``Channel estimation of long-code CDMA systems utilizing transmission induced cyclostationarity", Proc. IEEE Int. Conf. on Acoustics, Speech, and Signal Processing, pp.IV.105-8, April 2003.
[177] H. Samra, Zhi Ding, P.M. Hahn, ``Optimal symbol mapping diversity for multiple packet transmissions", Proc. IEEE Int. Conf. on Acoustics, Speech, and Signal Processing, pp.IV.181-4, April 2003.
[178] H. Xu, S. Dasgupta, and Zhi Ding, ``An improved feedback scheme for dual channel identification in wireless communication systems," Proc. IEEE Int. Conf. on Acoustics, Speech, and Signal Processing, pp.IV.77-80, April 2003.
[179] A. B. Parr, B. L. Cho, and Z. Ding, ``A new UWB pulse generator for FCC spectral masks", Proc. 57th IEEE Vehicular Technology Conference, Spring, Volume: 3, Page(s): 1664-1666 April 22-25, 2003
[180] N. Ammar and Z. Ding, ``On Blind Channel Identifiability Under Space-Time Coded Transmission", Proc. 36th Asilomar Conf., Nov., 2002.
[181] Xiangguo Tang and Zhi Ding, ``A simple iterative bi-directional equalization for EDGE wireless systems", IEEE Globecom, pp. 287-290, Taipei, Nov. 2002.
[182] Xiangguo Tang and Zhi Ding, ``Contradictory block arbitration for bi-directional decision feedback equalizers", IEEE Globecom, pp. 283-286, Taipei, Nov. 2002.
[183] H. Samra and Z. Ding, ``Precoded Integrated Equalization for ARQ Systems", Proc. of the 36th Asilomar Conf. on Signals, Systems, and Computers, Monterey, CA, Nov., 2002.
[184] N. Ammar and Z. Ding, ``Channel Estimation Under Space-Time Block-Coded Transmission", IEEE Sensor Array and Multichannel Signal Processing Workshop, Rosslyn, VA. Aug, 2002, pp. 422-426.
[185] J Liang, Z Ding, ``Higher order statistical approach for channel estimation usingmatrix pencils," IEEE International Conference on Communications (ICC), Volume: 1, page(s): 11-15, 28 April - 2 May 2002, New York.
[186] J. Liang and Z. Ding, ``A Higher Order Matrix Pencil Approach to Blind Channel Estimation," Proc. IEEE Int. Symposium on Circuits and Systems, Scottsdale, AZ, 2002.
[187] T. A. Drumright and Z. Ding, â€œModulation Classification of QAM Signals using Joint Characteristic Function," Proc. IEEE Int. Symposium on Circuits and Systems, Scottsdale, AZ, 2002.
[188] T. A. Drumright and Z. Ding, ``Gibbs Sampling Classification of QAM Signals in Frequency Selective Channels", 36th Asilomar Conf. on Signals, Systems and Computers, Asilomar CA, 2002, Page(s): 833-837.
[189] H. Samra and Z. Ding, ``Iterative Integrated Equalization for ARQ Systems", Int. Symp. on Info. Theory, Lausanne, Switzerland, Jun, 2002.
[190] H. Samra and Z. Ding, ``Integrated iterative equalization for ARQ Systems," IEEE Int. Conf. on Acoustics, Speech, and Signal Processing, Orlando, FL, 2002.

[191] J. Liang, Z. Ding, and S. Lin, ``Joint Equalization with LDPC Decoding under hybrid ARQ Scheme," 35th Asilomar Conference on Signals, Systems and Computers, Pacific Grove, CA, 2001.

[192] X.-G. Tang and Z. Ding, ``Turbo Equalization for EDGE System with DDF-SOVA," 35th Asilomar Conference on Signals, Systems and Computers, Pacific Grove, CA, Nov. 2001.

[193] S. Cui, Z. Luo, and Z. Ding, ``Robust CDMA Signal Detection in the Presence of User and Interference Signature Mismatch," Proc. 3rd IEEE Workshop on Signal Processing Advances in Wireless Communications, pp. 221-224, March 20-23, 2001.

[194] S. Cui, Z. Luo, and Z. Ding, ``Robust Blind Multiuser Detection against CDMA Signature Mismatch," Proc. Int. Conf. on Acoustics, Speech, and Signal Processing, pp. 2297-2300, Salt Lake City, May 2001.

[195] H. Xu, S. Dasgupta, and Z. Ding, ``A Novel Channel Identification Method for Fast Wireless Communication Systems," Pro. 2001 IEEE International Conference on Communications, pp. 2443-2448, 2001.

