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In re Patent of:	Xiaobo Zhang	
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Title:	METHOD AND DEVICE IN UE AND BASE STATION USED FOR PAGING	

DECLARATION OF DR. ZHI DING

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I, Zhi Ding declare that:

I. INTRODUCTION

1. I have been retained by counsel on behalf of Petitioner Apple Inc. ("Petitioner") to offer technical opinions related to U.S. Patent No 10,462,767 ("the '767 patent") (APPLE-1001). I understand that Apple is requesting that the Patent Trial and Appeal Board ("PTAB" or "Board") to institute an *inter partes* review ("IPR") proceeding of the '767 patent. For the purposes of this Declaration, I have not been asked to opine on any other issues not addressed below.

2. My opinions are based on my years of education, research and experience, as well as my investigation and study of relevant materials, including those identified in this Declaration. I may rely upon these materials, my knowledge and experience, and/or additional materials in forming any necessary opinions. Further, I may also consider additional documents and information to rebut arguments raised by the Patent Owner Apex Beam Technologies LLC ("Patent Owner" or "Apex"). I reserve any right that I may have to supplement this Declaration if further information becomes available or if I am asked to consider additional information. Furthermore, I reserve any right that I may have to consider and comment on any additional expert statements or testimony of Apex's expert(s) in this matter.

3. I am not and never have been, an employee of Apple. I received no compensation for this declaration beyond my normal hourly compensation based on my time actually spent analyzing the '767 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 ’767 patent.

4. My analysis of the materials produced in this investigation is ongoing and I will continue to review any new material as it is provided. This Declaration represents only those opinions I have formed to date. I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information and on my continuing analysis of the materials already provided.

II. QUALIFICATIONS

5. 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.

6. I presently hold the title of Distinguished Professor in the Department of Electrical and Computer Engineering at the University of California, Davis. 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 more than three decades of research experience on a wide range of topics related data communications and signal processing.

7. I earned my Bachelor of Science 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 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 in several

large-scale projects supported by the Defense Advanced Research Projects Agency (DARPA) with teams of researchers. 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. I also authored 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. The 4th edition of this book (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[1], 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

[1] https://scholar.google.com, as of August 21, 2024.

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 Information Officer of the IEEE Communications Society from Jan. 2018 to present.
- Chief Marketing Officer of the IEEE Communications Society from Jan. 2020 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 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." I received the 2020 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 and panelist.

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

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. My curriculum vitae, attached as 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 provide to an expert opinion in connection with this proceeding.

III. DOCUMENTS AND MATERIALS CONSIDERED

19. In preparing my opinions, I have reviewed the '767 Patent and its prosecution history and have also reviewed the other documents and materials cited herein and the materials listed below. When citing from these references, all emphasis is added unless otherwise noted.

Ex.	Description
APPLE-1001	U.S. Patent No. 10,462,767
APPLE-1002	U.S. Patent No. 10,462,767 File History
APPLE-1004	International Patent Publication No. 2018/126401 to Liu et al., filed January 5, 2017, and published July 12, 2018 ("*Liu*")
APPLE-1005	U.S. Patent 10,491,447 to Yeo at al., filed August 22, 2017, and claiming priority to KR applications 10-2016-0106427 (filed August 22, 2016) and 10-2016-0125809 (filed September 29, 2016) ("*Yeo*")
APPLE-1006	Certified translated copy of KR Application 10-2016-0125809 (filed September 29, 2016) ("*Yeo-Priority*")
APPLE-1007	International Patent Publication No. 2017/052199 to You et al., filed September 21, 2016, and published March 30, 2017 ("*You*")
APPLE-1008	International Patent Publication No. 2016/136143 to Mallick et al., filed January 28, 2016, and published September 1, 2016 ("*Mallick*")
APPLE-1009	3GPP TS 36.304 V14.2.0, Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode (Release 14), March 2017, ("*TS36*").

APPLE-1010	U.S. Patent Publication No. 2012/0122495 to Weng et al., filed November 11, 2010, and published May 17, 2012 ("*Weng*")
APPLE-1011	International Patent Publication No. 2017/174469 to Wong et al., filed March 31, 2017, and published October 12, 2017 ("*Wong*")
APPLE-1012	International Patent Publication No. 2017/026983 to Khoryaev et al., filed December 26, 2015, and published February 16, 2017 ("*Khoryaev*")
APPLE-1013	International Patent Publication No. 2015/113664 to Webb et al., filed November 13, 2014, and published August 6, 2015 ("*Webb*")
APPLE-1015	International Patent Publication No. 2016/130175 to Fwu et al., filed August 11, 2015, and published August 18, 2016 ("*Fwu*")
APPLE-1016	U.S. Patent Publication No. 2017/0215170 to Islam et al., filed January 26, 2016, and published July 27, 2017 ("*Islam*").
APPLE-1017	International Patent Publication No. 2017/079530 to Pelletier, filed November 4, 2016, and published May 11, 2017 ("*Pelletier*").
APPLE-1018	International Patent Publication No. 2017/171398 to Yi et al., filed March 29, 2017, and published October 5, 2017 ("*Yi*")
APPLE-1019	U.S. Patent No. 9,225,440 to Swarts et al., filed September 14, 2012, and issued December 29, 2015 ("*Swarts*").
APPLE-1020	U.S. Patent Publication No. 2015/0215944 to Kim et al., filed January 29, 2015, and published July 30, 2015 ("*Kim*").
APPLE-1021	U.S. Patent Publication No. 2011/0038330 to Luo et al., filed July 29, 2010, and published February 17, 2011 ("*Luo*").
APPLE-1022	Declaration of Friedhelm Rodermund
APPLE-1023	First Amended Complaint – filed May 2, 2024; *Apex Beam Technologies LLC, v. Apple Inc.*, Case No. 6:24-cv-00223-ADA-DIG, WDTX.
APPLE-1024	R1-165162, *On Numerology for New Radio Access Technology*, 3GPP TSG RAN WG1 Meeting #85, Nanjing, China, 23th – 27th May 2016.
APPLE-1025	3GPP TS 36.306 V14.1.0, Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities (Release 14), December 2016.

APPLE-1026	A. Roessler, J. Schlienz, S. Merkel, M. Kottkamp, "*LTE- Advanced (3GPP Rel.12) Technology Introduction White Paper*"

20. My opinions are also based upon my education, training, research, knowledge, and personal and professional experience. I reserve the right to supplement or amend this Declaration in the event that I hereafter become aware of additional relevant information.

IV. UNDERSTANDING OF LEGAL STANDARDS

21. I am not an attorney and have not been asked to offer an opinion on the law. I understand, however, that certain aspects of the law are relevant to my evaluation and opinions set forth herein. I have therefore been informed of and asked to apply the legal principles summarized below.

A. Earliest Effective Filing Date

22. I understand that the "earliest effective filing date" of a patent is the date of the earliest filing of a patent application in the priority chain of the patent that describes the subject matter of the challenged claims. In this case I understand the '767 Patent claims priority to a Chinese application filed April 19, 2017. While I have not independently evaluated whether the subject matter of the challenged claims of the '767 Patent are described in the Chinese application sufficiently to support the priority claim, I have nonetheless been instructed by Counsel to treat April 19, 2017 as the earliest effective filing date (also referred to herein as the "Critical Date") of the challenged claims for purposes of my analysis in this Declaration. I have done so.

B. Burden of Proof

23. I understand that Apple as the Petitioner bears the burden of establishing by a preponderance of the evidence that the challenged claims are unpatentable. It is my opinion that that prior art and evidence addressed in this Declaration is more than sufficient to meet this burden.

C. Obviousness Under 35 U.S.C. § 103

24. I understand that a claim is invalid if the invention recited in the claim would have been obvious to one of ordinary skill in the art by the earliest effective filing date. I understand this means that even if all the requirements of the claim cannot be found in a single prior art reference that would anticipate the claim, a person of ordinary skill in the field of the invention knowledgeable of the prior art would have come up with the claimed invention. In considering whether a claim is obvious, I have been asked to consider (a) the level of skill in the art at the time of the claimed invention, (b) the scope and content of the prior art, (c) any differences between the prior art and the claims of the patent-in-suit, and (d) any "secondary factors" tending to show non-obviousness of the claimed invention, including commercial success, long-felt but unresolved need, failure of others, copying, praise by others, unexpected results, and simultaneous invention by others.

25. I understand that a claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known in the prior art. I also understand that obviousness should not be analyzed using the benefit

of hindsight. Instead, it must be analyzed from the standpoint of what was known and understood by a POSITA at the time of the claimed invention. I further understand demonstrating that a modification to a reference or the combination of multiple references is obvious requires providing a reason for why a POSITA would modify a reference or combine multiple references and that reason must be supported with some rationale underpinning. Merely pointing out that two references are similar or in the same field of endeavor is not sufficient.

D. Secondary Considerations of Non-Obviousness

26. I understand that in determining whether the claims are obvious I must also consider any evidence bearing on secondary considerations of non-obviousness. These include practical factors such as (1) commercial success, (2) a long-felt need for a solution to the problem facing the inventors, (3) whether others tried and failed to solve the problem, (4) whether others copied the claimed invention, (5) whether the invention achieved unexpected results, (6) whether the prior art teaches away from combining certain known elements, and (7) whether others in the field praised the invention. I also understand that a nexus must be demonstrated between secondary considerations factors and the claimed invention for the factors to be considered.

V. LEVEL OF ORDINARY SKILL

27. I understand there is a concept in patent law known as a person having ordinary skill in the art (POSITA). I understand that this concept refers to a person who is trained in the relevant technical field of a patent without possessing extraordinary or

otherwise exceptional skill. I further understand that factors such as the education level of those working in the field, the sophistication of the technology, the types of problems encountered in the art, prior art solutions to those problems, and the speed at which innovations are made may help establish the level of skill in the art.

28. Taking these factors into consideration, in my opinion, with regard to the '767 Patent, a person of ordinary skill in the art would have a bachelor's degree in electrical engineering, computer engineering, computer science, or a similar field, along with two years of experience designing or developing wireless networks, including long-term evolution LTE/4G and 5G new radio (NR) cellular technology. Additional years of experience could substitute for an advanced-level degree (and vice versa).

29. Based at least on my educational and work experience, I was at least a person of ordinary skill in the art as of the effective filing date of the '767 Patent. And while I note that my qualifications and experiences exceed this definition of a person of ordinary skill of the art, in arriving at the conclusions in this Declaration, I have considered the issues from the perspective of a person of ordinary skill of the art at the relevant time.

30. Unless otherwise stated, I have applied this level of ordinary skill in the art for the purposes of this Declaration.

VI. TECHNOLOGY BACKGROUND

A. 3rd Generation Partnership Project (3GPP)

31. 3GPP is an international partnership of standards-setting organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, and TTC) for developing interoperable global standards for cellular phone systems, including 3rd generation wireless networks (3G), 4th generation wireless networks/Long Term Evolution (4G/LTE), and 5th generation wireless networks/new radio (5G/NR). 3GPP is a de facto international organization for setting standards that govern cellular networks. The 3GPP's Standards are described in Technical Specifications published by 3GPP and its member organizations.

B. Features of 4G/LTE and Older Networks

32. The '767 patent describes several concepts common to both 4G/LTE and 5G/NR technologies. A review of some such concepts is presented below.

1. Resource Grid and Frame Structure

33. In both 4G/LTE and 5G/NR, radio resources for transmission are represented on a time-frequency resource grid. The grid's horizontal axis denotes time, whereas the vertical axis denotes the frequency domain (APPLE-1010, [0191]-[0196], Fig. 6, below). The smallest unit is called a "resource element" (RE). Each RE spans one OFDM symbol in time and one subcarrier in the frequency domain (APPLE-1011, 5:27-30). As shown, a resource block (RB) consists of 84 resource elements (REs) spanning 12 contiguous subcarriers and 7 contiguous OFDM symbols..

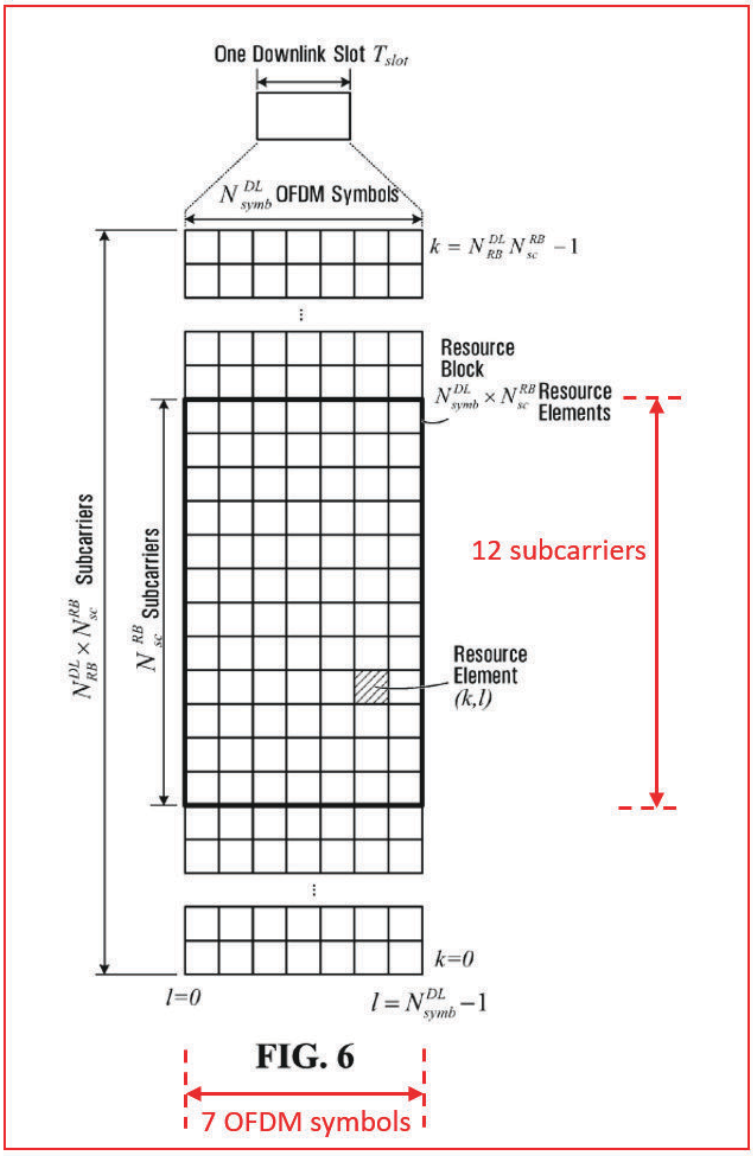


FIG. 6

Weng, Fig. 6, Annotated

34. In the frequency domain, the frequency span of a subcarrier is called "subcarrier spacing." And within the time domain, the radio resources are scheduled using time units such as frame, subframe, slot, and symbol, as shown in the below frame structure.

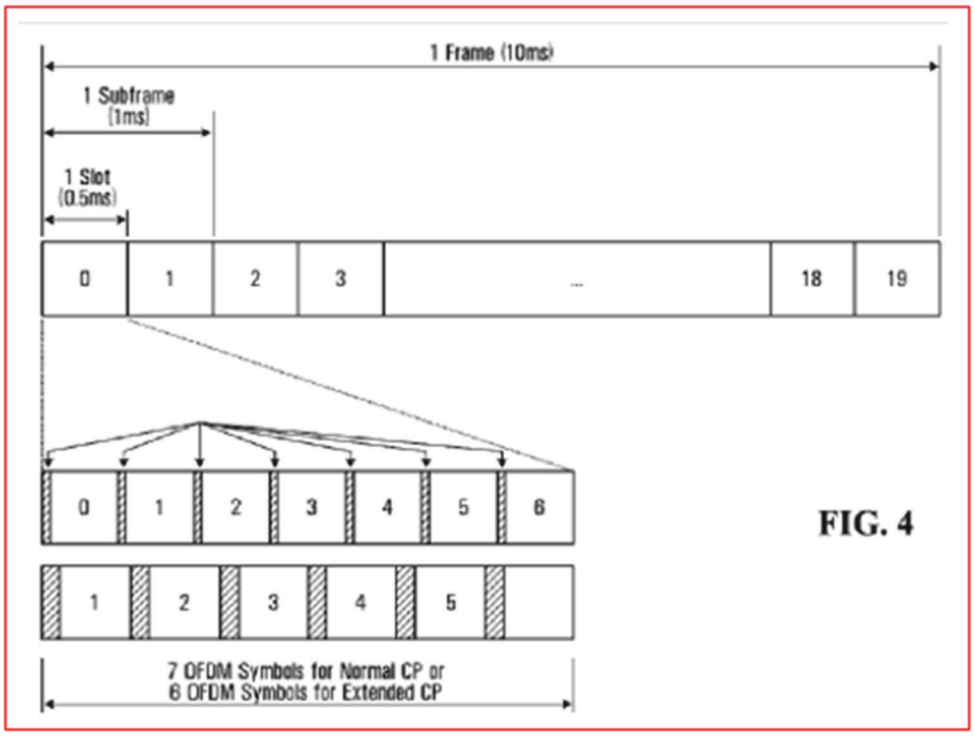


FIG. 4

Weng, Fig. 4.

2. Subcarrier Spacing

35. In a network, subcarrier spacing may correlate with the duration of a symbol or slot. For example, in 4G/LTE, a radio frame is 10 ms long, with 10 subframes per radio frame. Each subframe contains two slots and typically 14 OFDM symbols (APPLE-1010, [0178]-[0180]). The standard subcarrier spacing is 15 kHz, corresponding to a symbol duration of 66.7 μs, though other spacings like 7.5 kHz are also used, resulting in different frame structures (APPLE-1012, 9:19-31).

3. Paging

36. Paging in wireless networks allows UEs to conserve battery power by switching the UE to idle mode when no data is exchanged with the base station for a

while (APPLE-1010, [0003]). While in idle mode, the UE periodically checks for paging messages from the base station which pages the UE when it has downlink messages/data from the network that should be delivered to the UE. If a paging message is detected, the UE switches back to active mode to exchange data. These checks occur during specified "paging occasions," (or POs) within a "paging cycle". *Id*. The paging occasion may be a subframe within a "paging frame," with cycle durations ranging from a few subframes to many radio frames, determined by the UE's ID (APPLE-1010, [0228]-[0229], [0235]-[0236]). This mode of operation, where the UE needs to monitor only the POs within paging cycles to conserve energy, is referred to as discontinuous reception (DRX), and the time interval between monitoring POs by a specific UE is referred to as a discontinuous reception (DRX) cycle. APPLE-1009, p.8-10, 39

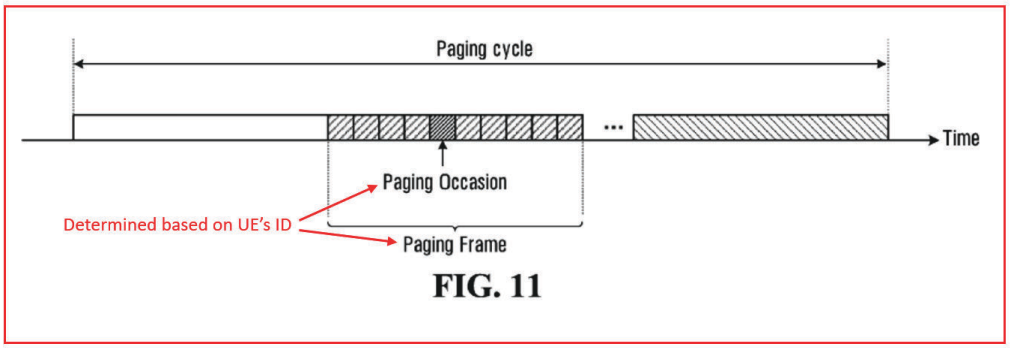


FIG. 11

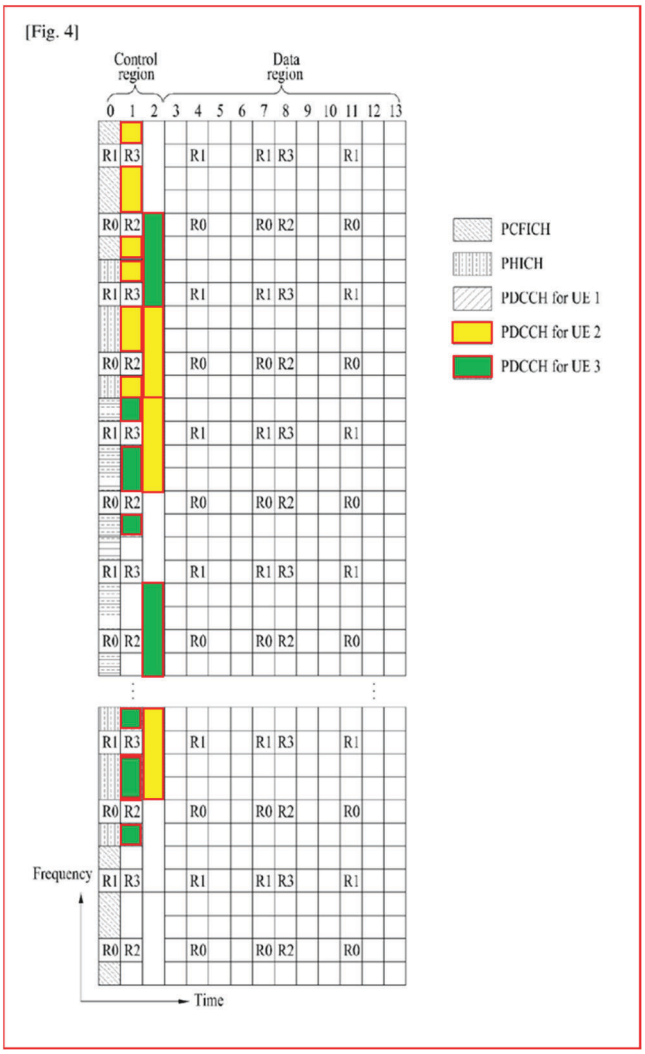
Weng, Fig. 11, Annotated.

