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DECLARATION OF DR. NARAYAN MANDAYAM

I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare that 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 the Title 18 of the United States Code.

Dated: 5-5-2025

By: 
Dr. Narayan Mandayam, Ph.D.

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I, Narayan Mandayam, Ph.D, declare and state as follows:

I. ASSIGNMENT

1. I have been retained by counsel for Petitioner Apple Inc. (“Petitioner” or “Apple”) as a technical expert in the above matter. I am submitting this Declaration to address the validity of claims 1-20 (“Challenged Claims”) in U.S. Patent No. 11,108,639 (“the ’639 Patent”). For the purposes of this Declaration, I have not been asked to opine on any other issues not addressed below.

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

3. My analysis of the materials produced in this investigation is ongoing and I will continue to review any new material as it is provided. This Declaration

represents only those opinions I have formed to date. I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information and on my continuing analysis of the materials already provided.

4. I am not and never have been, an employee of Apple. I received no compensation for this declaration beyond my normal hourly compensation based on my time actually spent analyzing the '639 Patent, the prior art publications cited below, and issues related thereto, and I will not receive any added compensation based on the outcome of any IPR or other proceeding involving the '639 Patent.

II. QUALIFICATIONS AND BACKGROUND

5. I am an independent consultant. All of my opinions stated in this declaration are based on my own personal knowledge and professional judgment. In forming my opinions, I have relied on my knowledge and extensive experience in the field of telecommunications networks, algorithms, and communication protocols.

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

7. My qualifications are summarized here and explained in more detail in my curriculum vitae, which is attached as Appendix A to this report.

8. I am a Distinguished Professor of Electrical and Computer Engineering at Rutgers University where I serve as the Director of the Wireless Information Network Laboratory (WINLAB), a world class wireless networking research center at Rutgers University. WINLAB has been serving as an industry-university cooperative research center since its inception in 1989. I have been writing, researching and teaching about wireless communications and networking since 1989.

9. I received my Bachelor's degree in Electrical Engineering from the Indian Institute of Technology (IIT) in Kharagpur, India in 1989 with honors. I received my M.S. in Electrical Engineering from Rice University in 1991 and my Ph. D in Electrical Engineering in 1994, also from Rice University. After completing my studies, I was hired as a Research Associate at WINLAB in 1994 before being hired as an Assistant Professor in 1996 in the Department of Electrical and Computer Engineering at Rutgers University. I was promoted to Associate Professor in 2001, to Professor in 2003, and to Distinguished Professor in 2014.

10. I also served as the Peter D. Cherasia Endowed Faculty Scholar at Rutgers University from 2010 to 2014, the Chair of the Electrical and Computer Engineering Department from 2016 to 2022, and as an Associate Director at WINLAB since 1999. I was a visiting faculty fellow in the Department of

Electrical Engineering at Princeton University in Fall 2002, and a visiting faculty at the Indian Institute of Science in Spring 2003.

11. I conduct research in various aspects of wireless systems and networks. I teach courses at Rutgers on the topics of Wireless System Design, Wireless Communication Technologies, Wireless Revolution, Detection and Estimation Theory and Introduction to Computing for Engineers. I have co-authored 2 books on wireless networks (Principles of Cognitive Radio, Cambridge (2012) and Wireless Networks: Multiuser Detection in Cross-Layer Design, Springer (2005)), 8 book chapters and published nearly 300 papers in prestigious international journals and conferences. I have also given numerous invited presentations at a variety of industry, government, and academic forums.

12. Over the last 30 years, I have published a wide range of articles on various aspects of wireless systems addressing PHY, MAC and Network layer issues including techniques for data transmission and multimedia communications, resource allocation strategies, algorithms for wireless network security, mathematical modeling, and performance analysis. Using constructs from game theory, communications, and networking, my work has focused on system modeling and performance, signal processing as well as radio resource management for enabling wireless technologies to support various applications.

13. I have made seminal research contributions to wireless data communications on issues ranging from the systems level (such as power control, base station assignment, capacity evaluation, protocol design, medium access control, and radio resource management) to the physical layer (such as data transmission and reception). I have also done seminal work in the area of the Physical-Layer security, where properties of the radio channel (PHY layer of the protocol stack) are exploited for the purposes of secret key generation, authentication and encryption. One of my papers on this topic is also featured in the Best Readings compilation of the IEEE Communications Society (COMSOC) as the top paper on Physical-Layer Authentication.

14. My expertise includes cellular systems such as for 2G, 3G, 4G, 5G, and I have published papers on a wide variety of topics related to the design and operation of GSM/TDMA, CDMA and LTE and 5G based systems. During this time, I have also worked extensively on wireless local area network (WLAN) and Wi-Fi technologies as well as wireless ad-hoc and sensor networks, and as such, I am quite familiar with 802.11 and Bluetooth.

15. I have also served as a technical consultant since its inception in 2002 to the company Mojo Networks Inc. (recently acquired by Arista Networks), a world leader in enterprise network security for WLANs and Wi-Fi networks that offers the next generation of intelligent edge, secure, and flexible Wi-Fi solutions. I

am familiar with the early developments in the area of cellular systems (2G, 3G, 4G and 5G) and have served on several graduate thesis defense committees pertaining to all aspects of wireless systems operation.

16. I have received several prestigious awards relating to my research on wireless networks and communications: the 2015 IEEE COMSOC Advances in Communications Award for seminal work on power control in wireless data networks (this is the highest paper award given by the IEEE Communications Society to the most impactful publication in the preceding 15 years), the 2014 IEEE Donald G. Fink Award (recognizes the most outstanding tutorial paper across all IEEE publications) for the paper titled “Frontiers of Wireless and Mobile Communications” that discusses the historical and future landscape of both WAN and LAN wireless technologies, and the Fred W. Ellersick Prize from the IEEE Communications Society in 2009 for work on dynamic spectrum access models and spectrum policy. I also received the Peter D. Cherasia Faculty Scholar Award from Rutgers University in 2010, the National Science Foundation Career Award in 1998, the Institute Silver Medal from the Indian Institute of Technology, Kharagpur, in 1989, and its Distinguished Alumnus Award in 2018.

17. I have served as an Editor for the journals IEEE Communication Letters (1999- 2002) and IEEE Transactions on Wireless Communications (2002-2004). I have also served as a guest editor of the IEEE JSAC Special Issues on

Adaptive, Spectrum Agile and Cognitive Radio Networks (2007) and Game Theory in Communication Systems (2008). I was elected Fellow of the IEEE for “contributions to wireless data transmission.” I have also served as a Distinguished Lecturer of the IEEE Communications Society.

18. My experience of over 30 years with networking and telecommunications in academic and practical situations as well as my hands on experience, has given me a detailed appreciation of the technology involved with the '639 Patent.

19. My opinions, as explained below, are based on my education, experience, and expertise in the fields relating to the '639 Patent. Unless otherwise stated, my testimony below refers to the knowledge of one of ordinary skill in the art as of the earliest possible priority date. Any figures that appear within this document have been prepared with the assistance of Counsel and reflect my understanding of the '639 Patent and the prior art discussed below.

III. OVERVIEW OF CONCLUSIONS FORMED

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

- Ground 1: Claims 1-20 are unpatentable over Fakoorian-1 in view of Takahashi
- Ground 2A: Claims 1-20 are unpatentable over Fakoorian-2
- Ground 2B: Claims 1-20 are unpatentable over Fakoorian-2 in view of Takahashi

21. In support of these conclusions, I provide an overview of the references in Section IX and more detailed comments regarding the obviousness of claims 1-20 (“the Challenged Claims”) of the ’639 Patent in Section X.

IV. LEGAL STANDARDS

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

A. Priority Date

23. I understand that the “priority date” of a patent is the date on which it is filed. I further understand that a patent may be entitled to the filing date of an earlier-filed application or foreign patent filing. In this case I understand the ’639 Patent claims priority to November 6, 2019.

B. Anticipation Under 35 U.S.C. § 102

24. I understand that patents or printed publications that qualify as prior art can be used to invalidate a patent claim as anticipated or as obvious. I understand that, once the claims of a patent have been properly construed, the second step in determining anticipation of a patent claim requires a comparison of the properly construed claim language to the prior art on a limitation-by-limitation basis. I understand that a prior art reference “anticipates” an asserted claim, and thus renders the claim invalid, if all limitations of the claim are disclosed in that prior art reference, either explicitly or inherently (i.e., necessarily present).

C. Obviousness Under 35 U.S.C. § 103

25. I understand that a claim is invalid if the invention recited in the claim would have been obvious to one of ordinary skill in the art at the time the invention was made. I understand this means that even if all the requirements of the claim cannot be found in a single prior art reference that would anticipate the claim, a person of ordinary skill in the field of the invention knowledgeable of the prior art would have come up with the claimed invention. In considering whether a claim is obvious, I have been asked to consider (a) the level of skill in the art at the time of the claimed invention, (b) the scope and content of the prior art, (c) any differences between the prior art and the claims of the patent-in-suit, and (d) any “secondary factors” tending to show non-obviousness of the claimed invention, including

commercial success, long-felt but unresolved need, failure of others, copying, praise by others, unexpected results, and simultaneous invention by others.

26. I understand that a claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known in the prior art. I also understand that obviousness should not be analyzed using the benefit of hindsight. Instead, it must be analyzed from the standpoint of what was known and understood by a POSITA at the time of the claimed invention. I further understand demonstrating that a modification to a reference or the combination of multiple references is obvious requires providing a reason for why a POSITA would modify a reference or combine multiple references and that reason must be supported with some rationale underpinning. Merely pointing out that two references are similar or in the same field of endeavor is not sufficient.

D. Secondary Considerations of Non-Obviousness

27. I understand that in determining whether the claims are obvious I must also consider certain factors that may help determine that a particular concept was not obvious. These include practical factors relating to the concept, including (1) commercial success, (2) a long-felt need for a solution to the problem facing the inventors, (3) whether others tried and failed to solve the problem, (4) whether others copied the claimed invention, (5) whether the invention achieved

unexpected results, (6) whether the prior art teaches away from combining certain known elements, and (7) whether others in the field praised the invention.

