

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ERICSSON INC., and
NOKIA OF AMERICA CORPORATION
Petitioners,

v.

ACTIVE WIRELESS TECHNOLOGIES LLC
Patent Owner.

U.S. PATENT NO. 10,601,566
Title: MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL
(PUCCH) DESIGN FOR 5TH GENERATION (5G) NEW RADIO (NR)

Inter Partes Review No.: IPR2024-00985

**DECLARATION OF DR. MARK P. MAHON UNDER 37 C.F.R. § 1.68
IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 10,601,566**

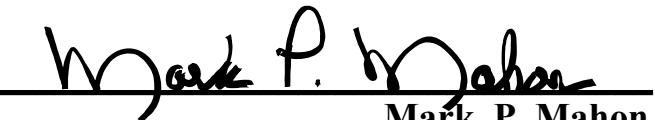
By: 
Mark, P. Mahon

TABLE OF CONTENTS

	Page
I. INTRODUCTION	6
II. BACKGROUND AND QUALIFICATIONS	7
III. MATERIALS REVIEWED	14
IV. LEGAL STANDARDS	15
V. LEVEL OF ORDINARY SKILL IN THE ART	20
VI. TECHNICAL BACKGROUND AND STATE OF THE ART	23
A. Frequency Hopping	23
B. Rate Matching and Puncturing	26
VII. OVERVIEW OF THE CHALLENGED PATENT	28
A. Priority Date	28
B. Overview of the Content of the Challenged Patent	28
C. Prosecution History	37
VIII. OVERVIEW OF THE PRIOR ART	40
A. Overview of Kim (EX-1004)	40
B. Overview of Gao (EX-1005, EX-1006)	44
IX. THE CHALLENGED CLAIMS OF THE '566 PATENT ARE OBVIOUS FROM KIM, ALONE, OR IN COMBINATION WITH GAO	48
A. Reasons to combine Kim and Gao	48
B. Detailed Application of Kim and Gao to the Challenged Claims	50
1. Claim 8	50

i.	[8.0] A base station (gNB), comprising:	50
ii.	[8.1] a processor; and memory in electronic communication with the processor, wherein instructions stored in the memory are executable to:.....	52
iii.	[8.2] transmit, to a user equipment (UE), a signaling, an uplink control channel (PUCCH) spans over multiple slots being determined based on the signaling; and	52
iv.	[8.3] receive uplink control information (UCI) with the frequency hopping for the configured multiple slots PUCCH, ...	53
v.	[8.4] wherein the number of symbols of the PUCCH is the same in each slot of the multiple slots, and the location of the symbols for the PUCCH is the same in the each slot of the multiple slots.....	55
2.	Claim 9	59
i.	[9.0] The gNB of claim 8, wherein the number of symbols of the PUCCH in each slot of the multiple slots PUCCH is greater than or equal to 4, and a reference symbol (RS) pattern in each slot is determined on a per slots basis by a long PUCCH format of a given the number of PUCCH symbols in the slot.	59
3.	Claim 10	63
i.	[10.0] The gNB of claim 8, wherein the same PUCCH symbol location may be allocated in each slot.	63
4.	Claim 11	66

i.	[11.1] The gNB of claim 8, wherein UCI encoded bits are rate matched and loaded to all to PUCCH UCI carrying symbols of each slot of the long PUCCH separately, ...	66
ii.	[11.2] if the number of symbols of the PUCCH in each slot is the same, the PUCCH format and encoded UCI in each slot is repeated in the multiple slots.	68
5.	Claim 13	71
i.	[13.0] The gNB of claim 8, wherein the frequency hopping is applied within each slot in the multiple slots PUCCH.	71
6.	Claim 14	72
i.	[14.0] The gNB of claim 8, wherein whether the frequency hopping is inter-slot or intra-slot can be configured by higher layer signaling for the multiple slots PUCCH.	72
7.	Claim 16	73
i.	[16.0] A method by a base station (gNB), comprising:	73
ii.	[16.1] transmit, to a user equipment (UE), a signaling, an uplink control channel (PUCCH) spans over multiple slots being determined based on the signaling;	74
iii.	[16.2] receiving uplink control information (UCI) with the frequency hopping for the configured multiple slots PUCCH, and.....	74
iv.	[16.3] wherein the number of symbols of the PUCCH is the same in each slot of the multiple slots, and the location of the symbols for the PUCCH is the same in the	

	each slot of the multiple slots.....	74
X.	THE CHALLENGED CLAIMS OF THE '566 PATENT ARE OBVIOUS FROM KIM, ALONE, OR IN COMBINATION WITH GAO AND IN FURTHER VIEW OF R1-1710555.....	75
A.	Overview of R1-1710555 (EX-1008)	75
1.	Public Accessibility of 3GPP R1-1710555.....	77
B.	Reasons to combine Kim and Gao with R1-1710555.....	84
C.	Detailed Application of Kim and Gao to the Challenged Claims in further view of R1-1710555.....	86
1.	Claim 12	86
i.	[12.0] The gNB of claim 8, wherein the frequency hopping is applied at slot boundaries in the multiple slots PUCCH.	86
XI.	THE CHALLENGED CLAIMS OF THE '566 PATENT ARE OBVIOUS FROM KIM, ALONE, OR IN COMBINATION WITH GAO AND IN FURTHER VIEW OF HUANG	89
1.	Overview of U.S. Patent No. 10,873,435 (“Huang”)	89
2.	Reasons to combine Kim and Gao with Huang.....	92
3.	Detailed Application of Kim and Gao further combination with Huang to the Challenged Claims	93
1.	Claim 12.....	93
i.	[12.0] The gNB of claim 8, wherein the frequency hopping is applied at slot boundaries in the multiple slots PUCCH.	93
XII.	SECONDARY CONSIDERATIONS DO NO REBUT THE PRIMA FACIE CASE OF OBVIOUSNESS.....	97
XIII.	CONCLUSION.....	98

I, Dr. Mark P. Mahon, declare as follows:

I. INTRODUCTION

1. I have been retained by Duane Morris on behalf of Petitioners as an independent, technical expert consultant in this proceeding before the United States Patent and Trademark Office (USPTO).¹ I have been ask to consider whether certain references disclose or suggest the limitations found in U.S. Patent No. 10,601,566 (“’566 Patent”) which I may reference as the “challenged patent” in this Declaration as discussed in detail below. My opinions are set forth below.
2. I am being compensated at my rate of \$550 per hour for my services. No part of my compensation depends on my opinions or the outcome of this proceeding. I have no financial interest in any of the parties to this proceeding.
3. In my analysis below, I generally refer to the ’566 Patent for citations unless otherwise noted.

¹ Where appropriate, I refer to exhibits that I understand are to be attached to the petition for *Inter Partes* Review of the challenged patent.

4. Unless otherwise indicated, the emphasis in quotations has been added.

II. BACKGROUND AND QUALIFICATIONS

5. My complete qualifications and professional experience are described in my Curriculum Vitae, a copy of which can be found in Appendix B to this Declaration.
6. The following is a brief summary of my relevant qualifications and professional experience
7. I am a Teaching Professor in the School of Electrical Engineering and Computer Science at Pennsylvania State University, University Park, PA (“Penn State” or “PSU”). I have worked on telecommunications and wireless networks, including Z-Wave, Bluetooth, Zigbee, Wi-Fi, NFC, AMPS, IS-95, CDMA2000, GSM, EDGE, UMTS/WCDMA, LTE, and 5G cellular systems since 1988.
8. I received my B.S. in Electronics Engineering from the University of Scranton in 1987. I received my M.S. in Electrical Engineering and Ph.D. in Acoustics from Penn State in 1991 and 2001, respectively.
9. In 1988, after I received my bachelor’s degree, I joined the Central Intelligence Agency (CIA) while pursuing my M.S. degree at Penn State part-time. My first job at the CIA involved designing and testing systems to

automatically capture and characterize telecommunication signals and emissions from various wireless and computer networking devices.

10. I returned to Penn State in early 1990 to pursue graduate research full-time and complete my M.S. degree. My graduate research work focused on wideband beamforming and adaptive signal processing. After completing my M.S. degree in EE in 1991, I accepted a full-time faculty research position at the Applied Research Lab at PSU, primarily working on classified programs, and began working on diverse radio frequency and acoustic sensor systems including wireless communications and small wireless networks for acoustic tracking, source localization, and feature extraction.
11. I began pursuing my Ph.D. part-time in 1993 while continuing my faculty research position. In 1997, as part of my faculty research position, I began working on classified programs focused on mathematical analytical modeling of cellular communication networks and the development of hardware and software systems to test against cellular networks. My role was to develop the algorithms and write the code running on a specially developed embedded system. For this work, I received a letter of recognition as the “genius behind the VELA software algorithms” from the

Director of National Reconnaissance Office (NRO) Systems Engineering and Technology Office. As part of this same work, I was extensively involved in protocol and signaling analysis as well as researching model-specific performance and unique functional characteristics associated with individual mobile devices. The work involved testing dozens of handsets from many manufacturers in controlled and real-world environments against network simulators and live operational networks for each research project.

12. In 2000, my research extended into utilizing non-orthogonal wavelets for improving detection and localization of cellular handsets from high altitude sensor systems. In 2001, I completed my Ph.D. and my research focused on the utilization of advanced communication signals for wideband characterization and remote sensing of propagation channels.
13. Beginning in 1997, my cellular communications research work focused on CDMA, GSM, EDGE, UMTS, LTE, and 5G cellular systems primarily under grants sponsored principally by the Department of Defense. This classified research work required 3GPP protocol analysis and development of real-time embedded hardware and software systems capable of interacting with cellular networks and cellular handsets. A large portion of my work was directed at architectures, protocols, software, and signaling.

14. I have been working on classified projects since 1988. Before 1998, because the work was not deemed highly classified, I was able to publish eight journal and conference papers prior to 2000. Between 1999 and 2015, however, I was allowed to publish only one article in an unclassified symposium and published and presented about a dozen articles in classified settings. This is because during this period, the vast majority of my research was highly classified. As a result, nearly all of my research results were summarized in classified reports and not available to the general public. Further, because the U.S. government owns any intellectual property resulting from the sponsored research work, I did not pursue or file patent applications.
15. In 2015, I transferred to the School of Electrical Engineering and Computer Science at Penn State as a teaching faculty member. In that role, I have continued teaching graduate and undergraduate courses, guiding Ph.D. and M.S. students in communication and mobile networking (including LTE and 5G cellular networks), and pursuing research in this and related areas. Since 2015, I have been an author on nine refereed papers as listed in my curriculum vitae (CV) (attached as Appendix B).
16. Because of my decades of research and my continuing work at Penn State, I

have intimate knowledge of telecommunication networks, including the technology involved in the patents in this case. I have been highly recognized as an expert in such systems within the research community. I was recognized twice by the National Reconnaissance Office with commendation letters for work dealing with detecting cellular signals in low signal to noise ratio environments. The U.S. government awarded me over \$12M in grants between 2003 and 2015 for projects focused on mobile communication devices and networks, in which I served as a Principal Investigator (PI), Co- PI, and/or technical lead.

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

range of computer scientists and engineers working on telecommunication network technologies and the familiarity with the classes taught to electrical engineers and computer scientists have allowed me to have a good understanding of the level of skills possessed by a person of ordinary skill in the field of cellular technology.

18. I have extensive experience with mobile networks in general and LTE and 5G specifically. While most of my research efforts between 1998 and 2015 were highly classified, I can state that they included detailed investigation of network architectures, signaling, and functional behavior. A typical research effort would involve studying 3GPP, 3GPP2, IEEE, and other protocol standards to fully comprehend all aspects of L1, L2, and L3 requirements including timing, bit-level construction of the control and user plane messages, and timing characteristics for a given standard as well as functional behavior of network components and user equipment.
19. From 2006 through 2015, my research focused specifically on LTE. My research continues to this day, although I am no longer operating in a classified environment. During this time, I investigated the performance and functional differences of many varied network and handset devices to see how differing signaling and hardware configurations (including MIMO) and

environmental factors influenced the behavior of user equipment in a given network environment. This included how diversity techniques (transmit and receive), synchronization, timing, and signal to interference plus noise ratio (SINR) for a given device would affect specific functional aspects including elements of the receiver structure, decoding and demodulation performance, calculation of parameters used by the device for making decisions and deriving parameters reported to the network.

20. As part of my research work, I built several custom CDMA, GSM, UMTS, and LTE platforms that implemented specific network-side and user equipment-side functionality including custom signal generation and processing structures, particularly the signal processing chains on both the transmit and receive sides. This equipment was developed using network simulation hardware in a laboratory environment and was later tested with corresponding networks in both controlled and fully operational environments. Implementing the transmit and receive chains for custom built protocol-enabled equipment required me to gain an intimate understanding of the relevant 3GPP protocol specifications and the underlying structures. Since 2015, I have been primarily focused on guiding graduate students pursuing research including network scheduling and

resource optimization techniques and using code domain non-orthogonal multiple access (NOMA) combined with MIMO sparse coding multiple access to minimize latency and maximize user density in grant free Internet of Things (IoT) environments. Additionally, I am guiding my graduate students in pursuing research in optimized distributed processing algorithms, implementation of block chain coding techniques to improve handover security, and edge computing resource allocation in 4G (LTE)/5G (NR) networks.

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

III. MATERIALS REVIEWED

22. The opinions contained in this Declaration are based on the documents I reviewed, my professional judgment, as well as my education, experience, and knowledge regarding cellular networking systems.
23. I have reviewed all of the documents referenced in this Declaration. I have reviewed the challenged patent and its prosecution history. I have listed the reviewed materials in in Appendix A to this Declaration.

IV. LEGAL STANDARDS

24. I am not an attorney and offer no legal opinions. My analysis and opinions are based on my expertise in this technical field and on the instructions that counsel has given me for the legal standards relating to patentability as outlined in the rest of this section. I have applied these principles in reaching the opinions set forth herein do not provide any legal opinions in this Declaration. I have been informed and understand that certain legal standards are to be applied by technical experts in forming opinions regarding the meaning and validity of patent claims.
25. I understand and the standard that I have used throughout my Declaration is that, in this proceeding, a patent claim may be deemed unpatentable as “anticipated” if it is shown by a preponderance of the evidence that each-and-every feature of the claim is found in a single prior art reference or rendered “obvious” if, in view of a prior art reference or a combination of prior art references, it would have been obvious to a person of ordinary skill in the art (“POSITA”) at the time of the invention, taking into account the following four issues: (1) the scope and intent of the prior art, (2) the differences between the prior art and the claim under consideration, (3) the level of ordinary skill in the art, and (4) any secondary evidence bearing on

obviousness.

26. Counsel has informed me that legal principles regarding unpatentability of a claim due to obviousness have been addressed by the U.S. Supreme Court and that, while not absolute, the principles relating to a “motivation,” “suggestion,” or “teaching” in the prior art to combine references are useful in analyzing whether an invention is obvious. Counsel has also informed me that the suggestion or motivation may be either explicit or implicit and may come from knowledge generally available to a POSITA, from the nature of the problem to be solved, or from a combination of these factors. The test for an implicit motivation, suggestion, or teaching is what the combined teachings, knowledge of a POSITA, and the nature of the problem to be solved as a whole would have suggested to those of ordinary skill in the art. The analysis is not focused on the specific problem solved by the invention, but the general problem that confronted the inventor prior to the invention.
27. Counsel has further informed me that the U.S. Supreme Court has clarified that additional principles may also be applied in such an analysis. Some of those principles are set forth below.
28. I have been informed by counsel that it is no longer always required to present evidence of an explicit teaching, suggestion, or motivation to

combine prior art references for purposes of determining whether an invention is obvious. Prior art can be combined based on several factors including: an express teaching, suggestion, or motivation from the prior art itself, or from a reasoned explanation of an expert or other witness.

29. I have been informed that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known in the prior art. In evaluating whether such a claim would have been obvious, I may consider whether there is a reason that would have prompted a person of ordinary skill in the field to combine the elements or concepts from the prior art in the same way as in the claimed invention.
30. To determine whether there was an apparent reason to combine the known elements in the way a patent claims, it will often be necessary to look to interrelated teachings of multiple pieces of prior art, to the effects of demands known to the design community or present in the marketplace, and to the background knowledge possessed by a POSITA. Also, in determining obviousness, one must be aware of the distortion caused by hindsight bias and be cautious of arguments relying upon hindsight reasoning. An obviousness argument cannot be sustained by mere conclusory statements.

Instead, it must be some articulated reasoning with some rational underpinnings to support the legal conclusion of obviousness.

31. In an obviousness analysis, it is my understanding that there are “secondary considerations” that should be analyzed if they apply. I am told that these considerations include (a) whether the prior art teaches away from the claimed invention, (b) whether there was a long felt but unresolved need for the claimed invention, (c) whether others tried but failed to make the claimed invention, (d) skepticism of experts, (e) whether the claimed invention was commercially successful, (f) whether the claimed invention was praised by others, and (g) whether the claimed invention was copied by others.
32. I have also been informed that in order for evidence of secondary considerations to be significant, there must be a sufficient relationship between the claimed invention and the evidence of secondary considerations. I understand that this relationship serves to provide a link between the merits of the claimed invention and the evidence of secondary considerations provided.
33. I have been informed by counsel that the Board construes claims according to the so-called “Phillips” standard. Under the Phillips standard, terms in a

claim are given their ordinary and customary meaning, consistent with the patent's specification, as understood by a POSITA. I have been informed by counsel that what is to be considered includes the claims, the patent specifications and drawings, and the prosecution history, including any art listed by the examiner or the Applicant. I have been informed by counsel that information external to the patent, including expert and inventor testimony and unlisted prior art, are to be considered if ambiguities remain. However, expert testimony may be useful in helping to explain the technology.

34. I have been informed and understand that a patent claim is not patentable as obvious if the differences between the patent claim and the prior art are such that the claimed subject matter as a whole would have been obvious at the time the claimed invention was made to a person having ordinary skill in the relevant art.
35. In analyzing the relevance of the differences between the claimed invention and the prior art, I have been informed that I must consider the impact of such differences on the obviousness or non-obviousness of the invention as a whole, not merely some portion of it. The person of ordinary skill faced with a problem is able to apply their experience and ability to solve the

problem and also look to any available prior art to help solve the problem.

36. I have been informed and understand that there are recognized, exemplary rationales for combining or modifying references to show the obviousness of claimed subject matter. Some of the rationales include the following:
- combining prior art elements according to known methods to yield predictable results; simple substitution of one known element for another to yield predictable results; use of a known technique to improve a similar device (method or product) in the same way; applying a known technique to a known device (method or product) ready for improvement to yield predictable results; choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art; and some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art teachings to arrive at the claimed invention.

V. LEVEL OF ORDINARY SKILL IN THE ART

37. It is my understanding that a person of ordinary skill in the art (“POSITA”)

is a hypothetical person who is used to analyze the prior art without the benefit of hindsight. I have been instructed that the level of ordinary skill may be reflected by the prior art of record, and that a person of ordinary skill in the art to which the claimed subject matter pertains would have the capability of understanding the scientific and engineering principles applicable to the pertinent art. I have been instructed that there are multiple factors that may be considered in determining the level of ordinary skill in the art may include: (1) type of problems encountered in the prior art; (2) prior art solutions to those problems; (3) rapidity with which innovations are made; (4) sophistication of the technology; and (5) educational level of active workers in the field. I also understand that a POSITA is also a person of ordinary creativity, not an automaton. They would be able to fit the teachings of multiple patents together like a puzzle and have the capability of understanding the scientific and engineering principles applicable to the pertinent art.

38. I have been asked to provide a definition for the level of ordinary skill in the art in the field of the challenged at the time the priority application was filed. As stated in the challenged '566 Patent, "The present disclosure relates generally to communication systems. More specifically, the present

disclosure relates to multiple slot long physical uplink control channel (PUCCH) design for 5th generation (5G) new radio (NR).” EX-1001, 1:18-21.