[196] J. Liang and Z. Ding, ``FIR Multichannel Identification using Weighted Cumulant Matrix," Proc. 34th Asilomar Conference on Signals, Systems and Computers, pp. 1573-1577, 2000.

[197] J. Liang and Z. Ding, ``A cumulant subspace approach to FIR multiuser channel estimation" Proc. 34th Asilomar Conference on Signals, Systems and Computers, pp. 616-620, 2000.

[198] Z. Ding and Li Qiu, ``Properties of matrix polynomials and MIMO channel identifiability from second order statistics", Proceedings of the 39th IEEE Conference on Decision and Control, vol. 5, Page(s): 4302 -4307 vol.5, 2000.

[199] X. Tang and Z. Ding, ``A Differential Correlation Approach to Blind Symbol Estimation," Proc. IEEE Wireless Communications and Networking Conference, Chicago, IL, September 2000.

[200] J. Liang and Z. Ding, ``A cumulant subspace approach to FIR multiuser channel estimation," Proc. 10th IEEE Workshop on Statistical Signal and Array Processing, pp. 616-620, Pocono Manor, PA, August 2000.

[201] E. Bai and Z. Ding, ``Blind decision feedback equalization of time-varying channels with DPSK inputs," Proceedings 2000 IEEE International Symposium on Circuits and Systems, Volume 4, 28-31 May 2000, 96 - 99

[202] E. Bai and Z. Ding, ``Zero-forcing equalizability of FIR and IIR multi-channel systems with and without perfect measurements," Proceedings 2000 IEEE International Symposium on Circuits and Systems, Volume 4, 28-31 May 2000, 699 - 701

[203] Zhu, J.; Cao, X.-R.; Ding, Z., ``An algebraic principle in blind separation of single source signal", Proceedings 2000 IEEE International Symposium on Circuits and Systems, Volume 4, 28-31 May 2000, Page(s):693 - 696.

[204] Xiangyang Zhuang, Zhi Ding, and A. Lee Swindlehurst, ``A Statistical Subspace Method for Blind Channel Identification in OFDM Communication", IEEE Int. Conf. on Acoustics, Speech, and Signal Processing, pp. 2493-2496, Istanbul, Turkey, May 2000.

[205] Jie Zhu, Wee Ser, and Zhi Ding, ``Blind ISI cancellation by anchoring an arbitrary impulse response coefficient of channels", IEEE Int. Conf. on Acoustics, Speech, and Signal Processing, pp. 2465-2468, Istanbul, Turkey, May 2000.

[206] Zhi Ding, S. Dasgupta, and R. Lopez-Valcarce, ``Interference cancellation and blind equalization for linear multi-user systems", IEEE Int. Conf. on Acoustics, Speech, and Signal Processing, pp. 145-148, Istanbul, Turkey, May 2000.

[207] Kennedy, R.A.; Hasnie, S.; Zhi Ding; McGinty, N.C.; ``Decision feedback equalization using fractionally spaced feedback filtering and vector quantization" Proc. 38th IEEE Conference on Decision and Control, . Volume 1, 7-10 Dec. 1999, Page(s):162 - 167.

[208] T. Li and Z. Ding, ``A Reduced-State Viterbi Algorithm for Blind Sequence Estimation of DPSK Sources," Proc. Global Telecommunications Conference (Globecom), pp. 2167-2171, Rio de Janeiro, Brazil, Dec. 1999.