E. Claim Construction

28. I understand that the words of a claim are generally given their ordinary and customary meaning, which I understand is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention, *i.e.*, as of the effective filing date of the patent application. I understand the person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification and prosecution history.

29. Additionally, I understand other extrinsic evidence external to the patent and prosecution history, such as dictionaries and treatises, may also be useful in determining the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention. I understand that such extrinsic evidence, however, is generally afforded less weight than intrinsic evidence in determining the meaning of claim terms, and overall is unlikely to result in a reliable interpretation of a patent claim scope unless considered in the context of the intrinsic evidence.

F. Level of Ordinary Skill

30. I understand there is a concept in patent law known as a person having ordinary skill in the art (POSITA). I understand that this concept refers to a person who is trained in the relevant technical field of a patent without possessing extraordinary or otherwise exceptional skill. I further understand that factors such as the education level of those working in the field, the sophistication of the technology, the types of problems encountered in the art, prior art solutions to those problems, and the speed at which innovations are made may help establish the level of skill in the art.

31. Specifically, my experience working with industry, undergraduate and post-graduate students, colleagues from academia, and designers and engineers practicing in industry has allowed me to become directly and personally familiar with the level of skill of individuals and the general state of the art. Taking these factors into consideration, in my opinion, with regard to the '639 Patent, a person of ordinary skill in the art would have a bachelor's degree in electrical engineering, computer engineering, computer science, or a similar field, along with two years of experience designing or developing wireless networks, including long-term evolution LTE/4G and 5G new radio (NR) cellular technology. Additional education (*e.g.*, advanced-level degree) might substitute for some of the

experience, and additional substantial experience might substitute for some of the educational background.

32. Based at least on my educational and work experience, I was at least a person of ordinary skill in the art as of the effective filing date of the '639 Patent. And while I note that my qualifications and experiences exceed this definition of a person of ordinary skill of the art, in arriving at the conclusions in this Declaration, I have considered the issues from the perspective of a person of ordinary skill of the art at the relevant time.

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

V. MATERIALS CONSIDERED

34. In preparing my opinions, I have reviewed the '639 Patent and its prosecution history and have also reviewed the other documents and materials cited herein and the materials listed below. When citing from these references, all emphasis is added unless otherwise noted.

Ex.	Description
Exhibit 1001	U.S. Patent 11,108,639
Exhibit 1002	Prosecution File History for U.S. Patent 11,108,639
Exhibit 1004	U.S. Patent Publication No. 2023/0084754 (“Fakoorian-1”)
Exhibit 1005	U.S. Patent No. 11,464,001 (“Fakoorian-2”)
Exhibit 1006	Certified English-language translation of WIPO PCT App. Pub. No. WO 2021/064961A1 to Takahashi <i>et al.</i> (“Takahashi”)
Exhibit 1007	RESERVED
Exhibit 1008	U.S. Provisional Application 62/868,632 filed on Jun. 28, 2019 (“Fakoorian-1-Provisional”)

Exhibit 1009	U.S. Provisional Application 62/888,098 filed on Aug. 16, 2019 (“Fakoorian-2-Provisional”)
Exhibit 1010	WIPO PCT App. Pub. No. WO 2021/064961A1 to Takahashi <i>et al.</i> (“Takahashi-Japanese”)

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

VI. THE ’639 PATENT

A. Overview of the ’639 Patent

36. The ’639 Patent relates to wireless device feedback for semi-persistent scheduling (“SPS”) release. APPLE-1001, Title. In general, SPS is an alternative to dynamic scheduling that can be used in long-term evolution (LTE) and 5G new radio (NR) technologies to pre-allocate radio resources for certain network transmissions.

37. The UE receives Radio Resource Control (RRC) messaging that includes configuration parameters of various SPS configurations. APPLE-1001, Abstract, *see* 26:58-27:8. An example of this well-known RRC concept is illustrated at least at Fig. 16 of the ’639 Patent (reproduced below). APPLE-1001, Fig. 16.

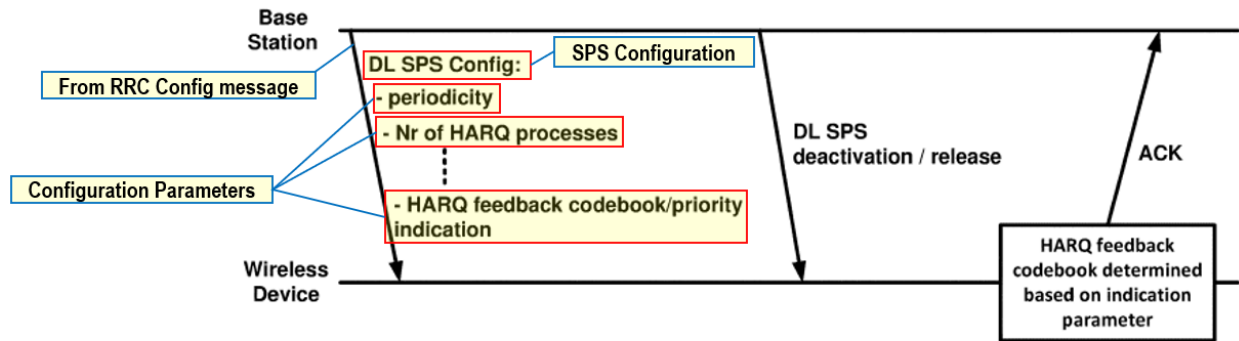


FIG. 16
APPLE-1001, Fig. 16 (annotated)

The UE “may receive one or more message[s] comprising configuration parameters,” where the “messages may comprise radio resource control (RRC) messages” and “[a] parameter of the configuration parameters may be in at least one of the one or more messages.” APPLE-1001, 26:58-63. The ’639 Patent states the “messages may comprise information element (IEs),” that an information element “includes single or multiple fields,” and that “fields in an IE may be individual contents of the IE.” *Id.*, 26:63-65. Notably, the ’639 Patent states plainly that “[t]he **terms configuration parameter, IE and field may be used equally in this disclosure.**” *Id.*, 26:66-27:1.

38. The parameters of the ’639 Patent indicate HARQ codebook identifiers, and the same HARQ codebook identifier can be indicated for at least two SPS configurations using the respective parameters of the at least two SPS configurations. APPLE-1001, Abstract, *see* 49:31-50, cl. 1. The UE receives a downlink (DL) control information (DCI) message with bit(s) that indicate a state

of the SPS configurations. APPLE-1001, Abstract. The DCI can include “a plurality of fields including a HARQ process number (HPN) field.” APPLE-1001, 49:3-5.

39. The preceding discussion provides context for understanding the alleged problem recited in the ’639 Patent. For deactivation of “DL SPS configurations, the base station may transmit a release/deactivation DCI indicating that the DL SPS configuration is deactivated” and the UE should “acknowledge the receipt of the release/deactivation DCI so that the base station determines that the wireless device correctly received the DCI and that the wireless device deactivated resources corresponding to the DL SPS configurations.” APPLE-1001, 32:56-63.

40. When a group of downlink (DL) “SPS configurations are jointly deactivated/released by a single deactivation/release DCI,” the ’639 Patent explains that “existing [prior art] acknowledgement processes or HARQ feedback codebook determination processes **lead to inefficient DL SPS operation**. There is a need to enhance the existing DL SPS deactivation/release mechanisms when a group of DL SPS configurations are jointly released/deactivated. Example embodiments enhance the DL SPS deactivation/release mechanisms when a group of DL SPS configurations are jointly released/deactivated.” *Id.*, 32:63-33:8.

41. The purported solution of the ’639 Patent involves the UE “transmit[ting] an acknowledgement (e.g., HARQ ACK)” “indicating the reception

of the DCI,” where the DCI “indicates SPS release of the first SPS configuration and the second SPS configuration.” *Id.*, 49:50-56. In particular, the UE “may transmit the acknowledgement based on *the first HARQ codebook identifier being the same as the second HARQ codebook identifier in response to the first SPS configuration index and the second SPS configuration index being associated with the same deactivation state.*” *Id.*, 49:58-62. Further, the UE “may transmit the acknowledgement [...] in response to the DCI indicating joint deactivation/release of the first SPS configuration and the second SPS configuration.” *Id.*, 49:63-67.

42. Upon my review of the ’639 Patent, it was quite clear that the alleged problem recited by the ’639 Patent was no problem at all, as it was already addressed in the art, and its purported solution was well-known at the time of filing the application that issued as the ’639 Patent. See §VIII.A.

B. Prosecution History of the ’639 Patent

43. The cover of the patent and Counsel has informed me that the ’639 Patent was issued on August 31, 2021 from U.S. Patent Application No. 17/236,001 (“the ’001 application”), which was filed on April 21, 2021 with 20 claims. APPLE-1002, pp. 4-24.

44. Counsel has informed me that the ’001 application is a continuation of U.S. Patent Application No. 17/086,383, that was filed on October 31, 2020, and

that has now become U.S. Pat. No. 11,018,946. Counsel has also informed me that the '001 application claims priority to a provisional application identified by U.S. Serial No. 62/931,798, and that provisional application was filed November 6, 2019. *Id.*, pp. 108-115.

VII. OVERVIEW OF THE PRIOR ART REFERENCES

A. Overview of Fakoorian-1¹

45. Like the '639 Patent, Fakoorian-1 is directed to “[j]oint activation and/or release for multiple configured grant and/or semi-persistent scheduling configurations.” APPLE-1004/APPLE-1008², Title. In Fakoorian-1, “a user equipment (UE) may receive a single downlink control information (DCI) message” and “map a bit sequence in the single DCI message to a configuration set

¹ General descriptions provided for this and other references and combinations thereof are incorporated into each subsection and mapping of the claims that includes citations to these references.

² Reference to “Fakoorian-1,” including citation to “APPLE-1004/APPLE-1008,” corresponds to APPLE-1004 and APPLE-1008, collectively.

that includes multiple downlink semi-persistent scheduling [SPS] configurations” “to be jointly activated ***or released***.” *Id.*³, Abstract.