39. In my opinion, a POSITA as of the claimed priority date of the challenged patent would have had (1) the equivalent of an undergraduate degree in Electrical Engineering or a related field; and (2) at least two years of experience in design, development, and/or testing of wireless telecommunication systems. In a similar vein, a POSITA would also have familiarity with the wireless standards and protocols related to data transmission and network management. It is also my opinion that more education could supplement practical experience or vice versa. For example, such knowledge could be acquired by a mixture of training and work experience such as a Master’s degree in Electrical Engineering with less work experience.
40. When forming my opinions herein, I analyzed and applied the prior art and claim constructions from a POSITA's perspective at the invention’s time.
41. I understand that a POSITA is presumed to have knowledge of all references that are sufficiently related to one another and to the pertinent art and to have knowledge of all arts reasonably pertinent to the particular problem that the claimed invention addresses.

42. All of my opinions in this Declaration are from the perspective of a POSITA, as I have defined it above and during the relevant time frame, *i.e.*, on or around date of the priority application. During this time frame, I possessed at least the qualifications of a person of ordinary skill in the art, as defined above, and I am capable of addressing the issues from the perspective of such a person. My opinions in this declaration reflect how a POSITA would have understood the claims and the specification of the challenged patent, the prior art to the patent, and the state of the art on or around the priority date.

VI. TECHNICAL BACKGROUND AND STATE OF THE ART

43. The following section describes the relevant state of the art as of the priority date. The prior art references, and the discussions of what was known to a POSITA, provide the factual support for the general description of the state of the art, assist in understanding how a POSITA would have understood the prior art, and provide the motivation to modify or combine the teachings of references.

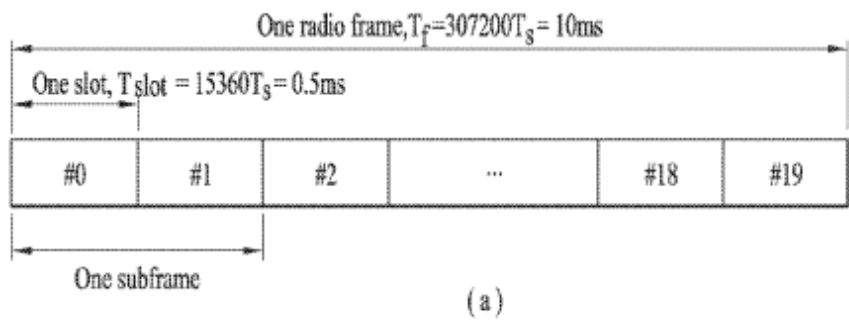
A. Frequency Hopping

44. By August 2017, frequency hopping was well-known for wireless access communication networks. Frequency hopping is a method of transmitting

wireless signals by changing the carrier frequency of the signal to be transmitted. Orthogonal frequency division multiplexing (“OFDM”) is a technique to encode data onto a plurality of subcarriers in a radio frame structure. EX-1004 (“Kim”) ¶ 71.

45. A radio frame can be divided into multiple subframes (as shown in FIG. 2 from Kim below), where the time required for transmitting one subframe is defined as the Transmission Time Interval (TTI). EX-1004 ¶71. The subframe can be further divided into a plurality of slots, each slot having a plurality of OFDM symbols. EX-1004 ¶¶71, 72.

FIG. 2



EX-1004 FIG. 2.

46. Kim discloses the radio frame structure can vary, stating the “radio frame structure is purely exemplary. Thus, the number of subframes in a radio

frame, the number of slots in a subframe, and the number of OFDM symbols in a slot may be changed.” EX-1004 ¶¶ 74, 150, 151, 152. Kim further describes TTIs of different sizes, including a TTI being equal to less than 1 ms, i.e., less than one subframe. EX-1004 ¶ 152. Kim further discloses examples of the radio frame structure where a TTI represents one slot. EX-1004 ¶ 227.

47. Frequency hopping maps the OFDM symbols to the different subcarriers used for transmitting the data. The 3GPP submission, “Support of long-PUCCH over multiple slots” (“R1-1710013”) discloses various patterns of frequency hopping that can be used in transmitting long-PUCCH over multiple slots. EX-1010 (“R1-1710013”), 2-4. For example, FIG. 2(a) of R1-1710013 discloses the hopping pattern of PUCCH channel where slot 1 has the same arrangement as slot 2, and FIG. 2(b) discloses the hopping pattern of the PUCCH channel where the arrangement of slot 2 is switched from the arrangement of slot 1. EX-1010 (“R1-1710013”), 2-3. The x-axis of the slot corresponds to length of time and the y-axis corresponds to the frequency. EX-1010 (“R1-1710013”) FIG. 2.

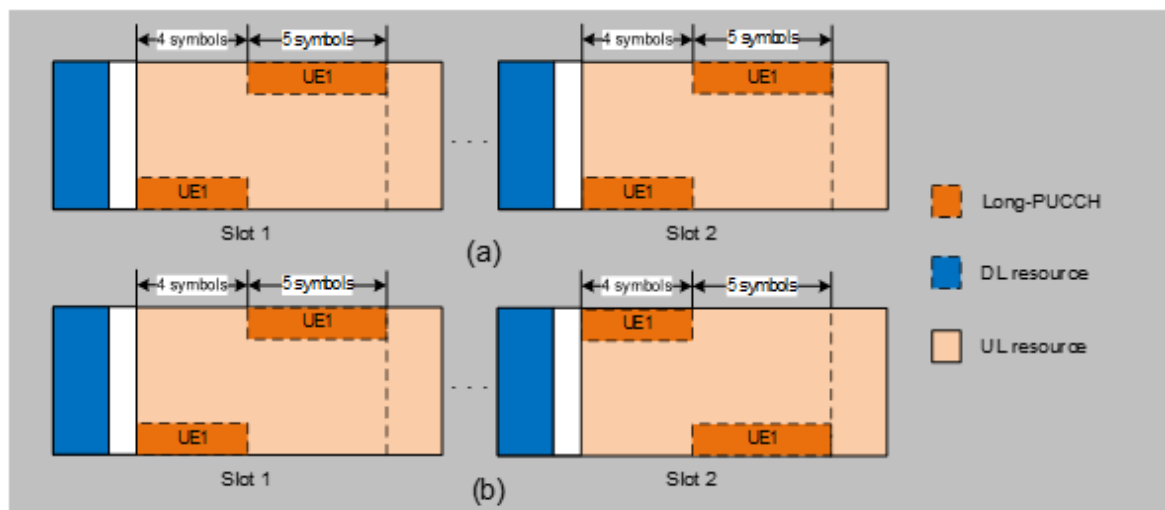


Figure 2. An example of 18 symbols in two slots for Option 1

EX-1007 FIG. 2.

48. U.S. Patent No. 8,705,339 (“Takaoka”; EX-1015) discloses frequency hopping. Takaoka states the following:

As described above, the frequency resource allocation and mapping method in an LTE UL physical channel (1) maps a signal to a continuous frequency band in a localized manner to thereby maintain a low PAPR characteristic of a UL SC-FDMA signal and (2) use *inter-slot frequency hopping*, and can thereby improve a frequency diversity effect and an effect of suppressing other cell interference.

EX-1015 (“Takaoka”) 1:57-63.

B. Rate Matching and Puncturing

49. By August of 2017, rate matching and puncturing of resources in wireless access systems were well-known. The 3GPP submission, “Editorial

correction to the calculation of Rate Matching parameters” (“R1-00426”), defines rate matching as “Rate matching means that bits on a transport channel are repeated or punctured.” EX-1014 (“R1-00426”), 1. R1-00426 further provides:

The number of bits on a transport channel can vary between different transmission time intervals. In the downlink the transmission is interrupted if the number of bits is lower than maximum. *When the number of bits between different transmission time intervals in uplink is changed, bits are repeated or punctured to ensure that the total bit rate after TrCH multiplexing is identical to the total channel bit rate of the allocated dedicated physical channels.*

EX-1014 (“R1-00426”), 2.

50. U.S. Patent No. 9,391,736 (“Nazar”; EX-1012) discloses a rate matching module that is configured to perform rate matching on encoded uplink control bits (HARQ ACK/NACK). EX-1012 (“Nazar”) 31:17-35, FIG. 11. Rate matching can be used to make the information occupy the resources within a PUCCH resource block, e.g., 48 bits. EX-1012 (“Nazar”) 31:17-35.
51. U.S. Patent No. 9,716,575 (“Ahn”; EX-1013) describes implementing rate matching/puncturing of a signal in an uplink control channel to address issues with the transmission of misaligned resources in the network. EX-

1013 (“Ahn”) 14:19-32. Ahn discloses, “[i]f the subframe timing is misaligned by more than the threshold, some of the UL signals may be subjected to dropping/puncturing/*rate-matching*, and if the subframe timing is misaligned by less than the threshold, a transmit power of some signals may be reduced.” EX-1013 (“Ahn”) 14:19-32.

VII. OVERVIEW OF THE CHALLENGED PATENT

A. Priority Date

52. I have been instructed, for this purpose of this IPR Petition, to assume the priority date for the challenged patent is August 10, 2017 (i.e., the filing date of U.S. Provisional Patent Application No. 62/543,795 to which the challenged patent claims priority). To the extent the Challenged Claims (i.e., claims 8-14 and 16) are only entitled to the August 8, 2018 filing date of International Patent Application No. PCT/US2018/045836, my analysis herein would not change.

B. Overview of the Content of the Challenged Patent

53. The Challenged Claims are directed to techniques for improving communication flexibility and/or efficiency for multiple slot long physical uplink control channel (PUCCH) design for 5G wireless systems. EX-1001 1:18-21, 1:43-45. Almost everything described in the claims was known

from prior 4G systems with some minor improvements for 5G.

54. The PUCCH is used to transmit uplink control information (“UCI”) from the user equipment (UE) such as a phone to the base station (also referenced as a “eNB” or “gNB”). The gNB configures the PUCCH format used by the UE for transmitting control information. EX-1001 5:40-55.
55. In 5G systems, data transmissions use “frames” that are broken down into “sub-frames” which can be further broken down into variable number of “slots” as depicted in Fig. 5 of the ’566 patent:

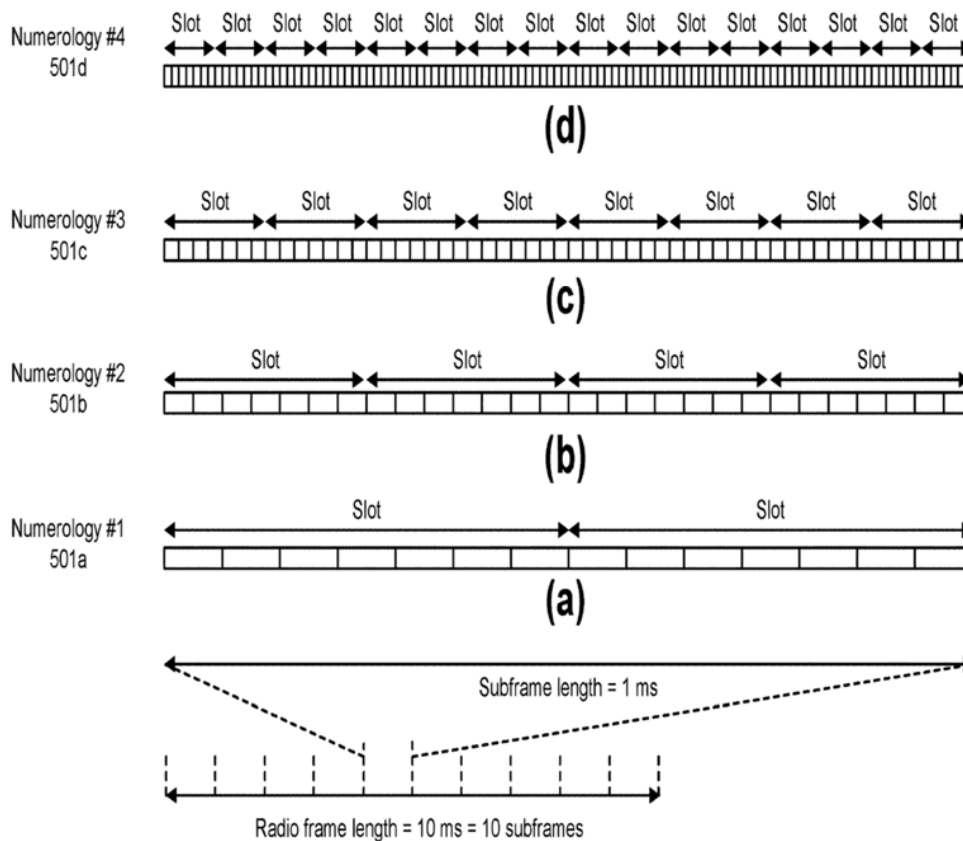


FIG. 5

56. EX-1001 Fig. 5. Each “slot” can have multiple “symbols.” The symbols carry data for particular channels. So, as shown in Figure 7, a slot may carry symbols that have data for different channels.

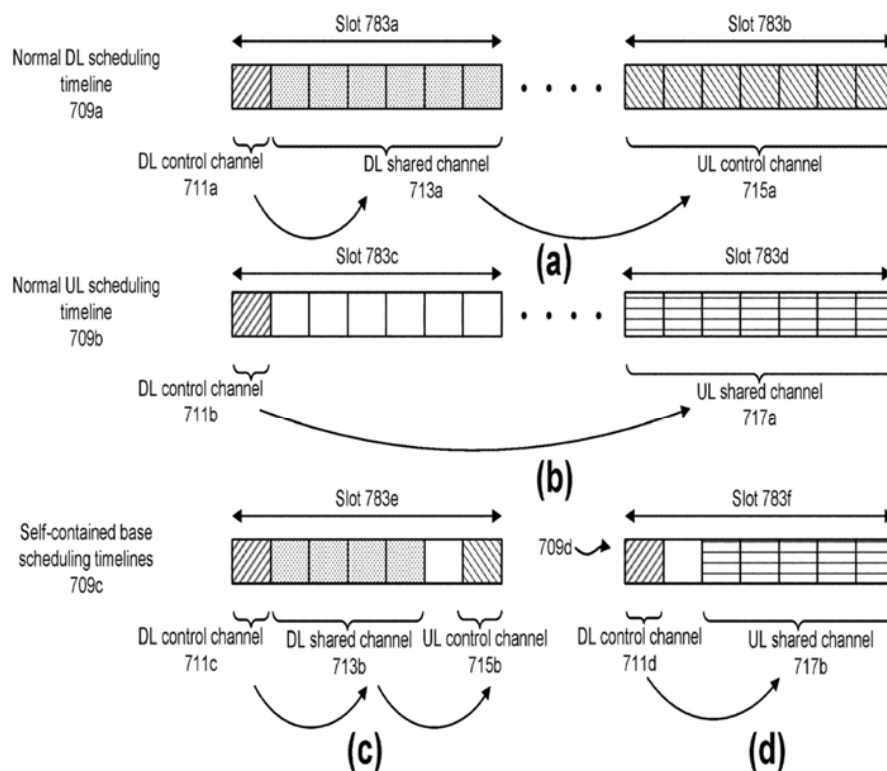


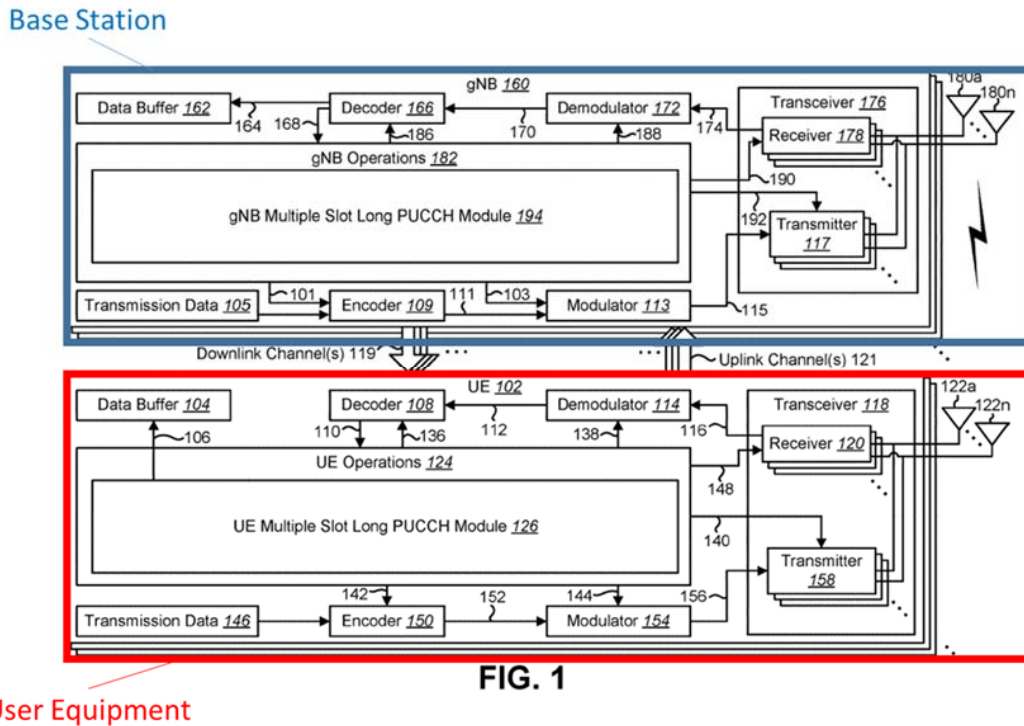
FIG. 7

EX-1001 Fig. 7. This architecture was well-known and part of the 3GPP standard prior to the '566 Patent.

57. The '566 Patent relates to a particular configuration of which slots and symbols that are used for the PUCCH. As was known prior to the '566 Patent, 5G systems could have a "short PUCCH" format or a "long PUCCH" format. EX-1001 5:44-46. The "long" format may span over multiple slots. EX-1001 5:47-49.

58. The systems and methods disclosed in the '566 Patent detail specific formats for long PUCCH design over multiple slots. EX-1001 5:50-51. Figure 1 of

the '566 patent shows the gNB and UE exchanging information across various uplink (to the gNB) and downlink (to the UE) channels.



EX-1001 FIG. 1 (annotated).²

59. The Challenged Claims require the base station (**blue**) to transmit a *signaling* to the UE (**red**). EX-1001 5:48-52. The signaling is used to configure the resource assignment for the UE to transmit control information and data over the various uplink channels to the base station including the

² All emphasis and annotations herein added unless otherwise stated.

“uplink control information” (UCI) transmitted over the PUCCH.

60. The '566 Patent teaches that the gNB will “configure” the UE to know how to transmit uplink control information on the PUCCH. EX-1001 26:19-37.

The Challenged Claims recite the gNB receiving the UCI. In other words, the gNB will configure the UE to transmit the UCI on particular slots and symbols and the gNB then receives that UCI on the configured slots / symbols.

61. The Challenged Claims recite three distinct aspects of the long PUCCH: (1) the number of PUCCH symbols must be the same between slots; (2) the location of the PUCCH symbols must be the same between slots; and (3) there must be “frequency hopping” (explained below) between slots. The '566 Patent includes Figures describing each of these claimed aspects.

62. FIG. 37 of the '566 Patent (reproduced below) teaches examples of how the “number” and “location” (aspects 1 and 2 above) may be the same or different. EX-1001 43:16-24.