[209] G. Li and Z. Ding, ``Blind Linear Equalization for GSM Signals in a Mobile Environment", Proc. IEEE Wireless Communications and Networking Conference, pp.801-804, New Orleans, LA, September, 1999.
[210] J. Shen and Z. Ding, ``Direct blind MMSE channel equalization based on second order statistics," 1999 IEEE International Conference on Communications, vol.3, pp.1537 -1541, Seattle, WA, June 1999.
[211] G. Li and Z. Ding, ``New Blind/semi-blind Equalization for GSM Systems", 1999 IEEE Workshop on Signal Processing Advances in Wireless Communications, pp.66-69, Annapolis, MD, May 1999.
[212] J. Shen and Z. Ding, ``Blind MMSE CDMA Detection in Multipath Channels", 1999 IEEE Workshop on Signal Processing Advances in Wireless Communications, pp.5-8, Annapolis, MD, May 1999.
[213] Z. Ding, ``Cumulant Matrix Subspace Algorithms for Blind Single FIR Channel Identification", 1999 IEEE Workshop on Higher Order Statistics, pp.85-88, June, Caesarea, Israel, 1999.
[214] Z. Ding, ``A Cumulant Matrix Subspace Algorithm for Blind Single FIR Channel Identification", SPIE Conference on Digital Wireless Communications, SPIE vol.3708, pp.193-201, April, Orlando, FL, 1999.
[215] J.E. Mooney, Z. Ding, and L.S. Riggs, "Performance Analysis of an Automated E-pulse Scheme in White Gaussian Noise," IEEE International Antennas and Propagation Symposium and URSI/USNC Radio Science Meeting, April, Orlando, FL, 1999.
[216] Junqiang Shen and Zhi Ding, ``Zero-Forcing Blind Equalization Based on Channel Subspace Estimates for Multiuser Systems", Proc. Int. Conf. on Acoustics, Speech, and Signal Processing}, Phoenix, AZ, March 1999.
[217] Z. Ding and G. Li, ``Feasibility of linear GSM blind channel equalization," Proc. Int. Telecommunications Symp., vol.1, pp.~359-364, Sao Paulo, Brazil, 1998.
[218] C. T. Ma, Z. Ding, and S. F. Yau, ``A Two-stage Algorithm for MIMO Blind Deconvolution of Colored Input Signals", Proceedings 9th IEEE SP Workshop on Statistical Signal and Array Processing, pp.~384-387, 1998.
[219] Chunqi Chang, Zhi Ding, Mark S.-F. Yau, and Francis H. Y. Chan, ``A Matrix-Pencil Approach to Blind Separation of Non-White Signals in White Noise", Proc. 1998 IEEE International Conf. on Acoustics, Speech, and Signal Processing, pp.2485-2488, Seattle, May 12, 1998.
[220] Zhi Ding, Iain Collings, Ruey-wen Liu, ``A New Blind Zeroforcing Equalizer for Multichannel Systems", Proc. 1998 IEEE International Conf. on Acoustics, Speech, and Signal Processing, pp.3177-3180, Seattle, May 12, 1998.
[221] Ge Li and Zhi Ding, ``Semi-Blind Channel Identification Used in GSM System," Proc. 1998 IEEE International Conf. on Acoustics, Speech, and Signal Processing, pp.3389-3392, Seattle, May 12, 1998.
[222] Zhi Ding and Ge Li, ``Single Channel Linear Blind Equalization for GSM Cellular Systems", Proc. 1998 IEEE International Conf. on Communications, Atlanta, June, 1998. pp. 355-359
[223] C. Chang, Z. Ding, S. F. Yau, and F. H. Y. Chan ``A Matrix-Pencil Approach to Blind Separation of Non-White Sources," Proc. International Symposium on Multimedia Information Processing, pp. 280-285, Taipei, Taiwan, December 1997.
[224] Jie Zhu, Xiren Cao, Zhi Ding, and Junqiang Shen, ``A Blind Intersymbol Interference Cancellation Method for Multi-user Systems with Channel Diversity", Proc. 1997 Asilomar Conference on Signals, Systems, and Computers, pp.565-569, Pacific Grove, 1997.
[225] Zhi Ding and Ge Li, ``New Methods of Blind Channel Equalization for GSM Systems", Proc. 1997 Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, 1997.
[226] Zhi Ding, ``Blind Wiener Filter Estimation for Multi-Channel Systems Base on Partial Information," Proc. 1997 IEEE International Conf. on Acoustics, Speech, and Signal Processing, pp.3609-3612, April 1997.

[227] Tuan Nguyen and Zhi Ding, ``CMA Beamforming for Multipath Correlated Sources", Proc. 1997 IEEE International Conf. on Acoustics, Speech and Signal Processing, pp.2521-2524, April 1997.

[228] Rodney A. Kennedy, Deva K. Borah, and Zhi Ding, ``Discretization Issues for the Design of Optimal Blind Algorithms", Proc. 1997 IEEE International Conf. on Acoustics, Speech, and Signal Processing, pp.51-54, April 1997.

[229] Junqiang Shen and Zhi Ding, ``Blind Adaptive Multiuser CDMA Detection Based on a Linear Projection Constraint", Proc 1st IEEE Workshop on Signal Processing Advances in Wireless Communications, pp.~261-264, Paris, France, April 1997.

[230] Kennedy, R.A.; Zhi Ding, ``Design and optimization of nonlinear mapping in decision feedback equalization," Proceedings of the 35th IEEE Decision and Control, Volume 2, Page(s):1888 - 1889, 11-13 Dec. 1996

[231] Z. Ding, ``An Outer-Product Decomposition Algorithm For Multichannel Blind Identification", Proc. 8th IEEE Workshop on Stat. Signal and Array Processing, pp.~132-135, Corfu, Greece, June 1996.