46. Fakoorian-1 teaches that SPS configurations are “initially indicated to the UE in an RRC configuration.” *Id.*, [0038]/[0037]. In Fakoorian-1, “[t]o configure SPS,” “radio resource control (RRC) signaling may indicate an interval at which the radio resources are periodically assigned.” *Id.* In particular, Fakoorian-1 discloses that “a downlink SPS configuration, which is initially indicated in an RRC configuration[,] and a subsequent DCI message activates and/or releases the downlink SPS configuration.” *Id.*, [0040]/[0039]. Fakoorian-1 describes various “hybrid automatic repeat request-acknowledgement (HARQ-ACK) codebook[s],” (cl. 5 (APPLE-1004)/cl. 14 (APPLE-1008)) including a “HARQ-ACK codebook for” transmitting “HARQ-ACK information that corresponds to an SPS PDSCH release” to “acknowledge the SPS configuration(s)

³ Each instance of “*Id.*” that follows “APPLE-1004/APPLE-1008” corresponds to that collective citation and, where required, includes a reference to the respective paragraph numbers of APPLE-1004 and APPLE-1008 being cited (or relied on), e.g., to the extent the respective paragraph numbers differ from the paragraph that were cited to in the preceding “APPLE-1004/APPLE-1008” collective citation.

[...] released by the single DCI message.” *Id.*, cl. 5 (APPLE-1004)/cl. 14 (APPLE-1008), [0062]/[0061].

47. For example, Fakoorian-1’s UE “receive[s], a single DCI message that includes a bit sequence to indicate [...] SPS configurations to be jointly [...] released.” *Id.*, [0045]/[0044]. Fakoorian-1’s bit sequence can be “provided in a [HARQ] process number field of the single DCI message.” *Id.*, cl. 19 (APPLE-1004)/cl. 11 (APPLE-1008). Fakoorian-1’s “HARQ process number” is described as a “4-bit field” used to indicate a “HARQ index that belongs to” an SPS configuration(s) and that “can be used to” “release,” or deactivate, the corresponding configuration. *Id.*, [0057]/[0056]. In the case of an “SPS configuration” that is released, “the UE may acknowledge” the “release by transmitting the acknowledgement in a codebook through a physical uplink control channel (PUCCH) resource.” *Id.*, [0058]/[0057].

48. Fakoorian-1 acknowledges the well-known advantages of semi-persistent scheduling configurations; noting, for example, that “[s]emi-persistent scheduling (SPS) enables radio resources to be semi-statically configured and allocated to a UE for a longer time period than one subframe.” *Id.*, [0038]/[0036]. This “may avoid the need for specific downlink assignment messages and/or uplink grant messages over a physical downlink control channel (PDCCH) for each subframe.” *Id.* For example, in prior art approaches “different downlink SPS

configurations [...] are activated and released individually,” such that “a base station needs to send N DCI messages to a UE” “to activate N downlink SPS configurations,” and “separately releas[e] the downlink SPS configurations.” *Id.*, [0041]/[0040]. This approach requires the network to transport multiple DCIs and the UE to receive and process the multiple DCIs,” which “increases network overhead and consumes substantial resources.” *Id.*

49. I further note that Fakoorian-1-Provisional (APPLE-1008) provides clear and unambiguous support for at least independent claim 1 of Fakoorian-1 (APPLE-1004). The following table identifies exemplary support in Fakoorian-1-Provisional for each limitation of Fakoorian-1’s claim 1:

	<u>Fakoorian-1 (APPLE-1004, Claim 1)</u>	<u>Exemplary Support Fakoorian-1-Provisional (APPLE-1008)</u>
[1]	A user equipment (UE) for wireless communication, comprising:	[0006] (“ <i>UE for wireless communication</i> ”); [0008] (“apparatus for wireless communication”); [0025] (“UEs 120 (e.g., 120a, 120b, 120c),” “A UE may be a ... <i>wireless communication device</i> ”);

		FIG. 1 (UE 120a, 120b, 120c, 120d); cl. 22.
[1a]	a memory; and	[0006] (“UE for wireless communication may include a memory and one or more processors operatively coupled to the memory.”); FIG. 2 (Memory 282); cl. 22.
[1b]	one or more processors, coupled to the memory, configured to:	[0006] (“UE for wireless communication may include a memory and one or more processors operatively coupled to the memory .”); FIG. 2 (Controller/Processor 280, Memory 282); cl. 22.
[1c]	receive a single downlink control information (DCI) message; and	[0005] (“a method of wireless communication, performed by a user equipment (UE), may include receiving a single downlink control information (DCI) message ”);

		[0035] (“UE 120 may include means for <i>receiving a single downlink control information (DCI) message</i>”); Abstract (“a user equipment (UE) may receive a single downlink control information (DCI) message.”); FIG. 4 (410); cl. 1, cl. 22-cl. 24.
[1d]	transmit, through a physical uplink control channel (PUCCH) resource, a codebook that includes an acknowledgement bit based at least in part on a bit sequence, in the single DCI message, indicating that one or more of multiple downlink semi-persistent scheduling (SPS) configurations are to be jointly released,	[0057] (“the UE may acknowledge the activation or release by transmitting the acknowledgement in a codebook through a physical uplink control channel (PUCCH) resource”); [0080] (“the UE may transmit, through a physical uplink control channel (PUCCH) resource, a codebook with an individual acknowledgement bit based at least in part on the bit sequence indicating that the multiple downlink SPS configurations are to be jointly released.”)

		[0059] (“the PUCCH resource to be used to transmit the acknowledgement bit may be defined by the single DCI message indicating the SPS configuration(s) to be activated or released”); FIG. 3, FIG. 4, cl. 1
[1e]	the acknowledgement bit being an individual acknowledgement bit used to acknowledge another one of the multiple downlink SPS configurations that was released.	[0061] (“Alternatively, the UE may provide only the individual acknowledgement bit in the codebook and no bits for the other PDSCH occasions that correspond to the activated or released SPS configurations, which may save codebook size.”); cl. 18 [0080] (“the UE may transmit, through a physical uplink control channel (PUCCH) resource, a codebook with an individual acknowledgement bit based at least in part on the bit sequence indicating that the multiple downlink SPS configurations are to be jointly released”)

B. Overview of Fakoorian-2

50. Like the '639 Patent, Fakoorian-2 is directed to “[j]oint activation [and release] of multiple semi-persistent scheduling configurations in a single message.” APPLE-1005, Title/APPLE-1009, Title⁴. Fakoorian-2’s UE is provided “multiple downlink SPS configurations ... for a given bandwidth part (BWP) of a serving cell.” *Id.*, 13:65-14:1/*Id.*, [0052]⁵. Fakoorian-2 configures SPS resources (*e.g.*, SPS configurations) at its UE via RRC signaling. For example, Fakoorian-2 describes that “[t]o configure SPS resources, radio resource control (RRC) signaling may indicate an interval at with which the radio resources are periodically assigned.” APPLE-1005, 12:59-62/APPLE-1009, [0048].

⁴ Reference to “Fakoorian-2,” including citation to *e.g.*, “APPLE-1005, x:xx/APPLE-1009, [00xx],” corresponds to APPLE-1005 and APPLE-1009, collectively.

⁵ Each instance of “*Id.*, x:x-x/*Id.*, [00xx].” that follows *e.g.*, “APPLE-1005, x:xx/APPLE-1009, [00xx],” corresponds to that collective citation and includes a reference to the respective column/line numbers and paragraph numbers of APPLE-1005 and APPLE-1009 being cited (or relied on).

51. Fakoorian-2's UE identifies "semi-persistent scheduling (SPS) configurations" to be jointly activated or released. *Id.*, cl. 1/*Id.*, cl. 1. Once the SPS configurations are activated, the UE "receive[s] DL data on the PDSCH for one or more of the activated SPS configurations during a first SPS reception." *Id.*, 17:21-23/*Id.*, [0065]. For each SPS configuration, the UE determines whether "the transmitted DL data was received and correctly decoded, and then transmit[s] HARQ feedback information to the base station [] on the PUCCH. The HARQ feedback information may include ACKs to acknowledge portions of the DL data that were received and correctly decoded." *Id.*, 17:24-30/*Id.*, [0065].

52. Fakoorian-2 discloses "jointly releasing multiple downlink SPS configurations" using a single DCI message. *Id.*, 14:51-53/*Id.*, [0054]. Fakoorian-2's single DCI message includes "an existing DCI field (*e.g.*, a HARQ process number)" that is "used to indicate which [SPS] configurations" are to be released, thereby avoiding a need to introduce a new DCI field to indicate which configurations are to be released. *Id.*, 14:66-15:3, *see* 27:46-50/*Id.*, [0054], *see* [00112]. Jointly "releasing multiple downlink SPS configurations" using a single DCI message can "conserve network resources, base station resources, and UE resources relative to current approaches that use multiple DCI messages to separately" release multiple DL SPS configurations. *Id.*, 14:51-58/*Id.*, [0054].

53. Fakoorian-2's different SPS configurations received by its "UE may be divided or otherwise grouped into different sets, and a bit sequence in a single DCI message can be used to indicate multiple SPS configurations" that are to be jointly released. *Id.*, 14:30-35/*Id.*, [0053]. Fakoorian-2's "bit sequence" includes a "codepoint that indicates an index associated with a particular SPS configuration" to be released, "and all SPS configurations ... that are members of the set that includes the particular SPS configuration" can be jointly "released by the single DCI message." *Id.*, 14:36-42/*Id.*, [0053].

54. Fakoorian-2's UE "transmit[s] a hybrid automatic repeat request acknowledgement (HARQ-ACK)" based on the DCI message. *Id.*, Abstract/*Id.*, cl. 1, Fig. 8, Fig. 9. For example, the UE "transmit[s] a message (to the base station 402) that jointly acknowledges all SPS configurations" that were released by the DCI message. APPLE-1005, 16:66-17:3/*Id.*, [0063]. For an SPS configuration that is released, the UE acknowledges the "release by transmitting the acknowledgement in a codebook through a PUCCH resource." APPLE-1005, 17:3-7/*Id.*, [0063].