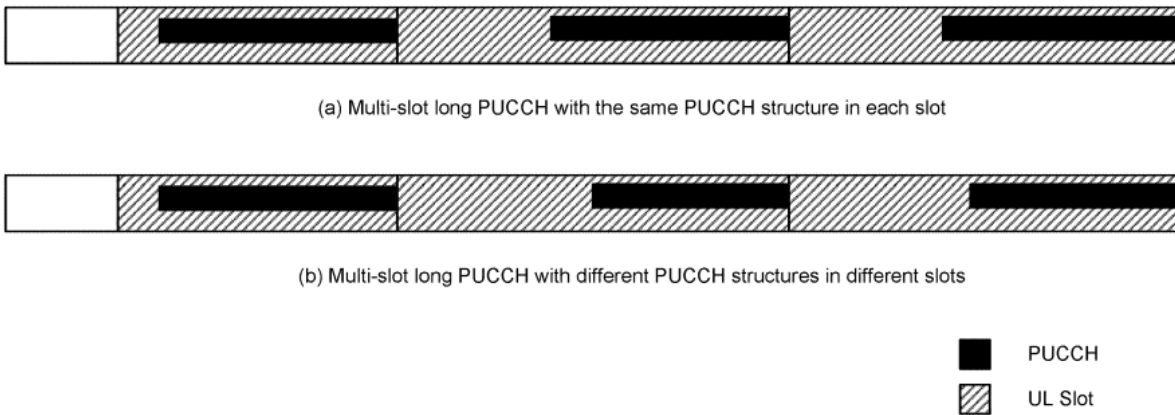


FIG. 37

EX-1001 FIG. 37.

63. As shown above, Fig. 37(a) shows an example in which the number and location of the PUCCH symbols is the same between slots. Fig. 37(b) shows a counter-example in which the location and number of PUCCH symbols is different between, for example, the left slot and the other two slots.
64. The third claimed aspect is that there must be “frequency hopping” between the slots for the PUCCH. Frequency hopping occurs when a signal is transmitted over different carrier frequencies, and if configured, the PUCCH symbols can be transmitted at different PUCCH regions of the slot. EX-1001 17:4-10.
65. Frequency hopping can be performed between slots (“inter-slot”) in which the frequencies change between slots. Alternatively, frequency hopping can

be performed within a single slot (intra-slot) in which frequencies change within a slot. EX-1001 6:32-36, 17:5-6, 21:65-66. FIG. 38(a) of the '566 Patent illustrates inter-slot frequency hopping. FIG. 38(b) discloses another intra-slot frequency hopping.

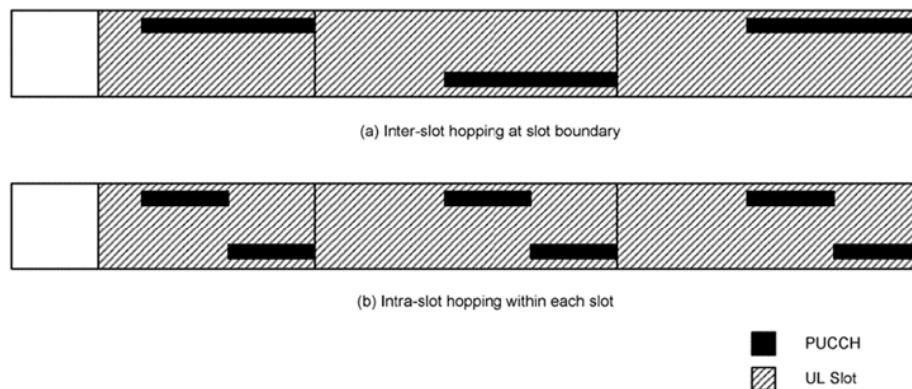


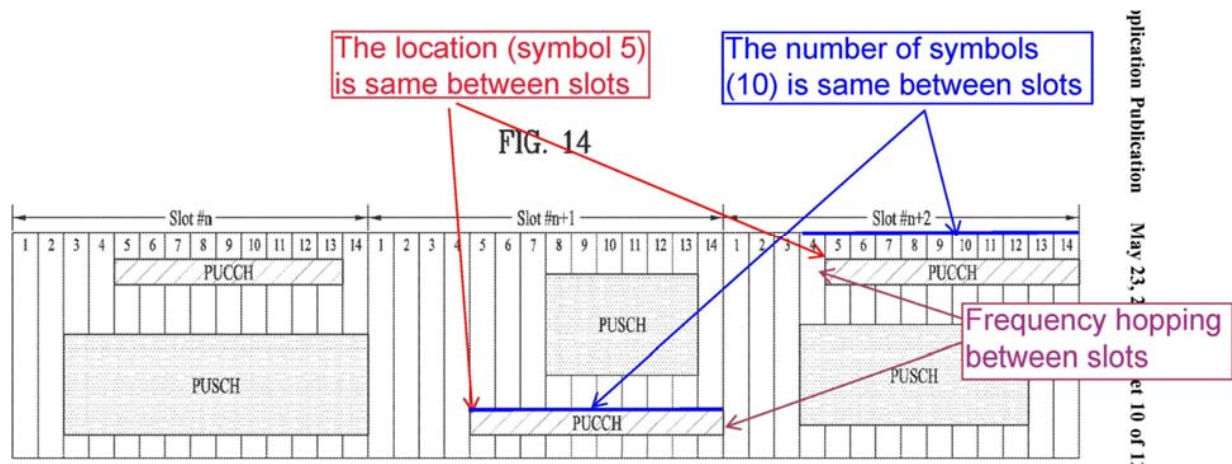
FIG. 38

EX-1001 FIG. 38, 43:32-49.

66. The frequency hopping is depicted by the vertical change in FIG. 38 (the vertical axis represents different frequencies).
67. As detailed below, everything in the Challenged Claims was known prior to the '566 patent filing. For example, the Kim reference³ describes the

³ U.S. Patent Application Publication No. 2019/0159191 A1 to Kim et al. ("Kim") (EX-1004).

configuration of the PUCCH as claimed in a single diagram.



68. EX-1004, Fig. 14.⁴ Kim shows a “long PUCCH transmission is configured over a total of two TTIs or slots, i.e., slot #n+1 and slot #n+2 as shown in FIG. 14.” EX-1004, ¶234. The **“location” (red)** is the same as both slot#n+1 and slot#n+2 start at symbol 5. The **number (blue)** of symbols is the same (10 symbols) going from symbols 5-14. **Frequency hopping** between slots is shown in purple by the symbols being at different locations on the vertical axis (which represents different frequencies).
69. Kim’s specification expressly discloses each of these concepts. First, the “number” and “location” of symbols may be the same. “[I]n the two slots, the last ten symbols among the twelve symbols are set as a long PUCCH

⁴ All annotations added unless otherwise stated.

region.” EX-1004 ¶234 (showing both the number [“ten”] and location [“last ten”] are the same between slots). See also EX-1004 ¶233 (“[T]he number of symbols allocated for the PUCCH transmission within one TTI may be constant for all TTIs.”) Kim describes the frequency hopping as either inter-slot or intra-slot:

information about a frequency hopping interval may be configured/indicated via DCI or higher layer signaling. In this case, the frequency hopping may be hopping in a single TTI (or slot), inter-TTI (or inter-slot) hopping as shown in FIG. 14,

EX-1004 ¶235.

70. Thus, the Challenged Claims recite nothing more than configuring the PUCCH in a manner that is well-known in the prior art. Thus, Petitioners respectfully request that the Board institute IPR and cancel the Challenged Claims.

C. Prosecution History

71. The ’566 Patent issued from U.S. Patent Application No. 16/059,926, which was filed on August 9, 2018 as a continuation of International Patent Application No. PCT/US2018/045836, filed on August 8, 2018 claiming priority to U.S. Provisional Patent Application No. 62/543,795, filed August

10, 2017 (“’795 Provisional”).

72. During prosecution, the Examiner rejected the originally pending claims as being obvious from Huawei, HiSilicon, “Long Duration PUCCH structure”, 3GPP TSG RAN WG1 Meeting #89, Hangzhou, China, R1-1706953, 19 May 2017, and in further view of NTT DOCOMO, INC., “Long-PUCCH for more than one slot”, 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1711102, 30 June 2017. EX-1002 (’566 Patent File History) 34-35. In response, Applicant amended the claims to incorporate the claim limitations shown in the excerpt below.

8. (Currently Amended) A base station (gNB), comprising:
a processor; and
memory in electronic communication with the processor, wherein instructions stored in the memory are executable to:
- ~~determine an uplink control channel (PUCCH) spans over multiple slots;~~
 - ~~determine a demodulation reference signals (DMRS) structure in the configured multi slot PUCCH;~~
 - ~~determine a frequency hopping method of the configured multi slot PUCCH;~~
 - ~~determine UCI encoding and loading methods on the configured multi slot PUCCH;~~
 - ~~determine a resource of a control channel for UCI feedback; and~~
 - transmit, to a user equipment (UE), a signaling, an uplink control channel (PUCCH) spans over multiple slots being determined based on the signaling; and
 - receive uplink control information (UCI) on a selected channel with the frequency hopping for the configured multiple slots PUCCH, wherein
the number of symbols of the PUCCH is the same in each slot of the
multiple slots, and
the location of the symbols for the PUCCH is the same in the each slot of
the multiple slots.

EX-1002 ('566 Patent File History), 30-31.

73. Applicant admitted that “[t]he cited reference R1-1706953 discusses the structures of an NR long PUCCH in multiple slots.” ('566 Patent File History), 34. The Applicant argued that [the cited references] do not teach or suggest to “transmit uplink control information (UCI) with the frequency

hopping, wherein the number of symbols of the PUCCH is the same in each slot of the multi slots, and the location of the symbols for the PUCCH is the same in the each slot of the multiple slots. R1-1711102 does not make up for the deficiencies of R1-1706953.” (’566 Patent File History), 34-35.

74. Subsequently, a Notice of Allowance issued on December 18, 2018. The Examiner did not set forth any additional substantive reasons for allowance. EX-1002 (’566 Patent File History), 14-15. As demonstrated below, the features added by amending the claims were well-known in LTE and NR technologies at the time of the purported invention recited in the Challenged Claims.

VIII. OVERVIEW OF THE PRIOR ART

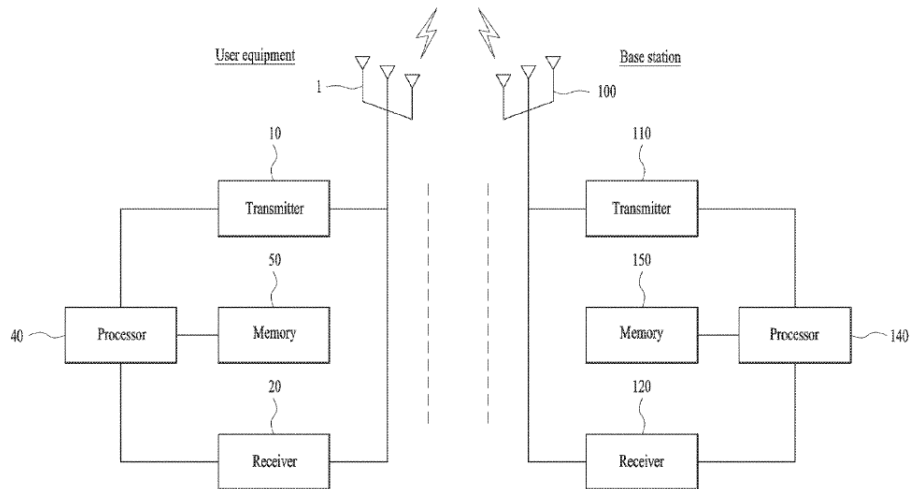
A. Overview of Kim (EX-1004)

75. Kim discloses methods for transmitting/receiving an uplink signal between a base station and a terminal. EX-1004 Abstract. Kim states:

In a wireless access system, a UE receives information from an eNB on a DL and transmits information to the eNB on a UL. The information transmitted and received between the UE and the eNB includes general data information and various types of control information. There are many physical channels according to the types/usages of information transmitted and received between the eNB and the UE. EX-1004 ¶ 59.

76. In Kim, one such physical channel is the PUCCH, which is used to carry uplink control information (UCI) to the base station. FIG. 18 of Kim depicts a system including a UE and a base station configured to implement embodiments of the method for transmitting and receiving PUCCH between the UE and the base station (eNB or gNB) 100. EX-1004 ¶¶ 306, 360, Abstract.

FIG. 18



EX-1004 FIG. 18.

77. Kim states, “The UCI includes a Hybrid Automatic Repeat and reQuest Acknowledgement/Negative Acknowledgement (HARQ-ACK/NACK), a Scheduling Request (SR), a Channel Quality Indicator (CQI), a Precoding Matrix Index (PMI), a Rank Indicator (RI), etc.” EX-1004 ¶67. The UCI is used for configuring the base station so that it knows what data/information

should be received from the UE. EX-1004 ¶¶67, 111-117, 225, 286, 287.

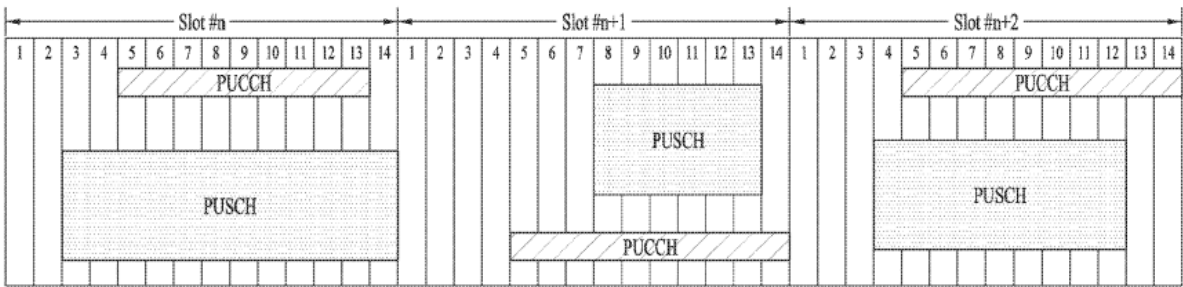
78. Kim discusses the information transmitted over the wireless network is arranged and sent over a Transmission Time Interval (TTI), stating “[a] time required for transmitting one subframe is defined as a Transmission Time Interval (TTI).” EX-1004 ¶71. Kim provides that “if the number of symbols within one TTI used for transmitting a UL control channel is equal to or more than a predetermined value (e.g., 4), the *UL control channel is defined as a long PUCCH*.” EX-1004 ¶¶67, 71. Kim provides methods that can be applied when the UL control information is transmitted across multiple TTIs (slots or subframes). EX-1004 ¶¶224, 225. “The UL control information (e.g., UCI, HARQ-ACK/CSI/SR (scheduling request)) can be transmitted over most or all of the multiple TTIs. Such a signal transmission and reception method has an advantage in that a UE located at a cell boundary (e.g., cell edge UE) can solve the coverage problem.” EX-1004 ¶225.

79. As part of the PUCCH configuration, the OFDM symbol position and location within the PUCCH can be configured to offer flexibility in communication, as Kim discloses, “[s]ymbol allocation in one TTI can be equally applied to a plurality of TTIs used/allocated for transmitting one

long PUCCH. In this case, the number of symbols allocated for the PUCCH transmission within one TTI may be constant for all TTIs or vary per TTI.” EX-1004 ¶233.

80. In order to increase the flexibility and efficiency of the PUCCH in the multiple slots, the symbols can be transmitted using different frequency resources (frequency hopping). EX-1004 ¶239. Frequency hopping prevents performance degradation in the continuously transmitted long PUCCH, which is caused by a power transient period. EX-1004 ¶239. Kim also describes configuring the frequency hopping of the PUCCH using downlink signaling, stating that “information about a time when frequency hopping is applied to such a long PUCCH and/or information about a frequency hopping interval may be configured/indicated via DCI or higher layer signaling.” EX-1004 ¶235.

FIG. 14



EX-1004 FIG. 14.

81. The frequency hopping and symbol location are the resources that are configured by the base station. EX-1004 ¶¶ 228-230, 235, 287. The base station of Kim configures the PUCCH in various ways, including providing signaling to the UE. For example, Kim states “information about a time when frequency hopping is applied to such a long PUCCH and/or information about a frequency hopping interval may be configured/indicated via *DCI or higher layer signaling*.” EX-1004 ¶¶ 235, 287. The configuration of the transmission region in a time domain can be applied to a single slot or multi-slot based long PUCCH, a PUSCH, or a PDSCH. EX-1004 ¶¶ 235, 242.

B. Overview of Gao (EX-1005, EX-1006)

82. Gao is an AIA reference and meets the ministerial requirements of 35 U.S.C. §§ 119 and 120. On its face, Gao claims priority to PCT/CN2018/089019, CN 2017/10457951.5, and CN 2017/0527934.4. PCT/CN2018/089019, which published as WO 2018/228194 (EX-1018), was filed within 12 months of the filing date of CN 2017/10457951.5 and CN 2017/0527934.4, and U.S. Patent Application No. 16/622,880, which issued as Gao, was filed within 30 months of CN 2017/10457951.5. Thus, all of the various applications in the Gao priority claim were co-pending with one another.

Each of Gao, PCT/CN2018/089019, CN 2017/10457951.5, and CN 2017/0527934.4 identify Xuejuan Gao as the sole inventor. EX-1005 (Gao); EX-1006 (Gao Prov.); EX-1018 (Gao PCT). Accordingly, Gao is entitled to the priority date afforded to it by the two Chinese priority applications. *Penumbra, Inc. v. RapidPulse, Inc.*, IPR2021-01466, Paper 34 (March 10, 2023). Petitioners cite to the both the Gao patent (EX-1005) and to the certified English translation of CN 2017/10527934.4 (EX-1006) demonstrating that the subject matter upon which Petitioners rely is prior art to the '566 Patent.

83. Gao discloses methods and systems for configuring and transmitting uplink control information in multiple slots of a long physical uplink control channel (PUCCH). EX-1005 (Gao) 2:1-10, 29:56-65, 30:42-40, Abstract; EX-1006 (Gao Prov.) 1:6-8; 2:3-5; 35:17-22, 36:13-18. FIG. 4 of Gao illustrates a method of receiving a PUCCH. EX-1005 (Gao) 20:66-21:3, FIG. 4; EX-1006 (Gao Prov.) 52:4-6, FIG. 4. At step 41, the UE determines the target slots for transmitting the UCI using the PUCCH. EX-1005 (Gao) 21:4-10, 21:39-48; EX-1006 (Gao Prov.) 25:7-11, 25:29-26:1.

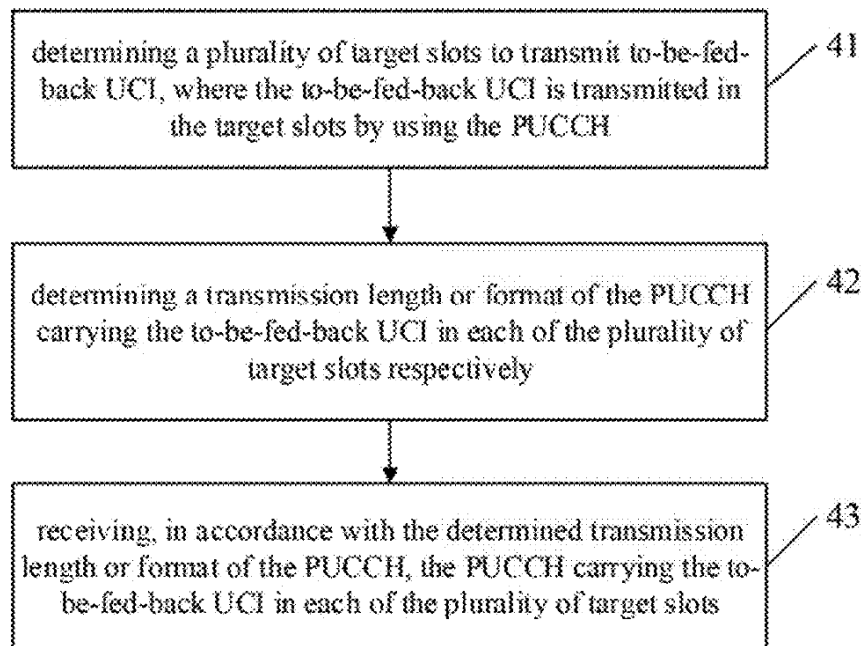


Fig. 4

EX-1005 (Gao) FIG. 4; EX-1006 (Gao Prov.) FIG. 4.