[232] Zhi Ding, ``On Convergence Analysis of Fractionally Spaced Adaptive Blind Equalizers", Int. Conf. on Acoustics, Speech, and Signal Processing, May 1996.

[233] J.E. Mooney, Z. Ding, and L.S. Riggs, "Robust Target Identification Using a Generalized Likelihood Ratio Test," Proc. 3rd International Conference on Ultra-Wideband, Short-Pulse Electromagnetics, pp.343-350, Albuquerque, NM, 1996.

[234] D. B. Ward, Z. Ding, and R. A. Kennedy ``Broadband DOA Estimation using Frequency-invariant Beam-space Processing", Int. Conf. on Acoustics, Speech, and Signal Processing}, pp.2892-2895, May 1996.

[235] R.A. Kennedy and Z. Ding, ``Quantizer Design and Optimization in Decision Feedback Equalization", Proc. 1996 Int. Symp. on Signal Proc. Applications, pp.614-617, August, Gold Coast Australia.

[236] Zhi Ding, ``A Blind Channel Identification Algorithm Based on Matrix Outer-Product", 1996 International Communications Conference, Dallas, TX. pp. 852-856.

[237] Casas, R.A.; Zhi Ding; Kennedy, R.A.; Johnson, C.R., Jr.; Malamut, R.; ``Blind adaptation of decision feedback equalizers based on the constant modulus algorithm", Proc. 29th Asilomar Conference on Signals, Systems and Computers, Volume 1, 30 Oct.-2 Nov. 1995 Page(s):698 - 702

[238] Zhi Ding, ``Myopic Channel Identification: Identifying unknown Channels based on known pulse shapes", 1995 IEEE Global Telecommunications Conference, vol.1, pp.670-674, Nov. 1995.

[239] Paul Burns* and Zhi Ding, ``Robustification of Cyclostationary Array Processing Techniques", Proc. Int. Conf. on Acoustics, Speech, and Signal Processing, pp. 1589-1592, Detroit, May 1995.

[240] Zhi Ding and Zhen Mao, ``Knowledge Based Identification of Fractionally Sampled Channels" Proc. Int. Conf. on Acoustics, Speech, and Signal Processing, pp. 1996-1999, Detroit, May 1995.

[241] Zhi Ding and Rodney A. Kennedy, ``An Algebraic Self-Training Algorithm for Multi-Channel Systems Identification", Equalizers", Proc. 33rd IEEE Conf. on Decision and Control Lake Buena Vista, FL, Dec. 1994.

[242] Y. Li and Zhi Ding, ``Global Convergence of Fractionally Spaced Godard Adaptive Equalizers", Proc. 28th Asilomar Conf. on Signals, Systems and Computers, pp.617-621, Nov. 1994.

[243] Zhi Ding and Rodney A. Kennedy, ``Algebraic Self-Training Algorithms for Multi-Channel System Identification and Equalization", Proc. 28th Asilomar Conf. on Signals, Systems and Computers, pp. 1453-1457, Pacific Grove, CA, Nov. 1994.

[244] Y. Li and Zhi Ding, ``Global Convergence of Adaptive Blind Equalizers", Proc. 4th Annual IEEE Dual-Use Technologies and Applications Conference, vol.II, pp. 402-411, Utica, NY, May 1994.

[245] Y. Li and Z. Ding, ``New Results on the Blind Identification of FIR Channels Based on Second Order Statistics", Proc. 1993 MILCOM, pp. 644-647, Boston, Oct. 1993.

[246] Y. Li and Z. Ding, ``A New Non-Parametric Cepstral Method for Blind Channel Identification from Cyclostationary Statistics", Proc. 1993 MILCOM, pp. 648-652, Boston, Oct. 1993.