55. I further note that Fakoorian-2-Provisional (APPLE-1009) provides clear and unambiguous support for at least independent claim 1 of Fakoorian-2 (APPLE-1005). The following table identifies exemplary support in the Fakoorian-2-Provisional for each limitation of Fakoorian-2's independent claim 1:

	<u>Fakoorian-2</u> <u>(APPLE-1005, Claim 1)</u>	<u>Exemplary Support</u> <u>Fakoorian-2-Provisional</u> <u>(APPLE-1009)</u>
[1]	A method of wireless communication performed by a user equipment (UE), comprising:	FIG. 8 – FIG. 10. [0086] (“FIG. 8 shows a flowchart of an example method 800 of wireless communication. The method 800 may be performed by a UE (e.g., the UE 104 of FIG. 1, the UE 404 of FIGS. 5-7, or the apparatus 1202/1202’ of FIG. 12).”)
[1a]	receiving a single downlink control information (DCI) message identifying a plurality of semi-persistent scheduling (SPS) configurations to be jointly activated or released;	[0087] (“At block 802, the UE 404 receives a single DCI message identifying a plurality of SPS configurations to be jointly activated or released. For example, the UE 404 may receive the DCI message 501 that jointly activates the first and second SPS configurations (SPS1 and SPS2).”)
[1b]	determining, for each SPS configuration of the plurality of	[0089] (“At block 804, the UE determines, for each SPS configuration, a

	SPS configurations, a number of time slots between an end of the received DCI message and a beginning of one or more downlink (DL) data frames based on a first value carried in the DCI message;	number of slots between an end of the received DCI message and a beginning of one or more DL data frames based on a first value carried in the DCI message.”)
[1c]	determining, for each SPS configuration of the plurality of SPS configurations, a number of time slots between an end of the one or more DL data frames and an instance in time at which the UE is to transmit a hybrid automatic repeat request acknowledgement (HARQ-ACK) based on a second value carried in the DCI message, the end of the one or more DL data frames corresponding to an end	[0090] (“[a]t block 806, the UE 404 determines, for each SPS configuration, a number of slots between an end of the one or more DL data frames and an instance in time at which the UE 404 is to transmit HARQ-ACK based on a second value contained in the DCI message.”) [0072] (“The end of the one or more DL data frames 521 corresponds to an end of the PDSCH reception occasion for the second SPS configuration, and the determined instance in time corresponds

	of a physical downlink shared channel (PDSCH) reception occasion, the determined instance in time corresponding to a start of a physical uplink control channel (PUCCH) resource;	to a start of the PUCCH resource upon which the HARQ feedback information is to be transmitted.”)
[1d]	determining a time difference between the end of the PDSCH reception occasion and the start of the PUCCH resource; and	[0084] (“the UE 404 may determine a time difference between an end of the PD SCH reception and the start of the PUCCH resource upon which the HARQ feedback information is to be transmitted”); FIG. 11 (1100)
[1e]	performing an operation associated with a plurality of HARQ-ACKs corresponding to the plurality of SPS configurations based on a comparison of the time difference and a value.	[0084] (“the UE 404 may ... may compare the determined time difference with a value to determine whether the UE 404 has enough time to decode the DL data and then construct the HARQ ACK/NACK before the instance in time at which the UE is to transmit HARQ

	feedback information to the base station 402.”) [0084] (“the UE 404 may refrain from transmitting the HARQ feedback information based on the determined time difference being less than the value.”) [00107] (“The software, when executed by the processor 1304, causes the processing system 1314 to perform the various functions described supra for any particular apparatus.”)
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C. Overview of Takahashi

56. Like the '639 Patent, Takahashi is directed to “a terminal and a wireless communication method capable of appropriate feedback of HARQ-ACK when multiple SPSs are used.” APPLE-1006, [0009]. In particular, Takahashi describes techniques for conveying delivery acknowledgement information, *e.g.*, hybrid automatic repeat request acknowledgement (HARQ-ACK) “for multiple SPSs.” *Id.*, [0008]. For example, Takahashi describes including “more than one

set of delivery acknowledgement information,” *e.g.*, HARQ-ACK, for multiple SPSs in one HARQ-ACK codebook. *Id.*

57. Takahashi teaches various “SPS and HARQ-ACK Codebook” concepts. APPLE-1006, [0038]. For example, Takahashi’s describes that “SPS setting[s],” which are also “referred to as setting information for the SPS,” may be set in the UE by using higher layer signaling such as “radio resource control (RRC) signaling.” *Id.*, [0019], [0020]. Takahashi’s “setting information for the SPS” can be “an ‘SPS-Config’ information element for RRC” and “may include an index (SPS index) for identifying the SPS. *Id.*, [0022], [0015]. Thus, Takahashi’s SPS settings disclose/include at least the SPS configurations, and corresponding configuration parameters, of the Challenged Claims.

58. Takahashi’s “UE may activate or deactivate (release) an SPS setting based on a downlink control channel (physical downlink control channel (PDCCH))” and “may receive a [PDSCH] of the corresponding SPS,” based on the activated SPS setting. APPLE-1006, [0014]. In particular, Takahashi discloses “DCI for activating or deactivating the SPS setting,” and clarifies that its “SPS deactivation DCI may be referred to as SPS release DCI.” *Id.*, [0016]. Takahashi discloses a UE that determines a size of a semi-static HARQ-ACK codebook “including a HARQ-ACK corresponding to a downlink shared channel (physical

downlink shared channel (PDSCH)) of semi-persistent scheduling (SPS).”

APPLE-1006, Abstract.

59. Takahashi’s UE determines the size “based on the number of set SPS settings, the number of set or activated cells, and the number of HARQ-ACK timing values” included in a set of HARQ-ACK timing values. APPLE-1006, Abstract, [0010]. Takahashi’s UE transmits “a HARQ-ACK information bit corresponding to the HARQ-ACK codebook by using a resource of an uplink control channel,” *e.g.*, a physical uplink control channel (PUCCH). *Id.* According to Takahashi, the “HARQ-ACK can [thus] be appropriately fed back even when multiple SPSs are used.” *Id.*, Abstract.

VIII. GROUND 1: CLAIMS 1-20 ARE OBVIOUS OVER FAKOORIAN-1 IN VIEW OF TAKAHASHI

A. Predictable Combination of Fakoorian-1 & Takahashi: Reasons to Combine & Reasonable Expectation of Success

60. Based on my experience and knowledge as well as my review of Fakoorian-1 & Takahashi, my opinion is that a POSITA would have found it obvious to combine Fakoorian-1 and Takahashi. In particular, a POSITA would have been motivated to utilize configuration parameters of an SPS configuration to indicate a particular HARQ codebook identifier, as suggested by Takahashi, when implementing techniques for efficient release of SPS configurations consistent with Fakoorian-1’s teachings. APPLE-1006, [0028]-[0046].

61. For example, Fakoorian-1 configures its SPS configuration using RRC signaling. APPLE-1004/APPLE-1008, [0040]/[0039] (“SPS configurations” “initially indicated to the UE in an RRC configuration”). Takahashi’s “HARQ-ACK codebook” is “set in the UE by using a higher layer **parameter**” corresponding to a configuration parameter, and Takahashi’s “**higher layer signaling** may be” “**radio resource control (RRC) signaling.**” APPLE-1006, [0031], [0020]. Indeed, Takahashi’s “UE may **determine which codebook to use based on higher layer signaling,**” *e.g.*, “**the RRC parameter.**” *Id.*, [0059]. I note that Takahashi provides additional teachings, including implementation (and/or configuration) details relating to HARQ processes, including configuring or defining a “HARQ-ACK codebook for multiple SPSs.” *Id.*, [0045]. These approaches would have allowed for implementing more efficient methods of transmitting HARQ acknowledgements (“HARQ-ACK”) in Fakoorian-1’s UE. *See* APPLE-1006, [0039]-[0046].

62. Notably, a POSITA would have been motivated to combine the teachings of Fakoorian-1 and Takahashi to achieve known advantages as articulated in each of Fakoorian-1 and Takahashi. The advantages include facilitating decreased network overhead and reduced resource consumption at least from: i) releasing (or deactivating) multiple SPS configurations using a single DCI message, as suggested by Fakoorian-1 (*see* APPLE-1004/APPLE-1008, Abstract,

[0006]/[0005], [0042]/[0041]-[0043]/[0042]); and ii) determining (or defining) “HARQ-ACK codebooks for multiple SPSs” such that “appropriate HARQ control” is “performed when multiple SPSs are used” and “appropriate feedback of HARQ-ACK” is communicated “when multiple SPSs are used,” as suggested by Takahashi⁶. APPLE-1006, [0007]-[0011].

63. In my opinion, a POSITA would have found it obvious to combine the teachings of Fakoorian-1 and Takahashi for multiple reasons.

64. **First**, a POSITA would have been motivated to combine Fakoorian-1’s technique of joint release for multiple semi-persistent scheduling configurations with Takahashi’s suggestions for “configuring multiple SPSs,” *e.g.*, “in one cell group” and “utilize[ing] multiple SPS settings for one or more serving cells” to facilitate the express benefit of “more flexible control,” in accordance with Takahashi. APPLE-1004/APPLE-1008, Title; APPLE-1006, [0044]. Indeed,