84. The base station can transmit the configuration information of the plurality of target slots of the PUCCH to the UE by means of a higher layer signaling. EX-1005 (Gao) 21:39-42, 22:7-16, 31:57-63; EX-1006 (Gao Prov.) 25:29-26:1, 26:18-24, 37:29-33. Upon configuring the PUCCH, the UE provides the control information to the base station over the PUCCH. EX-1005 (Gao) 29:56-65, 31:57-63; EX-1006 (Gao Prov.) 32:12-17, 35:17-22. The PUCCH comprises a plurality of symbols, and in Gao, the UCI is transmitted to the base station using a UCI+RS (Reference Symbol) structure (*pattern*) for a long PUCCH format (e.g., 4 symbols or greater). EX-1005 (Gao) 32:6-10;

EX-1006 (Gao Prov.) 37:29-33; 37:38-38:1. The “UCI+RS structure” is a structure that provides a mapping of the UCI and RS in the PUCCH, where the mapping indicates which symbols are used to transmit the UCI and which symbols are used to transmit the RS. EX-1005 (Gao) 24:21-45; EX-1006 (Gao Prov.) 3:18-24, 17:37-18:9, 28:34-38. Gao also makes a note that different structures of UCI and RS are possible on account of different transmission durations and whether there is frequency hopping between symbols. EX-1005 (Gao) 15:6-12, 24:46-52; EX-1006 (Gao Prov.) 18:10-14, 29:7-11. Prior to transmission of the UCI+RS structure to the base station, Gao discloses the UCI bits can be coded and the coded UCI bits can be rate matched. EX-1005 (Gao) 32:25-33; EX-1006 (Gao Prov.) 38:7-15.

85. At step 43 of the method shown in FIG. 4 referenced above, the PUCCH carrying the UCI feedback is received by the base station according to the configured transmission duration or format. EX-1005 (Gao) 21:19-22; EX-1006 (Gao Prov.) 25:17-21.
86. Gao addresses the need to configure the transmit uplink control information in multiple slots due to the varying size of the uplink regions of different slots. EX-1005 (Gao) 2:7-10; EX-1006 (Gao Prov.) 1:33-2:1. The disclosed methods of Gao provide for improved communication efficiency. EX-1005

(Gao) 2:1-10; EX-1006 (Gao Prov.) 1:33-2:1.

IX. THE CHALLENGED CLAIMS OF THE '566 PATENT ARE OBVIOUS FROM KIM, ALONE, OR IN COMBINATION WITH GAO

A. Reasons to combine Kim and Gao

87. A POSITA would have been motivated to combine the teachings of Kim and Gao for multiple reasons.
88. **First**, Kim and Gao are analogous art, pertaining to the same filed of endeavor as the '566 Patent, wireless network access systems. Both in Kim and Gao, the PUCCH can be configured for carrying various types of UCI by higher layer signaling from the base station. EX-1004 ¶¶65; EX-1005 (Gao) 21:39-48; EX-1006 (Gao Prov.) 25:29-26:1.
89. Kim addresses the problem of configuring the PUCCH and communication structure for devices using the same resource in the communication system. EX-1004 ¶¶24, 25.
90. Like Kim, Gao relates to methods and systems for transmitting and receiving a PUCCH in a wireless communication network. EX-1005 (Gao) 1:21-26; EX-1006 (Gao Prov.) 1:6-8. Gao provides a solution for transmitting uplink information in multiple slots by dynamically configuring a long PUCCH when the uplink regions of different slots vary in size. EX-1005 (Gao) 2:7-

10; EX-1006 (Gao Prov.) 1:37-2:1.

91. Thus, a POSITA would have found Gao's teachings reasonably pertinent to addressing the problem identified by Kim of having limited communication structures for communicating between the base station and UE. EX-1004

¶¶24, 25; EX-1005 (Gao) 2:7-10; EX-1006 (Gao Prov.) 1:33-2:1.

92. **Second**, a POSITA would have had reasonable expectation of success combining the teachings of Kim with Gao, because Kim's teachings are compatible with Gao's teachings of communicating over a wireless communications network according to the 3GPP standards to configure the PUCCH.

93. A POSITA would have been motivated to combine the teachings of Kim and Gao because the combination involves merely using known techniques (e.g., higher level signaling) in a known way (e.g., configuring the communication resources such as PUCCH, frequency hopping of the UCI, etc.) to yield a predictable result (e.g., providing additional communication structures for communicating between the base station and UE). Indeed, various configurations for PUCCH and frequency hopping were well-known and used in wireless communications systems.

94. Further, a POSITA would have been motivated to combine the teachings of

Kim and Gao because the POSITA would have understood that configuring the PUCCH and implementing various frequency hopping methods provide the benefits of increasing frequency diversity resulting in improved reliability of the transmission in the network, and the benefits of “prevent[ing] performance degradation caused by power transient period.” EX-1004 ¶239.

95. Therefore, incorporating the PUCCH configuration techniques of Gao into the PUCCH of Kim would thus involve nothing more than routine skill of a POSITA, and a POSITA would have a reasonable expectation of success.

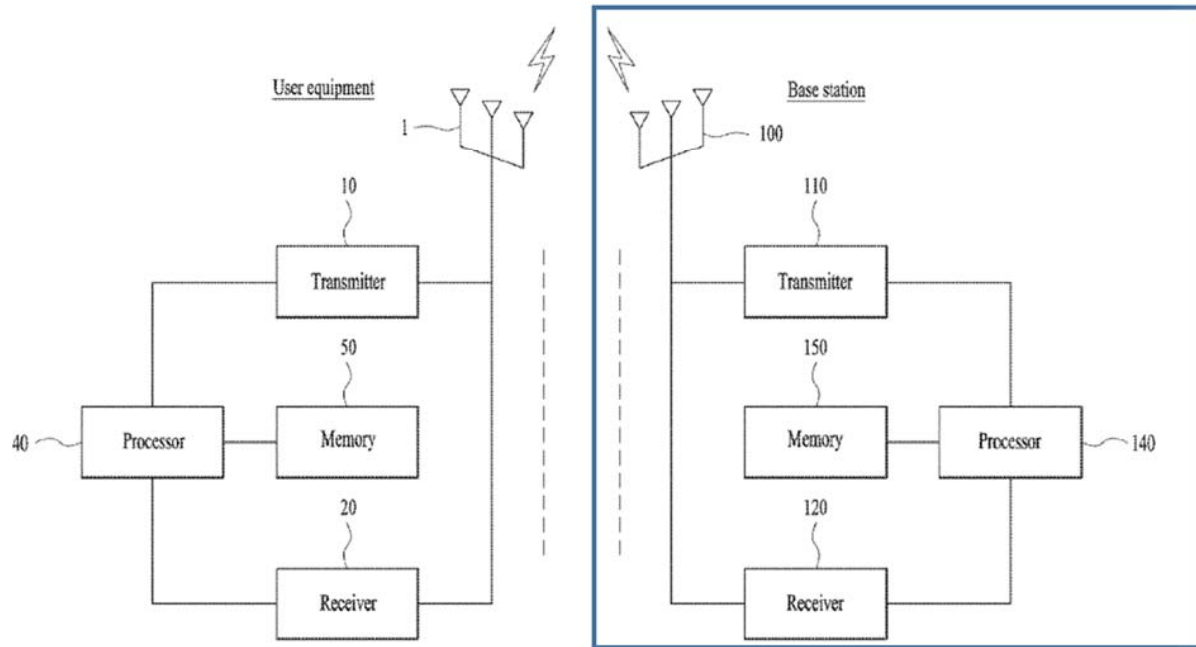
B. Detailed Application of Kim and Gao to the Challenged Claims

1. Claim 8

i. [8.0] A base station (gNB), comprising:

96. To the extent the preamble is limiting, Kim discloses this claim element. As shown and described with reference to FIG. 18, Kim discloses a base station (gNB 100) (blue) including various components for performing the method of the invention. “The UE and the base station shown in FIG. 18 operate to implement the embodiments of the method for transmitting and receiving PUCCH between the UE and the base station. EX-1004 ¶305.

FIG. 18



EX-1004, FIG. 18⁵.

97. Kim states that the term base station is exemplary and further states, “[t]he term ‘BS’ may be replaced with a fixed station, a Node B, an evolved Node B (eNode B or eNB), an Advanced Base Station (ABS), an access point, etc.” EX-1004 ¶48.

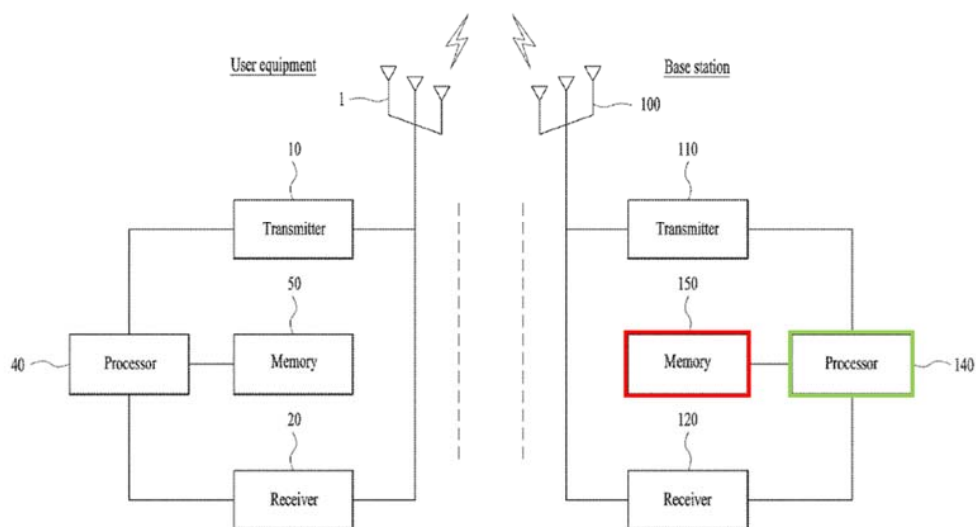
98. Kim discloses this claim element.

⁵ All annotations added unless otherwise stated.

ii. *[8.1] a processor; and memory in electronic communication with the processor, wherein instructions stored in the memory are executable to:*

99. Kim discloses this claim element. As shown in annotated FIG. 18 below, Kim discloses the processor 40, 140 (*processor*) (**green**) and memory 50, 150 (*memory*) (**red**). Kim further discloses software code may be stored in the memory 50, 150 (*instructions stored in the memory*) and executed by the processor 40, 140 (*instructions ... are executable*). EX-1004 ¶¶ 316, 317.

FIG. 18



EX-1004, FIG. 18.

100. Accordingly, Kim discloses this claim element.

iii. *[8.2] transmit, to a user equipment (UE), a*

signaling, an uplink control channel (PUCCH) spans over multiple slots being determined based on the signaling; and

101. Kim discloses this claim element. Kim discloses a base station that is configured to transmit downlink control information (DCI/L1 signaling) (*signaling*) to the UE for configuring the PUCCH. EX-1004 ¶¶ 59, 62, 85. Kim states, “***The region in which the long PUCCH is transmitted can be configured via DCI*** (e.g., DL assignment or higher layer signaling).” EX-1004 ¶ 228. The number of symbols per slot of the long PUCCH can be determined based on the signaling (e.g., DL assignment or higher layer signaling):

The number of slots where a long PUCCH (PUSCH or PDSCH) is transmitted and indices thereof can be determined by RRC signaling, first layer (e.g., PHY, L1) signaling, or a combination thereof.

EX-1004 ¶ 242, 244, 245.

102. Accordingly, Kim discloses this claim element.

iv. [8.3] receive uplink control information (UCI) with the frequency hopping for the configured multiple slots PUCCH,

103. Kim discloses this claim element. Kim discloses the base station receives uplink control information (UCI) from a UE in a PUCCH:

Referring to FIG. 4, a UL subframe may be divided into a control region and a data region in the frequency domain. *A PUCCH carrying UCI* is allocated to the control region and a PUSCH carrying user data is allocated to the data region.

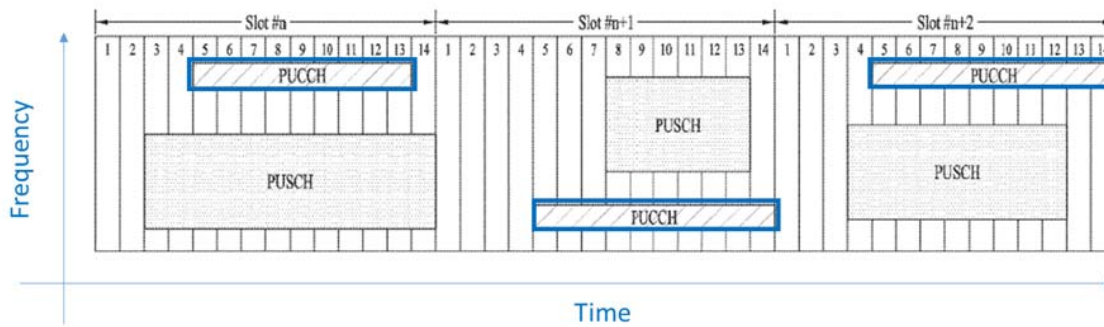
EX-1004 ¶ 82; *see also* EX-1004 ¶ 68.

104. Kim discloses that frequency hopping may be applied to the PUCCH based on the DCI (e.g., Layer 1) or higher layer signaling from the base station:

Additionally, *information about a time when frequency hopping is applied to such a long PUCCH and/or information about a frequency hopping interval may be configured/indicated via DCI or higher layer signaling*. In this case, the frequency hopping may be hopping in a single TTI (or slot), inter-TTI (or inter-slot) hopping as shown in FIG. 14, or hopping every several slots (for example, hopping may be performed every two slots).

EX-1004 ¶ 235.

FIG. 14



EX-1004 FIG. 14⁶.

105. Kim further provides, “In addition, *time/frequency resource candidate where UCI will be actually transmitted may be defined per format by higher layer signaling*, and the locations of the resources that will be actually used among the UCI resources may be dynamically indicated by the DCI that schedule multiple TTIs.” EX-1004 ¶ 287.

106. Accordingly, a POSITA would have understood that the base station receives UCI with the frequency hopping for the configured multiple slot PUCCH. Thus, Kim discloses this claim element.

- v. *[8.4] wherein the number of symbols of the PUCCH is the same in each slot of the multiple slots, and the location of the symbols for the PUCCH is the same in the each slot of the*

⁶ All annotations added unless otherwise stated.

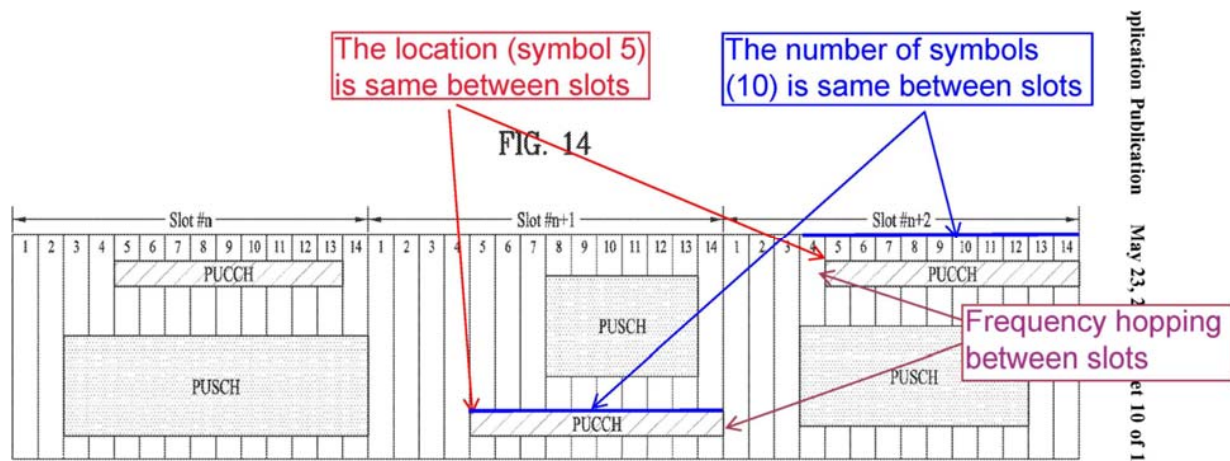
multiple slots.

107. Kim discloses this claim element, either alone or in combination with Gao.

Kim discloses “one TTI is illustrated as one slot.” EX-1004 ¶227. Kim discloses that the PUCCH includes a plurality of symbols and that “[t]he ***number of symbols allocated for the PUCCH transmission within one TTI may be constant for all TTIs***” EX-1004 ¶233. Although in the foregoing description Kim describes the number of symbols within a TTI, Kim further describes “the methods for transmitting and receiving UL/DL signals across a plurality of TTIs” can also be applied to ***slots*** and subframes. EX-1004 ¶¶222-223. Accordingly, based on the foregoing disclosures, a POSITA would have understood Kim as disclosing, or at least rendering obvious, that the number of symbols allocated for the PUCCH is the same in each slot.

108. Kim also states that the “PUCCH transmission ***symbol allocation in one TTI can be equally applied to a plurality of TTIs used/allocated for transmitting one long PUCCH.***” EX-1004 ¶233. As discussed above, Kim provides “methods of transmitting and receiving UL/DL signals across a plurality of TTIs (slots or subframes) will be described” and that “one TTI is illustrated as one slot.” EX-1004 ¶¶222-223, 227. A POSITA would have

understood that *equally applying PUCCH transmission symbol allocations* to each slot discloses the claim element of “the location of the symbols for the PUCCH is the same in each slot of the multiple slots.” EX-1004 ¶233. This is particularly true because Fig. 14 shows both the number and location of the PUCCH as being the same between slots $n+1$ and $n+2$ as shown below.



109. EX-1004, Fig. 14. Kim shows a “long PUCCH transmission is configured over a total of two TTIs or slots, i.e., slot $\#n+1$ and slot $\#n+2$ as shown in FIG. 14.” EX-1004, ¶234. The “**location**” (red) is the same as both slot $\#n+1$ and slot $\#n+2$ start at symbol 5. The **number** (blue) of symbols is the same (10 symbols) going from symbols 5-14.⁷

⁷ While Fig. 14 shows a different number of symbols used in the leftmost slot $\#n$

110. To the extent Kim does not expressly show *the location of the symbols for the PUCCH is the same in each slot of the multiple slots*, Gao discloses this limitation. Gao also discloses a method for transmitting and receiving a physical uplink control channel (PUCCH). EX-1005 (“Gao”) 1:21-26; EX-1006 (“Gao Prov.”) 1:6-8. Gao further discloses the plurality of slots (e.g., slot *i*, slot *i*+1) are the same and have the same transmission structure, i.e., the location of the symbols in each slot is the same. EX-1005 (Gao) 15:13-20, 31:53-63, FIG. 7; EX-1006 (Gao Prov.) 18:15-19, 37:26-33, FIG. 7.

Gao states:

The ***uplink regions*** in a plurality of target slots ***are the same***, as shown in FIG. 7, both structures of slots *i* and *i*+1 include a downlink region of 2 symbols, a guard period (GP) of 1 symbol, and ***an uplink region of 4 symbols***.