4. Monitoring of Physical Downlink Control Channel (PDCCH)

37. The resource grid is divided into a control region for transmitting and receiving control information (e.g., paging scheduling information) and a data region for transmitting and receiving data (e.g., paging messages). In the time domain, a subframe can be split into these regions, with the control region typically residing in the first 1-4 symbols, (APPLE-1007, [144]).

38. The control region may contain physical downlink control channels (PDCCHs) for transmitting downlink control information (DCI), which helps locate and decode resources on subsequent physical downlink shared channels (PDSCHs) (APPLE-1010, [0226]; APPLE-1007, [104]). In paging, the PDCCH carries paging scheduling information, and the PDSCH carries paging messages (APPLE-1007, [105]).

39. A UE typically does not know where its PDCCH resides within the control region, as different PDCCHs in the control region may be directed to different UEs (APPLE-1007, [121]). Each PDCCH occupies different resource elements in the grid (APPLE-1007, Fig. 4).



You, Fig. 4, Annotated.

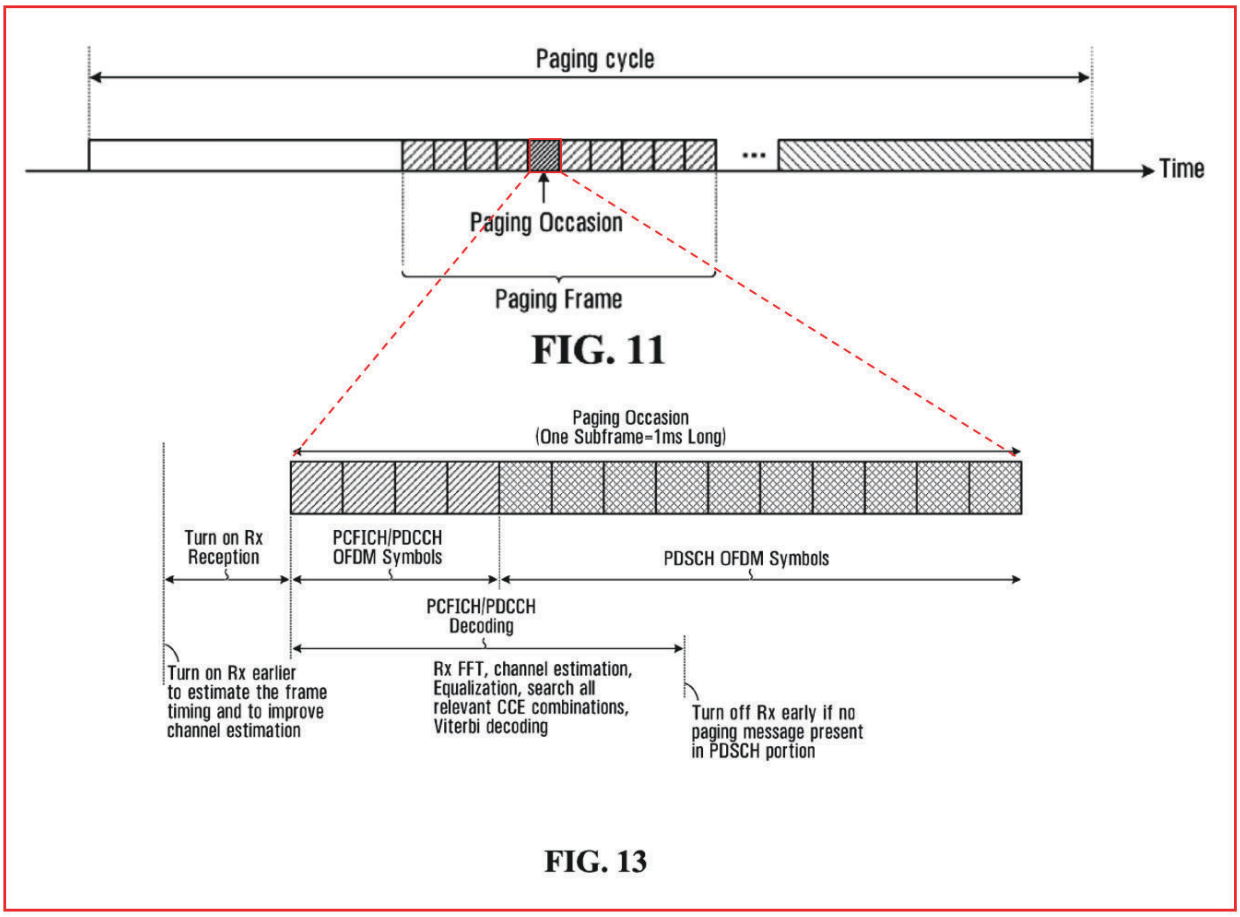
40. The UE must search for its PDCCH through the control region, known as the "PDCCH search space," by decoding each possible PDCCH space to determine if any are encoded with its identifier. APPLE-1007, ¶117. These possible PDCCH spaces are called "PDCCH candidates," suggesting any may contain DCI for the UE. Different PDCCH search spaces can be defined, either for all UEs in a

cell ("common search space" or "CSS") or for specific UEs ("UE-specific search space" or "USS"). APPLE-1007, ¶¶117, 119 (Table 9).

41. The UE monitors the PDCCH search space to find DCI intended for it by attempting to decode each PDCCH. This process, known as blind detection, continues until a PDCCH passes an error check with the cyclic redundancy check (CRC) code scrambled by the UE's identifier. If none are found, the UE continues to monitor the next subframe's control region. APPLE-1007, ¶121.

42. The UE monitors for its identifier information referenced as Radio Network Temporary Identity (RNTI), which is "the information indicating the UE to which the Downlink Control Information (DCI) transmitted on PDCCH is addressed." APPLE-1020, ¶¶[0010], [0213]. The specific type of RNTI that is used for paging is referred to as P-RNTI, which indicates to a UE whether or not a DCI message on the PDCCH is intended for paging. APPLE-1020, ¶[0213].

43. During paging, the UE initiates a reception (Rx) process to monitor (i.e., blindly decode) the PDCCH search space at a paging occasion (PO). If no paging indicator is found in the control region, the UE turns off the Rx process and waits for the next paging occasion. If DCI is detected, the UE decodes the corresponding PDSCH to obtain the paging message. APPLE-1010, ¶¶257-260.



Weng, Figs. 11, 13, Annotated

5. Coverage Enhancement (CE)

44. Conventional 4G/LTE includes a coverage enhancement (CE) mode where a base station may repeat signal transmissions, allowing a UE to attempt repeated receptions to improve decoding success. APPLE-1013, 13:22-24, 14:3-15:11, 15:23-16:8, Fig. 6. This is beneficial for weak signal reception, such as at the cell edge. In CE mode for paging, the same PDCCH may be repeatedly transmitted

in multiple common search spaces (CSSs) across several subframes, enabling a UE to monitor these CSSs during paging occasions. APPLE-1007, ¶¶186-200.

You, Fig. 8, Annotated.

C. 5G/NR Networks

1. Configurable Numerology

45. Due to various factors, including a wide range of available frequency bands (APPLE-1015, ¶¶33, 40), the 5G system supports configurable numerology, including variable subcarrier spacing and symbol duration. *Id.*, ¶57; APPLE-1016, p. 1. For example, during time period 90 in the figure below, bandwidth is divided into four subbands with 7.5, 15, 30, and 60 kHz subcarrier spacings, respectively. During time period 92, a new division creates two subbands with different subcarrier spacings. APPLE-1016, ¶35, Fig. 1. Each subcarrier spacing corresponds to a different symbol and/or slot duration because different subcarrier spacings lead to different symbol durations. APPLE-1017, ¶72; APPLE-1024, Table 2 (reproduced below); APPLE-1022, ¶21.

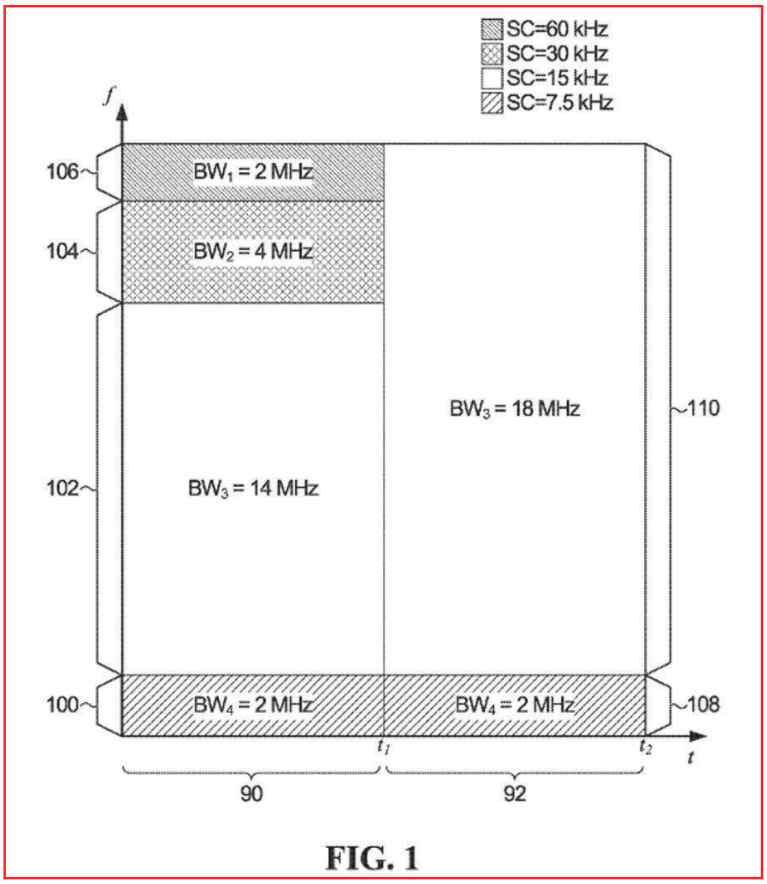


FIG. 1

Islam, Fig. 1.

Table 2. Candidate numerology sets

Subcarrier-spacing	15 KHz	60 KHz	75 KHz	120 KHz	240 KHz	375 KHz
OFDM symbol length (μs) (w/o CP)	66.67	16.67	13.33	8.33	4.17	2.67
CP Length (ns)	4687	1172	938	586	293	188

R1-165162, (APPLE-1024), Table 2

2. Various Frame Structures

46. As discussed above, different subcarrier spacings (i.e., numerologies) result in different frame structures. Thus, 5G's flexible numerology allows for multiple frame

structures to schedule DCI transmission/monitoring, such as paging scheduling information. APPLE-1018, ¶¶155-163 (Tables 1-3). The ’767 patent's portrayal of this flexibility as inventive is unfounded, as it already existed in prior art, including *Yeo*, *Liu*, *Fwu*, and *Pelletier*. For instance, *Yeo* describes “acquiring system information using numerology associated with the control channel among a plurality of numerologies that the terminal supports,” as well as using different frame structures resulting from different subcarrier spacings. APPLE-1005, 4:67-5:3, FIGs. 2B-2D; APPLE-1006, FIGs. 3b-3d, [0474].

VII. THE ’767 PATENT

A. Summary

47. The ’767 patent describes a method and device for paging transmission in a communication system with multiple numerologies, which include various subcarrier spacings and corresponding symbol time durations (APPLE-1001, 1:15-18, 1:34-37). It outlines a process for determining paging transmission opportunities based on the numerology used (*Id*., 2:1-9). Specifically, it claims: (i) using a first signaling to schedule a paging message; (ii) monitoring the first signaling in X time intervals; and (iii) using location of a subband associated with the first signaling to determine the X time intervals. *Id*., 23:2-20.

48. As to the first aspect (i), annotated FIG. 8 below shows that the first signaling determines scheduling information for the first radio signal (APPLE-1001, 19:54-64). This signaling can be physical layer signaling, like DCI (downlink control

information), transmitted via a PDCCH (*Id.*, 20:8-14). The first radio signal carrying the paging message may be sent on a PDSCH (*Id.*, 20:18-19). The "second radio signal [can be] transmitted on a Physical Broadcast channel (PBCH)" and carry either "Master Information Block Information (MIB) information" or "System Information Block Information (SIB) information." *Id.*, 5:37-44.

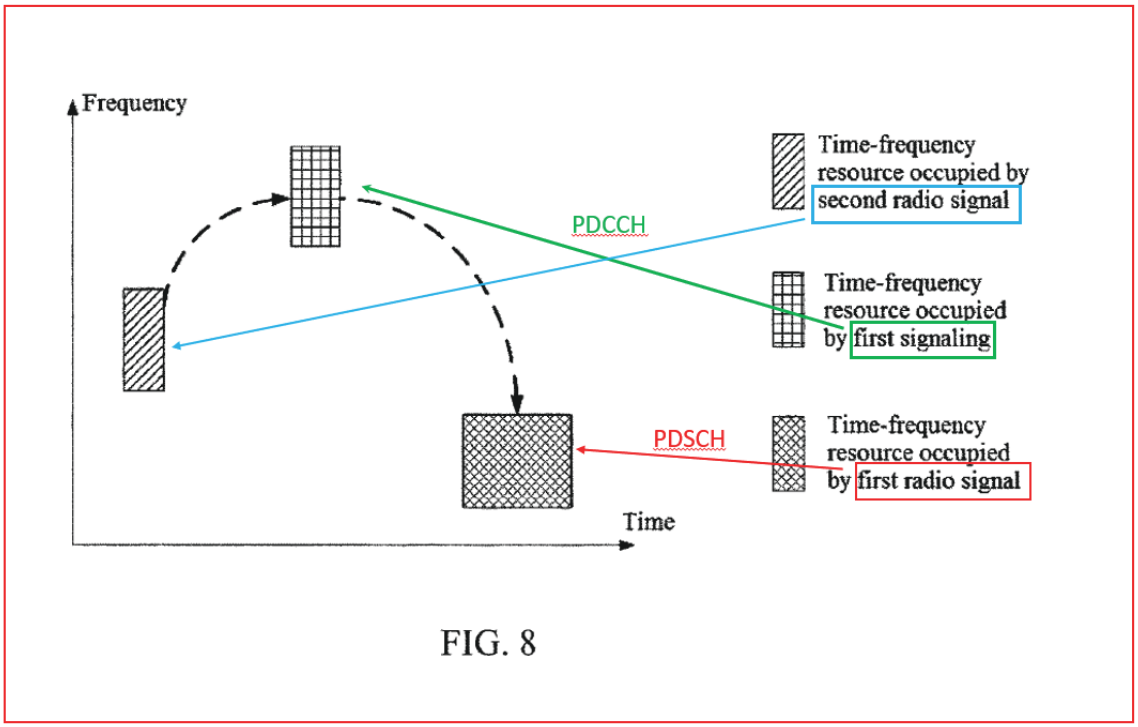


FIG. 8

49. Second concept (ii) is depicted below in annotated FIG. 6 (below), where each filled rectangle signifies a paging time interval monitored by a specific UE within a particular time window. *Id.*, 17:47-54. For instance, UE#2 monitors a first signaling in X2 time intervals, which are part of time window #b. *Id.*, 17:47-56, 17:63-64.

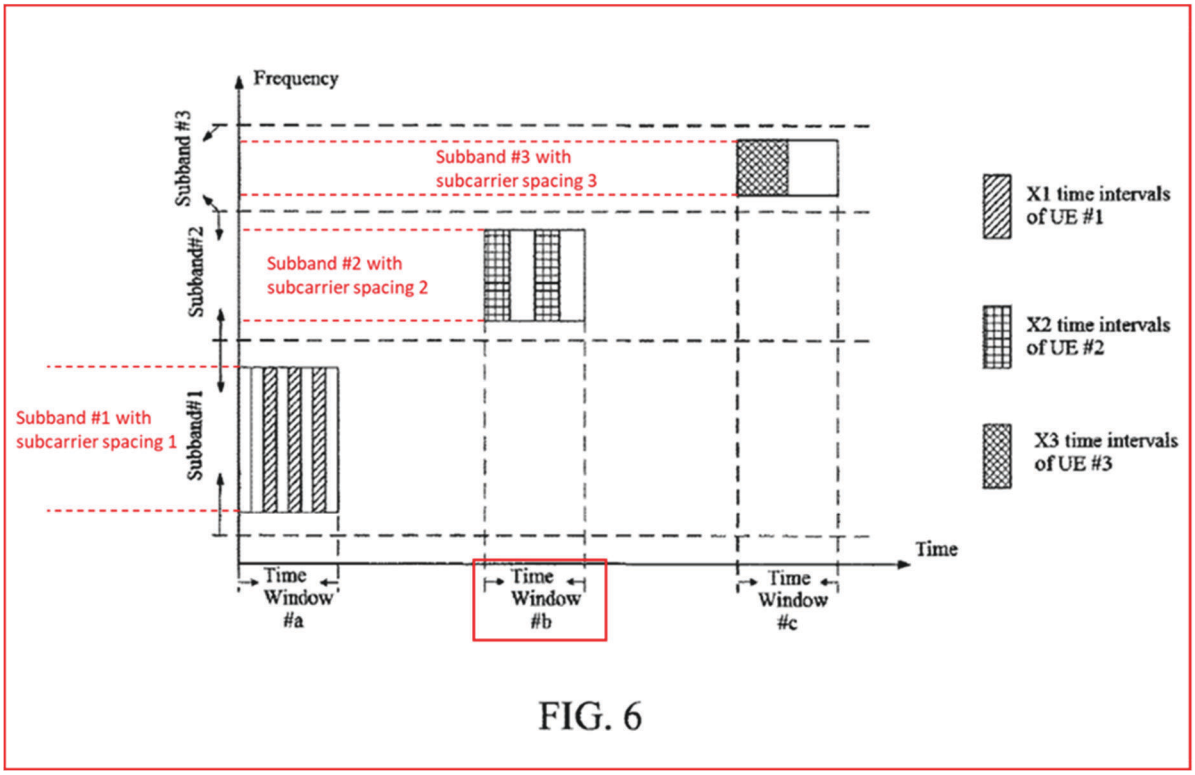


FIG. 6

50. Regarding concept (iii), although the '767 Patent claims that the location of a subband is used for determining X, the patent does not explicitly describe how the determination is made based on the location of the subband. Rather, the '767 patent states that, for each UE, the subband of the frequency domain resource used for transmitting the first signaling "includes a positive integer number of consecutive subcarriers in frequency domain." *Id*., 17:58-59. Annotated FIG 7 illustrates a special case (X=1) for using the subcarrier spacing to determine the X time intervals. *Id*., 18:49-54. Specifically, each UE (UE_a, UE_b, UE_c, or UE_d) is associated with a respective time window. *Id*., 18:55-64, Fig. 7. The subcarrier spacing associated with each UE affects how to divide the respective time window into Y time intervals, and the feature ID of the UE is used to determine which one of the Y time intervals includes the X=1

time interval. *Id*. The '767 patent further clarifies that the time length of each X time interval is correlated with the subcarrier spacing. *Id*., 19:7-10. Thus, subcarrier spacing determines both the time-domain location (i.e., which Y time interval) and the duration (i.e., time length) of each X time interval.