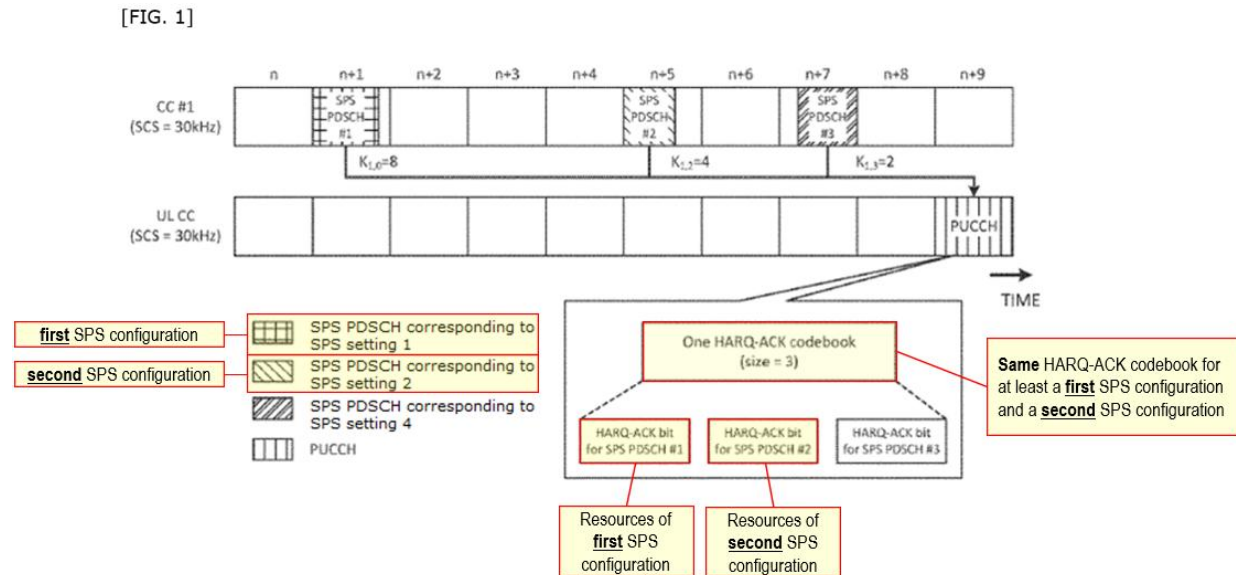
⁶ In my opinion, Takahashi includes a clear articulation of the “Problem to Be Solved by the Invention” and “Means for Solving the Problem.” APPLE-1006, *headers preceding* [0005] and [0010]. The problem and solution articulated by each of Fakoorian-1 and Takahashi is like the purported problem and solution recited by the ’639 Patent itself. *See e.g.*, APPLE-1001, 32:56-33:5; APPLE-1004/APPLE-1008, [0041]/[0040]-[0043]/[0042]; APPLE-1006, [0005]-[0011].

Takahashi teaches methods for appropriately feeding back the HARQ-ACK when multiple SPSs are used. APPLE-1006, Abstract, [0011], [0046].

65. Specifically, Takahashi discloses parameters of an SPS configuration that indicate a HARQ codebook identifier. Takahashi's "UE may determine [] the HARQ-ACK codebook corresponding to the SPS setting" (*i.e.*, SPS configuration) "based on an **RRC parameter** 'n1PUCCH-AN' indicating a PUCCH resource of the SPS setting." *Id.*, [0061], [0091] ("***UE may determine the HARQ-ACK codebook size and corresponding bits to transmit*** in the UL slot based on the determined set of occasions for candidate SPS PDSCH reception"), [0093] ("***the UE may determine which codebook to use based on higher layer signaling*** (for example, ***the RRC parameter***"). A POSITA would have predictably looked to other teachings such as Takahashi to implement and further enhance Fakoorian-1's flexibility to control how a UE jointly releases multiple downlink SPS configurations and transmits a message to jointly acknowledge SPS configurations that were jointly released. See APPLE-1004/APPLE-1008, [0057], [0058].

66. **Second**, a POSITA would have been motivated to combine Fakoorian-1 and Takahashi to achieve the benefit of using the one (*i.e.*, the same) HARQ codebook to transmit HARQ acknowledgement (ACK) information for at least two SPS configurations, as taught by Takahashi. It would have been apparent to a POSITA, based on Takahashi's disclosure, that HARQ feedback for multiple

SPS configurations, including SPS PDSCHs, may be transmitted using the same HARQ feedback codebook. For example, Takahashi discloses that “more than one set of HARQ-ACK information for multiple SPSs” can be “included in one HARQ-ACK codebook.” APPLE-1006, [0045]; Fig. 1 (reproduced below).



APPLE-1006, Fig. 1 (annotated)

67. Relatedly, Fakoorian-1 teaches that certain “SPS configurations” of the UE may be “grouped within the same configuration set.” APPLE-1004/APPLE-1008, [0048]/[0047]. Fakoorian-1’s UE transmits, through a PUCCH resource, “a codebook that includes an individual acknowledgement bit” based on the bit sequence indicating “**the multiple downlink SPS configurations to be jointly released.**” *Id.*, [0081]/[0080]. In Fakoorian-1, a “single DCI message” can release multiple SPS configurations. *Id.*, [0059]/[0058]. And, based on the single DCI message, the UE can transmit a HARQ acknowledgement, or a

location of an acknowledgement bit in the codebook, which is an individual bit used to acknowledge all SPS configurations that were released. APPLE-1004/APPLE-1008, [0059]/[0058].

68. When reviewing the combined teachings of Fakoorian-1 and Takahashi, it is my opinion that a POSITA would have recognized the benefits of transmitting HARQ acknowledgement (ACK) information using one (*i.e.*, the same) HARQ codebook for at least two SPS configurations to be released. Moreover, I believe a POSITA would have been motivated to combine Takahashi's explicit teaching of transmitting HARQ feedback for multiple SPS configurations using the same HARQ feedback codebook with Fakoorian-1's suggestion of a codebook (and codepoint), individual acknowledgement bit, and bit sequence that are associated with **multiple downlink SPS configurations to be jointly released**. *See* APPLE-1006, [0045]; *see* APPLE-1004/APPLE-1008, [0057]/[0056], [0059]/[0058], [0048]/[0047], [0081]/[0080].

69. **Third**, combining the teachings of Fakoorian-1 with Takahashi would have merely involved combining prior art elements according to known methods to yield predictable results. For example, it is my understanding from my discussions with counsel that when a patent simply arranges old elements with each element performing the same function it had been known to perform and yields nothing more than one would expect from such an arrangement, then that combination is

obvious. It is my opinion that this is the case with respect to the claimed invention of the '639 Patent.

70. Based upon my knowledge and experience in this field, I believe a POSITA would have had a reasonable expectation of success based on the straightforward programming changes that would have been used to modify Fakoorian-1's RRC signaling/messaging. For example, the combination would have merely involved at least one of Fakoorian-1's "multiple SPS configurations" having (or being modified to include) a configuration parameter that indicates the same HARQ codebook identifier indicated by a configuration parameter of another of Fakoorian-1's SPS configuration.

71. This would have been consistent with Takahashi's teachings, and a POSITA would have recognized that the Fakoorian-1 and Takahashi combination requires only routine knowledge of software (and/or hardware) implementation techniques, which would have been well within the POSITA's skill. Indeed, the resulting UE functions of the combined UE/system were already contemplated by Fakoorian-1's teachings, and a POSITA would have understood that Takahashi's teachings are consistent with Fakoorian-1's techniques for SPS configuration, SPS release, DCI messaging, and transmission of HARQ codebook acknowledgements. APPLE-1004/APPLE-1008, [0059]/[0058] ("single DCI message activating or releasing one or more SPS configurations," "transmit the acknowledgement and/or

a location of an acknowledgement bit in the codebook,” “individual bit used to acknowledge all of the SPS configurations that were activated or released,” “multiple SPS configurations are jointly activated or released”); APPLE-1006, [0102] (“multiple SPS settings (SPS settings 1 to 4) set for one active serving cell (CC #1) are set for the UE”), [0045] (“HARQ-ACK information for multiple SPSs [...] included in one HARQ-ACK codebook”), [0014] (“[a] UE may activate or deactivate (release) an SPS setting based on a [DCI]”).

72. Moreover, Fakoorian-1 and Takahashi are in the same field of endeavor/technology as the claimed invention of the '639 Patent. For example, each relate to semi-persistent scheduling (SPS) release, including joint release for multiple SPS configurations in 3GPP systems, use of a DCI to cause joint release of the SPS configurations and SPS PDSCH resources of each SPS configuration, and transmitting an HARQ-ACK associated with the release. APPLE-1004/APPLE-1008, Abstract (“semi-persistent scheduling configurations” “to be jointly” “released”), [0040]/[0039] (“DCI message [...] releases the downlink SPS configuration”); APPLE-1006, Abstract (“semi-persistent scheduling (SPS) based on the number of set SPS settings”), [0014] (“deactivate (release) an SPS setting based on a downlink control channel”). Given this extensive overlap in subject matter, a POSITA would have had reason to consult Takahashi when assessing Fakoorian-1’s disclosure. In particular, a POSITA would have had a reasonable

expectation of success in modifying Fakoorian-1's UE SPS configuration release, DCI processes, and timing operations to include Takahashi's teachings from the same field.

73. Takahashi, like Fakoorian-1, discloses techniques for deactivating or releasing multiple SPS configurations based on RRC signaling, HARQ codebooks, and DCI messages, and teachings of Takahashi's RRC signaling, configuration parameters, and HARQ codebook identifiers would have been readily implemented in Fakoorian-1. APPLE-1006, [0009], [0011], [0022], [0045]. Additionally, in my opinion a POSITA would have found implementation of techniques for jointly releasing multiple SPS configurations based on Fakoorian-1 and Takahashi to be a matter of design choice, in view of the conventional use of such technologies.

B. Application to Challenged Claims

74. For the reasons I describe in detail below, and based on my review of the '639 Patent, its file history, and the prior art references cited in this declaration, a POSITA would have plainly understood that the teachings of Fakoorian-1 and Takahashi ("Fakoorian-1-Takahashi" or "the Fakoorian-1-Takahashi combination") provide all elements of claims 1-20.