UE determines, according to a feedback period of periodic UCI, that

(from symbols 5-13), Kim’s description clarifies that the configuration for the slots #*n*+1 and #*n*+2 is an alternative configuration. EX-1004 ¶0234 (“For example, if long PUCCH transmission is configured over a total of two TTIs or slots, i.e., slot #*n*+1 and slot #*n*+2 as shown in FIG. 14, the first four symbols in each slot may be reserved for DL control (and/or a guard period).”).

CSI/SR feedback is to be conducted in slot i and determines that *a transmission duration of the PUCCH is 4 symbols* by a predetermined duration or a duration configured by means of a higher layer signaling in advance or a size of an uplink region (or a region for a PUCCH transmission in the uplink region) in at least one of two slots.

EX-1005 (Gao) 31:53-63, FIG. 7; EX-1006 (Gao Prov.) 37:26-33.

111. FIG. 7 of Gao further illustrates the symbols used for the PUCCH (PUCCH1 and PUCCH2) are in the same location in slot i and slot $i+1$. EX-1005 (Gao) 31:53-56, FIG. 7, EX-1006 (Gao Prov.) 37:26-28, FIG. 7.

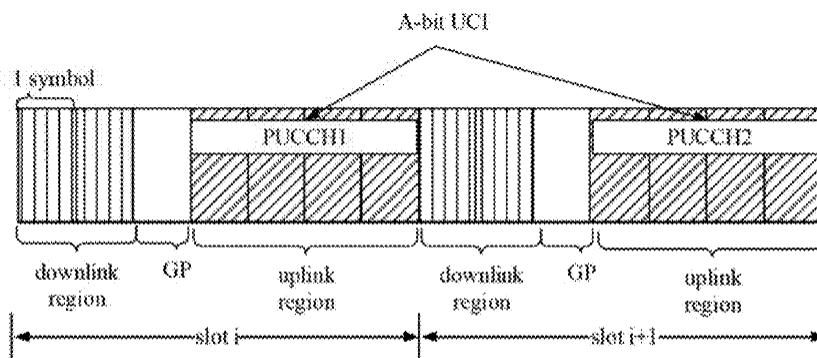


Fig. 7

EX-1005 (Gao) FIG. 7; EX-1006 (Gao Prov.) FIG. 7.

112. Accordingly, Kim, alone or in combination with Gao disclose this limitation. As such, Kim, alone or in combination with Gao, render obvious claim 8.

2. Claim 9

- i. [9.0] The gNB of claim 8, wherein the number of*

symbols of the PUCCH in each slot of the multiple slots PUCCH is greater than or equal to 4, and a reference symbol (RS) pattern in each slot is determined on a per slots basis by a long PUCCH format of a given the number of PUCCH symbols in the slot.

113. Kim, alone or in combination with Gao, renders obvious claim 9. First, Kim discloses the specific number of symbols (4 or more) recited in claim 9 (wherein the number of symbols of the PUCCH in each slot of the multiple slots PUCCH is greater than or equal to 4). For example, as shown in Figure 14 (above for claim 8), Kim teaches using 10 symbols in slots #n+1 and #n+2.

114. Moreover, Kim expressly recites the specific number of symbols recited in the claim:

Hereinafter, if the number of symbols within one TTI used for transmitting a UL control channel is equal to or more than a predetermined value (e.g., 4), the UL control channel is defined as a long PUCCH. In addition, to support wider coverage, the long PUCCH may be transmitted over a plurality of TTIs.

EX-1004 ¶226.

115. Thus, a POSITA would have understood that Kim discloses the number of symbols within one TTI being greater than or equal to 4 also applies to each

slot.

116. Kim discusses the transmission of reference symbols, but does not expressly disclose that a reference symbol (RS) pattern in each slot is determined on a per slots basis by a long PUCCH format of a given number of PUCCH symbols in the slot. EX-1004 ¶155, FIG. 9. However, Gao discloses a method for transmitting the UCI in the PUCCH in each of the plurality of target slots. EX-1005 (Gao) 3:15-26; EX-1006 (Gao Prov.) 37:12-14. Gao further discloses the method determines a transmission structure of the UCI and a reference signal (RS) (*reference symbol pattern*) in the PUCCH in each of the plurality of target slots in accordance with the determined transmission duration or format of the PUCCH (*PUCCH format of a given [the] number of PUCCH symbols in the slot*) carrying the to-be-fed-back UCI in each of the plurality of target slots. EX-1005 (Gao) 14:42-25:5; EX-1006 (Gao Prov.) 17:29-18:9. Additionally, Gao states:

One transmission duration or format corresponds to one transmission structure of UCI and RS, that is, *a structure of mapping the UCI and RS for PUCCH may be determined by the transmission duration or format*, namely, which symbols among multiple symbols occupied by the PUCCH are used to transmit the UCI, and which symbols are used to transmit the RS.

EX-1005 (Gao) 14:53-60; EX-1006 (Gao Prov.) 17:37-18:1, 28:34-38.

117. Indeed, Gao discloses determining a transmission structure (i.e., the placement of an RS) for “each” target slot (*per slot basis*). EX-1005 (Gao) 14:42-52; EX-1006 (Gao Prov.) 17:29-36. Gao further discloses “the slot structure... may apply to the case that *each slot* includes 14 symbols” and states, “[t]he PUCCH of a transmission duration of 4 symbols (or a format corresponding to the transmission duration of 4 symbols) is for exemplification only, the PUCCH may be transmitted by using a duration of another *quantity of symbols*/another format, e.g., a duration of any integer quantity of symbols ranging from 4 to 14.” EX-1005 (Gao) 34:6-15; EX-1006 (Gao Prov.) 39:38-40:8. Gao discloses the same long PUCCH as described by the ’566 Patent, which provides the long PUCCH in a slot may have durations from 4 to 14 symbols.” EX-1001 9:66-10:15; EX-1005 (Gao) 2:3-7, 11:30-31; EX-1006 (Gao Prov.) 1:34-37.
118. Accordingly, a POSITA would have understood that configuring the RS pattern based on a per slot basis provides for efficient utilization of the PUCCH when slots of various sizes are transmitted, as opposed to using a fixed/static RS pattern for all slots regardless of its size. Also, a POSITA would have been motivated to combine the teachings of Kim and Gao to

provide a method in which the RS pattern is determined on a per slot basis to allow for the dynamic configuration of the PUCCH of the wireless access network as needed.

3. Claim 10

- i. [10.0] The gNB of claim 8, wherein the same PUCCH symbol location may be allocated in each slot.*

119. Kim, alone or in combination with Gao, renders obvious claim 10. As discussed above, Kim discloses “methods of transmitting and receiving UL/DL signals across a plurality of TTIs (*slots* or subframes)” and that “one TTI is illustrated as *one slot*.” EX-1004 ¶¶222, 223, 227. Therefore, Kim’s discussion of TTIs is applicable to slots. EX-1004 ¶227. Kim discloses that if a TTI (slot) has more than a predetermined number of symbols (e.g., 4) used for transmitting the UL control channel, the UL control channel is defined as a long PUCCH. EX-1004 ¶¶225, 226.
120. Kim further states, “PUCCH transmission *symbol allocation* in one TTI can be *equally applied to a plurality of TTIs* used/allocated for transmitting one long PUCCH,” and “[t]he number of symbols allocated for the PUCCH transmission within one TTI may be *constant for all TTIs* or vary per TTI.” EX-1004 ¶233. Kim, in describing that one TTI represents one slot,

discloses the PUCCH transmission allocation for one slot being equally applied to the plurality slots discloses this claim limitation because the symbol allocation defines the symbol location. EX-1004 ¶¶223, 227.

121. A POSITA would have understood that *equally applying PUCCH transmission allocation* and having a *constant symbol allocation for all TTIs* (slots) to mean that the same PUCCH symbol location may be allocated in each slot. Therefore, Kim discloses the claim element. Moreover, as shown in Kim’s Figure 14 (detailed for claim 8), slots #n+1 and #n+2 have the same symbol locations for PUCCH.
122. To the extent Kim does not expressly disclose the “same PUCCH symbol location” may be allocated in each slot, Gao discloses this limitation at least for the reasons set forth in claim element [8.4] above and discussed below. **See Error! Reference source not found..** For example, Gao states:

The uplink regions in a plurality of target slots *are the same*, as shown in FIG. 7, both structures of slots i and i+1 include a downlink region of 2 symbols, a guard period (GP) of 1 symbol, and *an uplink region of 4 symbols*.

123. EX-1005 (Gao) 15:12-25, 31:53-56, FIG. 7; EX-1006 (Gao Prov.) 18:15-22, 37:26-28, 29-33.

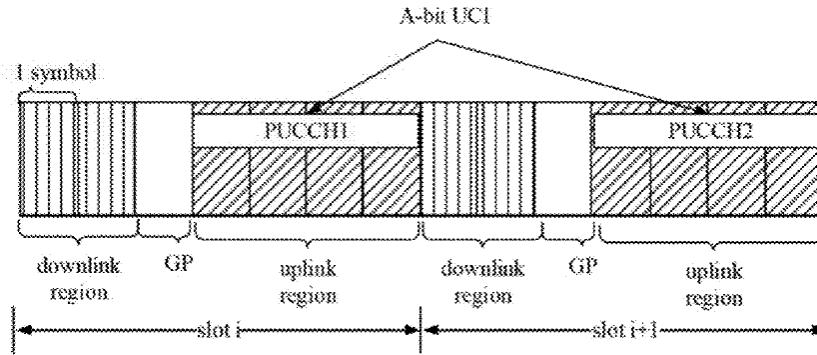


Fig. 7

EX-1005 (Gao) FIG. 7; EX-1006 (Gao Prov.) FIG. 7.

124. As shown in FIG. 7 above, the PUCCH 1 and PUCCH 2, are provided in the same location in each “slot i” and “slot i+1,” respectively. The location describes the position of the symbol in the slot and the uplink region of the slot, and Gao provides “the positions of PUCCH in the plurality of target slots may be the same,” i.e., the location of the symbols in each slot is the same. EX-1005 (Gao) 15:13-20, 31:53-63, FIG. 7; EX-1006 (Gao Prov.) 18:15-19, 37:26-33, FIG. 7.

125. A POSITA would have been motivated to combine Gao’s express teachings of allocating the PUCCH symbols in the *same location* in each slot with Kim’s teachings for allocating symbols in the PUCCH in order to reduce the overhead signaling in the network by avoiding the need to re-configure (configure) the PUCCH for different symbol allocations using the DCI or

other higher layer signaling. EX-1004 ¶235. A POSITA would have understood the modification Kim’s teaching of the PUCCH with Gao’s teachings of the PUCCH symbol placement to involve nothing more than routine skill of a POSITA and matter of design choice, given that Kim already disclosed the “PUCCH transmission *symbol allocation* in one TTI can be *equally applied to a plurality of TTIs* used/allocated for transmitting one long PUCCH,” where the TTI represents a single slot. EX-1004 ¶233. A POSITA would also have a reasonable expectation of success for the combined teachings of Kim and Gao because disclose symbol allocation of the PUCCH. Accordingly, Kim, alone or in combination with Gao, discloses the limitations of claim 10. Claim 10 therefore is obvious from the combination of Kim and Gao.

4. Claim 11

- i. ***[11.1] The gNB of claim 8, wherein UCI encoded bits are rate matched and loaded to all to PUCCH UCI carrying symbols of each slot of the long PUCCH separately,***

126. Kim, alone or in combination with Gao, renders obvious claim 11. Gao discloses this claim limitation in claim 11. Gao discloses “the PUCCH is transmitted by a UCI+RS structure with a duration of 4 symbols in both

uplink regions of slots i and $i+1$, as shown by PUCCH1 and PUCCH2 in FIG. 7.” EX-1005 (Gao) 32:6-8; EX-1006 (Gao Prov.) 37:38-39.

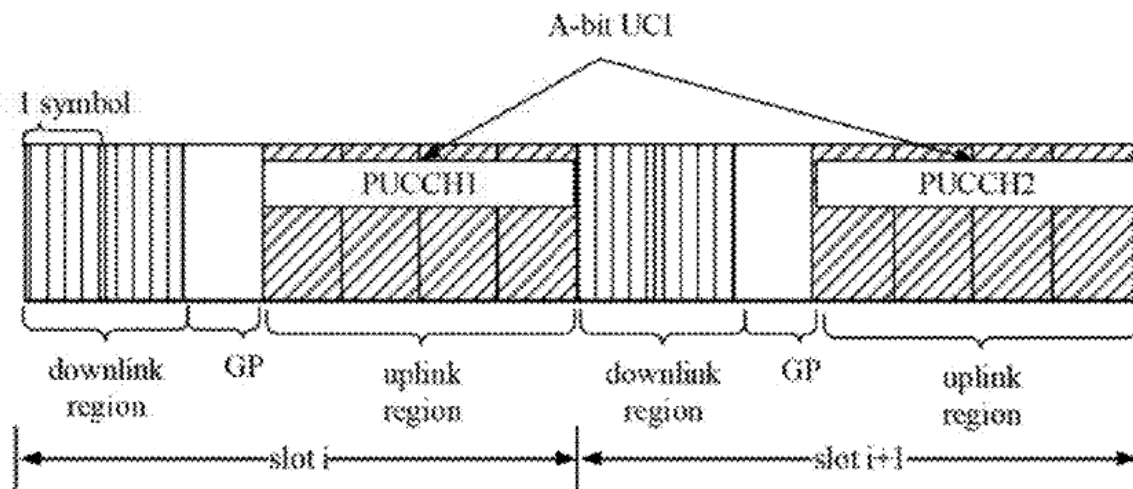


Fig. 7

EX-1005 (Gao) FIG. 7; EX-1006 (Gao Prov.) FIG. 7.

127. Gao states, “[t]he UCI may be transmitted repeatedly in every slot, that is, UE performs *channel coding and rate matching based on a quantity of transmission symbols of UCI* in the UCI+RS structure determined by the transmission duration” (*UCI encoded bits are rate matched*). EX-1005 (Gao) 32:27-33; EX-1006 (Gao Prov.) 38:7-22. Gao further states the UE “*then transmits the same coded sequence in two slots repeatedly*” (*loaded to all to PUCCH UCI carrying symbols of each slot of the long PUCCH*

separately). EX-1005 (Gao) 32:27-33; EX-1006 (Gao Prov.) 38:7-22.

128. A POSITA would have understood that transmitting the “same coded sequence” in “two slots” discloses *UCI encoded bits... loaded to all [the] PUCCH UCI carrying symbols of each slot of the long PUCCH separately*. EX-1005 (Gao) 32:19-32:44; EX-1006 (Gao Prov.) 38:7-22.

129. A POSITA would have been motivated to combine the teachings of Kim and Gao because the POSITA would have understood rate matching to improve the utilization of the channel by having the total bit rate of the TTI (slot) equal to the channel rate and also to improve the alignment of transmitted resources in the network. EX-1014 (“R1-00426”), 2; EX-1012 (“Nazar”) 31:17-35; EX-1013 (“Ahn”) 14:19-32. Both Kim and Gao disclosed the use of rate-matching, and modifying the teachings of Kim with the teachings of Gao would require nothing more than routine skill of a POSITA, where the combination would yield a predictable result (e.g, improved channel utilization). EX-1004 10, 14, 32:27-33; EX-1006 (Gao Prov.) 38:7-22.

Accordingly, a POSITA would have understood Gao as disclosing the limitation of wherein UCI encoded bits are rate matched and loaded to all to PUCCH UCI carrying symbols of each slot of the long PUCCH separately.

ii. [11.2] if the number of symbols of the PUCCH in

each slot is the same, the PUCCH format and encoded UCI in each slot is repeated in the multiple slots.

130. Gao discloses this claim limitation. As described and shown in FIG. 7 of Gao below, the number of symbols in each slot is the same and the encoded UCI bits are repeated in multiple slots (i.e., slot i , slot $i+1$) as required by the claim limitation.

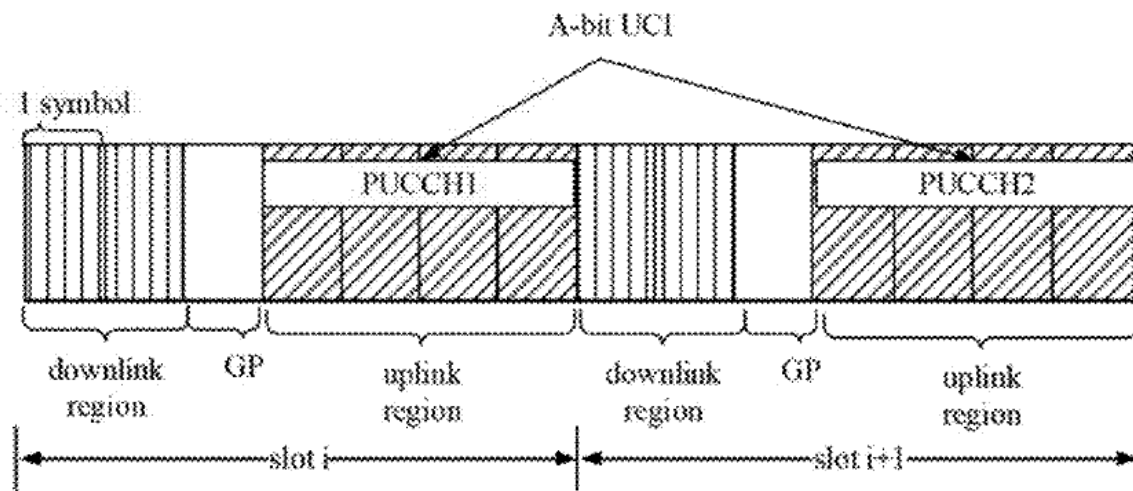


Fig. 7

EX-1005 (Gao) FIG. 7; EX-1006 (Gao Prov.) FIG. 7.

131. As shown in FIG. 7 above, “slots i ” and “slots $i+1$ ” are the same as required by claim 11. Gao states, “both structures of slots i and $i+1$ include a downlink region of 2 symbols, a guard period (GP) of 1 symbol, and an uplink region of 4 symbols.” EX-1005 (Gao) 31:53-54; EX-1006 (Gao

Prov.) 37:26-28. Gao further discloses that the transmission duration can be determined by, for example, higher layer signaling or a size of an uplink region (or a region for a PUCCH transmission in the uplink regions). EX-1005 (Gao) 32:6-10; EX-1006 (Gao Prov.) 37:38-38:4 (“The PUCCH is transmitted by a UCI+RS structure with a duration of 4 symbols in both uplink regions of slots i and $i+1$, as shown by PUCCH1 and PUCCH2 in FIG. 7.”).

132. Gao further describes the UCI is transmitted in every slot (*repeated in every slot*) by a determined UCI+RS structure (*the PUCCH format and encoded UCI in each slot*) corresponding to a same transmission duration (*number of symbols of the PUCCH in each slot is the same*). EX-1005 (Gao) 32:19-33; EX-1006 (Gao Prov.) 38:7-14.

133. A POSITA would have been motivated to combine the teachings of Kim with Gao’s teachings of repeating the PUCCH format and encoded UCI in slot in order to reduce the signaling overhead (e.g., DCI or other higher layer signaling) in the network used to re-configure/configure the PUCCH for each slot. Provided that both Kim and Gao disclosed techniques for configuring the PUCCH, it would have required nothing more than routine skill of a POSITA to modify the teachings of Kim with Gao. EX-1004 ¶233;

EX-1005 (Gao) 15:13-20, 31:53-63, FIG. 7; EX-1006 (Gao Prov.) 18:15-19, 37:26-33, FIG. 7. Accordingly, a POSITA would have understood Gao if the number of symbols of the PUCCH in each slot is the same, the PUCCH format and encoded UCI in each slot is repeated in the multiple slots. Claim 11 is invalid over Gao.