	Index of X=1 time interval in the first time window			
	Feature ID=a	Feature ID=b	Feature ID=c	Feature ID=d
Y=1	0	0	0	0
Y=2	0	1	0	1
Y=4	0	1	2	3
Y=8	1	3	5	7
Y=16	2	6	10	14

This table illustrates, for example, that for a UE with Feature ID=b, if the time window is divided into Y=16 time intervals, the X=1 paging occasion is at interval no. 6 of the time window spanned by the 16 intervals numbered 0, 1,...,15.

FIG. 7

B. Brief Prosecution History

51. During prosecution, the application received a first-action allowance. APPLE-1002, pp. 99-102. A published application associated with *Yeo* was cited during prosecution, but not used in a rejection, or substantively discussed at any level. *TS36* and *Mallick* were never considered.

C. Claim Construction

52. I understand that the words of a claim are generally given their ordinary and customary meaning, which I understand is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention, *i.e*., as of the

effective filing date of the patent application. I understand the person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification and prosecution history. Additionally, I understand other extrinsic evidence external to the patent and prosecution history, such as dictionaries and treatises, may also be useful in determining the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention. I understand that such extrinsic evidence, however, is generally afforded less weight than intrinsic evidence in determining the meaning of claim terms, and overall is unlikely to result in a reliable interpretation of a patent claim scope unless considered in the context of the intrinsic evidence.

53. I have been instructed that the "intrinsic record" includes the patent itself, including the claims, description, and figures (APPLE-1001, '767 Patent), and the patent's prosecution history—*i.e.*, the record of proceedings at the U.S. Patent and Trademark Office ("Patent Office") concerning the patent (APPLE-1002, Prosecution History). I understand that, like the claims and written description, the prosecution history provides evidence to a person of ordinary skill in the art of how the inventor intended his patent to be understood, and how the Patent Office understood the patent. I understand that the inventor is permitted to apply a special definition to the terms or to limit the scope of claim terms in his patent claims, which may differ from the term's

plain and ordinary meaning. That special definition or limitation on scope may be provided in the patent's written description, the patent's prosecution history, or both. I understand that claim interpretation may also be informed by "extrinsic evidence" (that is, evidence outside of the patent record itself). I have been informed that extrinsic evidence may include dictionaries, technical treatises, and other materials evidencing the meaning of a claim term and the understanding held by a POSITA in the relevant time period.

54. I have been asked for purposes of this declaration to apply the plain and ordinary meaning of the claim terms as they would have been understood by a person of ordinary skill in the art at the earliest effective filing date of the '767 Patent.

55. For two particular terms—"receiver module" and "transmitter module"—I have been informed that the two terms are being construed—in addition to according to their plain and ordinary meanings—under 35 U.S.C. 112(f), where the standard is whether the words of the claim are understood by persons of ordinary skill in the art to have a sufficiently definite meaning as the name for structure. Accordingly, I have been asked to review the '767 Patent to identify the corresponding structures associated with the functions being performed by entities implicated by the above claim terms, and I have done so (as noted in detail below).

56. I understand that no claim term's construction is in dispute at this time. Based on my review of these materials and my personal knowledge and experience, I

have considered each term of the ’767 Patent as it would have been understood by a person of ordinary skill in the art at the earliest effective filing date of April 19, 2017. I also understand that I am to interpret each claim term by its plain and ordinary meaning when applying the prior art, which I have done here. In my opinion, Claims 1-20, under their plain and ordinary meaning, are unpatentable for at least the reasons I address below in Grounds 1 and 2.

D. The Challenged Claims

57. I understand that claims 1-20 of the ’767 patent are being challenged in this proceeding. The claims are arranged as follows:

- Claims 1-5: Method for UE
- Claims 6-10: Method for base station
- Claims 11-15: UE device
- Claims 16-20: Base station device

58. Both independent claim 1 and independent claim 11 are directed at the UE device for paging reception. In my opinion, independent claim 11 is substantially similar to claim 1, except it is an apparatus claim directed to “[a] UE for paging,” and requires (1) “a first receiver module” to monitor a first radio signaling in X time intervals, and (2) “a second receiver module” to receive a first radio signal. In addition, claims 2-5 and claims 12-15 are also substantially identical.

59. The following table demonstrates the similarity between claims 1-5 and claims 11-15, with identical language italicized.

Claim 1	**Claim 11**
[1pre] *A* method in a User Equipment (*UE*) *for paging, comprising:*	[11pre] *A UE for paging, comprising:*
[1a] monitoring *a first signaling in X time intervals; and*	[11a] a first receiver module, to monitor *a first signaling in X time intervals; and*
[1b] receiving *a first radio signal;*	[11b] a second receiver module, to receive *a first radio signal;*
[1c] *wherein X is a positive integer;*	[11c] *wherein X is a positive integer;*
[1d] *the first signaling is used for determining scheduling information for the first radio signal;*	[11d] *the first signaling is used for determining scheduling information for the first radio signal;*
[1e] *the scheduling information comprises at least one of {occupied time-frequency resource, adopted* Modulation Coding Scheme (*MCS*)*, subcarrier spacing of subcarriers in occupied frequency domain resource};*	[11e] *the scheduling information comprises at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource};*
[1f] *the first radio signal carries a paging message;*	[11f] *the first radio signal carries a paging message;*
[1g] *the frequency domain resource used for transmitting the first signaling belongs to a first subband;*	[11g] *the frequency domain resource used for transmitting the first signaling belongs to a first subband;*

[1h] *the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and*	[11h] *the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and*

Claim 1	**Claim 11**
[1i] *at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.*	[11i] *at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.*

Claim 2	**Claim 12**
[2a] *The* method *according to claim* 1, *wherein any one of the X time intervals belongs to a first time window in time domain;*	[12a] The UE *according to claim* 11, *wherein any one of the X time intervals belongs to a first time window in time domain;*
[2b] *the time length of the first time window is predefined;*	[12b] *the time length of the first time window is predefined;*
[2c] *the first time window is divided into Y time intervals;*	[12c] *the first time window is divided into Y time intervals;*
[2d] *the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X;*	[12d] *the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X;*
[2e] *the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and*	[12e] *the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and*

[2f] *a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.*	[12f] *a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.*
Claim 3	**Claim 13**
[3a] *The* method *according to claim* 2*, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1;*	[13a] *The* UE *according to claim* 12*, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1;*
[3b] *Z is predefined, or Z is configurable;*	[13b] *Z is predefined, or Z is configurable;*
[3c] *any two of the Z time windows have an equal time length; and*	[13c] *any two of the Z time windows have an equal time length; and*
[3d] *the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.*	[13d] *the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.*

Claim 4	**Claim 14**
[4a] *The* method *according to claim* 1*,* further comprising: receiving *a second radio signal;*	[14a] *The* UE *according to claim* 11*,* wherein the first receiver module further receives *a second radio signal;*
[4b] wherein *the second radio signal is* used *for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.*	[14b] *the second radio signal is for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.*

Claim 5	Claim 15
[5a] *The* method *according to claim* 1*,* further comprising: receiving *a second signaling;*	[15a] *The* UE *according to claim* 11*,* wherein the first receiver module further receives *a second signaling;*

Claim 5	Claim 15
[5b] wherein *the second signaling is* used *for determining Q subbands, Q being a positive integer;*	[15b] *the second signaling is for determining Q subbands, Q being a positive integer;*
[5c] *the first subband belongs to one of the Q subbands;*	[15c] *the first subband belongs to one of the Q subbands;*
[5d] *any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and*	[15d] *any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and*
[5e] *the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.*	[15e] *the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.*

60. Both independent claim 6 and independent claim 16 are directed at the base station for paging transmission. Independent claim 16 is substantially similar to claim 6, except it is an apparatus claim directed to a base station for paging, and requires (1) "a first transmitter module" to transmit a first signaling in a positive integer number of time intervals of X time intervals, and (2) "a second transmitter module" to transmit a first radio signal.

61. The following table demonstrates the similarity between claims 6-10 and claims 16-20, with identical language italicized.

Claim 6	Claim 16
[6pre] *A* method in a *base station for paging, comprising:*	[16pre] *A base station for paging, comprising:*
[6a] transmitting *a first signaling in a positive integer number of time intervals of X time intervals; and*	[16a] a first transmitter module, to transmit *a first signaling in a positive integer number of time intervals of X time intervals; and*
[6b] transmitting *a first radio signal;*	[16b] a second transmitter module, to transmit *a first radio signal;*
[6c] *wherein X is a positive integer;*	[16c] *wherein X is a positive integer;*
[6d] *the first signaling is used for determining scheduling information for the first radio signal;*	[16d] *the first signaling is used for determining scheduling information for the first radio signal;*
[6e] *the scheduling information comprises at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource};*	[16e] *the scheduling information comprises at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource};*
[6f] *the first radio signal carries a paging message;*	[16f] *the first radio signal carries a paging message;*
[6g] *the frequency domain resource used for transmitting the first signaling belongs to a first subband;*	[16g] *the frequency domain resource used for transmitting the first signaling belongs to a first subband;*

[6h] *the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and*	[16h] *the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and*
[6i] *at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.*	[16i] *at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.*

Claim 7	**Claim 17**
[7a] *The* method *according to claim* 6*, wherein any one of the X time intervals belongs to a first time window in time domain;*	[17a] *The* base station *according to claim* 16*, wherein any one of the X time intervals belongs to a first time window in time domain;*
[7b] *the time length of the first time window is predefined;*	[17b] *the time length of the first time window is predefined;*
[7c] *the first time window is divided into Y time intervals;*	[17c] *the first time window is divided into Y time intervals;*
[7d] *the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X;*	[17d] *the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X;*
[7e] *the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and*	[17e] *the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and*
[7f] *a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.*	[17f] *a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.*

Claim 8	Claim 18
[8a] *The* method *according to claim* 7*, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1;*	[18a] *The* base station *according to claim* 17*, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1;*
[8b] *Z is predefined, or Z is configurable;*	[18b] *Z is predefined, or Z is configurable;*
[8c] *any two of the Z time windows have an equal time length; and*	[18c] *any two of the Z time windows have an equal time length; and*
[8d] *the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.*	[18d] *the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.*

Claim 9	Claim 19
[9a] *The* method *according to claim* 6*,* further comprising: transmitting *a second radio signal;*	[19a] *The* base station *according to claim* 16*,* wherein the first transmitter module further transmits *a second radio signal;*
[9b] wherein *the second radio signal is* used *for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.*	[19b] *the second radio signal is for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.*

Claim 10	Claim 20
[10a] *The* method *according to claim* 6*,* further comprising: transmitting *a second signaling;*	[20a] *The* base station *according to claim* 16*,* wherein the first transmitter module further transmits *a second signaling;*
[10b] wherein *the second signaling is* used *for determining Q subbands, Q being a positive integer;*	[20b] *the second signaling is for determining Q subbands, Q being a positive integer;*
[10c] *the first subband belongs to one of the Q subbands;*	[20c] *the first subband belongs to one of the Q subbands;*
[10d] *any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and*	[20d] *any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and*
[10e] *the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.*	[20e] *the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.*

62. Claims 1-5 and 6-10 recite corresponding methods performed by a UE and base station, respectively. The following table demonstrates the similarity between claims 1-5 and claims 6-10, with identical language italicized.

Claim 1	Claim 6
[1pre] *A method in a* User Equipment (UE) *for paging, comprising:*	[6pre] *A method in a* base station *for paging, comprising:*
[1a] monitoring *a first signaling in X time intervals; and*	[6a] transmitting *a first signaling in* a positive integer number of time intervals of *X time intervals; and*

[1b] receiving *a first radio signal;*	[6b] transmitting *a first radio signal;*
[1c] *wherein X is a positive integer;*	[6c] *wherein X is a positive integer;*
[1d] *the first signaling is used for determining scheduling information for the first radio signal;*	[6d] *the first signaling is used for determining scheduling information for the first radio signal;*
[1e] *the scheduling information comprises at least one of {occupied time-frequency resource, adopted* Modulation Coding Scheme (*MCS*)*, subcarrier spacing of subcarriers in occupied frequency domain resource};*	[6e] *the scheduling information comprises at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource};*
[1f] *the first radio signal carries a paging message;*	[6f] *the first radio signal carries a paging message;*
[1g] *the frequency domain resource used for transmitting the first signaling belongs to a first subband;*	[6g] *the frequency domain resource used for transmitting the first signaling belongs to a first subband;*
[1h] *the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and*	[6h] *the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and*
[1i] *at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.*	[6i] *at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.*

Claim 2	**Claim 7**
[2a] *The method according to claim* 1*, wherein any one of the X time intervals belongs to a first time window in time domain;*	[7a] *The method according to claim* 6*, wherein any one of the X time intervals belongs to a first time window in time domain;*

[2b] *the time length of the first time window is predefined;*	[7b] *the time length of the first time window is predefined;*
[2c] *the first time window is divided into Y time intervals;*	[7c] *the first time window is divided into Y time intervals;*
[2d] *the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X;*	[7d] *the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X;*
[2e] *the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and*	[7e] *the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and*
[2f] *a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.*	[7f] *a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.*

Claim 3	**Claim 8**
[3a] *The method according to claim* 2*, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1;*	[8a] *The method according to claim* 7*, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1;*
[3b] *Z is predefined, or Z is configurable;*	[8b] *Z is predefined, or Z is configurable;*
[3c] *any two of the Z time windows have an equal time length; and*	[8c] *any two of the Z time windows have an equal time length; and*
[3d] *the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.*	[8d] *the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.*

Claim 4	Claim 9
[4a] *The method according to claim* 1, *further comprising:* receiving *a second radio signal;*	[9a] *The method according to claim* 6, *further comprising:* transmitting *a second radio signal;*
[4b] *wherein the second radio signal is* used *for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.*	[9b] *wherein the second radio signal is* used *for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.*

Claim 5	Claim 10
[5a] *The method according to claim* 1, *further comprising:* receiving *a second signaling;*	[10a] *The method according to claim* 6, *further comprising:* transmitting *a second signaling;*
[5b] *wherein the second signaling is* used *for determining Q subbands, Q being a positive integer;*	[10b] *wherein the second signaling is used for determining Q subbands, Q being a positive integer;*
[5c] *the first subband belongs to one of the Q subbands;*	[10c] *the first subband belongs to one of the Q subbands;*
[5d] *any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and*	[10d] *any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and*
[5e] *the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.*	[10e] *the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.*

63. The following table demonstrates the similarity between claims 1-5 and claims 16-20, with identical language italicized.

Claim 1	**Claim 16**
[1pre] *A* method in a User Equipment (UE) *for paging, comprising:*	[16pre] *A* base station *for paging, comprising:*
[1a] monitoring *a first signaling in X time intervals; and*	[16a] a first transmitter module, to transmit *a first signaling in* a positive integer number of time intervals of *X time intervals; and*
[1b] receiving *a first radio signal;*	[16b] a second transmitter module, to transmit *a first radio signal;*
[1c] *wherein X is a positive integer;*	[16c] *wherein X is a positive integer;*
[1d] *the first signaling is used for determining scheduling information for the first radio signal;*	[16d] *the first signaling is used for determining scheduling information for the first radio signal;*
[1e] *the scheduling information comprises at least one of {occupied time-frequency resource, adopted* Modulation Coding Scheme (*MCS*)*, subcarrier spacing of subcarriers in occupied frequency domain resource};*	[16e] *the scheduling information comprises at least one of {occupied time-frequency resource, adopted MCS, subcarrier spacing of subcarriers in occupied frequency domain resource};*
[1f] *the first radio signal carries a paging message;*	[16f] *the first radio signal carries a paging message;*
[1g] *the frequency domain resource used for transmitting the first signaling belongs to a first subband;*	[16g] *the frequency domain resource used for transmitting the first signaling belongs to a first subband;*

[1h] *the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and*	[16h] *the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and*

Claim 1	**Claim 16**
[1i] *at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.*	[16i] *at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals.*

Claim 2	**Claim 17**
[2a] *The* method *according to claim* 1, *wherein any one of the X time intervals belongs to a first time window in time domain;*	[17a] *The* base station *according to claim* 16, *wherein any one of the X time intervals belongs to a first time window in time domain;*
[2b] *the time length of the first time window is predefined;*	[17b] *the time length of the first time window is predefined;*
[2c] *the first time window is divided into Y time intervals;*	[17c] *the first time window is divided into Y time intervals;*
[2d] *the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X;*	[17d] *the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X;*
[2e] *the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and*	[17e] *the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and*

[2f] *a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.*	[17f] *a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals.*

Claim 3	**Claim 18**
[3a] *The* method *according to claim* 2, *wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1;*	[18a] *The* base station *according to claim* 17, *wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1;*
[3b] *Z is predefined, or Z is configurable;*	[18b] *Z is predefined, or Z is configurable;*
[3c] *any two of the Z time windows have an equal time length; and*	[18c] *any two of the Z time windows have an equal time length; and*
[3d] *the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.*	[18d] *the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows.*

Claim 4	**Claim 19**
[4a] *The* method *according to claim* 1, *further* comprising: receiving *a second radio signal;*	[19a] *The* base station *according to claim* 16, wherein the first transmitter module *further* transmits *a second radio signal;*

[4b] wherein *the second radio signal is* used *for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.*	[19b] *the second radio signal is for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}.*
Claim 5	**Claim 20**
[5a] *The* method *according to claim* 1, *further* comprising: receiving *a second signaling;*	[20a] *The* base station *according to claim* 16, wherein the first transmitter module *further* transmits *a second signaling;*
[5b] wherein *the second signaling is* used *for determining Q subbands, Q being a positive integer;*	[20b] *the second signaling is for determining Q subbands, Q being a positive integer;*
[5c] *the first subband belongs to one of the Q subbands;*	[20c] *the first subband belongs to one of the Q subbands;*
[5d] *any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and*	[20d] *any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and*
[5e] *the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.*	[20e] *the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands.*

64. Similarly, claims 11-15 and 16-20 recite corresponding features in a UE and a base station, respectively.

VIII. ANALYSIS OF THE CHALLENGED CLAIMS

A. [GROUND 1] *Yeo* and *TS36* render obvious claims 1, 4-6, 9-11, 14-16, 19, and 20

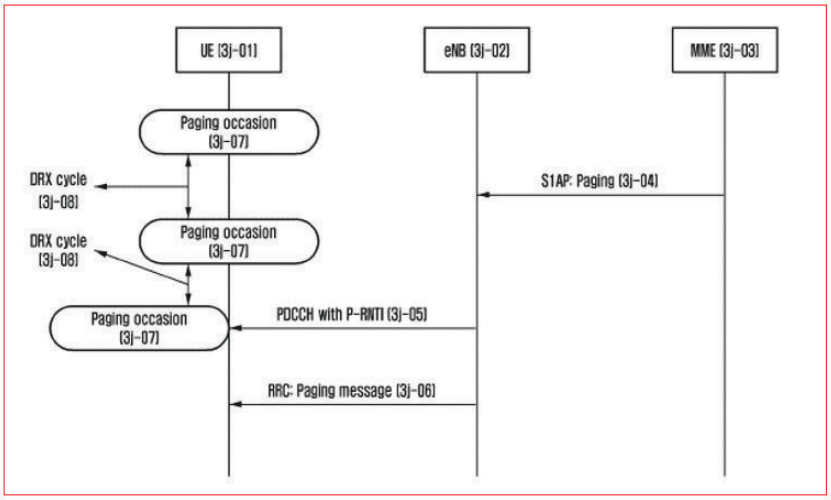
1. Effective Filing Date of Yeo

65. I understand that *Yeo* (APPLE-1005) claims priority to KR Application 10-2016-0125809 filed on September 29, 2016 (APPLE-1006-*Yeo-Priority*). For my review below, I have provided citations to *Yeo* (APPLE-1005) and also to the corresponding portions in *Yeo-Priority* (APPLE-1006). *Yeo* also claims priority to KR applications 10-2016-0106427 (filed August 22, 2016), but I have not relied on this document for my analysis.