1) Claim 1

p) *Limitation [1pre] A wireless device comprising:*

75. Fakoorian-1-Takahashi provides a wireless device. For example, Fakoorian-1 discloses “[a] user equipment (UE)” of a “wireless communication network” comprising “a number of user equipment (UEs).” APPLE-1004/APPLE-1008, [0004]/[0003]. Specifically, Fakoorian-1 discloses “a UE for wireless communication” with a base station (BS) via “downlink and uplink” wireless transmissions. *Id.*, [0007]/[0006], [0004]/[0003].

a) *Limitation [1a] one or more processors; and*

76. The Fakoorian-1-Takahashi combination includes one or more processors. For example, Fakoorian-1’s UE includes “a memory and one or more processors operatively coupled to the memory.” APPLE-1004/APPLE-1008, [0007],[0008]/[0006],[0007]. Fakoorian-1 also discloses “one or more instructions” can be “executed by one or more processors of a user equipment (UE)” to cause the UE to perform operations for SPS configuration release. *Id.*, cl. 1, cl. 17 (APPLE-1004)/cl. 22, cl. 23 (APPLE-1008).

b) *Limitation [1b] memory storing instructions that, when executed by the one or more processors, cause the wireless device to:*

77. Fakoorian-1-Takahashi provides [1b]. For example, Fakoorian-1’s memory includes “a non-transitory computer-readable medium” that “store[s] one or more instructions for wireless communication.” APPLE-1004/APPLE-1008, [0008]/[0007]. Fakoorian-1’s “**one or more instructions, when executed by one**

or more processors of a UE, may cause the one or more processors,” and the UE, to perform operations related to SPS configuration release. *Id.*

c) ***Limitation [1c] receive one or more radio resource control (RRC) messages comprising⁷:***

78. In the Fakoorian-1-Takahashi combination, the UE (*e.g.*, Fakoorian-1’s UE) receives one or more RRC messages, and therefore renders obvious Limitation [1c]. For example, Fakoorian-1’s UE includes “multiple downlink SPS configurations” based on “**a radio resource control [RRC] configuration message**” received at the UE. APPLE-1004/APPLE-1008, [0079]/[0078]. Indeed, Fakoorian-1’s “SPS configurations” are “**indicated to the UE in an RRC configuration**” received via one or more RRC messages. APPLE-1004/APPLE-1008, [0045]/[0044].

79. Accordingly, my opinion is that the Fakoorian-1-Takahashi combination renders obvious Limitation [1c]. Additionally, the Fakoorian-1-Takahashi combination renders obvious Limitation [1c] for at least the reasons I discuss below at Limitations [1d] and [1e] (Ground 1), which are incorporated here.

d) ***Limitation [1d] a first configuration parameter, of a first semi-persistent scheduling (SPS) configuration, indicating a***

⁷ The “comprising” element is addressed more fully with reference to limitations [1d] and [1e].

first hybrid automatic repeat request (HARQ) codebook identifier;

80. The Fakoorian-1-Takahashi combination provides, and renders obvious, a first configuration parameter, of a first semi-persistent scheduling (SPS) configuration, indicating a first HARQ codebook identifier. Additionally, the Fakoorian-1-Takahashi combination renders obvious Limitation [1d] for at least the reasons I discuss below at Limitations [1e], [1i] (Ground 1) and above at Limitation [1c], which are incorporated here.

A first configuration parameter of a first SPS configuration

81. In the combination, Fakoorian-1 includes “multiple SPS configurations,” which provides at least a first SPS configuration. APPLE-1004/APPLE-1008, [0065]/[0064]. Fakoorian-1’s first SPS configuration includes configuration parameters comprising a “periodicity,” “a CS-RNTI,” “a **HARQ process number**,” and “service type.” APPLE-1004/APPLE-1008, [0047]/[0046], [0050]/[0049], [0053]/[0052]-[0055]/[0054], [0057]/[0056].

82. As described in the ’639 Patent, each of these items are configuration parameters of an SPS configuration. APPLE-1001, 33:12-15 (“DL SPS configuration may comprise a first parameter indicating a **periodicity**, a second parameter indicating a **number of HARQ processes** associated with the DL SPS configurations”). It is my opinion that any one of Fakoorian-1’s **CS-RNTI, periodicity, and number of HARQ processes** represents a first configuration

parameter, a second configuration parameter, or both (*e.g.*, across first and second SPS configurations). Fakoorian-1 explains that “multiple downlink SPS configurations that are associated with the UE” can form a configuration set and that “a mapping between the [SPS] configurations and the configuration set[] may be indicated to the UE **in an RRC configuration.**” APPLE-1004/APPLE-1008, [0048]/[0047].

First configuration parameter indicating a first HARQ codebook identifier

83. In the combination, Fakoorian-1’s “HARQ process number” provides the first configuration parameter indicating a first HARQ codebook identifier. A POSITA would have recognized that data pertaining to the number of HARQ processes of the first SPS configuration is a configuration parameter that indicates a HARQ codebook identifier. For example, Fakoorian-1’s “HARQ process number” is “used to indicate which [SPS] configuration(s) are to be” released, and Fakoorian-1’s UE acknowledges the “release by transmitting the acknowledgement in a **codebook** through a physical uplink control channel (PUCCH) resource.” APPLE-1004/APPLE-1008, [0043]/[0042], [0058]/[0057].

84. Specifically, the HARQ process number comprises a “bit sequence” of “4 bits” that indicates a HARQ index “used to activate or **release** the corresponding [SPS] configuration.” *Id.*, [0057]. From at least these descriptions, it is my opinion that it would have been apparent and obvious to a POSITA that

Fakoorian-1's HARQ process number indicates an identifier for the HARQ codebook to be used by the UE to transmit the acknowledgment.

- e) ***Limitation [1e] a second configuration parameter, of a second SPS configuration, indicating a second HARQ codebook identifier, wherein the second HARQ codebook identifier is the same as the first HARQ codebook identifier; and:***

85. Based upon my knowledge and experience in this field, I believe the Fakoorian-1-Takahashi combination provides, and renders obvious, a second configuration parameter, of a second SPS configuration, indicating a second HARQ codebook identifier. Additionally, I believe the Fakoorian-1-Takahashi combination renders obvious Limitation [1e] for at least the reasons I discuss above at Limitations [1c], [1d], which are incorporated here.

A second configuration parameter of a second SPS configuration

86. In the combination, Fakoorian-1 includes “multiple downlink SPS configurations that are associated with the UE,” which provides at least a second SPS configuration, as stated in Limitation [1e]. APPLE-1004/APPLE-1008, [0048]/[0047]. In my opinion, a POSITA would have recognized that Fakoorian-1's “multiple downlink SPS configurations” includes at least a first SPS configuration and a second SPS configuration. Indeed, Fakoorian-1's express description that its “UE has **16 downlink SPS configurations**” necessarily provides at least the first and second SPS configurations (*i.e.*, 2 of the 16 downlink SPS configurations). APPLE-1004/APPLE-1008, [0049]/[0048]. Fakoorian-1's

second SPS configuration comprises configuration parameters corresponding to a “**periodicity**,” “a **CS-RNTI**,” “a **HARQ process number**,” and “a codepoint that indicates a [] configuration index.” *Id.*, [0047]/[0046], [0053]/[0052], [0057]/[0056]; see §VIII.B.1.d, Analysis of Limitation [1d] (Ground 1).

Second configuration parameter indicating a second HARQ codebook identifier that is the same as the first HARQ codebook identifier

87. In the combination, Fakoorian-1’s “HARQ process number” of its second SPS configuration provides the second configuration parameter indicating a second HARQ codebook identifier. I believe it would have been apparent and obvious to a POSITA that the number of HARQ processes of the second SPS configuration is a second configuration parameter that indicates a HARQ codebook identifier. In the combination, Fakoorian-1’s “HARQ process number” indicates which SPS configurations are to be released, and the UE acknowledges the “release by transmitting the acknowledgement in a **codebook** through a physical uplink control channel (PUCCH) resource.” APPLE-1004/APPLE-1008, [0043]/[0042], [0058]/[0057].

88. In the combination, Fakoorian-1 provides a state that is mapped to multiple SPS configurations such that each of those SPS configurations is configured with the same HARQ codebookID.

89. For example, Fakoorian-1’s “bit sequence may be a codepoint that indicates **a particular configuration index**,” and this particular configuration index is used to jointly “**release all members of a [SPS] configuration set that includes the particular configuration index as a member.**” APPLE-1004/APPLE-1008, [0047]/[0046].

90. In more detail, Fakoorian-1’s “UE may identify a codepoint from the bit sequence,” where “the codepoint” “correspond[s] to a configuration index associated with a particular” SPS configuration to be released. *Id.* The UE can jointly “release each” “**SPS configuration that is a member of the same set as the particular**” “SPS configuration corresponding to the codepoint indicated in the bit sequence.” *Id.* The binary value(s) of the bit sequence indicates a release state (or “deactivation states”) of the SPS configurations to be jointly released. This provides that “a state is mapped” (*e.g.*, deactivation or release) to those multiple SPS configurations, such that each of those SPS configurations is configured with the same HARQ codebook identifier. APPLE-1007, ¶311; *see* APPLE-1001, 49:31-47 (“first HARQ codebook identifier, indicated by the first SPS configurations, and the second HARQ codebook identifier, indicated by the second SPS configurations, **may be the same** in response to the first SPS configuration (first SPS **configuration index**) and the second SPS configuration

(second SPS **configuration index**) being associated **with the same SPS deactivation state**”).

91. From at least these descriptions, I believe a POSITA would have recognized that Fakoorian-1 provides a state that is mapped to multiple SPS configurations, such that each of those SPS configurations is configured with the same HARQ codebookID.

92. Additionally, Fakoorian-1’s “SPS configurations” may be “grouped within the same configuration set” when the configuration “parameters” indicate the SPS configurations belong to the “**same service type.**” APPLE-1004/APPLE-1008, [0048]/[0047]. For example, “because different service types (*e.g.*, URLLC, eMBB, MMTC, and/or the like) may generally share various **parameters** (*e.g.*, with respect to latency, data rate, and/or the like),” SPS configurations that “**belong to the same service type may grouped within the same configuration set.**” *Id.* Accordingly, a state may be mapped to these multiple SPS configurations in the set such that each of these SPS configurations is configured with the same HARQ codebookID. *See* APPLE-1004/APPLE-1008, [0057]/[0056].

93. Based upon my knowledge and experience in this field, even if Fakoorian-1 did not expressly describe Limitation [1e] (which it does), a POSITA would have additionally found it obvious to configure Fakoorian-1’s RRC messaging to convey, and its UE to receive, a configuration parameter of a second

SPS configuration that indicates the same HARQ codebook identifier as the HARQ codebook identifier indicated by the first configuration parameter of the first SPS configuration, in accordance with Takahashi's teachings. *See* Analysis at §VIII.A (Predictable Fakoorian-1-Takahashi combination).