[247] Y. Li and Z. Ding ``Blind Channel Identification Based on Second order Cyclostationary Statistics", Proc. 1993 IEEE ICASSP, pp. IV:81-84, Minneapolis, April 1993.
[248] J. Y. Hung and Z. Ding, ``Minimization of Torque Ripple in Permanent Magnet Motors," 1992 IEEE Industrial Electronics Conference, San Diego, CA.
[249] Z. Ding and Y. Li, ``Channel Identification Using Second Order Cyclic Statistics," Proc. 26th Asilomar Conf. on Signals, Systems, and Computers, Pacific Grove, CA, November 1992.
[250] Z. Ding, ``On Channel Identifiability Based on Second Order Cyclic Spectra," Proc. IEEE 1992 Milcom, San Diego, October 1992.
[251] K. Yamazaki, R. A. Kennedy, and Z. Ding, ``Candidate Admissible Blind Equalization Algorithms for QAM Communication Systems," Proc. 1992 IEEE Int. Conf. on Communications, pp. 1518-1522, June 1992.
[252] K. Yamazaki, R. A. Kennedy, and Z. Ding, ``Globally Convergent Blind Deconvolution Algorithms for Complex Data System," Proc. 1992 IEEE ICASSP, San Fransisco, CA, April 1992.
[253] Z. Ding and R. A. Kennedy, ``A New Adaptive Algorithm for Joint Blind Equalization and Carrier Recovery," Proc. 25th Asilomar Conf. on Signals, Systems, and Computers, pp. 699-703, Pacific Grove, CA, November 1991 (Invited).
[254] Z. Ding and C. R. Johnson, Jr., ``Existing Gap Between Theory and Application of Blind Equalization," Adaptive Signal Processing, Simon Haykin, Editor, Proc. SPIE 1565, pp. 154-165, 1991 (Invited).
[255] Z. Ding, ``A New Method for Automatic Beamforming," Proc. 25th Asilomar Conf. on Signals, Systems, and Computers, pp. 689-693, Pacific Grove, CA, November 1991.
[256] Z. Ding, C. R. Johnson, Jr., and R. A. Kennedy, ``Local Convergence of `Globally Convergent' Blind Adaptive Equalization Algorithms," Proc. 1991 IEEE ICASSP, pp. 1529-1532, Toronto, Canada, May 1991.
[257] Z. Ding,``Joint Blind Equalization and Carrier Recovery of QAM Systems," Proc. 25th Conf. on Info. Sciences and Systems, Baltimore, MD, March 1991.
[258] R. A. Kennedy, B.D.O. Anderson, Z. Ding, and C. R. Johnson, Jr., ``Local stable minima of the Sato recursive identification scheme", Proceedings of the 29th IEEE Conference on Decision and Control, vol.6, Page(s):3194 - 3199, 5-7 Dec. 1990.
[259] Z. Ding, C. R. Johnson, Jr., and R. A. Kennedy, `` Nonglobal convergence of blind recursive identifiers based on gradient descent of continuous cost functions", Proceedings of the 29th IEEE Conference on Decision and Control, vol.1, Page(s):225 - 230, 5-7 Dec. 1990.
[260] Z. Ding, C. R. Johnson, Jr., and R. A. Kennedy, ``On the admissibility of blind adaptive equalizers", Proc. Int. Conf. on Acoustics, Speech, and Signal Processing, vol.3, Page(s):1707 - 1710, 3-6 April 1990.
[261] Z. Ding, C. R. Johnson, R. A. Kennedy and B. D. O. Anderson, ``On the Ill-Convergence of Godard Blind Equalizers in Data Communication Systems", In Proceedings of Conf. Information Science and Systems, vol. 89, pp. 538-543, Baltimore, MD, 1989.

Professional Services and Achievements

- Chief Information Officer, IEEE Communications Society, 2018-2022
- Chief Marketing Officer, IEEE Communications Society, 2020-2022, 2024-Present
- Parliamentarian, IEEE Communications Society, 2022-2024
- Steering Committee Chairman, *IEEE Transactions on Wireless Communications,* 1.2008-1-2010
- Canadian National Science and Engineering Research Council Panelist, 2009-2012
- Fellow of IEEE
- Steering Committee Member, *IEEE Transactions on Wireless Communications,* 1.2006-1-2008
- General Chair, IEEE 2016 International Conference on Acoustics, Speech, and Signal Processing, Shanghai, China.
- Technical Program Chair, *IEEE 2006 Globecom*, San Francisco, CA.
- Editorial Board Member, *IEEE Signal Processing Magazine*, 1/2003-1/2007.
- Associate Editor, *IEEE Signal Processing Letters*, 1.2002-1.2005.
- Associate Editor, IEEE Transactions on Signal Processing, 1.2001-1.2004.
- Editor, Special Issue on Multiuser Detection and Blind Estimation, *EURASIP Journal on Applied Signal Processing*, Dec. 2002.
- Member, IEEE Statistical Signal and Array Processing Technical Committee, 1993-1998.
- Member, IEEE Signal Processing for Communications Technical Committee, 1998-2004.
- Associate Editor, IEEE Transactions on Signal Processing, 1994-1997.
- Technical Program Committee Member, 3rd IEEE Workshop on Signal Processing Advances in Wireless Communications, Taiwan, March 2001.
- Organization Committee Member, 1st IEEE Workshop on Signal Processing Advances in Wireless Communications, Paris, France, April 1997.
- Review Panelist, National Science Foundation, 1997, 2003, 2004, 2005, 2007, 2008, 2010, 2014, 2015, 2016.