5. Claim 13

- i. [13.0] The gNB of claim 8, wherein the frequency hopping is applied within each slot in the multiple slots PUCCH.*

134. Kim, alone or in combination with Gao, renders obvious claim 13. As discussed above, Kim discloses “methods of transmitting and receiving UL/DL signals across a plurality of TTIs (*slots* or subframes)” and that “one TTI is illustrated as *one slot*.” EX-1004 ¶¶222, 223, 227. Therefore, Kim’s discussion of TTIs is applicable to slots. EX-1004 ¶227.
135. Kim further discloses that if a TTI (slot) has more than a predetermined number of symbols (e.g., 4) for transmitting the UL control channel, the UL control channel is defined as a long PUCCH. EX-1004 ¶¶225, 226. As previously discussed above for claim element [8.3], Kim further discloses applying frequency hopping to the long PUCCH and states, “the frequency hopping may be *hopping in a single TTI (or slot)*.” EX-1004 ¶235.

136. Kim further discloses that the frequency hopping can be applied to multiple slots by describing the PUCCH transmission symbol allocation in one TTI can be *equally applied to a plurality of TTIs used/allocated for transmitting one long PUCCH*. EX-1004 ¶233. Kim discloses that frequency hopping that occurs *in a single slot* and *equally applying the symbol allocation to a plurality of TTIs* for the long PUCCH discloses the limitation. EX-1004 ¶¶225, 226, 233. Therefore, Kim discloses the elements of claim 13.

6. Claim 14

- i. *[14.0] The gNB of claim 8, wherein whether the frequency hopping is inter-slot or intra-slot can be configured by higher layer signaling for the multiple slots PUCCH.*

137. Kim, alone or in combination with Gao, renders obvious claim 14. Kim discloses the PUCCH that spans over multiple slots. EX-1004 ¶¶225, 226. As discussed above, Kim discloses “methods of transmitting and receiving UL/DL signals across a plurality of TTIs (*slots* or subframes)” and that “one TTI is illustrated as *one slot*.” EX-1004 ¶¶222, 223, 227. Therefore, Kim’s discussion of TTIs is also applicable to slots. EX-1004 ¶227.

138. Kim further provides that if a TTI (slot) has more than a predetermined

number of symbols (e.g., 4) for transmitting the UL control channel, the UL control channel is defined as a long PUCCH. EX-1004 ¶¶225, 226. As discussed with reference to claim element [8.3] above, Kim further discloses the frequency hopping is configured by **higher layer signaling** for the multiple slots PUCCH. EX-1004 ¶235.

139. Kim states, “[i]nformation about a time when frequency hopping is applied to such a long PUCCH and/or information about a frequency hopping interval may be configured/indicated via DCI or **higher layer signaling**. In this case, the **frequency hopping may be hopping in a single TTI (or slot), inter-TTI (or inter-slot) hopping....**” EX-1004 ¶235. Kim further discloses other types of signaling can be used for configuring the PUCCH, for example, a **high-layer signaling** (e.g., via RRC or a like), lower-layer signaling (e.g., via a physical control channel or a broadcast channel), or a combination thereof, EX-1004 ¶56.

140. Kim discloses this limitation of claim 14.

7. Claim 16

i. [16.0] A method by a base station (gNB), comprising:

141. To the extent the preamble is limiting, Kim discloses a method performed by

a base station. Kim further discloses the base station as set forth above in claim element [8.1].

- ii. [16.1] transmit, to a user equipment (UE), a signaling, an uplink control channel (PUCCH) spans over multiple slots being determined based on the signaling;***

142. Kim discloses this claim element for the same reasons set forth above in claim element [8.3].

- iii. [16.2] receiving uplink control information (UCI) with the frequency hopping for the configured multiple slots PUCCH, and***

143. Kim discloses this claim element for the same reasons set forth above in claim element [8.4].

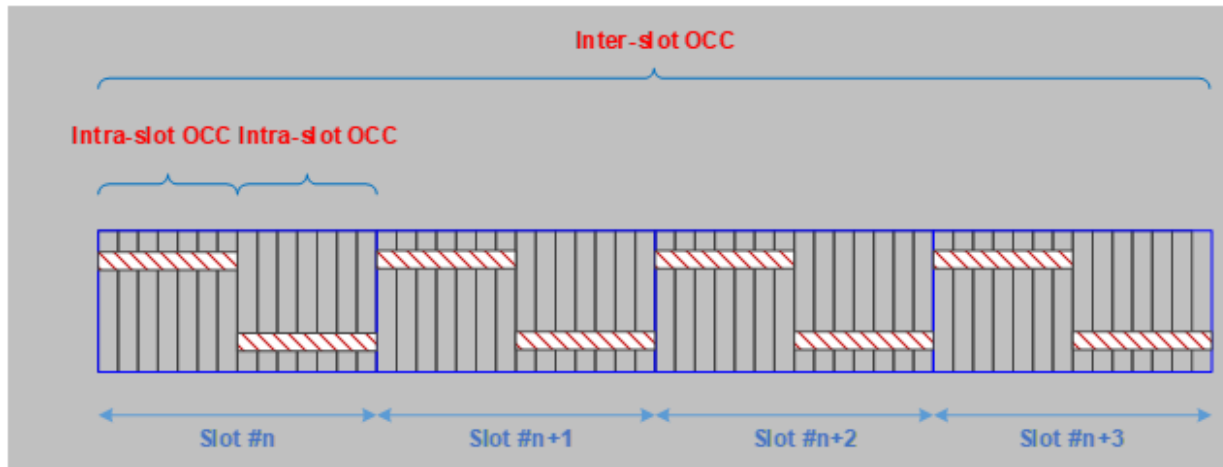
- iv. [16.3] wherein the number of symbols of the PUCCH is the same in each slot of the multiple slots, and the location of the symbols for the PUCCH is the same in the each slot of the multiple slots.***

144. Kim discloses this claim element for the same reasons set forth above in claim element [8.5].

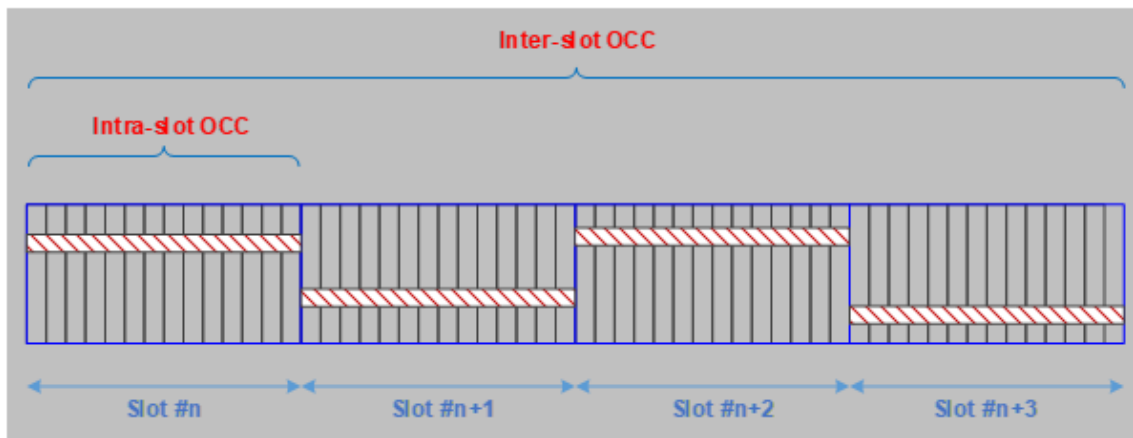
X. THE CHALLENGED CLAIMS OF THE '566 PATENT ARE OBVIOUS FROM KIM, ALONE, OR IN COMBINATION WITH GAO AND IN FURTHER VIEW OF R1-1710555

A. Overview of R1-1710555 (EX-1008)

145. The 3GPP submission, “Long PUCCH Over Multiple Slots” (“R1-1710555”), discloses resource allocation and frequency hopping for long PUCCH with multiple slot durations. EX-1011 (R1-1710555). Specifically, R1-1710555 discloses that inter-slot frequency hopping and intra-slot frequency hopping have been in use to improve frequency diversity in wireless transmission. EX-1011 (R1-1710555) 1-2. For example, R1-1710555 discloses that “inter-slot frequency hopping may be employed to further improve the link budget for long PUCCH.” EX-1011 (R1-1710555) 3. FIG. 2(a) below depicts a frequency hopping pattern that performs switching at the slot boundaries and FIG. 2(b) depicts an inter-slot frequency hopping pattern that performs switching within the slot. The x-axis of the illustration of FIGS. 2(a), 2(b) represents time (duration of the slot) and the y-axis represents the frequency of the PUCCH. EX-1011 (R1-1710555) 1-3.



(b) Inter-slot hopping with intra-slot hopping.



(a) Inter-slot hopping without intra-slot hopping.

Figure 2. Intra-slot and inter-slot frequency hopping of long PUCCH with OCC.

EX-1011 (R1-1710555) FIG. 2(a), 2(b).

146. As shown above in FIG. 2(b), intra-slot hopping occurs within the slot boundaries. FIG. 2(a) shows inter-slot frequency hopping occurs at the slot boundary (no frequency hopping within the single slot). EX-1011 FIG. 2(a), 2(b).

1. Public Accessibility of 3GPP R1-1710555

147. R1-1710555 was publicly accessible prior to the earliest claimed priority date of the '566 Patent which is August 10, 2017. 3GPP develops and maintains various cellular communication standards (e.g., 3G, 4G LTE, 5G NR standards). When developing these standards, working groups are formed to work on a specific project and numerous submissions/documents are presented and discussed at the meetings. Once consensus is reached within the working group, the draft submissions are then proposed to the larger group for approval and adoption into the standard. A POSITA would have familiarity with the 3GPP technical specifications. As a preliminary matter, the various specification may be located within a simple web search (e.g., Google search) of the specification number. For example, below is a partial screenshot of what Google returns when "3GPP R1-1710555" is entered in the search query. As shown below, multiple links to the 3GPP website for the R1-1710555 submission is shown. Clicking on one of the links takes the user to the 3GPP website, where a user may select one of many submissions of interest. The specifications are freely accessible to anyone conducting the Internet search, without the need to register or enter credentials or other exclusive access criteria.



3GPP R1-1710555






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... **1710555**, Long PUCCH over multiple slots, Intel ... **R1-1710556**, Transmit diversity for PUCCH, Intel Corporation ... **R1-1711625**. 946, **R1-1710824**, On 4-step RACH ...

148. R1-1710555 is listed on the face of the '566 Patent, as shown below.

(56) **References Cited**

OTHER PUBLICATIONS

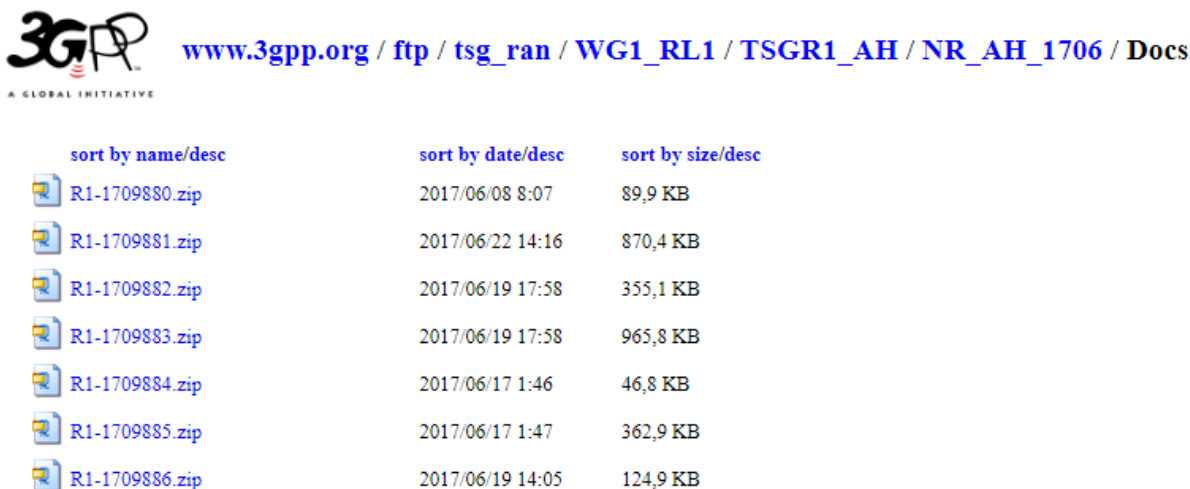
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Intel Corporation, "Long PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710555, Jun. 30, 2017.

EX-1001, Field 56 (References Cited).

149. As shown above, R1-1710555 is listed on the face of the '566 Patent with a June 2017 date, which is the date provided by the Applicant when citing the 3GPP submission in an Information Disclosure Statement (IDS) on August 9, 2018. EX-1002 ('566 Patent File History), 129.

150. The June 2017 date shown on the face of the '566 Patent is consistent with the date when the document was uploaded to the 3GPP website, www.3gpp.org. R1-1710555 was uploaded to the 3GPP website on June 17, 2017, as shown in the screenshot below.



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[OCS](#)

151. Additionally, the examiner, in the first Office Action rejected the claims in view of Huawei, HiSilicon “Long duration PUCCH structure” (“R1-1706953”) (19 May 2017) and NTT DOCOMO, Inc., “Long-PUCCH for more than one slot” (“R1-1711102”) (30 June 2017). EX-1002 (’566 Patent File History), 42.
152. Therefore, Patent Office and the ’566 Patent acknowledge that the 3GPP TSG RAN WG1 Meeting was held on May 19, 2017 in Hangzhou, China (R1-1706953) and the 3GPP TSG RAN WG1 NR Ad-Hoc #2 was held on June 30, 2017 in Qingdao, China (R1-1711102). EX-1002, 3. Thus, the ’566 Patent itself demonstrates that the 3GPP submissions to the RAN meetings were published and publicly accessible prior to the earliest claimed priority date of the ’566 Patent.

153. R1-1706953 was uploaded to the 3GPP website on May 5, 2017 as shown in the screenshots below from the 3GPP website. The first screenshot is provided to show the column headers (e.g., Name Description, Date, etc.), which are not visible in the second screenshot that shows R1-1706953 was uploaded on May 8, 2017.



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 R1-1706867.zip	2017/05/07 14:56	13,5 KB
 R1-1706868.zip	2017/05/07 14:56	15,3 KB
...		
 R1-1706950.zip	2017/05/08 10:26	68,9 KB
 R1-1706951.zip	2017/05/08 10:26	287,9 KB
 R1-1706952.zip	2017/05/08 10:26	249,4 KB
 R1-1706953.zip	2017/05/08 10:26	387,4 KB
 R1-1706954.zip	2017/05/08 10:26	32,2 KB
 R1-1706955.zip	2017/05/08 10:26	511,5 KB
 R1-1706956.zip	2017/05/08 10:26	398,7 KB
 R1-1706957.zip	2017/05/08 10:26	93 KB
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https://www.3gpp.org/ftp/tsg_ran/wg1_rl1/TSGR1_89/Docs

154. R1-1706953 is also listed on the face of the '566 Patent, as shown below.

(56)

References Cited

OTHER PUBLICATIONS

...

Huawei, HiSilicon, "Long Duration PUCCH structure", 3GPP TSG RAN WG1 Meeting #89, Hangzhou, China, R1-1706953, May 19, 2017.

EX-1001 ('566 Patent), Field 56 (References Cited).

155. As shown above, R1-1706953 is listed on the face of the '566 Patent with a May 2019 date, which is the provided by the Applicant when citing the document in an Information Disclosure Statement (IDS) on December 11, 2018. EX-1002 ('566 Patent File History), 91.
156. Similarly, R1-1711102 is also listed on the face of the '566 Patent shown as having been uploaded to the 3GPP directory on June 16, 2027.

(56)

References Cited

OTHER PUBLICATIONS

...

NTT DOCOMO, Inc., "Long-PUCCH for more than one slot", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1711102, Jun. 30, 2017.

157. EX-1001('566 Patent), Field 56 (References Cited).
158. R1-1711102 was uploaded to the 3GPP website on June 17, 2017 as shown

in the screenshots below from the 3GPP website. The first screenshot is provided to shown the column headers (e.g., Name Description, Date, etc.), which are not visible in the second screenshot that shows R1-1711102 was uploaded on June 17, 2017.

[www.3gpp.org / ftp / tsg_ran / WG1_RL1 / TSGR1_AH / NR_AH_1706 / Docs](http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_AH/NR_AH_1706/Docs)

sort by name/desc	sort by date/desc	sort by size/desc
 R1-1709880.zip	2017/06/08 8:07	89,9 KB
 R1-1709881.zip	2017/06/22 14:16	870,4 KB
 R1-1709882.zip	2017/06/19 17:58	355,1 KB
 R1-1709883.zip	2017/06/19 17:58	965,8 KB
 R1-1709884.zip	2017/06/17 1:46	46,8 KB
 R1-1709885.zip	2017/06/17 1:47	362,9 KB
 R1-1709886.zip	2017/06/19 14:05	124,9 KB
 R1-1711099.zip	2017/06/17 4:13	541,2 KB
 R1-1711100.zip	2017/06/17 4:13	144,2 KB
 R1-1711101.zip	2017/06/17 4:13	102,1 KB
 R1-1711102.zip	2017/06/17 4:13	66 KB
 R1-1711103.zip	2017/06/17 4:13	73,3 KB
 R1-1711104.zip	2017/06/17 4:13	98,6 KB
 R1-1711105.zip	2017/06/17 4:13	99,1 KB

https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_AH/NR_AH_1706/Docs

159. The Applicant of the '566 Patent did not challenge the public availability or

accessibility of the R1-1706953 and R1-1711102 during prosecution. Even further, R1-1710555 (relied upon in the '566 IPR Petition), was available on the very same page of the 3GPP website as R1-1711102 which was acknowledged by the examiner as prior art.

160. Thus, the 3GPP submissions, including the R1-1710555, were publicly accessible before August 10, 2017, the earliest priority date of the '566 Patent.

B. Reasons to combine Kim and Gao with R1-1710555

161. A POSITA would be motivated to combine Kim's techniques for configuring and receiving long PUCCH in a wireless access network, as modified with Gao's teachings of providing symbols for the PUCCH is the same location in each slot of the multiple slots, with R1-1710555's teachings of performing interslot frequency hopping at slot boundaries, which had the benefit of increasing the frequency diversity of a transmission.
162. Kim and Gao involve the configuration of PUCCH for communication over the wireless network and allowing PUCCH transmission in multiple slots. EX-1004 ¶¶1, 2, 6; EX-1005 (Gao) 1:21-26; EX-1006 (Gao Prov.) 1:6-8.
163. R1-1710555 discloses various frequency hopping schemes. EX-1011 (R1-1710555) FIG. 2(a), 2(b). A POSITA would have understood that the

frequency hopping schemes disclosed by R1-1710555 could be applied to Kim to provide benefits including increasing the frequency diversity of the transmission. Frequency diversity was known to improve the reliability of the transmission from interference of other signals. R1-1710555 discloses an additional benefit of frequency hopping and states “inter-slot frequency hopping may be employed to further improve the link budget for long PUCCH.” EX-1011 (R1-1710555) 3.