2. Yeo

66. *Yeo* is directed to, among other things, "paging in wireless cellular communication system" – and is therefore in the same technology area as the '767 Patent. APPLE-1005, Title; APPLE-1006, [0013]. Like the '767 Patent, *Yeo* addresses, in the relevant portions, paging transmission in a "5G communication system… for supporting a plurality of numerologies or subcarrier spacings in one system. APPLE-1005, 3:12-16, APPLE-1006, [0014]. As background information, *Yeo* describes the paging procedure employed in 4G LTE systems, and then extends the concept to adapt to variable numerologies available in 5G NR systems. For example, with reference to FIG. 3J, reproduced below with annotations, *Yeo*

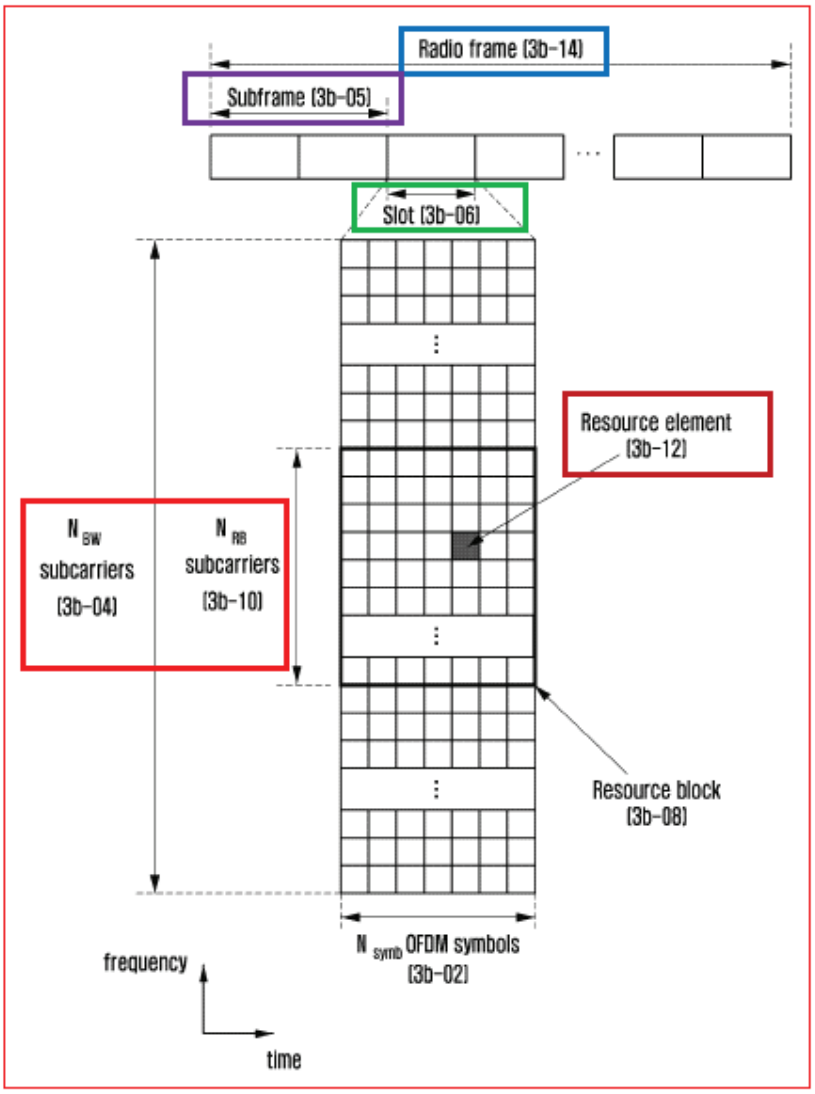
describes that in an efficient paging procedure, a terminal (or user equipment (UE)) wakes up for "a little while in a predetermined time interval… to observe the paging information from the network, allowing the terminal…to be…idle…for most of the time." APPLE-1005, 53:8-12; APPLE-1006, [0455]. For this, *Yeo*, adopts the basic paging structure of LTE, noting that a paging occasion (PO) is "a subframe in which the PDCCH [is] configured [to transmit information that] a paging message exists," and a paging frame (PF) is "one radio frame including one or more POs." The UE is described as being able to "observe one PO per discontinuous reception (DRX) period." APPLE-1005, 53:12-20; APPLE-1006, [0455].



Yeo, Fig. 3J.

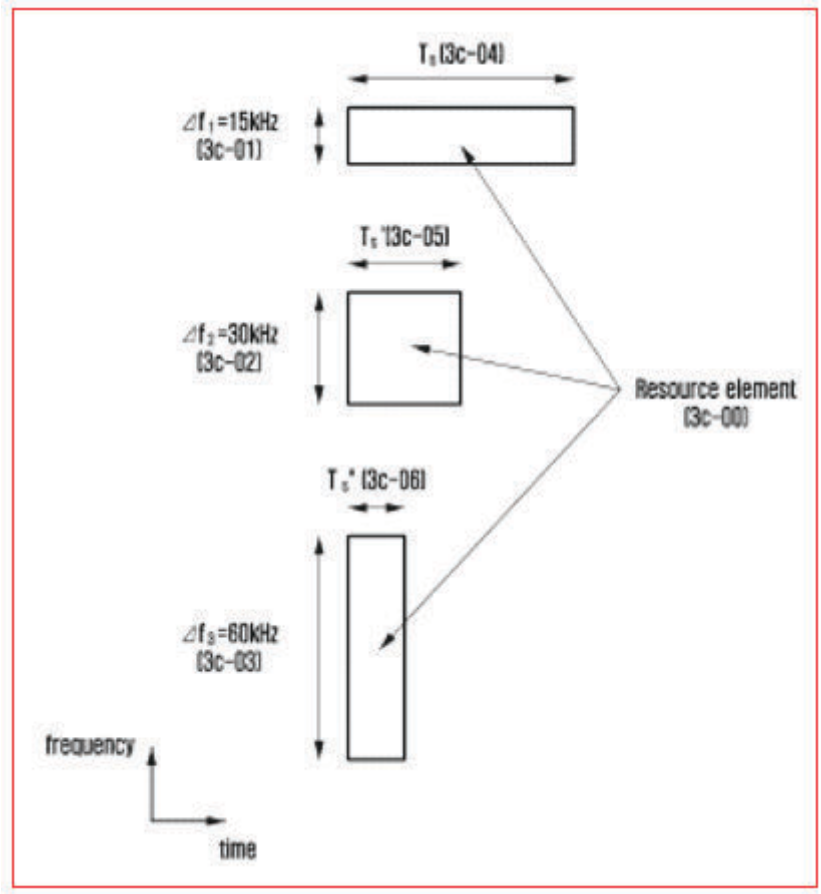
67. The structure of the paging frame and PO subframe generally adheres to the basic structure used in LTE with each radio frame including multiple

subframes and each subframe including two slots, each of which includes multiple OFDM symbols. APPLE-1005, FIG. 3B (annotated below); APPLE-1006, FIG. 1a. Each OFDM symbol includes multiple resource elements that each having a different frequency range. The frequency range corresponding to each resource element in an OFDM symbol is referred to as a subcarrier, and the width of the frequency range is referred to as subcarrier spacing.



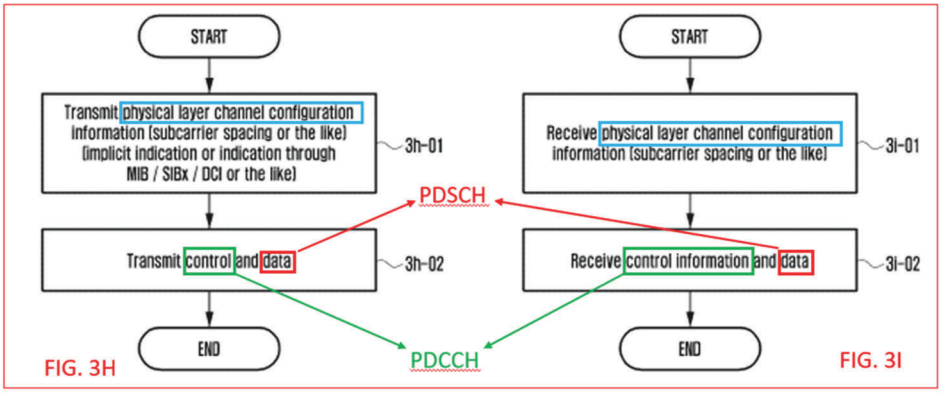
Yeo, FIG. 3B, Annotated

68. *Yeo* extends the above frame structure to the variable numerology concept in 5G, where the length or duration of each OFDM symbol varies with subcarrier spacing. Specifically, FIG. 3C (annotated below) shows resource elements for subcarrier spacings 15KHz, 30 KHz, and 60Khz, and it is noted that "the subcarrier spacing and the length of the OFDM symbol have a reciprocal relationship with each other." APPLE-1005, 43:49-62; APPLE-1006, [0383].



Yeo, FIG. 3C

69. Because the OFDM symbol durations are different for different subcarrier spacings, a UE needs to know the numerology information to decode the information received during paging occasions. More specifically, with reference to its FIG. 3H and 3I (annotated below) as well as FIGs. 3L and 3M, *Yeo* describes that a base station "transmits information on numerology (e.g., subcarrier spacing, etc.) for the physical layer channel used for paging," prior to transmitting any "control information and data for paging." The information on numerology can include a Master Information Block (MIB) or a system information block (SIBx). A terminal (or user equipment UE) receives the "information on the physical layer numerology" and upon determining that the terminal supports the numerology, proceeds to receive "the control information and data reception." APPLE-1005, 56:12-27; APPLE-1006, [0452]. The data for paging or "paging message" is transmitted on the PDSCH, and scheduling information on the PDSCH can be acquired from the PDCCH. APPLE-1005, 3:48-50; APPLE-1006, [0013].



Yeo, Figs. 3H and 3I, Annotated

70. *Yeo* further describes various types of UEs that are served by the wireless network, including UE type that supports massive machine type communication (mMTC), UE type that supports MIMO (multiple-input-multipl-output), UE type that supports enhanced mobile broadband (eMBB), and UE type that supports ultra-reliable and low-latency communications (URLLC). APPLE-1005, 2:13-23, 10:10-14; APPLE-1006, [0004], [0027]. Massive MTC (mMTC) is a type of MTC that supports mass communications among connected devices. APPLE-1005, 29:5-7; APPLE-1006, [0211]. The frequency subband in use for a UE can vary with the type of devices/communications and associated requirements, and thus be allocated accordingly. See, for example, APPLE-1005, FIG. 1D, 9:60-10:21; APPLE-1006, FIG. 1d, [0027].

71. *Yeo* is analogous art to the '767 Patent. Indeed, comparison of *Yeo*'s FIGs. 3H and 3I with FIG. 8 from the '767 Patent (*supra*) reveals that *Yeo* describes the overall solution that the '767 purports to solve – determining "transmission opportunities of paging according to the numerology employed by the paging." APPLE-1001, 2:1-5.

3. TS36

72. *TS36* is a Technical Specification document published by the 3GPP and pertains to Evolved Universal Terrestrial Radio Access (E-UTRA) UE procedures in idle mode. E-UTRA technology is well-known to be associated with

4G/LTE. APPLE-1019, 1:25-31. In the relevant portions, *TS36* specifically describes details of paging procedures, in particular, details of the DRX mode referred to in *Yeo*. APPLE-1009, p.39. For example, *TS36* specifically covers details of implementations where a paging frame (PF) contains "one or multiple Paging Occasion(s)" and the UE "needs only to monitor one PO per DRX cycle" – as also described in *Yeo* with respect to FIG. 3J. APPLE-1009, p.39; APPLE-1005, 53:12-20; APPLE-1006, [0455]. Monitoring the PO includes monitoring PDCCH within the PO for the identifier P-RNTI - which indicates to a UE whether or not paging is scheduled in the PO for the UE. The UE performs the paging message reception in a Paging Narrowband (PNB) that is within the subband assigned to the UE. APPLE-1009, p.39. The subband can be assigned depending on the type of services of services—such as enhanced mobile broadband (eMBB), mMTC, ultra-reliable and low-latency communications (URLLC), etc.—provided by the UE. APPLE-1005, FIG. 1D, 9:60-10:21; APPLE-1006, FIG. 1d, [0027].

73. *TS36* provides the formulae that are used for determining PF and PO in implementing paging in DRX – based on DRX parameters provided as portions of System Information (SI). Specifically, the system frame number (SFN) of the radio frame corresponding to PF is determined as:

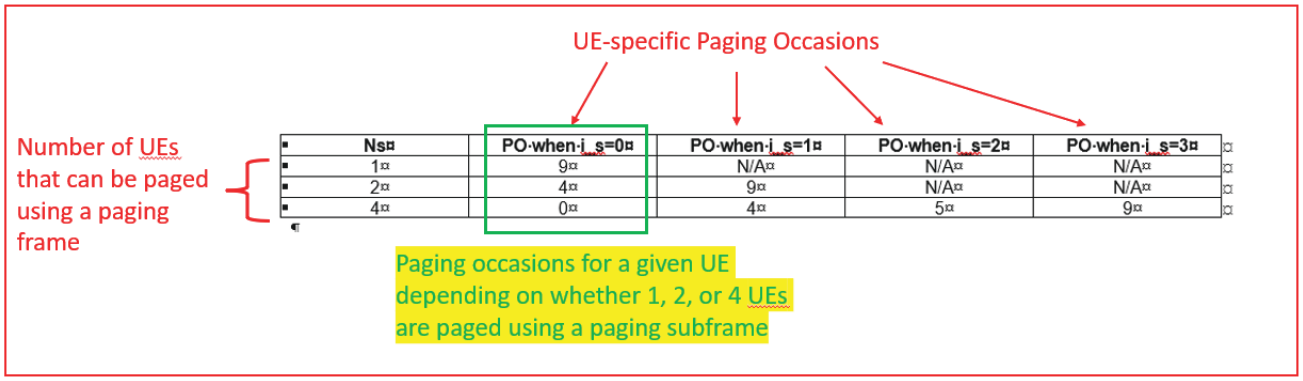
SFN mod T= (T div N)*(UE_ID mod N)

An index i_s that points to the PO within the PF is determined as:

i_s = floor(UE_ID/N) mod Ns

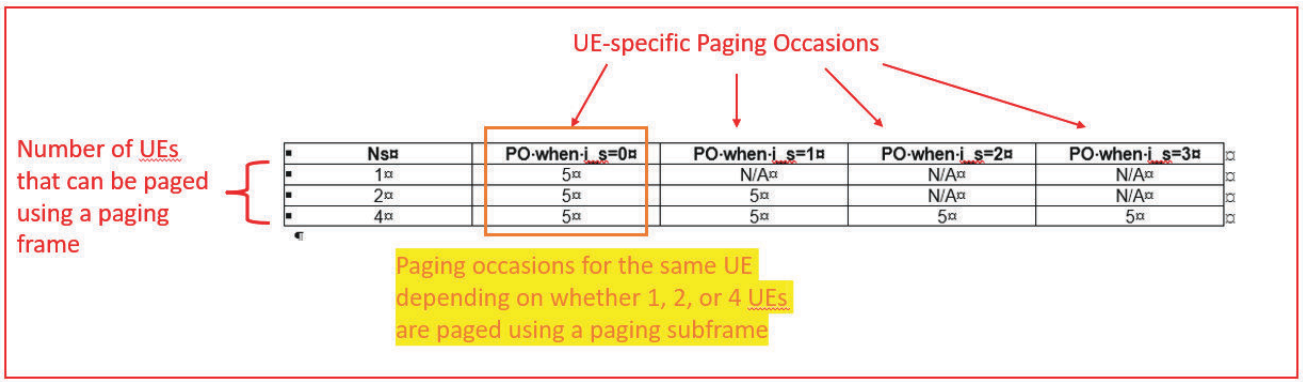
Notably, the determination of the PF and PO depends explicitly on an identifier (UE_ID) of the UE – signifying that each UE has a designated PF and PO in a paging cycle. APPLE-1009, p.39.

74. *TS36* also shows how the determination of PO is affected by the location of the system bandwidth. For example, *TS36* describes that "if P-RNTI is transmitted on MPDCCH with system bandwidth > 3MHz", the paging occasions can be determined as per the following table (APPLE-1009, page 40, annotated):



Ns	PO when i_s=0	PO when i_s=1	PO when i_s=2	PO when i_s=3
1	9	N/A	N/A	N/A
2	4	9	N/A	N/A
4	0	4	5	9

75. *TS36* further describes that "if P-RNTI is transmitted on MPDCCH with system bandwidth of 1.4MHz and 3MHz", i.e., for system bandwidths narrower than the previous case of bandwidth greater than 3 MHz, the corresponding paging occasions can be determined as per the following table (APPLE-1009, page 41, annotated):



76. Thus, *TS36* describes that determination of the time intervals corresponding to the POs depends on the system bandwidth. It was also well-known to a POSITA as of the Critical Date that different system bandwidths could be allocated to different locations in the frequency domain (with the allocation varying over time). *See* for example, FIG. 1 of *Islam* (reproduced above), which shows that allocations change from one time period to another. APPLE-1016, FIG. 1. As such, *TS36* makes it clear that the determination of paging occasions depends explicitly on the width (and hence location) of the system bandwidth.

4. Combining Yeo and TS36

77. Although *Yeo* describes that a "PF is defined as one radio frame including one or more POs," and that a UE "can observe one PO per discontinuous reception (DRX) period," *Yeo* leaves out some implementation details – e.g., how a UE identifies the one or more POs in a PF. APPLE-1005, 53:14-17; APPLE-1006, [0455]. Yet, to implement the technology described in *Yeo*—for example, to have a UE monitor a PO where PDCCH is encoded with P-RNTI (as described with

respect to FIG. 3J)—a POSITA would look for such implementation details. However, such details were well-known by the Critical Date, for example, through technical specifications published by 3GPP working groups in the relevant technical areas. *Yeo* specifically mentions "long term evolution (LTE) or evolved universal terrestrial radio access (E-UTRA) of the 3GPP," (APPLE-1005, 11:48-49; APPLE-1006, [0036]) as well as paging operations of a UE in an idle mode (APPLE-1005, 3:39-59; APPLE-1006, [0013]), and a POSITA would have turned to *TS36* to implement these feature sets at least because *TS36* specifically provides the requisite technical specifications for the paging operations described in *Yeo*.