94. Takahashi discloses “multiple SPS settings (SPS settings 1 to 4)” and “[p]arameters (the SPS period, etc.) of each SPS setting **may be the same as** or different from each other.” APPLE-1006, [0063]. Takahashi therefore describes at least first and second SPS configurations (*e.g.*, first and second SPS settings among its “multiple SPS settings”) as well as first and second configuration parameters (*e.g.*, its “[p]arameters” “of each SPS setting”). *Id.*; *see* Analysis at §VIII.C (“Takahashi's SPS settings disclose/include at least the SPS configurations, and corresponding configuration parameters, of the Challenged Claims”). To be clear, a POSITA would have recognized that Takahashi's multiple SPS settings provide the first and second SPS configurations of Limitations [1d] and [1e]. And Takahashi's configuration parameters (its parameters “of each SPS setting”) that “**may be the same**” provides the first and second configuration parameters of Limitations [1d] and [1e].

95. Takahashi explains that the “HARQ-ACK codebook [] to be used” is “set in the UE” using “a higher layer **parameter**,” *e.g.*, an “RRC parameter.” APPLE-1006, [0031], [0059]. In particular, Takahashi's UE determines which

“**HARQ-ACK codebook to use**” “based on at least one of an SPS index, the SPS period, etc.,” *i.e.*, a configuration parameter. *Id.*, [0062]. From at least these descriptions, it would have been apparent and obvious to a POSITA that Takahashi describes configuration parameters of its SPS settings/configurations that indicate a HARQ codebook identifier.

96. The Fakoorian-1-Takahashi combination’s UE would have received one or more RRC messages comprising a configuration parameter of a second SPS configuration that indicates a HARQ codebook identifier that is the same as the HARQ codebook identifier indicated by the first parameter of the first SPS configuration, in accordance with Takahashi’s teachings. Indeed, each of Fakoorian-1 and Takahashi discloses using RRC (*e.g.*, RRC configuration, messages, or signaling) to establish SPS configurations at the UE. *See* APPLE-1004/APPLE-1008, [0038]/[0037]-[0040]/[0039]; APPLE-1006, [0020], [0022], [0038], [0061]-[0063]. And Fakoorian-1 teaches its HARQ index is “associated with the individual [SPS] configuration to be activated **or released**.” APPLE-1004/APPLE-1008, [0070]/[0069].

f) *Limitation [1f] a third configuration parameter indicating a state that is mapped to the first SPS configuration and the second SPS configuration;*

97. The Fakoorian-1-Takahashi combination includes, and renders obvious, a third configuration parameter indicating **a state** that is mapped to the

first and second SPS configurations. Additionally, the Fakoorian-1-Takahashi combination renders obvious Limitation [1f] for at least the reasons I discuss below at Limitation [1g] (Ground 1), which are incorporated here.

98. In the combination, Fakoorian-1’s “configuration index” (or “configuration set”) provides the third configuration parameter. APPLE-1004/APPLE-1008, [0047]/[0046] (“bit sequence may be a codepoint that indicates a particular **configuration index (e.g., an index associated with ... a particular SPS configuration)**”). It is my opinion that Fakoorian-1’s configuration index is also included in an RRC configuration message received by its UE that includes one (e.g., a single) configuration set. *Id.*, [0055]/[0054] (“mapping between configurations and one ... configuration set[]”).

99. For example, Fakoorian-1’s “mapping between configurations” and one configuration set “may be **RRC configured (e.g., based on service type, periodicity, MCS, time offset, and/or the like),**” and its “configuration set may be associated with an index.” *Id.*, [0055]/[0054]. This establishes Fakoorian-1’s “configuration index” (or “configuration set”) as “a third configuration parameter” that would have been included in the RRC configuration messages provided to Fakoorian-1’s UE.

100. Additionally, as I explain below, it is my opinion that the particular configuration index, and particular SPS configuration, may be used as a proxy to

jointly activate or release all members of a configuration set that includes the particular configuration index as a member. *Id.*, [0047]/[0046].

101. Fakoorian-1's "configuration index" indicates a "release" state that is mapped to Fakoorian-1's SPS configurations, which are associated with its configuration index. See APPLE-1004/APPLE-1008, [0047]/[0046]. For example, Fakoorian-1's "**configuration index**" is "used as a proxy to jointly" "release all members of a configuration set that includes the particular configuration index as a member." APPLE-1004/APPLE-1008, [0047]/[0046]. In other words, I believe that Fakoorian-1's configuration index: i) corresponds to a single configuration set; ii) may be a member of the configuration set, which includes individual SPS configurations (*e.g.*, a first & second SPS configuration); and iii) indicates "a state" (*i.e.*, **release**) that is mapped to those SPS configurations (*e.g.*, the first & second SPS configurations) in the configuration set. See APPLE-1004/APPLE-1008, [0049]/[0048], FIG. 3.

102. To illustrate an indication of an example configuration index, Fakoorian-1's Fig. 3 (reproduced below) includes a bit sequence (or codepoint) indicating "a configuration [set] with index '0110' is to be" "**released.**" APPLE-1004/APPLE-1008, [0049]/[0048]. The UE can identify all SPS configurations that are members of a configuration set, and **the identified SPS configurations** may be **jointly "released."** APPLE-1004/APPLE-1008, Fig., 3, [0052]/[0051].

For example, Fakoorian-1's UE identifies the "SPS configuration with the index '0110'" and jointly "**release[s] all members of the configuration set that includes the**" "SPS configuration with the index '0110' as a member."

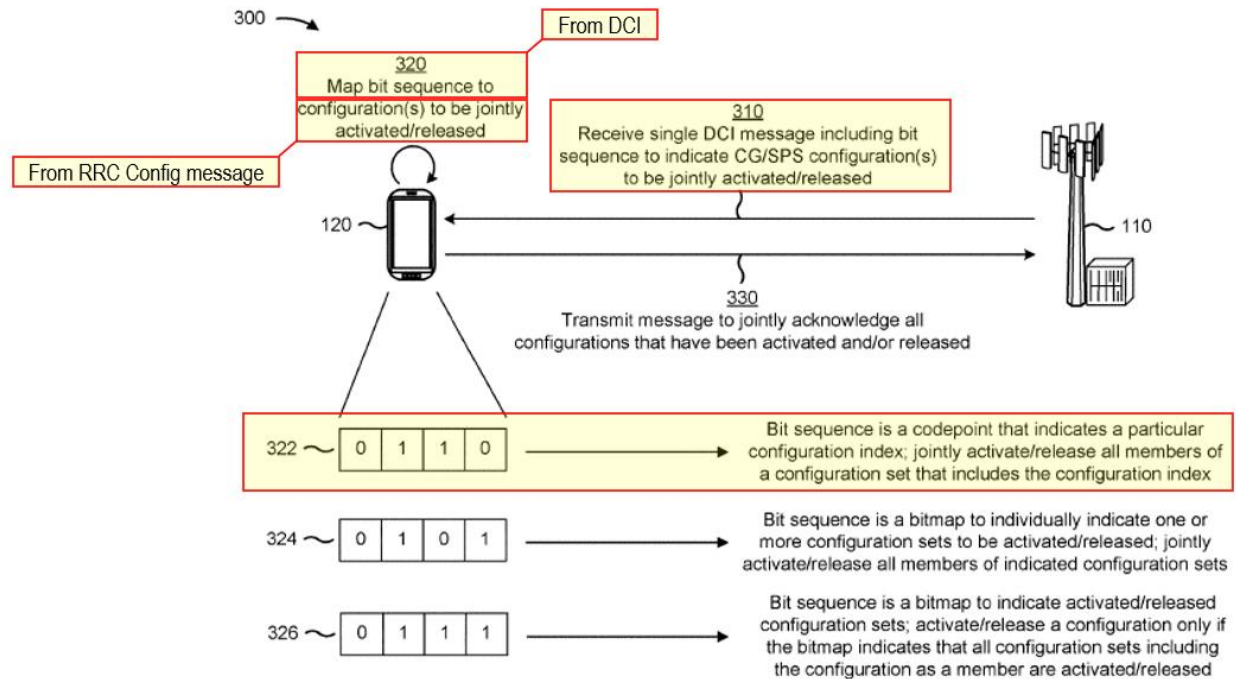


FIG. 3

APPLE-1004/APPLE-1008, Fig. 3 (annotated)

103. Specifically, Fakoorian-1 describes that a configuration set comprising "4 members" (i.e., 4 SPS configurations), and the configuration index '0110,' may be jointly released based on the index '0110' being a member of the configuration set. APPLE-1004/APPLE-1008, [0049]/[0048]. In other words, all members of a configuration set may be jointly released when "an individual configuration index within that configuration set is to be" "released." *Id.* ("all members of a configuration set may be **jointly** activated or **released** when the

codepoint indicates **that an individual configuration index within that configuration set is to be** activated or **released**").

104. Fakoorian-1's configuration index is used as a proxy to represent all members (*i.e.*, SPS configurations) of the corresponding configuration set, which would include the first and second SPS configurations. *Id.* Thus, in my opinion this demonstrates that Fakoorian-1 provides "**a state** that is mapped to the" first and second SPS configurations, as claimed in the '639 Patent.

g) *Limitation [1g] receive a downlink control information (DCI), wherein a value of one or more bits of a HARQ process number field of the DCI indicates the state;*

105. The Fakoorian-1-Takahashi combination renders obvious a wireless device (or UE) that receives a DCI, wherein a value of one or more bits of a HARQ process number field of the DCI indicates the state mapped to the SPS configurations. Additionally, the Fakoorian-1-Takahashi combination renders obvious Limitation [1g] for at least the reasons I discuss below at Limitation [1h] (Ground 1) and above at Limitation [1f], which are incorporated here.

106. In the combination, Fakoorian-1's UE "**receiv[es] a single** downlink control information (**DCI**) **message**" and "a bit sequence in the single DCI message" is "**mapp[ed] ... to a configuration set that includes multiple downlink semi-persistent scheduling configurations**" to be jointly released.

APPLE-1004/APPLE-1008, [0036]/[0035]. Fakoorian-1's bit sequence is a 4-bit

field corresponding to the HARQ process number field. *Id.*, [0057]/[0056] (“a HARQ process number, which is a 4-bit field;” “field for the HARQ process number has 4 bits”); [0078]/[0077] (“bit sequence is provided in a HARQ process number field of the DCI message”).