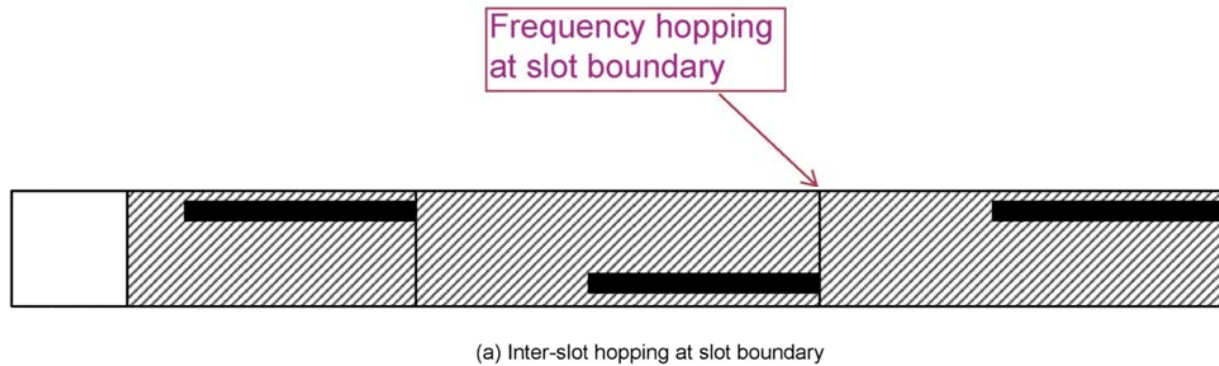
164. Further, a POSITA would have had a reasonable expectation of success because a POSITA would have recognized that the frequency hopping techniques of R1-1710555 were compatible with the teachings of Kim’s interslot and intraslot frequency hopping techniques. EX-1004 ¶235.
165. Additionally, incorporating the frequency hopping techniques disclosed in R1-1710555 into Kim’ frequency hopping configuration of the PUCCH as modified by Gao would thus involve nothing more than routine skill of a POSITA as Kim already discloses interslot and intraslot frequency hopping.
166. A POSITA would thus have been motivated to combine the teachings of Kim and Gao with R1-1710555.

C. Detailed Application of Kim and Gao to the Challenged Claims in further view of R1-1710555

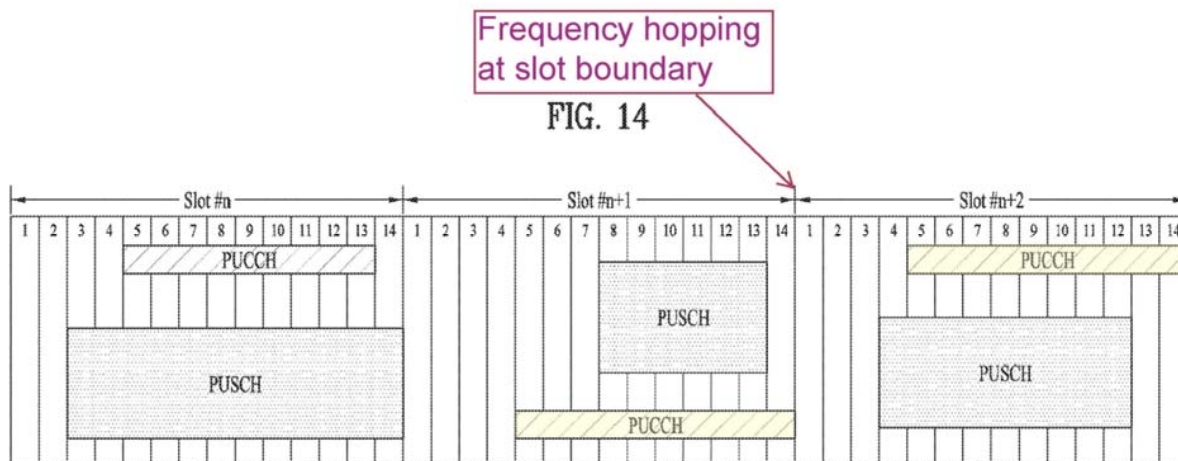
1. Claim 12

i. [12.0] The gNB of claim 8, wherein the frequency hopping is applied at slot boundaries in the multiple slots PUCCH.

167. Kim, alone or in combination with Gao and R1-1710555, renders obvious claim 12. Kim and R1-171055 each disclose this limitation. The '566 Patent equates frequency hopping at slot boundaries with “inter-slot hopping.” “In one approach, frequency hopping may be applied at slot boundaries in a multi-slot PUCCH (*i.e., inter-slot hopping*).” EX-1001 ('566 Patent) 40:13-15. *See also* EX-1001 ('566 Patent) 41:63-65.
168. A comparison of Fig. 38 from the '566 Patent and Fig. 14 from Kim shows that Kim discloses the same frequency hopping at the slot boundary as is disclosed in the '566 Patent. FIG. 38(a) of the '566 Patent illustrates “inter-slot hopping at slot boundary.”



169. EX-1001 ('566 Patent) FIG. 38 (annotation added), 43:32-49. Kim's Fig. 14 shows exactly the same sort of frequency hopping occurring at the slot boundary.



170. EX-1004 ("Kim") Fig. 14 (annotation added). Moreover, Kim, just like the '566 Patent description of this claim element, uses the same language of "inter-slot" hopping, ¶¶ 235-236 ("the frequency hopping may be hopping in a single TTI (or slot), inter-TTI (or *inter-slot*) hopping as shown in FIG. 14... Alternatively,... *inter-slot hopping can be applied to the long*

PUCCH transmission resources....”).

171. To the extent Kim does not expressly disclose the claim limitation *wherein the frequency hopping is applied at slot boundaries in the multiple slots PUCCH*, R1-1710555 discloses this limitation. As shown in FIG. 2(a), the frequency hopping of the PUCCH occurs at the slot boundary of each slot (e.g., the slot boundary between slot #n and slot #n+1), and not within the slot boundary of each slot.

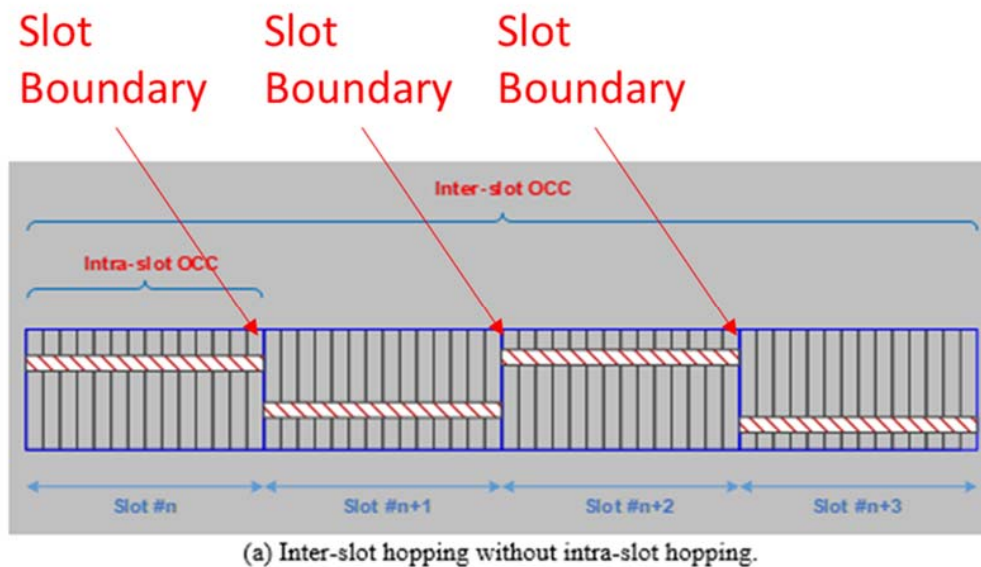


Figure 2. Intra-slot and inter-slot frequency hopping of long PUCCH with OCC.

EX-1011 (“R1-1710555”) FIG. 2(a) (annotations added).

172. A POSITA would have understood that inter-slot frequency hopping occurring at the slot boundaries was well-known and providing a variety of frequency hopping patterns increase frequency diversity which improves the

reliability in the transmission. EX-1008 FIG. 2(a). Accordingly, to the extent Kim does not disclose the limitation, R1-1710555 discloses this limitation. Thus, claim 12 is obvious from Kim in view of Gao and R1-1710555.

XI. THE CHALLENGED CLAIMS OF THE '566 PATENT ARE OBVIOUS FROM KIM, ALONE, OR IN COMBINATION WITH GAO AND IN FURTHER VIEW OF HUANG

1. Overview of U.S. Patent No. 10,873,435 (“Huang”)

173. Huang is an AIA reference and meets the ministerial requirements of 35 U.S.C. §§ 119 and 120. On its face, Huang (EX-1016) was filed on May 3, 2018 claiming priority to U.S. Provisional Patent Application No. 62/501,681, which was filed on May 4, 2017 (EX-1017). Accordingly, Huang was co-pending with the Huang provisional application. Huang identifies Yi Huang, Renqui Wang, Hao Xu, and Seyong Park as inventors (EX-1016 Huang Reference (72)), which are all listed as inventors in the Huang provisional application. (EX-1017 Huang Prov., 1). Accordingly, Huang is entitled to the priority date afforded to it by the Huang provisional application. *Penumbra*, IPR2021-01466, Paper 34. Petitioners cite to the both the Huang and the Huang provisional applications demonstrating that the subject matter upon which Petitioners rely is prior art to the '566 Patent.

174. Huang relates generally to communication systems and more specifically to uplink control channels in a communication system. EX-1016 (Huang) 1:18-20; EX-1017 (Huang Prov.) ¶1. Huang discloses various frequency hopping methods including intra-slot hopping and inter-slot hopping. Huang states, “Intra-slot hopping may include individual PUCCHs hopping between frequencies within a set of frequencies used for the PUCCHs. Inter-slot hopping may include changing sets of frequencies used for PUCCHs hopping, e.g., changing from one set of frequencies to another set of frequencies.” EX-1016 (Huang) 15:55-59; EX-1017 (Huang Prov.) ¶60. Huang illustrates the inter-slot frequency hopping in FIG. 4 below.

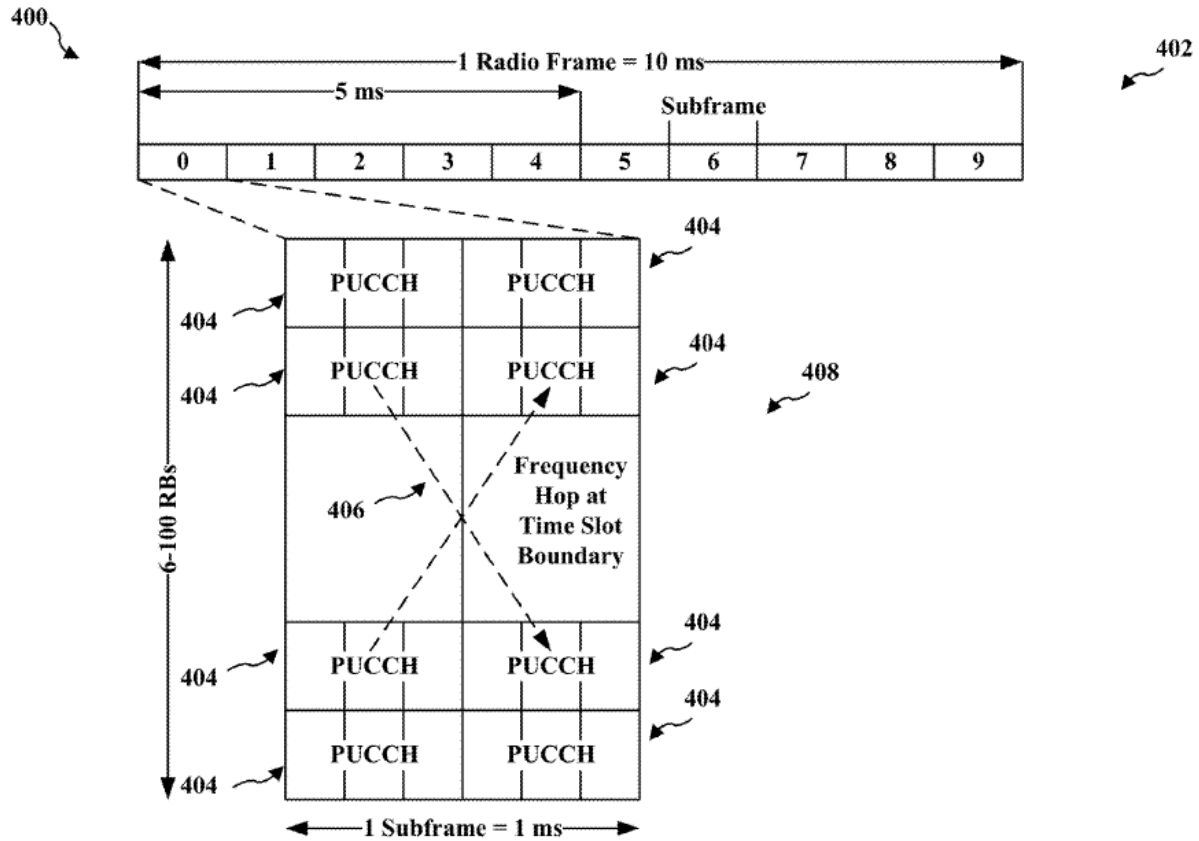


FIG. 4

EX-1016 (Huang) FIG. 4; EX-1017 (Huang Prov.) FIG. 4.

175. Similarly, FIG. 6 of Huang illustrates another example of inter-slot frequency hopping at the slot boundary is shown below.

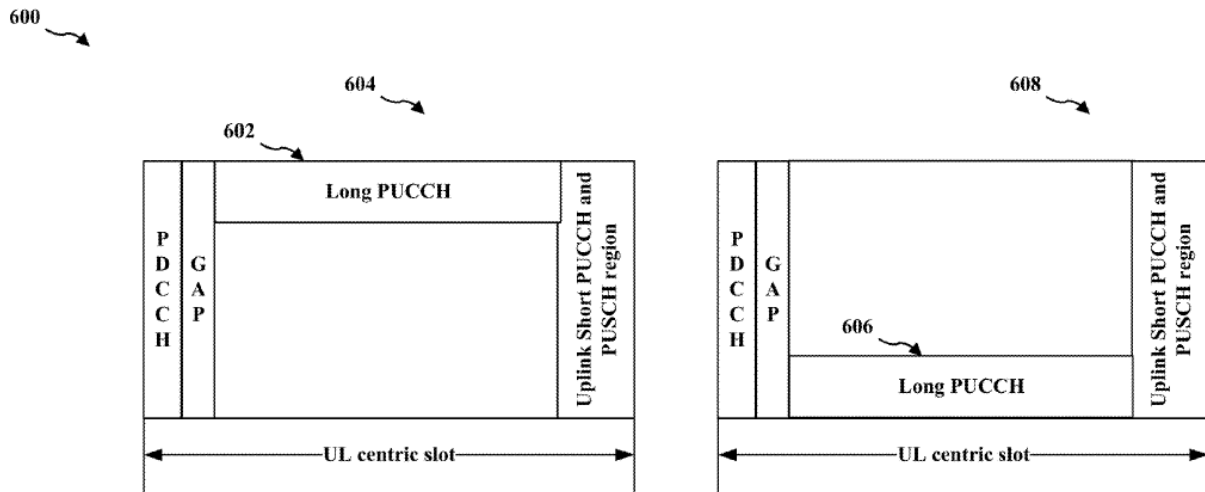


FIG. 6

EX-1016 (Huang) FIG. 6; EX-1017 (Huang Prov.) FIG. 6.

2. Reasons to combine Kim and Gao with Huang

176. A POSITA would be motivated to combine Kim's techniques for configuring a long PUCCH in a wireless access network, as modified with Gao's teachings of configuring symbol location in a slot of the PUCCH, with Huang's teachings of performing inter-slot frequency hopping at slot boundaries, which had the benefit of achieving frequency diversity. EX-1016 (Huang) 16:35-36; EX-1017 (Huang Prov.) ¶61.
177. Further, a POSITA would have had a reasonable expectation of success because a POSITA would have recognized that the frequency hopping

techniques of Huang disclose the same interslot and intraslot frequency hopping techniques of Kim. EX-1004 (Kim) ¶235; EX-1016 (Huang) 15:55-59; EX-1017 (Huang Prov.) ¶60. Similarly, Huang is compatible with Gao as they both address the configuration of variable length PUCCH for the 5G NR systems. EX-1005 (Gao) 2:1-10; EX-1006 (Gao Prov.) 1:33-2:1; EX-1016 (Huang) 2:8-11; EX-1017 (Huang Prov.) ¶6.

178. Additionally, incorporating the frequency hopping techniques disclosed in Huang into Kim' frequency hopping configuration of the PUCCH as modified by Gao would thus involve nothing more than routine skill of a POSITA as Kim already discloses interslot and intraslot frequency hopping.
179. A POSITA would thus have been motivated to combine the teachings of Kim and Gao with Huang.

3. Detailed Application of Kim and Gao further combination with Huang to the Challenged Claims

1. Claim 12

- i. [12.0] The gNB of claim 8, wherein the frequency hopping is applied at slot boundaries in the multiple slots PUCCH.*

180. Kim, alone or in combination with Gao and Huang, renders obvious claim 12.
181. To the extent that the combination of Kim and Gao does not disclose this

limitation (e.g., “*wherein the frequency hopping is applied at slot boundaries in the multiple slots PUCCH*”), Kim and Gao in view of Huang does.

182. Huang states, “With inter-slot hopping, a frequency of a PUCCH may be changed within a subframe across a time slot boundary. For example, referring back to FIG. 4, for inter-slot hopping, the time/frequency blocks 408 may be moved from subframe 0 and split between two subframes, e.g., the latter half of subframe 4 and the first half of subframe 5, such that a frequency of a PUCCH may be changed within a subframe across a time slot boundary, e.g., between the first and second time slots at the border of subframe 4 and subframe 5.” EX-1016 (Huang) 16:4-13; EX-1017 (Huang Prov.) ¶¶60-62.

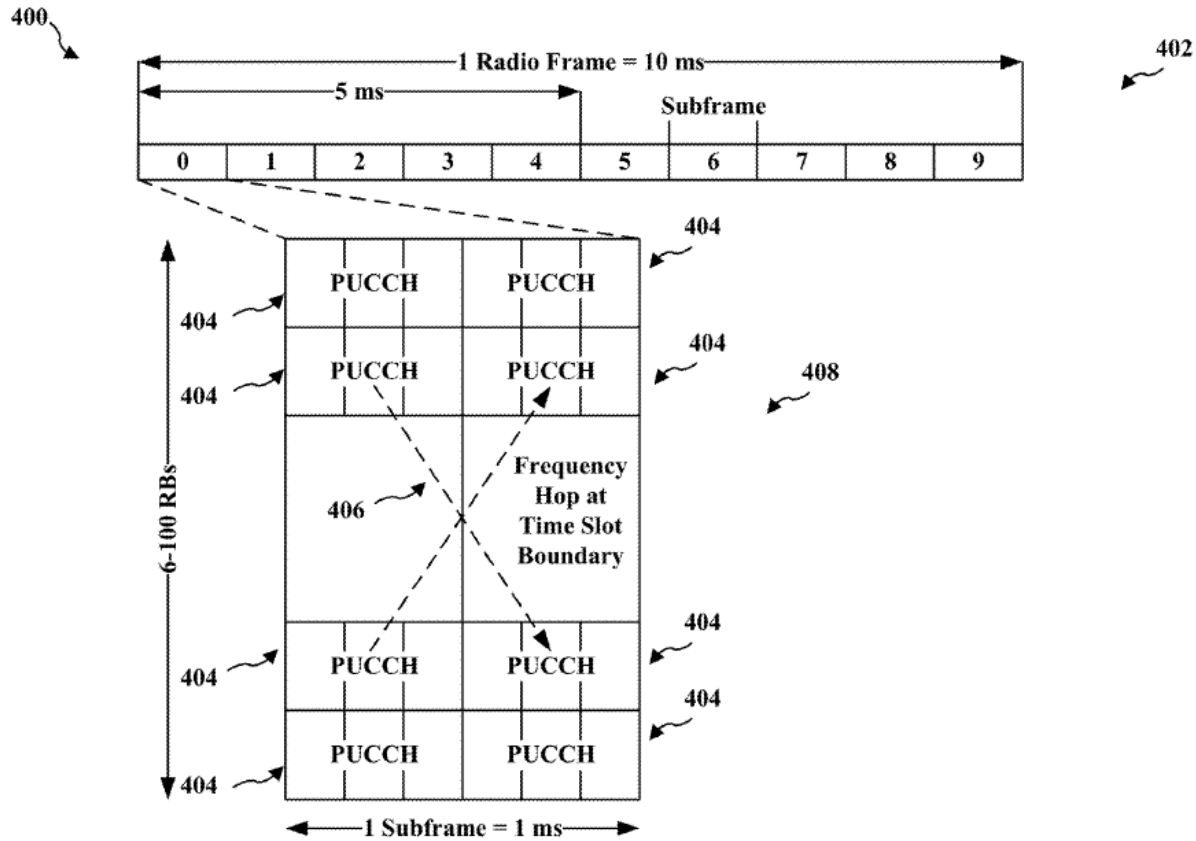


FIG. 4

EX-1016 (Huang) FIG. 4; EX-1017 (Huang Prov.) FIG. 4.