78. A POSITA would have known that the 3GPP Technical Specification Group (TSG) has already approved standardization that "specifies the Access Stratum (AS) part of the Idle Mode procedures applicable to a UE", which provides the paging details of UE in idle mode compatible with other aspects of the 3GPP cellular standard. APPLE-1009, p.6. Indeed, *TS36* bears the title "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode" and supplies details of the implementations that are missing from *Yeo*.

79. For example, while *Yeo* (i) describes the exact same equation for determining a PF as *TS36*, and (ii) notes that a PF includes "one or more POs,"

Yeo does not specifically describe how those "one or more POs" are determined by a UE (*compare Yeo*'s "equation 3" in column 53 to the equation "SFN mod T= (T div N)*(UE_ID mod N)" on page 39 in *TS36*). *TS36* fills in this gap by describing that the index "i_s pointing to PO" is given by the equation "i_s = floor(UE_ID/N) mod Ns." A POSITA would have had a reasonable expectation of success in combining *Yeo* with *TS36* at least because the combination leads to the predictable result of determining the UE-specific POs within the PF of *Yeo*.

80. Overall, a POSITA would have referred to the equations and tables described in *TS36* to determine the implementations details associated with implementing the paging procedure described in *Yeo*. APPLE-1009, p.39-40. The combination would yield predictable results by allowing for different UE-specific POs within PFs of *Yeo*'s system as a function of the location of the paging subband.

1. Independent Claim 1

[1pre]: "A method in a User Equipment (UE) for paging, comprising:"

81. As shown in FIG. 3I and 3J (reproduced above), *Yeo* describes a method in a UE for paging, for example, to monitor a PDCCH in a paging occasion. APPLE-1005, FIGs. 3I and 3J, 52:50-54; APPLE-1006, FIGs. 5h

and 5i, [0452]. The combination of *Yeo* with *TS36* at least renders this feature obvious.

[1a]:"monitoring a first signaling in X time intervals; and"

82. *Yeo* describes that a terminal or UE "[i]n order to observe the paging information, the terminal wakes up for a little while at a predetermined time interval to observe control signaling." APPLE-1005, 3:40-43; APPLE-1006, [0013]. *Yeo*'s "PDCCH configured as P-RNTI" constitutes or at least renders obvious the claimed "first signaling" because *Yeo* describes that in order to receive paging messages, "specific mapping location in the frequency domain, the modulation scheme, or the like may be determined based on the DCI transmitted through the PDCCH." APPLE-1005, 14:5-8, APPLE-1006, [0055]. The combination of *Yeo* with *TS36* renders this feature obvious.

83. *Yeo* defines each paging occasion "as a subframe in which the PDCCH [is] configured as the P-RNTI," and a paging frame as "one radio frame including one or more POs." APPLE-1005, 53:14-17; APPLE-1006, [0455]. As such, the time intervals associated with the POs in *Yeo* constitute or at least render obvious the "X time intervals."

84. In the Complaint filed against Apple in the Western District of Texas, Patent Owner explicitly equates "first signaling" to"paging DCI" and

"P-RNTI," and the "X time intervals" to "PDCCH monitoring occasions" – which, as described above, are disclosed by *Yeo*. APPLE-1023, ¶¶81, 83, 85, 257. The combination of *Yeo* with *TS36* at least renders this feature obvious.

[1b]: "receiving a first radio signal;"

85. *Yeo* describes this limitation by disclosing that "[t]he paging message is transmitted through the PDSCH, and scheduling information on the PDSCH can be acquired from the PDCCH configured as P-RNTI." APPLE-1005, 53:48-51; APPLE-1006, [0013]. Here, the PDSCH containing the paging message constitutes or at least renders obvious the claimed "first radio signal" because *Yeo* describes that "downlink data may be transmitted on a physical downlink shared channel (PDSCH) that is a physical channel for downlink data transmission." APPLE-1005, 14:1-3; APPLE-1006, [0055]. From at least this description, a POSITA would have understood that the PDSCH is a radio signal. Indeed, this is also consistent with the position adopted by the Patent Owner in pending litigation. APPLE-1023, ¶¶81, 83, 84 (equating "first radio signal" to paging messages on PDSCH). The combination of *Yeo* with *TS36* at least renders this feature obvious.

[1c]: "wherein X is a positive integer;"

86. As discussed for [1a], *Yeo* describes a paging frame to include "one or more POs." APPLE-1005, 53:14-17; APPLE-1006, [0455]. A POSITA would have understood that the number of POs can only be positive integers. The combination of *Yeo* with *TS36* at least renders this feature obvious.

[1d]: "the first signaling is used for determining scheduling information for the first radio signal;"

87. *Yeo* describes that "[t]he paging message is transmitted through the PDSCH, and scheduling information on the PDSCH can be acquired from the PDCCH configured as P-RNTI." APPLE-1005, 53:48-51; APPLE-1006, [0013]. As described with respect to limitations [1a] and [1b], *Yeo*'s "PDCCH configured as P-RNTI" constitutes or at least renders obvious the claimed "first signaling," and the PDSCH constitutes or at least renders obvious the claimed "first radio signal." This is identical to what Patent Owner alleges in the pending litigation – noting that in the "Accused Products," "the first signaling (e.g., paging DCI, P-RNTI) is used for determining scheduling information for the first radio signal." APPLE-1023, ¶83, 258. The combination of *Yeo* with *TS36* at least renders this feature obvious.

[1e]: "the scheduling information comprises at least one of

{occupied time-frequency resource, adopted Modulation Coding Scheme (MCS), subcarrier spacing of subcarriers in occupied frequency domain resource};"

88. While the above feature requires the scheduling information to include only one of three different parameters, *Yeo* describes all three.

89. *Yeo* describes that the "the scheduling information…is transmitted…through downlink control information (DCI)," and in "DCI format 1" includes "at least one of the following control information":

- "Resource allocation type 0/1 flag:…The type 0 applies a bitmap scheme to allocate a resource in a resource block group (RBG) unit. In the LTE system, a basic unit of the scheduling is the resource block (RB) represented by a time-frequency domain resource and the RBG includes a plurality of RBs and thus becomes a basic unit of the scheduling in the type 0 scheme. The type 1 allocates a specific RB within the RBG."…

- "Modulation and coding scheme (MCS)"

APPLE-1005, 13:21-40; APPLE-1006, [0046]-[0048].

90. *Yeo* also describes embodiments in which the scheduling information includes "subcarrier spacing of subcarriers in occupied frequency domain

resource." For example, *Yeo* describes that "the base station…can include information on the subcarrier spacing of the PDSCH…to which the contention resolution message is transmitted in the DCI transmitted to the PDCCH." While this description is generic and not specific to only paging messages. While the PDCCH described above is configured with C-RNTI, a POSITA would have readily understood that it is straightforward to extend the concept to other RNTI transmissions including DCI transmitted over PDCCH configured with P-RNTI such that the UE can detect and receive paging. APPLE-1005, 52:10-14, 38-40; APPLE-1006, [0450], [0228]. The combination of *Yeo* with *TS36* at least renders this feature obvious.

[1f]: "the first radio signal carries a paging message;"

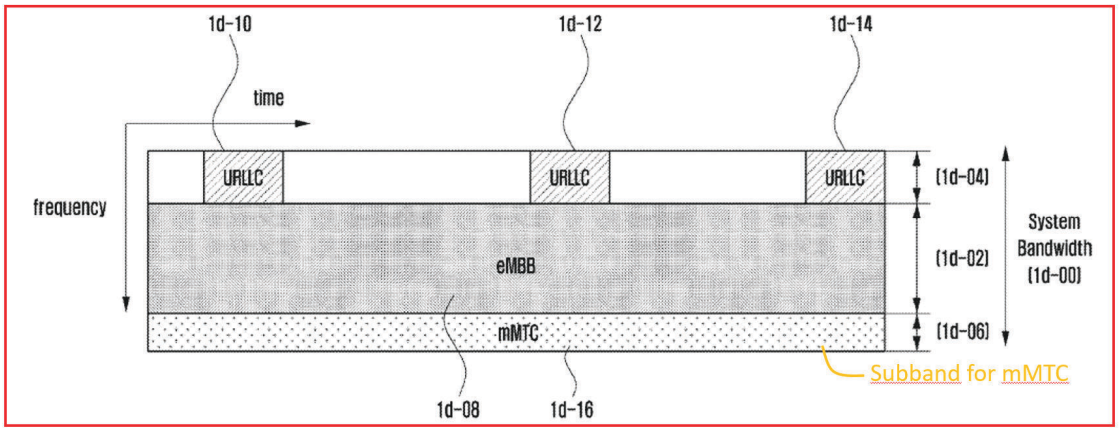
91. As discussed in [1b], *Yeo* describes that "[t]he paging message is transmitted through the PDSCH." APPLE-1005, 3:48-49; APPLE-1006, [0464]. The combination of *Yeo* with *TS36* at least renders this feature obvious.

[1g]: "the frequency domain resource used for transmitting the first signaling belongs to a first subband;"

92. *Yeo* in combination with *TS36* renders obvious this feature. As described with respect to limitation [1a], *Yeo*'s "PDCCH configured as P-RNTI" constitutes or at least renders obvious the claimed "first signaling." *Yeo* further describes "mapping location in the frequency domain of the PDCCH

maybe…transmitted over the entire system transmission bandwidth." APPLE-1005, 13:64-67; APPLE-1006, [0054]. As such, a POSITA would have readily understood from this disclosure that the bandwidth for transmitting the PDCCH constitutes or at least renders obvious "the frequency domain resource."

93. Further, as discussed above, *Yeo* describes various types of UEs that are served by the wireless network, including UE type that supports massive machine type communication (mMTC), UE type that supports MIMO, UE type that supports enhanced mobile broadband (eMBB), and UE type that supports ultra-reliable and low-latency Communications (URLLC). APPLE-1005, 2:13-23; APPLE-1006, [0004]. Massive MTC (mMTC) is a type of MTC that supports mass communications among connected devices. APPLE-1005, 29:5-7; APPLE-1006, [0211]. The frequency bands in use can vary with the type of devices/communications and associated requirements, and thus be allocated accordingly. APPLE-1005, FIG. 1D, 9:60-10:21; APPLE-1006, FIG. 1d, [0027]. *Yeo* describes—with reference to FIG. 1D (annotated below)—"the subband 1d-06…for mMTC data transmission." APPLE-1005, 16:24-36.; APPLE-1006, [0168].



Yeo, FIG. 1D, Annotated

94. It was well known to a POSITA as of the Critical Date that "a downlink (DL) means a radio transmission path of a signal transmitted from a base station to a terminal," and a "Master information block (MIB)…includes…[i]nformation on downlink cell bandwidth." APPLE-1005, 18:56-57, 45:29-35; APPLE-1006, [0182], [0391]-[0394]. It was also well-known as of the Critical Date that downlink information is transmitted over DL transport channels which could include "a Broadcast Channel (BCH), Downlink Shared Data Channel (DL-SDCH) and a Paging Channel (PCH)." APPLE-1021, [0043].

95. A POSITA would have understood from the description of *Yeo* that because the mMTC transmissions occur within the subband 1d-06, the subband 1d-06 would include the associated DL transport channels including the associated PCH, and the paging transmissions for mMTC would also take place within the

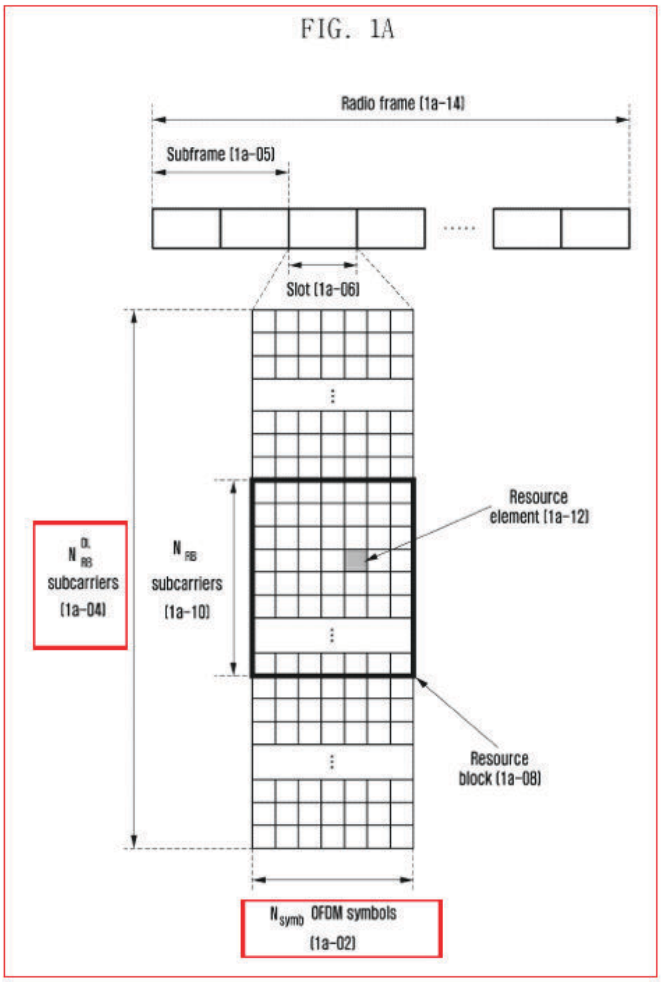
subband 1d-06. Further, *TS36* describes that for MTC (which mMTC is a type of), the PDCCH (referred to as MPDCCH) is monitored in a narrower band (referred to as the paging narrowband PNB) within the subband 1d-06. As such, a subband for a specific service – such as the subband 1d-06 for mMTC constitutes or at least renders obvious the claimed "first subband." APPLE-1009, p.39-40.

96. As discussed above, although *Yeo* describes paging mechanism in general, as well as a different subband for mMTC services, *Yeo* leaves out some implementation details, e.g., those specific to the mMTC services. For example, while *Yeo* describes—in the context of paging—that a paging frame "PF is defined as one radio frame including one or more [paging occasions] POs," and that a UE "can observe one PO per discontinuous reception (DRX) period," *Yeo* does not specifically describe how a paging channel is determined for particular services such as mMTC. *TS36* provides these details and fills the gap by describing that "[i]f P-RNTI is monitored on MPDCCH, the PNB is determined by the following equation: PNB = floor(UE_ID/(N*Ns)) mod Nn." A POSITA would have understood that the PNB refers to the band associated with the paging channel, and as such, would have had a reasonable expectation of success in combining *Yeo* with *TS36* a least because a POSITA would have recognized that the combination leads to the predictable result of implementing the paging channels in mMTC as

described in *Yeo*. As such, *Yeo* in view of *TS36* renders obvious the foregoing feature.

[1h]: "the first subband comprises a positive integer number of consecutive subcarriers in frequency domain; and"

97. *Yeo* describes that information in a "data or a control channel is transmitted" using "a basic structure of a time-frequency domain that is a radio resource region" as shown in FIG. 1D (annotated below) – which shows the arrangement of OFDM symbols within a slot of a subframe, and that each OFDM symbol includes a positive integer number of consecutive subcarriers. APPLE-1005, 12:20-34; APPLE-1006, [0039]-[0040]. *Yeo* also describes that "[the DCI] may be transmitted within first N OFDM symbols within the subframe." Because *Yeo* describes that DCI is "transmitted through the PDCCH," (*see* APPLE-1005, 14:1-8; APPLE-1006, [0055]), and the PDCCH is transmitted in a service-specific subband (*see* discussion related to limitation [1g]), a POSITA would have readily understood that the service-specific subband would include the subcarriers associated with the corresponding OFDM symbols – the subcarriers constituting "a positive integer number of consecutive subcarriers in frequency domain." APPLE-1005, FIG. 1A, 12:35-41; APPLE-1006, FIG. 1a, [0060]. The combination of *Yeo* with *TS36* at least renders this feature obvious.



[1i]: "at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband} is used for determining the X time intervals."

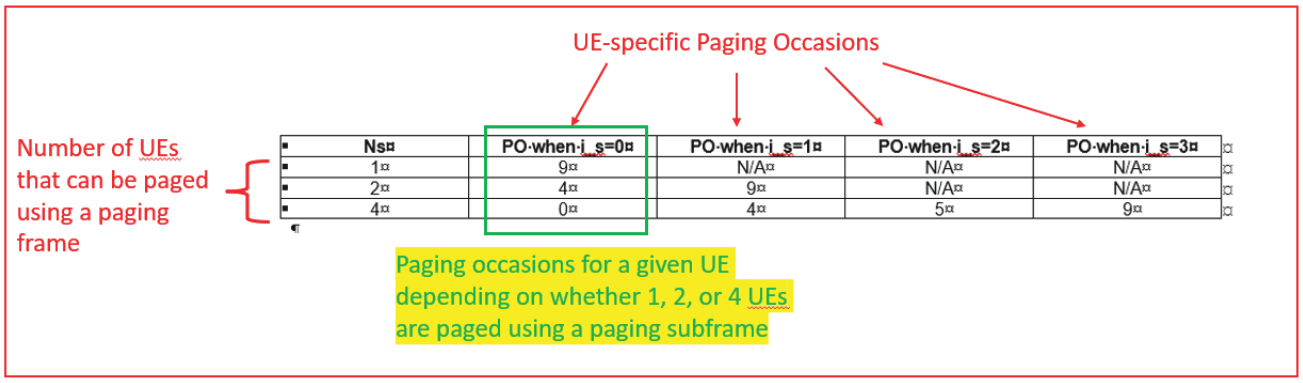
98. As described with respect to limitation [1a], the time intervals associated with the paging occasions (POs) in *Yeo* constitute or at least render obvious the "X time intervals." However, although *Yeo* describes that a "PF is defined as one radio frame including one or more POs," and that a UE "can observe one PO per discontinuous reception (DRX) period," *Yeo* does not

explicitly specify how a UE identifies the one or more POs. APPLE-1005, 53:14-17; APPLE-1006, [0455]. Specifically, while *Yeo* (i) describes the exact same equation for determining a PF as *TS36*, and (ii) notes that a PF includes "one or more POs," *Yeo* does not specifically describe how those "one or more POs" are determined by a UE. *TS36* fills in this gap by describing that the index "i_s pointing to PO" is given by the equation "i_s = floor(UE_ID/N) mod Ns."

99. Further, *Yeo* also describes that the above 4G concepts can be extended to support various types of services such as enhanced mobile broadband (eMBB), mMTC, ultra-reliable and low-latency communications (URLLC), etc.—as supported by 5G NR—and the requirements for such services can vary. APPLE-1005, 10:10-21; APPLE-1006, [0027]. Indeed, *Yeo* also describes—with reference to its FIG. 1D (reproduced above)—dividing the system frequency bands into corresponding subbands for different services, with mMTC occupying subband 1d-06, for example. APPLE-1005, 16:24-37; APPLE-1006, [0168].