183. Huang discloses inter-slot frequency hopping at the time slot boundary as shown in FIG. 4 and states:

The frequency used to transmit the longer PUCCH may vary. For example, the x-axis in FIG. 6 may be time and the y-axis in FIG. 6 may be frequency. Frequency may increase along the y-axis. For example, the long PUCCH 602 may be at a higher frequency as compared to the long PUCCH 606. For intra-slot hopping, different PUCCHs may

change frequency within each long PUCCH 602 and/or a long PUCCH 606. For inter-slot hopping, a set of PUCCH may change frequency. For example, for inter-slot hopping, the long PUCCH may change frequency from the frequencies for the long PUCCH 602 to the frequencies for the long PUCCH 606.

EX-1016 (Huang) 16:38-49; EX-1017 (Huang Prov.) ¶60.

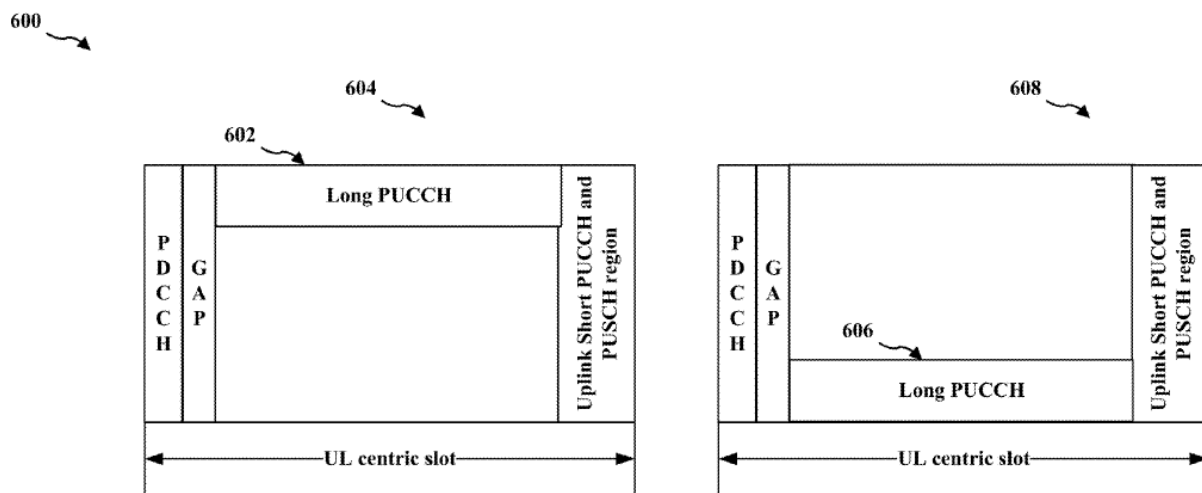


FIG. 6

EX-1016 (Huang) FIG. 6; EX-1017 (Huang Prov.) FIG. 6.

184. A POSITA would have understood that inter-slot frequency hopping could occur at the slot boundaries. “Factors such as number of symbols available for each PUCCH, channel conditions, a need for efficiency in the use of symbols, a lack of a need for efficiency in the use of symbols, or other factors may be used to determine when hopping should be used or not used.”

EX-1016 (Huang) 12:17-28; EX-1017 (Huang Prov.) ¶52. “Inter-slot hopping may be turned on (or off) to achieve frequency diversity” based on the factors listed above. EX-1016 (Huang) 16:35-36; EX-1017 (Huang Prov.) ¶¶52, 61.

185. Accordingly, Kim, alone or in combination with Gao and Huang, renders obvious claim 12.

XII. SECONDARY CONSIDERATIONS DO NO REBUT THE PRIMA FACIE CASE OF OBVIOUSNESS

186. In my opinion, secondary considerations do not rebut the prima facie case of obviousness for at least two reasons.

187. First, I have not seen any evidence of any secondary considerations to date. As such, I do not believe any such secondary considerations exist. To the extent Patent Owner seeks to proffer evidence of any secondary considerations in this proceeding, I reserve the right to comment on such evidence.

188. Second, I do not believe that Patent Owner will be able to establish a nexus between any secondary considerations and the Challenged Claims. I have been advised that a nexus does not exist where the alleged secondary considerations result from something other than what is both claimed and

novel in the claims.

189. As I have explained above, there is nothing novel in the claims. Indeed, all claim elements are disclosed in the prior art. Thus, I do not see any basis for Patent Owner to assert that there is a nexus between any secondary considerations and the claims.

XIII. CONCLUSION

190. My findings and opinions set forth in this Declaration are based on my work and examination to date. I may continue my examinations in view of additional documents or other factual evidence over the course of this proceeding that may necessitate supplementing and/or refining my opinions. I reserve the right to add to, alter, or delete any of my opinions and my Declaration upon discovery of additional information. I reserve the right to make any changes as necessary.
191. In signing this Declaration, I understand that this Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross-examination in this case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time

allowed for cross-examination. I declare that all statements made herein of my knowledge, all statements made on information and belief are believed to be true, and these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001, of Title 18 of the United States Code.

[SIGNATURE ON COVER PAGE]

APPENDIX A

MATERIALS CONSIDERED

Exhibit #	Description
1001	U.S. Patent No. 10,601,566 (the “’566 Patent”)
1002	Select portions of prosecution history of the ’566 Patent (“File History”)
1004	U.S. Patent Application Publication No. 2019/0159191 (“Kim”)
1005	U.S. Patent No. 10,951,350 (“Gao”)
1006	Certified English translation of Chinese Patent Application No. 2017/10527934.4 (“Gao Provisional”)
1007	Chinese Patent Application No. 2017/10527934.4
1008	Certified English translation of Chinese Patent Application No. 2017/10457951.5 (“Gao Provisional”)
1009	Chinese Patent Application No. 2017/10457951.5
1010	3GPP, “Support of long-PUCCH over multiple slots” (R1-1710013)
1011	3GPP, “Long PUCCH Over Multiple Slots” (R1-1710555)
1012	U.S. Patent No. 9,391,736 (“Nazar”)
1013	U.S. Patent No. 9,716,575 (“Ahn”)
1014	3GPP, “Editorial correction to the calculation of Rate Matching parameters” (R1-000426) (TS25.212 CR 059r1 V3.1.0)
1015	U.S. Patent No. 8,705,339 (“Takaoka”)
1016	U.S. Patent No. 10,873,435 (“Huang”)
1017	U.S. Provisional Application No. 62/501,681 (“Huang Provisional”)

1018	PCT Publication No. WO 2018/228194
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APPENDIX B

CURRICULUM VITAE

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

Highlights

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

Education

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

Employment

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

June 2018 – June 2021: *Associate Teaching Professor*

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

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

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

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

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

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

Detailed Research Experience:

Current ongoing research:

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

2015 – Present

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

2014 – 2015

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

2014

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

2013-2014

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

2013

Implemented a novel matched filter receiver for a unique OFDM signal of interest to facilitate signal detection in a high co-channel interference environment of a wide field of view high altitude receiver and wideband signal set design in highly complex propagation environments for

Department of Defense (DoD).

2012-2013

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

2012

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

2011-2012

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

2011

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

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

2009 – 2010

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

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

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

2006 – 2009

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

2005-2006

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

2003 – 2006

Principal Investigator for multi-year Office of Secretary of Defense sponsored research program in the area of multi-intelligence data fusion as part of the overall initiative of Force Transformation; worked extensively with NGA, DIA, DISA, OSD, all military services, and some coalition components.

2002 – 2003

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

1998 – 2002

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

1997 – 1998

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

1991 – 1997

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

1988-1989

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

Case History:

Ericsson Inc. and Nokia of America v. Active Wireless Technologies, LLC. IPR2024-00xx

Consulting for petitioners Ericsson and Nokia on improvements in system information transmissions in 4G systems. Wrote declaration.

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

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

September 2023 – April 2024, McKool Smith

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

August 2023 – December 2023, Greenberg Traurig

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

August 2023 – Present, McKool Smith

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

Consulting for Complainant Ericsson on technology related to 5G cellular signaling technology.

August 2023 – Present, Caldwell, Cassady and Curry

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

June 2023 – November 2023, Duane Morris

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

January 2023 – April 2023, McKool Smith

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

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

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

Consulting for patent owner FedEx. Wrote IPR declaration. Deposed 4/19/23.

Technology related to sensor information collected by tracking devices.

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

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

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

September 2022 – June 2023, Quinn Emanuel, LLP

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

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

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

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

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

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

August 2022 – Present, Venable, LLP

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

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

Technology relates to VoIP in cellular networks.

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

March 2022 – Dec. 2022, Knobbe, Martens, Olson & Bear, LLP
Jawbone Innovations, LLC v. Amazon.com, Inc., et al.
Consulting for petitioner Amazon re: IPR. Case stayed. No reports.
Technology related to tracking using acoustic arrays.

May 2022 – Dec. 2022, McKool Smith; Alston Bird
Ericsson Inc. and Telefonaktiebolaget LM Ericsson vs. Apple Inc., Case No. 2:21-cv-376, EDTX
Consulted for plaintiff and counter-defendant Ericsson.
Report on Essentiality and Rebuttal report (FRAND). Deposed 10/4/2022. Testified 12/7/2022. Case settled during trial.
Broad spectrum of technology related to cellular networks (core network and mobile device)

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

January 2022 – March 2023, Duane Morris
Telecom Network Solutions v. AT&T Inc., et al, Case No. 2:21-cv-415 and Verizon Communications Inc., et al, Case No 2:21-cv-416, EDTX
Consulted for defendants AT&T and Verizon on Invalidity. Case settled; no reports filed.
Technology related to QoS in cellular networks.

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

September 2021 – December 2021, Quinn Emanuel, LLP
L2 Mobile Technologies, LLC v. Google, Case No. 6:21-cv-358, WDTX
Consulted for defendant Google. Wrote reply Claim Construction brief. Case settled.
Technology related to control signaling in cellular systems.

August 2021 – May 2022, McKool Smith
Godo Kaisha IP Bridge I v. Ericsson, Case No. 2:21-cv-00213-JRG, EDTX
Consulted for defendant Ericsson. IPR and Claim Construction declarations.
Technology related to signaling in OFDM systems.

July 2021 – August 2021, Quinn Emanuel, LLP
Finesse Wireless, LLC v. Nokia, et al., Case No. 2:21-CV-00063-JRG, EDTX
Consulted for defendant Nokia on claim construction. Wrote declaration and deposed on 8/17/21.
Technology related to coding techniques in wireless systems.

June 2021 – Dec 2021, Knobbe, Martens, Olson & Bear, LLP
Vocalife LLC v. Amazon.com, Inc., et al., Case No. 2:20-cv-00401-JRG-RSP, EDTX
Consulted for defendant Amazon on claim construction. Stayed pending sister case outcome.
Technology related to echo cancelation and signal enhancement in acoustic systems.

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

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

November 2020 – June 2021, Sheppard Mullin
Hong Kong uCloudlink v. SIMO Holdings, Inc. and Skyroam, Inc., Case No. 18-cv-05031-EMC, NDCA. Consulted for plaintiff uCloudlink on infringement and validity. Deposed (3/26/21). Case settled. Virtual SIM technology.

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

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

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

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

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

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

Case Testimony History:

October 2023 – April 2024, Erise IP; Finnegan, DLA Piper, Husch Blackwell
BNR v. ASUSTek/Media Tek/Laird/NXP Inc. Inv. No. 337-TA-1367 (USITC). Consulting for defendant ASUS on ASUS (Qualcomm-based products) non-infringement and JDG (ASUS/Media Tek/ Laird/ NXP) on Tech DI non-infringement. Wrote on WiFi wireless devices and semiconductor chips with wireless capabilities related to wireless transmission technologies. Wrote rebuttal report. Deposed 2/8/24. BNR settled with ASUS and Media Tek; BNR withdrew complaint before hearing.

November 2022 – April 2023, Finnegan, Henderson, Farabow, Garrett & Dunner, LLP
Qualcomm, Inc. vs. FedEx, Inc., IPR 2022-00585
Consulting for patent owner FedEx. Wrote IPR declaration. Deposed 4/19/23.
Technology related to sensor information collected by tracking devices.

September 2023 – June 2023, Quinn Emanuel, LLP
Google LLC v. Sonos, Inc., Inv. No. 337-TA-1330 (USITC)
Consulting for patent owner Google. Wrote infringement and validity rebuttal reports.
Technology related to voice assistants and smart devices. Deposed 4/14/23. Testified 6/20-23/23.

September 2022 – November 2023, BC Law Group, P.C.
Apple, Inc., vs. Speir Technologies Limited, IPR2022-01512 and -00151
Consulted for patent owner Speir on UWB localization technology. Wrote IPR declarations. Deposed 10/25/23. Case dismissed 11/18/23.

August 2022 – Present, Venable, LLP
VoIP-Pal.com, Inc. v. Verizon Communications Inc. Case No. 6:21-cv-00672, WDTX
Consulting for defendant Verizon. Wrote non-infringement report. Deposed 5/17/23.
Technology relates to VoIP in cellular networks.

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

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

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

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

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

March 2021 – Sept 2021, Wilson Sonsini

Lenovo Holding Co, Inc., et al. v. InterDigital Technology Corp.

IPR. Consulted for InterDigital. Technology related to control signaling in cellular systems. Wrote three declarations. Deposed 7/27/21.

November 2020 – June 2021, Sheppard Mullin

Hong Kong uCloudlink v. SIMO Holdings, Inc. and Skyroam, Inc., Case No. 18-cv-05031-EMC,

NDCA. Consulted for plaintiff uCloudlink on infringement and validity. Technology related to virtual SIM. Deposed 3/26/21.

August 2019 – August 2020; June 2021 – Sept 2021 McKool Smith/Irell & Manella

Optis Wireless Technology, LLC et al. v. Apple, Inc., EDTX, Civ No. 2:19-cv-66

SEPs – Consulted for plaintiff Optis on control channel MIMO switching, control channel information fields. Infringement and validity analysis/reports, IPR. Deposed 06/01/20 and testified at trial 8/3/20 – 8/9/20. Testified at re-trial for damages 8/10/21 – 8/16/21.

2016 – March 2019 Sidley Austin, LLP

Huawei v. Samsung, NDCA

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Consulted for plaintiff Huawei on original complaint and for defendant Huawei. Assisted claim construction, IPR petition and preliminary response, wrote validity and non-infringement reports. Deposed 6/20/18, and 7/19/18.

2016 Russ, August & Kabat

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2015 - 2016 Hueston & Hennigan

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Case No. 2:14-cv-912-JRG-RSP (consolidated)

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

Teaching:

Courses:

- CSE 516 (Mobile Networks): Redesigned the course to integrate latest developments in mobile network architecture design. The course now includes signaling, control, and protocol issues unique to 4G/5G architectures addressing eMBB, mMTC, and URLLC use cases critical to IoT and future wireless network development and future NG networks.
- CSE 514 (Communication Networks)
- CSE 590 (Colloquium)
- CMPEN 462 (Wireless Communication Systems and Security): Created and designed this course to address a gap in the wireless communications area focusing on security. This course is included in the cybersecurity computational foundations minor.
- EE 456 (Introduction to Neural Networks): This course is intended to address the need for EE and CMPEN students to be exposed to the principles associated with artificial intelligence with a focus on the integration of physics-based approaches.
- CMPEN/EE 362 (Communication Networks)
- CMPSC 263 (Blockchains and Modern Web Development): This course is ‘module’ driven and

designed to provide students with a broad range of academic backgrounds an opportunity to learn about blockchains and cryptography. Under supervision, students in the Distributed Ledger Society teach the modules including theory and practice in the areas of programming, math, and cryptography.

- ACS 505 (Experimental Techniques in Acoustics)
- MATH 141 (Calculus with Analytical Geometry II)
- CMPSC 101 (Programming in C++)

Publications:

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

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

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

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

Sorensen, Mehmeti, Mahon, Qui, Chan, Qui, and LaPorta, “Optimal Resource Allocation for Crowdsourced Image Processing”, *IEEE Transactions on Mobile Computing*. June 2022.

Sorensen, Mehmeti, Mahon, La Porta, Cao, “Mutli-User Competitive Energy-Aware and QoE-Aware Video Streaming on Mobile Devices”, *ACM Proceedings of the QoS and Security for Wireless and Mobile Networks (Q2SWinet) Symposium collocated with Modeling, Analysis, and Simulation of Wireless and Mobile Systems (MSWIM 2020)*, Alicante, Spain, Nov. 2020.

Sorensen, Mehmeti, Mahon, Qui, Chan, and LaPorta, “Optimal Resource Allocation for Crowdsourced Image Processing”, *IEEE International Conference on Sensing and Networking (IEEE SECON 2020)*, Como, Italy, June 2020.

Swanson, Mahon, Norris, and Mast, “Atmospheric Multipath Resolution Using Spread Spectrum Acoustic Signals”, *Proceedings of Meetings on Acoustics*, September 2017.

Aquaviva, Mahon, Einfalt, and LaPorta, “Optimal Cyber-Defense Strategies for Advanced Persistent Threats: A Game Theoretic Approach,” *2017 International Symposium on Reliable and Distributed Systems*, Hong Kong, China, September 27 – 29, 2017.

Young, Mahon, and Wyckoff, “Automated Information Management,” Chap. 12, *Mathematical Techniques in Multisensor Data Fusion*, Hall, David L., Artech House Inc., Mar 2004

Mahon, Sonstebly, and Wenchel, “Application of Non-Orthogonal Waveletes for Geolocation,” *Radiolocation and Direction Finding Symposium*, Southwest Research Institute, San Antonio, Texas, 2-4 Nov. 1999.

Myers, Lovette, Kilgus, Giannini, Swanson, Reichard, Mahon, Mast, "A Java-based Information System for Wayside Sensing and Control," *Proc. of the 1998 ASME/IEEE Joint Railroad Conference*, 1998, pp. 135-147.

Swanson, Mast, Mahon, "Atmospheric Multipath Resolution Using Spread Spectrum Acoustic Signals," *Proceedings of the 133rd Meeting of the ASA*, June 15-20, 1997.

Mahon, Swanson, "Acoustic Holography as an Active Control Measurement Tool," *Proceedings of Active 95, The 1995 International Symposium on Active Control of Sound and Vibration*, Newport Beach, CA, July 1995, pp. 673-684.

Mahon, Sibul, Valenzuela, "A Sliding Window Update for the Basis Matrix of the QR Decomposition," *IEEE Transactions on Signal Processing*, May 1993, pp. 1951-1953.

Mahon, Sibul, Valenzuela, "An Alternative Updating Scheme for the QR Algorithm as Applied to Adaptive Beamforming," *Proc. 25th Annual Conf. on Info. Sciences and Systems*, Johns Hopkins University, Baltimore, MD, March 1991, pp. 193-199.

Awards/Honors:

Senior Member IEEE

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

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

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

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

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

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

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

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