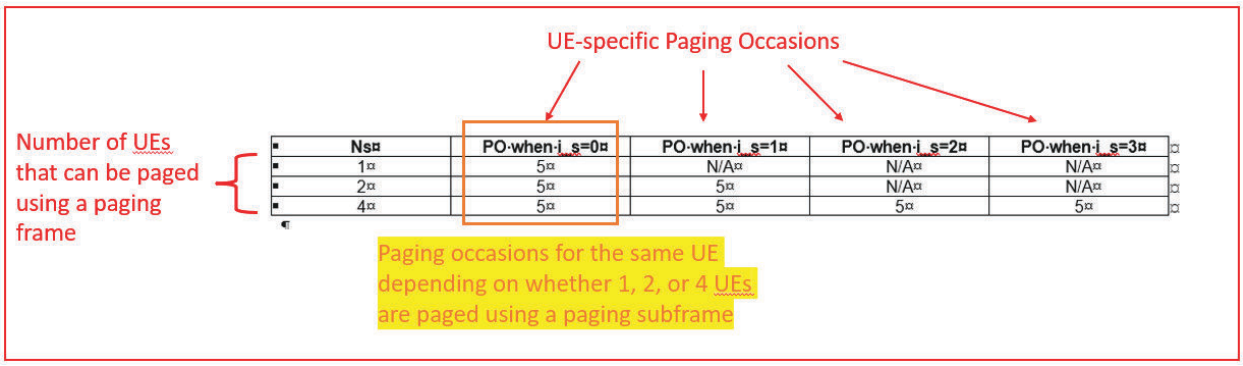
100. To the extent *Yeo* does not describe the details of how the time intervals associated with the one or more POs are determined for the individual subbands, such details were well-known to a POSITA as of the Critical Date, and the details make it clear that the location of the corresponding subband is used in determining the time intervals associated with the one or more POs. Specifically, *TS36* covers implementation details that specify locations of "one or multiple

Paging Occasion(s)" within a paging frame, and shows how the location of the one or more POs vary depending on the location of the subband. APPLE-1009, p.39-40. For example, and as discussed above, *TS36* shows that for otherwise-same operating parameters, the POs are different for a subband in the 1.4MHz-3MHz range as compared to the POs for a subband that is above 3MHz. APPLE-1009, p.39-40. Specifically, *TS36* describes that "if P-RNTI is transmitted on MPDCCH with system bandwidth > 3MHz", the paging occasions can be determined as per the following table:



Ns	PO·when·i_s=0	PO·when·i_s=1	PO·when·i_s=2	PO·when·i_s=3
1	9	N/A	N/A	N/A
2	4	9	N/A	N/A
4	0	4	5	9

On the other hand, "if P-RNTI is transmitted on MPDCCH with system bandwidth of 1.4MHz and 3MHz", the corresponding paging occasions can be determined as per the following table:



APPLE-1009, p.40-41, annotated.

101. As such, *Yeo* in view of *TS36* renders obvious that the determination of one or more POs—depends explicitly on the system bandwidth. A POSITA would have readily understood that a change in system bandwidth necessarily results in a change in one or both boundaries of the corresponding frequency band, and hence, in a change of location of the system band. Further, a POSITA would have also understood that the designated band for a specific type of device/service (e.g., mMTC) would be the subband allocated to that type of device/service (e.g., the subband 1d-06 discussed with reference to feature [1g]) For at least these reasons, a POSITA would have readily understood from the teachings of *Yeo* in view of *TS36*, that the determination of one or more POs depends on a location of the system band corresponding to the type of device/service (e.g., mMTC), and as such, the combination of the references renders obvious using a "location of the first subband in frequency domain" to determine the X time intervals.

2. Claim 4

[4a]: "The method according to claim 1, further comprising: receiving a second radio signal;"

102. *Yeo* describes that "data for eMBB, URLLC, and mMTC, which are services to be considered in a 5G or NR system are allocated in frequency-time resources," and also specifically "allocating frequency and time resources for information transmission in each system." APPLE-1005, 15:64-16:3; APPLE-1006, [0165]-[0166]. *Yeo* also describes that "base station is the subject performing resource allocation of a terminal," and that "downlink (DL) means a radio transmission path of a signal transmitted from a base station to a terminal." APPLE-1005, 18:48-50; APPLE-1006, [0182]. Because *Yeo* is directed to wireless communications, a POSITA would have readily understood from these disclosures, that any frequency allocation (e.g., the subband allocation depicted in FIG. 1C and 1D) would be communicated over a radio signal that would constitute or at least render obvious "the second radio signal." Specifically, *Yeo* describes that "the system information is transmitted in two ways over two different transmission channels. Master information block (MIB): transmission using PBCH 3d-03" and "System information block (SIB): transmission using PDSCH 3d-04." APPLE-1005, 45:27-32; APPLE-1006, [0390]-[0392].

103. Patent Owner's infringement contentions in the related litigation proceeding equates the "second radio signal" to both "MIB information element"

as well as a "BCH/BCCH channel." *Yeo* specifically describes—with reference to FIG. 3D—"a physical broadcast channel (PBCH)…to which a master information block (MIB)…is transmitted." The MIB includes "[i]nformation on downlink cell bandwidth." APPLE-1005, 45:29-35; APPLE-1006, [0391]. The combination of *Yeo* with *TS36* at least renders this feature obvious.

[4b]: "wherein the second radio signal is used for determining at least one of {location of the first subband in frequency domain, subcarrier spacing of subcarriers included in the first subband}."

104. As discussed for limitations [4a], frequency allocation information (e.g., "location of the first subband" depicted in FIG. 1D) would be communicated as system information over "the second radio signal" communicated over a physical broadcast channel PBCH. Such a radio signal would be used by an UE to decode bandwidth for communicating with a base station. For example, *Yeo* describes that "MIB transmitted through the PBCH…includes…[i]nformation on downlink cell bandwidth," which is then used for communicating DCI information– thereby disclosing the above feature. APPLE-1005, 45:33-35; APPLE-1006, [0393]-[0394]. The combination of *Yeo* with *TS36* at least renders this feature obvious.

3. Claim 5

[5a]: "The method according to claim 1, further comprising:

receiving a second signaling;"

105. *Yeo* describes—with reference to FIG. 1D (reproduced above)—that "frequency band 1d-00 may be divided and used to transmit services and data in the respective subbands 1d-02, 1d-04, 1d-06," and also that "[i]nformation related to the subband setting…may be transmitted from the base station **to the terminal** through higher signaling." APPLE-1005, 16:24-29; APPLE-1006, [0168]. Thus, the higher signaling described in *Yeo* constitutes or at least renders obvious the claimed "second signaling." The combination of *Yeo* with *TS36* at least renders this feature obvious.

[5b]: "wherein the second signaling is used for determining Q subbands, Q being a positive integer;"

106. *Yeo* describes—with reference to FIG. 1D (reproduced above)—that the "frequency band 1d-00 may be divided and used to transmit services and data in the respective subbands ld-02, ld-04, ld-06," and that "the subband 1d-02 is used for eMBB data transmission, the subband 1d-04 is used for URLLC data transmission, and the subband ld-06 is used for mMTC data transmission." APPLE-1005, 16:24-36, APPLE-1006, [0168]. As discussed with respect to [5a], the above division into three separate subbands (the claimed "Q subbands" with Q=3, a positive integer) is indicated to a UE or terminal by "higher signaling," and as such, *Yeo* describes that "the second signaling is used for determining Q

subbands." The combination of *Yeo* with *TS36* at least renders this feature obvious.

[5c]: "the first subband belongs to one of the Q subbands;"

107. As discussed for limitation [1g], a subband for a specific service – such as the subband 1d-06 for mMTC—as disclosed in *Yeo*—constitutes or at least renders obvious the claimed "first subband," and the subband 1d-06 is one of the three subbands. APPLE-1005, FIG. 1D, APPLE-1006, FIG. 1d. The combination of *Yeo* with *TS36* at least renders this feature obvious.

[5d]: "any one of the Q subbands comprises a positive integer number of consecutive subcarriers; and"

108. As discussed for limitation [1h], *Yeo* describes that the UE monitors the MPDCCH—i.e., the PDCCH for mMTC device/services—on a mMTC subband comprising consecutive subcarriers. APPLE-1005, FIG. 1A, 12:35-41; APPLE-1006, FIG. 1a, [0060]. As such, A POSITA would have understood that any one of the service-specific subbands (the claimed "Q subbands")—"the subband 1d-02…for eMBB data transmission, the subband 1d-04… for URLLC data transmission, and the subband ld-06…for mMTC data transmission"—comprises consecutive subcarriers. APPLE-1005, 16:24-36, APPLE-1006, [0168]. The combination of *Yeo* with *TS36* at least renders this feature obvious.

[5e]: "the feature ID of the monitor of the first signaling is used for determining the first subband in the Q subbands."

109. The phrase "**the** feature ID" lacks antecedent basis, and as best understood, is intended to refer to "**a** feature ID of the monitor." As discussed for limitation [1a], *Yeo* describes a UE for "monitoring a first signaling," and hence, a feature identifier associated with the UE in *Yeo* would constitute or at least render obvious "the feature ID of the monitor of the first signaling." As discussed above, *Yeo* describes various types of UEs that are served by the wireless network, including UE type that supports massive machine type communication (mMTC), UE type that supports MIMO, UE type that supports enhanced mobile broadband (eMBB), and UE type that supports ultra-reliable and low-latency Communications (URLLC). APPLE-1005, 2:13-23; 10:10-14; APPLE-1006, [0004], [0027]. It was well known to a POSITA as of the Critical Date that feature ID (i.e., UE categoryDL number) of a UE can be used to determine downlink frequency subbands supported by a UE, and as such, the foregoing feature is rendered obvious by the *Yeo*/*TS36* combination. For example, the 3GPP Technical Specification *3GPP TS 36.306 V14.1.0 (2016-12)* enumerates various "UE radio access capability parameters," which specifically includes the UE categoryDL number and ue-CategoryUL number to define downlink/uplink capability respectively. A POSITA would have understood (*see* APPLE-1026, page 5: "DL

Category 0 / UL category 0 was specifically added designed for support of MTC applications. Table 2-2 shows the basic capabilities in downlink and uplink, respectively"). A POSITA would have readily understood the *ue-CategoryDL* number to be a "feature ID" of a UE which would allow the UE to identify the subband 1d-06 for mMTC—as disclosed in *Yeo.*

110. As another example, the 3GPP Technical Specification *3GPP TS 36.306 V14.1.0 (2016-12)* enumerates various "UE radio access capability parameters," which specifically includes the parameter "*supportedBandList-r13*"-defining which "radio frequency bands…are supported by the UE," and noting that the "field is only applicable for UEs of any *ue-Category-NB*" APPLE-1025, p.35. A POSITA would have readily understood *ue-Category-NB* to be a "feature ID" of a UE, which would allow the UE to use a parameter such as *supportedBandList-r13* to determine frequency bands or subbands supported by the UE. The combination of *Yeo* with *TS36* at least renders this feature obvious.

4. Claim 6

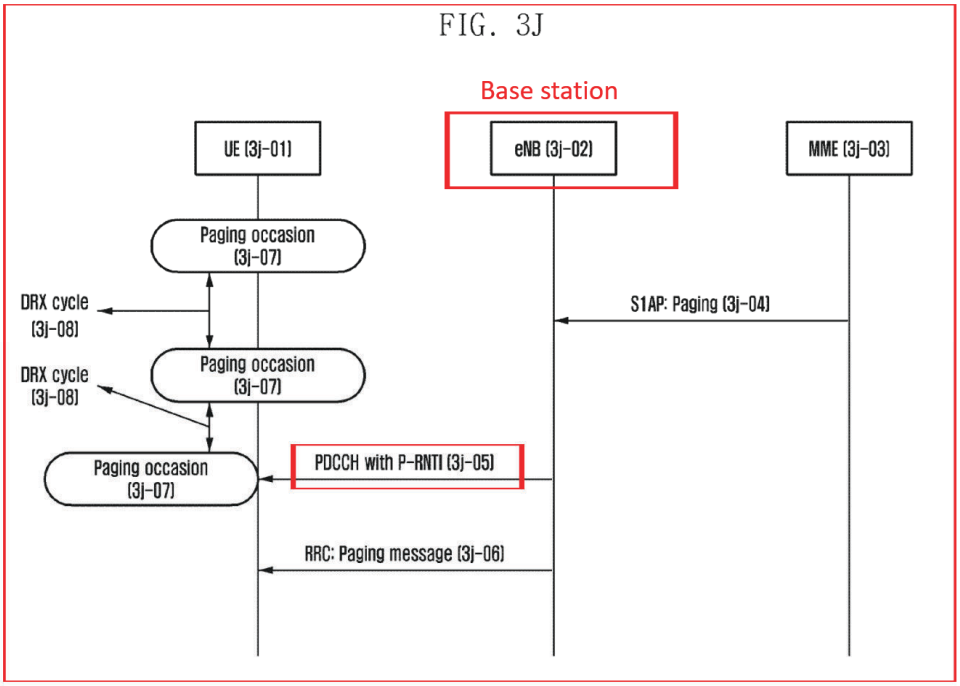
[6pre]: "A method in a base station for paging, comprising:"

111. As discussed for claim [1pre], *Yeo* describes a method in a UE for paging, to monitor a PDCCH in a paging occasion. *Yeo* also describes the paging process from the perspective of a base station. APPLE-1005, FIG. 3L; APPLE-

1006, FIG. 5k. The combination of *Yeo* with *TS36* at least renders this feature obvious.

[6a]: "transmitting a first signaling in a positive integer number of time intervals of X time intervals; and"

112. As discussed for claim [1a], *Yeo* describes monitoring a PDCCH configured as P-RNTI and paging DCI (which constitute or at least render obvious claimed "first signaling") in paging occasions - the time intervals for which correspond to the claimed X time intervals. *Yeo* also describes transmitting the PDCCH configured as P-RNTI from a base station eNB. APPLE-1005, FIG. 3J (annotated below); APPLE-1006, FIG. 5i. The combination of *Yeo* with *TS36* at least renders this feature obvious.



[6b]: "transmitting a first radio signal;"

113. As discussed for limitation [1b], *Yeo* describes that "[t]he paging message is transmitted through the PDSCH, and scheduling information on the PDSCH can be acquired from the PDCCH configured as P-RNTI." APPLE-1005, 53:48-51; APPLE-1006, [0013]. A POSITA would have understood that the PDSCH is a radio signal and as such, the foregoing feature is rendered obvious by the *Yeo/TS36* combination.

Remaining limitations of claim 6

114. The remaining limitations of claim 6 are substantially similar to limitations [1c]-[1i] of claim 1, and thus are respectively rendered obvious by the *Yeo/TS36* combination for the same reasons discussed above for limitations [1c]-[1i]. See claim comparisons provided above.

5. Claim 9

115. The *Yeo/TS36* combination renders obvious claim 6. The remaining limitations of claim 9 are substantially similar to claim 4, and thus are rendered obvious by *Yeo* in view of *TS36* for the reasons discussed for claim 4.

6. Claim 10

116. The *Yeo/TS36* combination renders obvious claim 6. The remaining limitations of claim 10 are substantially similar to claim 5, and thus are rendered obvious by the combination for the reasons discussed for claim 5.

7. Claims 11, 14, and 15

117. Independent claim 11 is substantially similar to claim 1, except it is an apparatus claim directed to "[a] UE for paging," and requires (1) "a first receiver module" to monitor a first radio signaling in X time intervals, and (2) "a second receiver module" to receive a first radio signal. *Yeo* in view of *TS36* renders obvious these apparatus-related limitations as shown below.

"A UE for paging"

118. *Yeo* describes a UE executing a paging process. APPLE-1005, FIG. 3J; APPLE-1006, FIG. 5i.

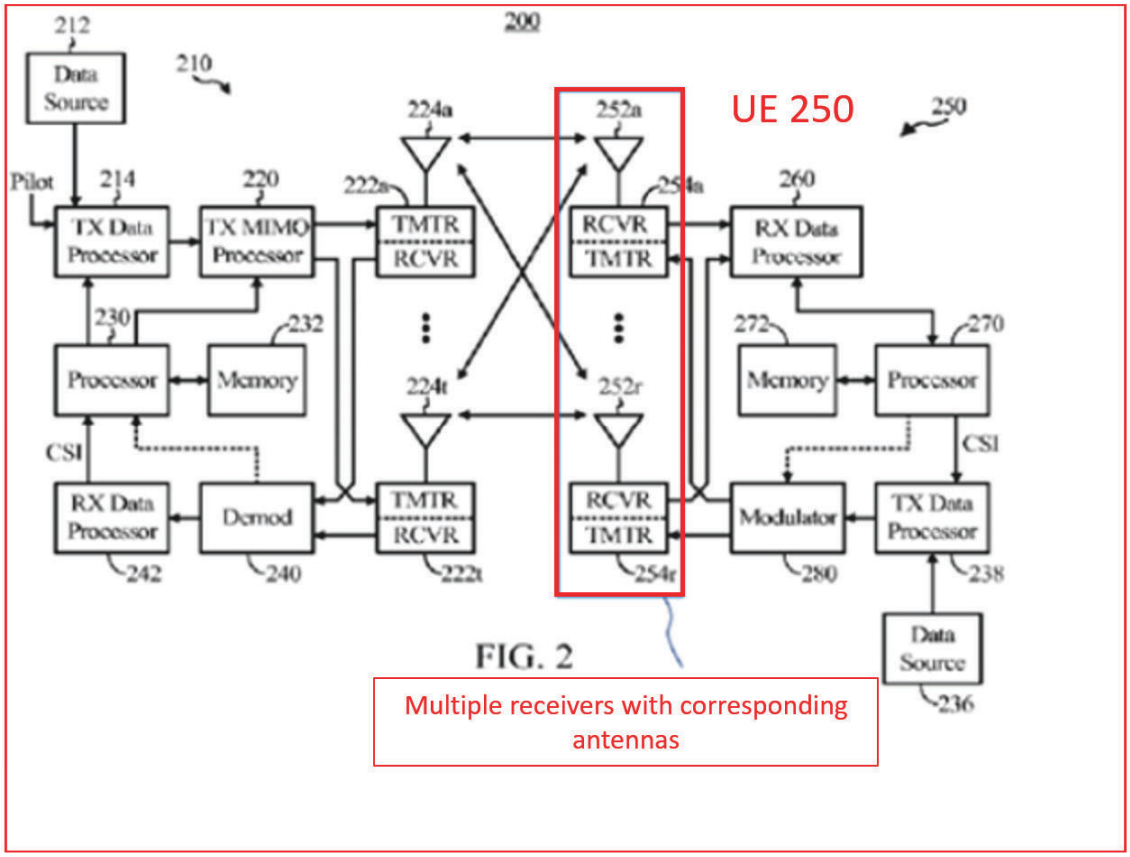
"a first receiver module" and "a second receiver module"

119. The structure attributed by the '767 Patent to each of the "first receiver module" and the "second receiver module" is "the transmitter/receiver 456 (including the antenna 460), the receiving processor 452 and the controller/processor 490 shown in FIG. 4." APPLE-1001, 20:59-67. *Yeo* discloses the structure for the claimed receiver modules at least as much as the '767 Patent discloses. For example, *Yeo*'s "block diagram of a structure of a terminal

transceiver" renders obvious the claimed "first receiver module" and "second receiver module." APPLE-1005, FIG. 3Q; APPLE-1006, FIG. 5m. *Yeo* specifically notes the a "terminal may include user equipment (UE), a mobile station (MS), a cellular phone, a smart phone, a computer, or a multimedia system performing a communication function." APPLE-1005, 18:52-55; APPLE-1006, [0083]. *Yeo* further describes that a "terminal receiver…and the terminal transmitter…may collectively be referred to as a transceiver," and "the transceiver may include…an RF receiver" that "may receive a signal through a radio channel and output the received signal to the terminal processor." From at least the foregoing description in *Yeo*, a POSITA would have understood that the structure espoused for each of the "first receiver module" and the "second receiver module" is disclosed by *Yeo*.

120. Inasmuch as the '767 Patent points to the same structure for each of the "first receiver module" and the "second receiver module," each/both would have been obvious to a POSITA based on the combination of *Yeo* and *TS36*. Specifically, *Yeo* describes transmitting and receiving DCI information by "spatial multiplexing using…multiple antenna," APPLE-1005, 13:11-24; APPLE-1006, [0144]. A POSITA would have reasonably envisaged or gleaned as obvious from this that multiple receiver circuits are connected, respectively, to multiple antennas,

with each receiver circuit being used to process the signal received from its respective antenna. Such parallel processing of the antenna signals was well-known to a POSITA as of the Critical Date, (*see* APPLE-1021, Fig. 2 (annotated below - showing one receiver at each antenna)), and would allow *Yeo*'s terminal receiver to simultaneously decode and demodulate the signals received from multiple receive antennas, thereby improving the system speed. *Id.*, [0037]-[0038].



Luo, Fig. 2., Annotated.

121. Therefore, *Yeo* in view of *TS36* renders obvious multiple receiver modules, each including a receive antenna and an associated receiver circuit that includes a transmitter, a receiver and one or more processors. APPLE-1005, FIG. 3Q; APPLE-1006, FIG. 5m. A POSITA would have reasonably expected to succeed in providing two receiver modules, each receiving the claimed "first signaling" and "first radio signal" respectively, in *Yeo*'s UE because multiple receiver modules receiving these signals were conventional and routine in the MIMO antennas described in *Yeo*, APPLE-1005, 1:32-40; APPLE-1006, [0002]; APPLE-1021, Fig. 2. As such, the combination represents nothing more than known components operating according to their ordinary and expected functions to yield predictable results (receiving signals).

122. Further, a POSITA would understand the plain and ordinary meaning for the term "receiver module" to mean or at least include a wireless receiver such as in a UE. As described above, *Yeo* describes one or more instances of such a wireless receiver. Notably, Patent Owner's infringement contentions do not mention the term "module," let alone a "first receiver module" and a "second receiver module." Patent Owner notes instead with respect to claim 11 that "[t]he Accused Products monitor a first signaling (e.g., Paging DCI) in X time intervals (e.g., PDCCH monitoring occasions)." APPLE-1023, ¶¶80-81. Under the position

that Patent Owner advances in the litigation, the foregoing features are disclosed or at least rendered obvious by *Yeo*'s description of a terminal/UE. APPLE-1005, 18:52-55; APPLE-1006, [0083].

Remaining limitations of claims 11, 14, and 15

123. Given the similarity between claims 1 and 11, the remaining features of claim 11 are respectively rendered obvious for the same reasons discussed above for the corresponding features of claim 1. See claim comparison table provided above.

124. Similarly, claims 4 and 14, and 5 and 15, are respectively similar to one another and are rendered obvious for the same reasons discussed above with respect to claims 4 and 5, respectively. See claim comparison table provided above.

8. Claims 16, 19, and 20

125. Independent claim 16 is substantially similar to claim 6, except it is an apparatus claim directed to a base station for paging, and requires (1) "a first transmitter module" to transmit a first signaling in a positive integer number of time intervals of X time intervals, and (2) "a second transmitter module" to transmit a first radio signal. See claim comparison table provided

above. *Yeo* in view of *TS36* renders obvious these apparatus- related limitations as shown below.

"A base station for paging"

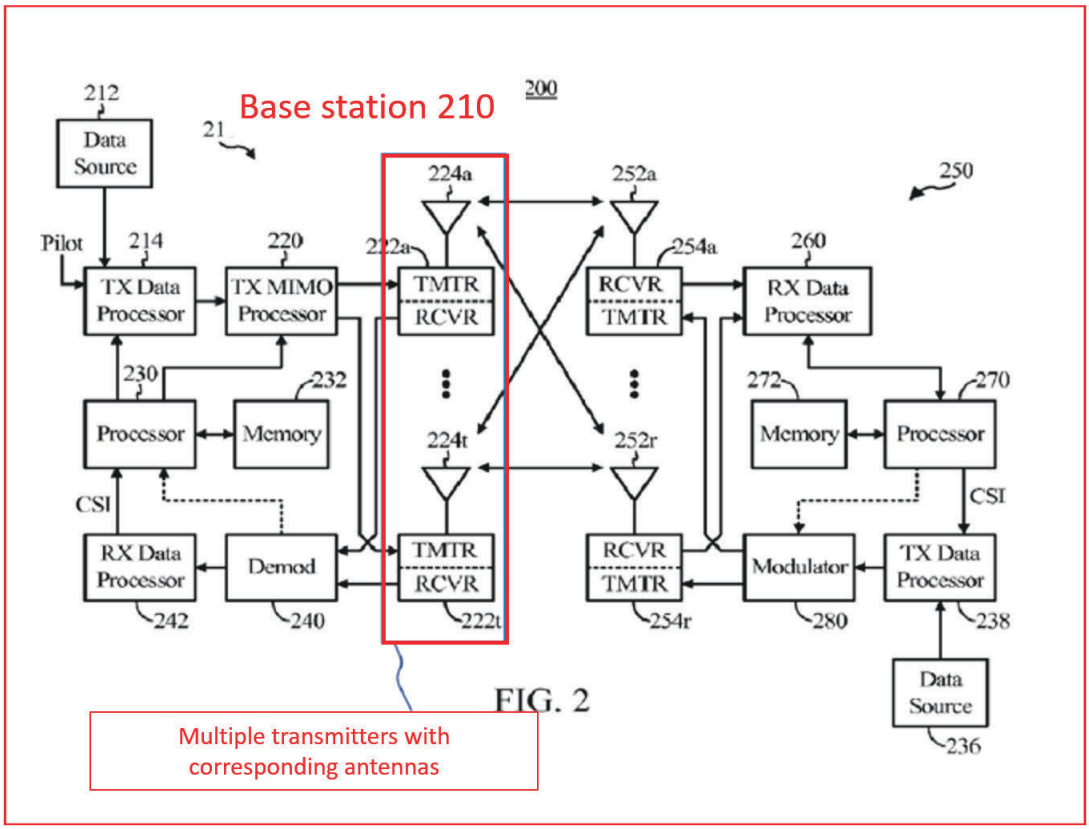
126. *Yeo* describes a base station executing a paging process. APPLE-1005, FIG. 3J (*see* annotated version above); APPLE-1006, FIG. 5i.

"a first transmitter module" and "a second transmitter module"

127. The structure attributed by the '767 Patent to each of the "first transmitter module" and the "second transmitter module" is "to transmit," which it describes as performed by the following structure: "the transmitter/receiver 416 (including the antenna 420), the transmitting processor 415 and the controller/processor 440 shown in FIG. 4." APPLE-1001, 21:51-58. *Yeo* discloses the structure for the claimed transmitter modules at least as much as the '767 Patent discloses. For example, *Yeo*'s "block diagram of a structure of a base station transceiver" renders obvious the above limitations. APPLE-1005, FIG. 3R; APPLE-1006, FIG. 5n. *Yeo* further describes that a "base station receiver…and the base station transmitter…are collectively referred to as a transceiver," and that "the transceiver may include…an RF transmitter" that may "transmit the signal output from the base station processor." From at least the foregoing description in *Yeo*, a

POSITA would have understood that the structure espoused for each of the "first transmitter module" and the "second trasnmitter module" is disclosed by *Yeo*.

128. Insofar the '767 Patent points to the same structure for each of the "first transmitter module" and the "second transmitter module," each/both would have been obvious to a POSITA based on the combination of *Yeo* and *TS36*. Specifically, *Yeo* describes transmitting and receiving DCI information by "spatial multiplexing using…multiple antenna," APPLE-1005, 13:11-24; APPLE-1006, [0144]. A POSITA would have reasonably envisaged or gleaned as obvious from this that multiple transmitter circuits are connected, respectively, to multiple antennas, with each transmitter circuit being used for transmitting signals through the respective transmit antenna. Such parallel processing of the antenna signals was well-known to a POSITA as of the Critical Date (*see* APPLE-1021, Fig. 2 (annotated below - showing one transmitter for each antenna)), and would allow *Yeo*'s base station to simultaneously transmit signals through multiple transmit antennas, thereby implementing a MIMO system. *Id.*, [0035]-[0036].



Luo, Fig. 2., Annotated

129. Therefore, *Yeo* in view of *TS36* renders obvious multiple transmitter modules, each including a transmit antenna and an associated transmitter circuit. A POSITA would have reasonably expected to succeed in providing two transmitter modules, each transmitting the claimed "first signaling" and "first radio signal" respectively, in *Yeo*'s base station because multiple transmitters transmitting these signals were conventional and routine in

the MIMO antennas described in *Yeo*, APPLE-1005, 1:32-40; APPLE-1006, [0002]; APPLE-1021, Fig. 2. As such, the combination represents nothing more than known components operating according to their ordinary and expected functions to yield predictable results (receiving signals).

130. Even if Petitioner's proposed construction is not adopted and plain and ordinary meaning is instead applied, the above limitations are rendered obvious by *Yeo*. A POSITA would understand the plain and ordinary meaning for this term to mean or at least include a wireless transmitter such as in a base station. As described above, *Yeo* describes one or more instances of such a wireless transmitter.

Remaining limitations of claims 16, 19, and 20

131. Given the similarity between claims 6 and 16, the remaining features of claim 16 are respectively rendered obvious for the same reasons discussed above for the corresponding features of claim 6. See claim comparison table provided above.

132. Similarly, claims 9 and 19, and 10 and 20, are respectively similar to one another and are rendered obvious for the same reasons

discussed with respect to the corresponding claims. See claim comparison table provided above.

B. Claims 2, 3, 7, 8, 12, 13, 17, and 18 Are Obvious over *Yeo*, *TS36*, and *Mallick* (Ground 2)

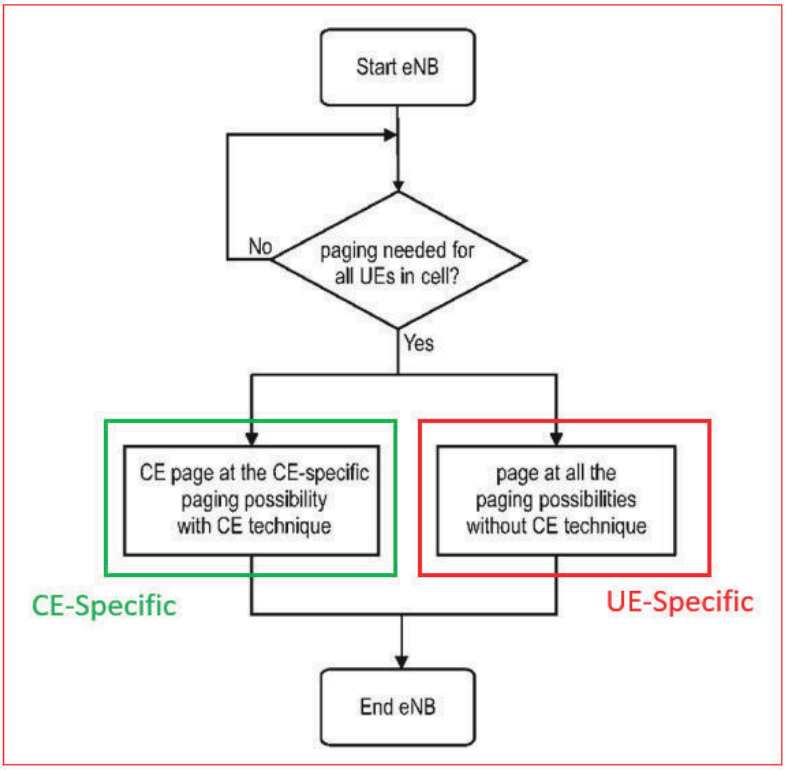
1. Overview of *Mallick*

133. Similar to *Yeo*'s description of mMTC for coverage enhancement (see APPLE-1005, 41:61-67; APPLE-1006, [0309]), *Mallick* discusses using coverage extension (CE) to page MTC devices (APPLE-1008, Abstract, [0140]-[0141], [0145]). *Mallick* also explains that "[c]overage [e]xtension" is another term for coverage enhancement. *Id.*, [0060]. *Mallick* recognizes that CE requires repeated transmission of paging control information and/or increased power, imposing a heavier burden on the base station than normal coverage. *Id*., [0072], [0078], [0151]. To alleviate this problem, instead of indiscriminately applying CE to all UEs in a cell and at all the possible paging occasions, *Mallick* proposes limiting CE to only a selected group of UEs at a subset of the paging occasions. *Id*., [0160].

134. Specifically, the UEs in a cell covered by a base station are divided into UEs that experience bad radio conditions and thus require CE ("CE-UEs"), and normal UEs that do not require CE ("non-CE-UE[s]"). *Id*., [0075], [0135].

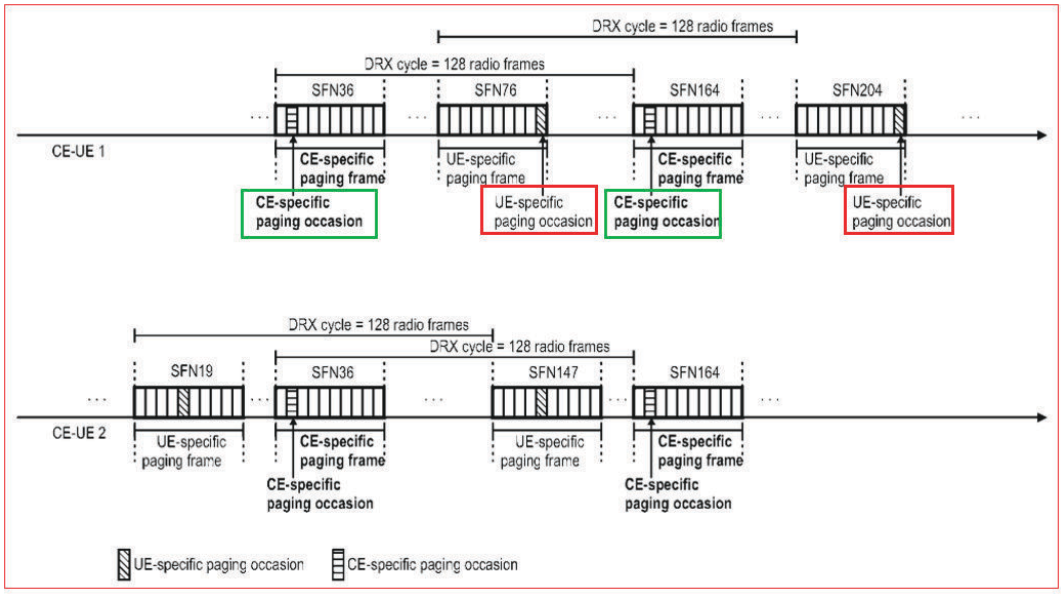
As shown in Figure 7, the base station (i.e., eNB) may page all the UEs in its cell (including the CE-UEs and non-CE-UEs) at UE-specific paging possibilities without using the CE technique. *Id*., [0146], [0159], Fig. 7. Additionally, the eNB also pages the CE-UEs at CE-specific paging possibilities by using the CE technique. *Id*. The term "paging possibility" refers to the combination of a paging frame (i.e., a radio frame) and a paging occasion (i.e., one or more subframes within the paging frame). *Id*., [0024], [0072], [0148], [0161].

135. The UE-specific paging possibilities are determined based on the ordinary UE identifiers (UE-specific IDs), in the same way defined in the 4G/LTE standards, and thus are specific to the UEs. *Id*., [0025]-[0029], [0148]. The CE-specific paging possibilities may be determined based on a CE-specific ID common to a group of CE-UEs, and thus are the same for these CE-UEs. *Id*., [0079], [0093], [0101], [0107], [0148], [0169]-[0170], claim 5.



Mallick., Fig. 7., Annotated

136. Figure 5 shows two CE-specific UEs monitoring the normal paging PDCCHs at different UE-specific paging possibilities, and monitoring the CE paging PDCCHs at the same CE-specific paging possibilities. *Id*., [0157]-[0158]. Meanwhile, non-CE-UEs (not shown) only monitor their respective UE-specific paging possibilities. *Id*., [0148], [0154].



Mallick, Fig. 5., Annotated

137. By limiting the CE to the CE-specific paging possibilities, the downlink resources can be saved and the burden on the base station can be reduced. *Id*., [0078], [0160], [0174]-[0175].

138. *Mallick* is analogous art to the ’767 patent because *Mallick*, like the ’767 patent, describes methods for a UE to monitor paging scheduling information for a number of times. *Compare Id.*, [0001], [0139], [0152], *with* APPLE-1001, Abstract, 2:27-39.

2. Combining *Yeo/TS36* with *Mallick*

139. A POSITA would have been motivated to combine *Yeo/TS36* with *Mallick*'s improved CE paging procedure, including its teachings about how to determine the UE-specific paging possibilities and CE-specific paging possibilities. *Mallick*, *Yeo*, and *TS36* are all related to paging/DRX procedure in MTC UEs that are compliant with 3GPP 4G/LTE or 5G/NR standards. APPLE-1005, 53:8-20; APPLE-1006, [0455]; APPLE-1009, p.39-40; APPLE-1008, Abstract, [0143], [0145]; APPLE-1001, 1:45-47, 5:1-3. *Mallick* describes that limiting the CE to CE-UEs and the CE-specific paging possibilities can save downlink resources and reduce the burden on the base station. APPLE-1008, [0078], [0160], [0174]-[0175]. Moreover, for a higher granularity, *Mallick*'s CE-specific IDs and CE-specific paging possibilities can be further classified according to the CE levels, such that a CE-UE can skip monitoring the CE-specific paging possibilities not associated with its CE level, thereby reducing the CE-UE's power consumption. *Id*., [0169]-[0172]. And *Yeo* describes coverage enhancement of UEs specifically for mMTC in 5G. APPLE-1005, 41:61-67; APPLE-1006, [0309]. Thus, a POSITA would combine *Mallick*'s advantageous CE design to improve the implementations contemplated by the *Yeo*/*TS36* combination. A POSITA would have a reasonable expectation of success in combining *Yeo*/*TS36* with *Mallick* because it only requires combining elements according to known methods. Indeed, *Mallick*'s equations

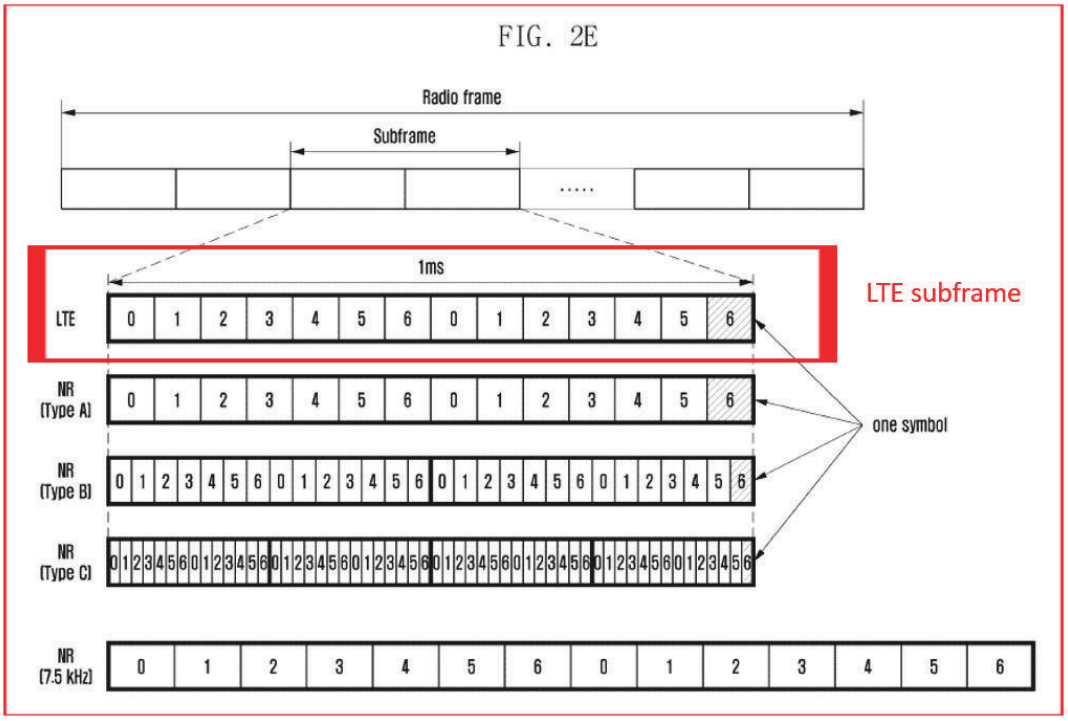
"SFN mod T=(T div N)*(UE_ID mod N)" to determine the paging frame number SFN, and "i_s= floor(UE_ID/N) mod Ns" to determine the paging occasion index i_s are identical to the corresponding equations described in *TS36*. A POSITA would have a reasonable expectation of success in combining *Mallick* with the *Yeo/TS36* combination at least because *Mallick* explicitly refers to an earlier version of the *TS36* as the specification relied on for determining paging occasions. APPLE-1008, [0025]-[0028]; APPLE-1009, p.39-40. A POSITA would also have understood that the combination would lead to predictable results by reducing the burden on a base station and/or power consumption in certain UEs—as described by *Mallick*—in the paging/DRX procedure in MTC UEs, as described by the *Yeo*/*TS36* combination.

1. Claim 2

[2a]: "The method according to claim 1, wherein any one of the X time intervals belongs to a first time window in time domain;"

140. As discussed with respect to [1a], *Yeo* defines each paging occasion "as a subframe in which the PDCCH [is] configured as the P-RNTI," and a paging frame as "one radio frame including one or more POs." APPLE-1005, 53:14-17; APPLE-1006, [0455]. *Yeo* also describes that "a radio frame…is a time domain unit which includes 10 subframes." APPLE-1005, 30:11-12; APPLE-1006, [0372]. As such, for LTE (having a subframe duration

of 1 ms)—as shown in FIG. 2E of *Yeo* (annotated below)—the radio frame length is 10 ms. The 10 ms time window corresponding to an LTE frame constitutes or at least renders obvious the claimed "first time window." APPLE-1005, FIG. 2E; APPLE-1006, FIG. 3e. The combination of *Yeo/YS36/Mallick* renders this feature obvious.



[2b]: "the time length of the first time window is predefined;"

141. As noted with reference to limitation [2a], the duration of an LTE frame is 10 ms – which is a predefined time window. Thus, *Yeo* in view of *TS36* and *Mallick* renders obvious that the time length of the first time window is predefined.

[2c]: "the first time window is divided into Y time intervals;"

142. *Yeo* describes that the 10 ms time window is divided into multiple time intervals and the number of time intervals depends on the subframe type. For example, in a frame structure Type A, the subframe size is 1 ms, and the number of time intervals is Y=10; in a frame structure Type B, the subframe size is 0.5 ms, and the number of time intervals is Y=20; in a frame structure Type C, the subframe size is 0.25 ms, and the number of time intervals is Y=40. APPLE-1005, 30:67-31:15; APPLE-1006, [0224]. The combination of *Yeo/YS36/Mallick* renders this feature obvious.

[2d]: "the X time intervals are X time intervals of the Y time intervals, Y being a positive integer not smaller than X;"

143. As discussed with respect to [1a], *Yeo* defines each paging occasion "as a subframe in which the PDCCH [is] configured as the P-RNTI," and a paging frame as "one radio frame including one or more POs." APPLE-1005, 53:14-17; APPLE-1006, [0455]. *Yeo* further describes that the duration of a subframe is 1 ms, 0.5 ms, or 0.25 ms, depending on whether the NR frame structure is of Type A, Type B, or Type C, respectively – resulting in the following parameters within the **10 ms "first time window"**:

NR frame type	Subframe duration	No. of subframes or Y time intervals per 10 ms time window	No. of frames or paging occasions (X) per 10 ms time window
Type A	1 ms	10	1
Type B	0.5 ms	20	2
Type C	0.25	40	4

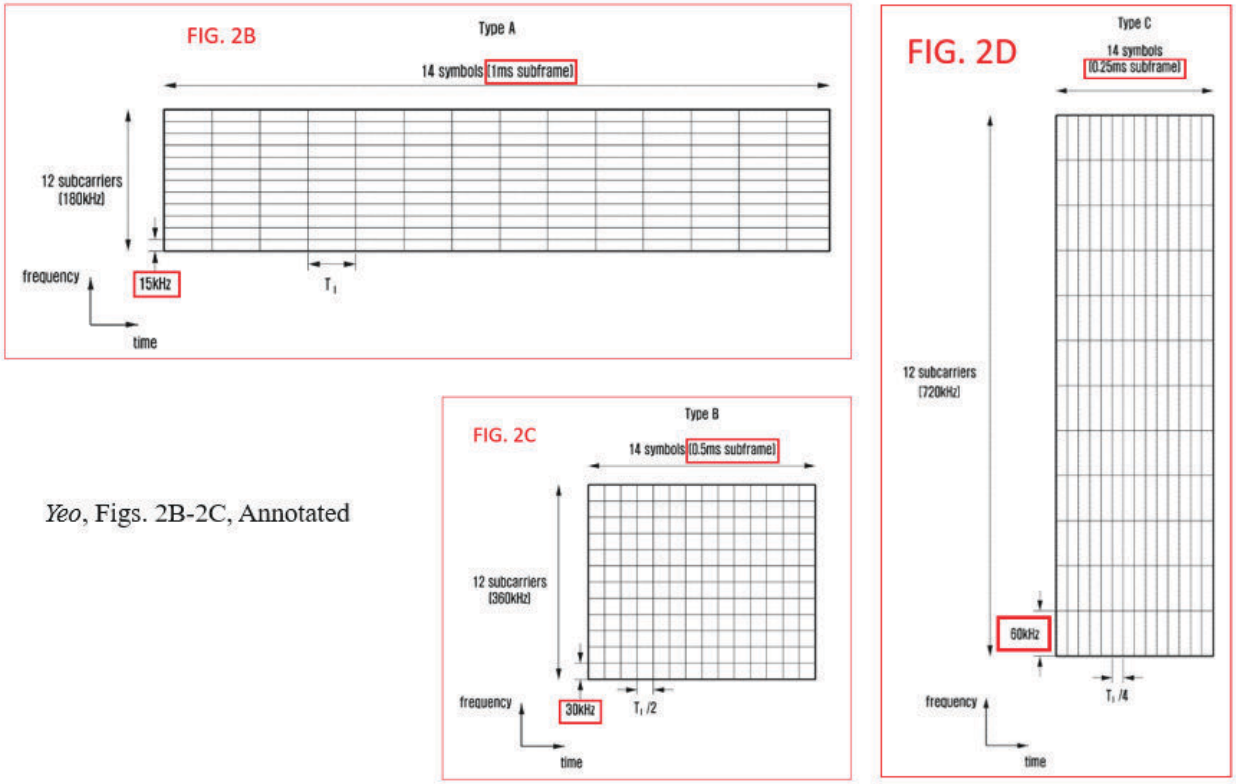
APPLE-1005, 30:67-31:15; APPLE-1006, [0224].

Because for each frame type, the number of paging occasions X is one of the subframes corresponding to the Y time intervals, *Yeo* describes the foregoing feature. The combination of *Yeo/YS36/Mallick* renders this feature obvious.

[2e]: "the subcarrier spacing of subcarriers included in the first subband is used for determining Y; and"

144. As shown with respect to limitation [2d], the number of Y time intervals within the 10 ms "first time window" depends on the subframe duration. *Yeo* further describes with respect to FIGs. 2B, 2C, and 2D (reproduced below with annotations) that the duration of the subframe in turn depends on the subcarrier spacing. Specifically, *Yeo* describes that "in a frame structure type A, subcarrier spacing is 15 kHz, a subframe of 1 ms includes 14 symbols"; "in a frame structure type B, the subcarrier spacing is 30 kHz, a subframe of 0.5 ms includes 14

symbols"; and "in a frame structure type C, subcarrier spacing is 60 kHz, a subframe of 0.25 ms includes 14 symbols." APPLE-1005, 30:67-31:15; APPLE-1006, [0224]. For at least the foregoing reasons, *Yeo* describes that the Y intervals are determined based on the subcarrier spacing of subcarriers included in the first subband. The combination of *Yeo/YS36/Mallick* renders this feature obvious.



Yeo, Figs. 2B-2C, Annotated

[2f]: "a feature ID of a monitor of the first signaling is used for determining the X time intervals in the Y time intervals."

145. *Yeo* in view of *TS36* and *Mallick* renders obvious this limitation. As discussed for limitation [1a], *Yeo*'s "PDCCH configured as P-RNTI" constitutes or at least renders obvious the claimed "first signaling." APPLE-1005, 14:5-8, APPLE-1006, [0055]. *Yeo* further defines the "subframe in

which the PDCCH [is] configured as the P-RNTI," as a paging occasion and a paging frame as "one radio frame including one or more POs," APPLE-1005, 53:14-17; APPLE-1006, [0455]. However, while *Yeo* (i) describes the exact same equation for determining a PF as *TS36*, and (ii) notes that a PF includes "one or more POs," *Yeo* does not specifically describe how those "one or more POs" are determined by a UE. Both *TS36* and *Mallick* fill this gap by describing that the index "i_s pointing to PO" is given by the equation "i_s = floor(UE_ID/N) mod Ns." Because the UE monitors the PDCCH, and a POSITA would readily recognize that the UE_ID constitutes or at least renders obvious the "feature ID" of the UE that is used for determining paging occasions, both *TS36* and *Mallick* describe the claimed "feature ID of a monitor of the first signaling," and that it "is used for determining the X time intervals.". APPLE-1009, p.39-40; APPLE-1008, [0027], [0170]. A POSITA would have a reasonable expectation of success in combining *Yeo* and *TS36/Mallick* at least because a POSITA would understand that the combination leads to the predictable result of determining the UE-specific POs within the PF of *Yeo*.

146. In addition, *Mallick* describes multiple paging occasions for an UE within a predefined time window. For example, *Mallick* describes (with reference to FIG. 5, reproduced below with annotations) that "CE-UE1 monitors a UE-specific paging possibility at radio frame number 76 and number

204…etc., respectively at subframe 9…and that CE-UE2 monitors a UE-specific paging possibility at radio frame number 19 and 147…etc., respectively at subframe 4." APPLE-1008, [0157]. *Mallick* also clarifies that "the term paging possibility [refers] to the combination of the paging frame and paging subframe," and is determined as a function of the UE_ID. APPLE-1008, [0024]-[0027].

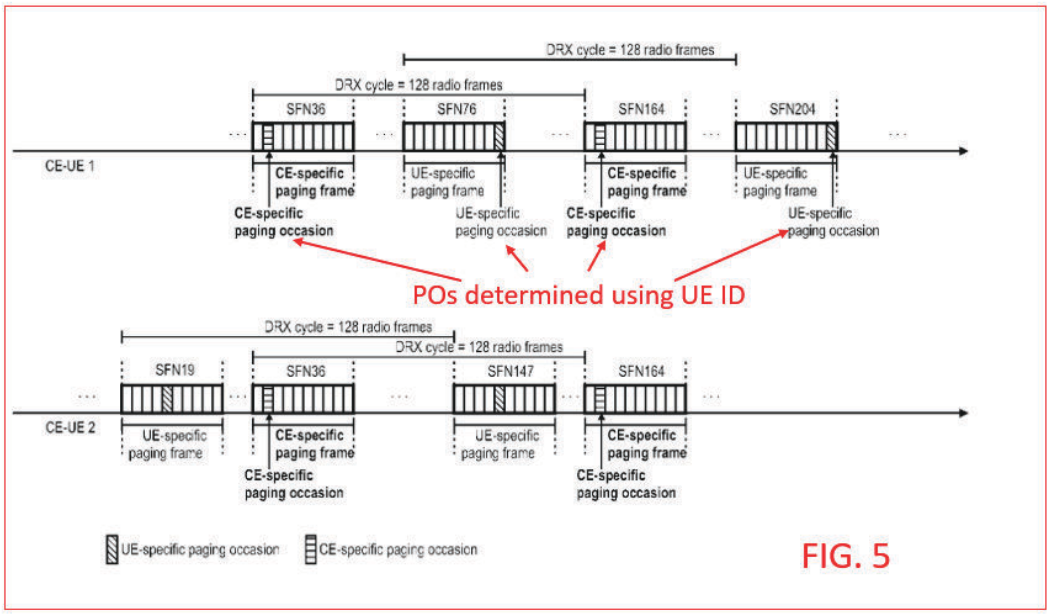


FIG. 5

147. As shown with respect to limitation [2d], the number of subframes within a given time window constitutes or at least renders obvious the Y time intervals, and the *Yeo*/*TS36*/*Mallick* combination renders obvious determining the paging occasions within the Y time intervals based on the UE_ID. Specifically, Because *Yeo* describes coverage enhancement of UEs specifically for mMTC in 5G (APPLE-1005, 41:61-67; APPLE-1006, [0309]), a POSITA

would have been motivated to combine *Yeo/TS36* with *Mallick*'s improved CE paging procedure, including its teachings about how to determine the UE-specific paging possibilities and CE-specific paging possibilities. A POSITA would have had a reasonable expectation of success in combining *Mallick* with the *Yeo/TS36* combination at least because *Mallick* explicitly refers to an earlier version of the *TS36* as the specification relied on for determining paging occasions, (APPLE-1008, [0025]-[0028]; APPLE-1009, p.39-40), and the combination would lead to predictable results by reducing the burden on a base station and/or power consumption in certain UEs—as described by *Mallick*—in the paging/DRX procedure in MTC UEs, as described by the *Yeo*/*TS36* combination. As such, the limitation [2f] is rendered obvious by *Yeo*, *TS36*, and *Mallick*.

2. Claim 3

[3a]: "The method according to claim 2, wherein the first time window belongs to one of Z time windows, Z being an integer greater than 1;"

148. As discussed for limitation [2a], *Yeo*/*TS36* in view of *Mallick* renders obvious that the paging occasions are subframes within a 10 ms time window. *Mallick* further describes that a DRX cycle contains an integer number (e.g., 32, 64, 128 or 256) of radio frames. APPLE-1008, [0038], Fig. 5 (reproduced below with annotations).

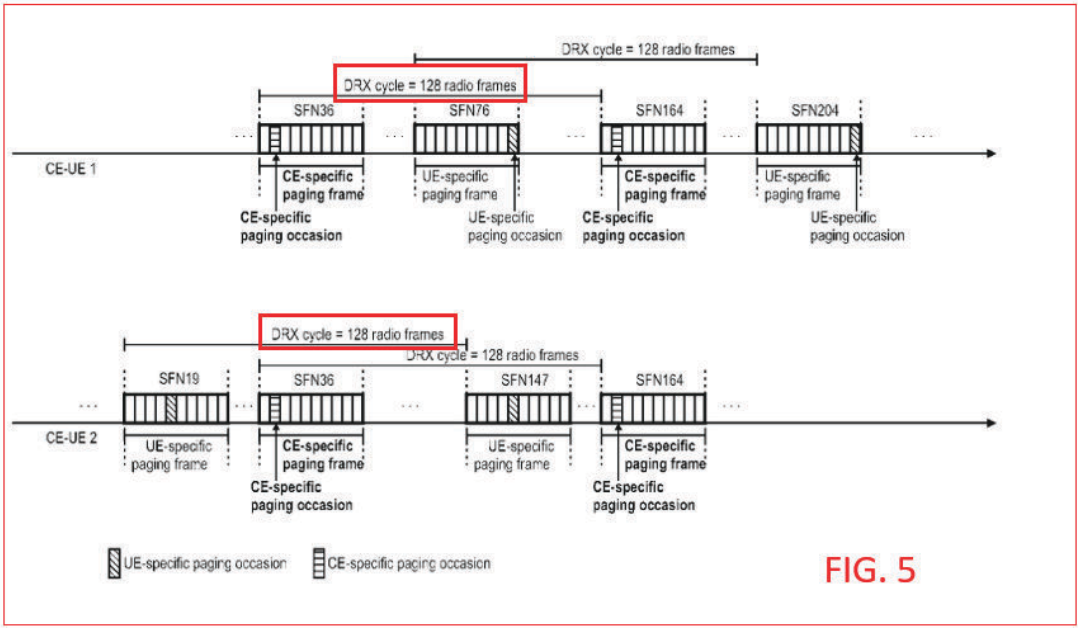


FIG. 5

149. Taking the example of the shortest default paging cycle of 32 radio frames, and the NR Type A frame described in *Yeo* (Figure 2E, above), the duration of the paging cycle is 32 * 10 ms = 320 ms - a time duration that includes 32 time windows each of duration 10 ms. The 32 time windows (each of duration 10 ms) in the paging cycle constitute or at least render obvious the "Z time windows," and the "first time window" of 10 ms is one of the 32 time windows. In the examples of 64, 128, or 256 frame paging cycles for the NR Type A frame, the number of Z time windows is 64, 128, or 256, respectively, and the "first time window" of 10 ms is one of the corresponding number of time windows. As such, *Yeo*/*TS36* in view of *Mallick* renders obvious feature [3a].

[3b]: "Z is predefined, or Z is configurable;"

150. *Yeo* in view of *TS36* and *Mallick* renders obvious this limitation. *Yeo* describes—with reference to FIG. 2E—multiple frame structures both for LTE as well as for NR. APPLE-1005, FIG. 2E, APPLE-1006, FIG. 3e. *Yeo* also describes that in LTE systems "a length of the subframe is 1.0 ms," which does not change. APPLE-1005, 30:10-11; APPLE-1006, [0372]. *Yeo* also describes that in 5G "the frame structure type is generalized, the subcarrier spacing, the CP length, and the subframe length that are the essential parameter sets have an integer multiple relationship with each other for each type, such that high scalability may be provided." APPLE-1005, 31:20-24; APPLE-1006, [0227]. As such, *Yeo* describes that the frame structures are either predefined (LTE) or configurable (NR Types A, B, C).

151. Further, as described with reference to limitation [3a], the subframe structure directly affects the number of time windows Z in a paging cycle of a given length. Because *Yeo* describes that the frame structures are either predefined or configurable, *Yeo* therefore describes predefined or configurable number of time windows Z.

[3c]: "any two of the Z time windows have an equal time length; and"

152. As shown with reference to the limitation [3a], taking the example of the shortest default paging cycle of 32 radio frames, and the NR Type A frame described in *Yeo* (Figure 2E, above), the duration of the paging cycle is 32 * 10 ms = 320 ms - a time duration that includes 32 time windows each of duration 10 ms. As such, *Yeo* describes that "any two of the Z time windows have an equal time length." The combination of *Yeo/YS36/Mallick* renders this feature obvious.

[3d]: "the feature ID of the monitor of the first signaling is used for determining the first time window in the Z time windows."

153. As discussed for limitation [2f], both *TS36* and *Mallick* describe the claimed "feature ID of a monitor of the first signaling" by disclosing a UE ID that is used for determining a paging occasion in a paging frame. Both *TS36* and *Mallick* further describe that the same UE ID can be used to determine the paging frame itself. *Compare* APPLE-1008, [0025] and APPLE-1009, p.39-40 *with* '767 patent, 5:15-19 (using substantially the same formula to determine "the paging frame number (SFN)" based on the "UE_ID"). As such, the combination of *Yeo* with *TS36* and *Mallick* renders obvious this limitation.

3. Claims 7 and 8

154. Aside from their dependency on claim 6, claims 7 and 8 are substantially similar to claims 2 and 3, respectively, and thus are described

by *Yeo* in view of *TS36* and *Mallick* for the reasons discussed for claims 6, 2, and 3. See claim comparison chart provided above.

4. Claims 12 and 13

155. Aside from their dependency on claim 11, claims 12 and 13 are substantially similar to claims 2 and 3, respectively, and thus are rendered obvious by *Yeo* in view of *TS36* and *Mallick* for the reasons discussed for claims 11, 2, and 3. See claim comparison chart provided above.

5. Claims 17 and 18

156. Aside from their dependency on claim 16, claims 17 and 18 are substantially similar to claims 2 and 3, respectively, and thus are rendered obvious by *Yeo* in view of *TS36* and *Mallick* for the reasons discussed for claims 16, 2, and 3. See claim comparison chart provided above.

IX. CONCLUSION

157. For all the reasons I have noted in the foregoing paragraphs, claims 1-20 of the ’767 Patent are obvious in view of the references discussed above.

158. 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: 2025.05.01 15:03:05 -07'00'

Date: May 1, 2025

By: _____

Dr. Zhi Ding

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.

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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.