107. Fakoorian-1’s “**existing DCI field (e.g., a HARQ process number)**” is “**used to indicate** which [SPS] configuration(s) are to be [...] released.” APPLE-1004/APPLE-1008, [0043]/[0042]. This provides the DCI that is received at the UE, as claimed. And Fakoorian-1’s indication of “release[.]” (or deactivation) corresponds to the “state” indicated by the one or more bits of Fakoorian-1’s HARQ process number. *Id.* For example, Fakoorian-1’s “bit sequence is provided in a [**HARQ**] **process number field of the single DCI message.**” APPLE-1004/APPLE-1008, cl. 3/APPLE-1008, cl. 11.

108. Fakoorian-1 also discloses that “the PUCCH resource to be used to transmit the acknowledgement bit may be defined **by the single DCI message indicating the SPS configuration(s) to be [...] released.**” APPLE-1004/APPLE-1008, [0060]/[0059].

h) ***Limitation [1h] deactivate the first SPS configuration and the second SPS configuration in response to receiving the DCI; and***

109. The Fakoorian-1-Takahashi combination includes, and renders obvious, a wireless device (or UE) that deactivates the first and second SPS

configurations in response to receiving the DCI. Additionally, the Fakoorian-1-Takahashi combination renders obvious Limitation [1h] for at least the reasons I discuss above at Limitation [1g], which are incorporated here.

110. For example, in the combination Fakoorian-1's UE receives a single DCI message, and **"based on the single DCI message,"** the UE transmits a HARQ acknowledgement, or a location of an acknowledgement bit in the codebook, which is an individual bit used to acknowledge all SPS configurations that were released. *Id.*, [0006]/[0005], [0059]/[0058].

111. In the combination, Fakoorian-1's FIG. 3, and its related description, describe joint release for multiple semi-persistent scheduling configurations. *Id.*, [0015]/[0014]. Fakoorian-1's UE uses "a single DCI message to jointly" "release multiple downlink SPS configurations." APPLE-1004/APPLE-1008, [0042]/[0041]. This provides the deactivate (or release) of the first SPS configuration and the second SPS configuration in response to receiving the DCI, as claimed.

112. The UE may also transmit "a message to jointly acknowledge all" "SPS configurations that were" **"released by the single DCI message."** *Id.*, [0058]/[0057]. In Fakoorian-1, "all the members of a configuration set are" **"jointly released based on the codepoint and/or bitmap indicated in the single DCI message."** *Id.*, [0055]/[0054]. For example, as shown by reference number

322 of Fakoorian-1's FIG. 3 (reproduced below), "the bit sequence is a codepoint that indicates a particular configuration index" and the **DCI** causes the UE to "jointly []release all members of a configuration set that indicates the configuration index." *Id.*, FIG. 3.

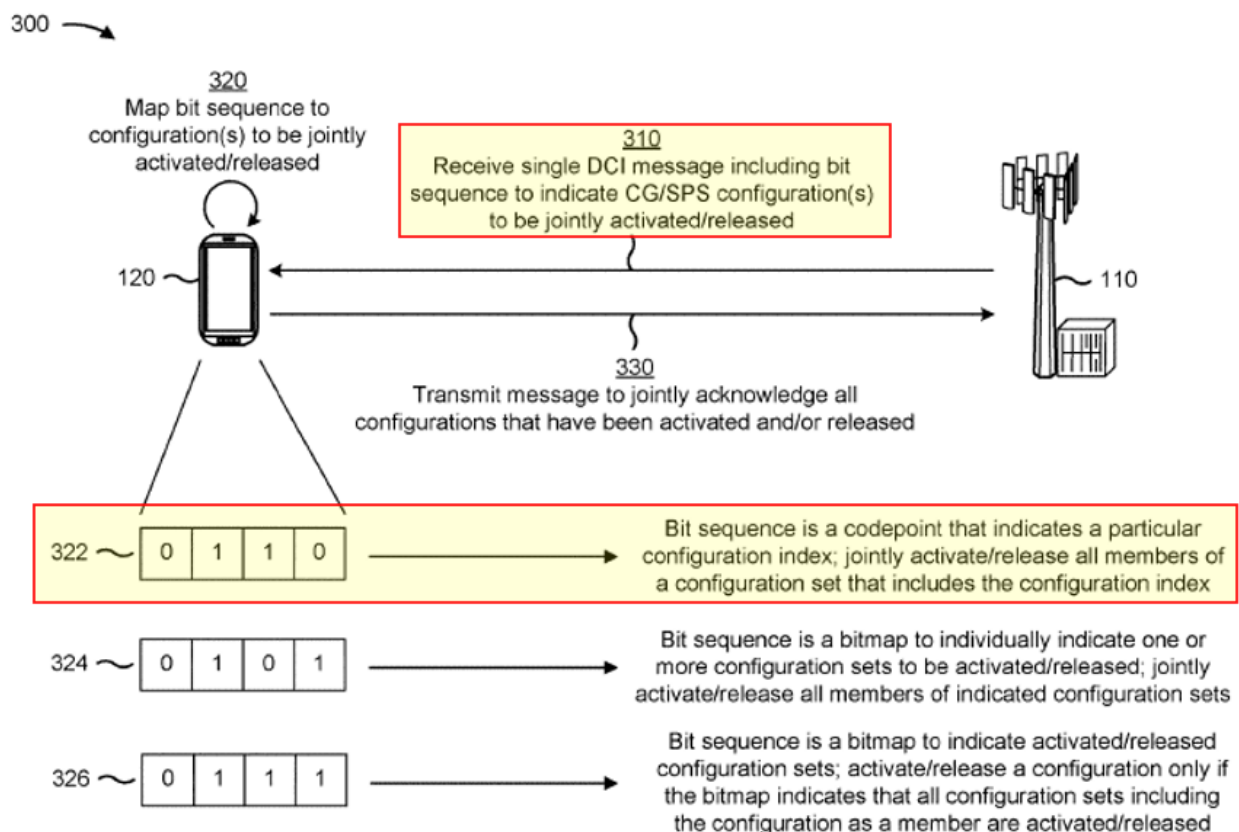


FIG. 3

APPLE-1004/APPLE-1008, Fig. 3 (annotated)

i) *Limitation [1i] transmit an acknowledgment.*

113. It is my opinion that the Fakoorian-1-Takahashi combination provides, and renders obvious, a wireless device (or UE) that transmits an acknowledgment.

114. For example, Fakoorian-1 states that “in the case of an SPS configuration that is [] **released**, the UE may acknowledge the [] **release** by transmitting the acknowledgement in a codebook through a physical uplink control channel (PUCCH) resource.” APPLE-1004/APPLE-1008, [0058]/[0057]. Indeed, Fakoorian-1’s UE “transmit[s], to the BS, a message to jointly acknowledge all” “SPS configurations that were” “**released by the single DCI message.**” *Id.* This provides the transmit of the acknowledgement, as claimed in the ’639 Patent.

115. In the combination, Fakoorian-1 describes “receiving a single downlink control information (DCI) message; and **transmitting**, through a physical uplink control channel (PUCCH) resource, a codebook that includes **an acknowledgement bit based at least in part on a bit sequence, in the single DCI message, indicating that one or more of multiple downlink semi-persistent scheduling (SPS) configurations are to be jointly released.**” APPLE-1004/APPLE-1008, cl. 9/see cl. 14.

116. Additionally, it is my opinion one of ordinary skill in the art would have known that 5G NR, 3GPP specification has defined the HARQ codebook for use at least by a UE to provide the feedback to a base station (BS) for downlink data transmission, *i.e.*, PDSCH Data. In this regard, a UE in wireless communication with the BS sends the ACK/NACK for a corresponding PDSCH in PUSCH/PUCCH. *Id.*

117. Accordingly, my opinion is that Fakoorian in view of Takahashi renders obvious all limitations of claim 1.

2) Claim 2

[2a] The wireless device of claim 1, wherein deactivating the first SPS configuration and the second SPS configuration comprises deactivating: a first plurality of resources associated with the first SPS configuration; and

118. The Fakoorian-1-Takahashi combination discloses, and renders obvious, deactivating (*i.e.*, releasing) resources associated with the first and second SPS configurations. Additionally, the Fakoorian-1-Takahashi combination renders obvious Limitation [2a] for at least the reasons I discuss above at Limitation [1h], which are incorporated here.

119. In the combination, it is my opinion that each of Fakoorian-1 and Takahashi describe deactivating/releasing resources of a first SPS configuration. For example, Fakoorian-1 discloses that jointly “releasing multiple downlink SPS configurations” using a single DCI message “conserve[s] network **resources**, base station **resources**, UE resources” relative to current approaches that use multiple DCIs to release the multiple downlink SPS configurations. APPLE-1004/APPLE-1008, [0043]/[0042]. In my opinion a POSITA would have known that some of these resources include channel resources, such as time/frequency resource allocations, that include at least an SPS PDSCH resource for a given SPS configuration, *e.g.*, a first and second SPS configuration.

120. When Fakoorian-1's SPS configurations are individually released, "a location of the acknowledgement bit in the codebook is associated with the physical downlink shared channel (PDSCH)" resource corresponding to the individually "**released SPS configuration** (*e.g.*, based on a **time domain resource allocation (TDRA) table**)." *Id.*, [0059]/[0058]. Fakoorian-1 describes "SPS PDSCH release" "for a corresponding SPS PDSCH reception," including a "PDSCH reception occasion of the SPS configuration." *Id.*, [0062]/[0061]. It is well-known that PDSCH is a resource allocation (*e.g.*, time/frequency resources) to a UE that is used to convey user data to the UE. Fakoorian-1's "SPS PDSCH release" therefore provides deactivating (or releasing) resources associated with multiple SPS configurations, which would include resources of at least a first and second SPS configuration.

121. Additionally, it is my opinion that Takahashi describes resources associated with at least a first SPS configuration that are released (*i.e.*, deactivated) with deactivation of the SPS configurations. For example, Takahashi's SPS configuration (*e.g.*, "SPS-Config") includes "an index (SPS index) for identifying the SPS," information (*e.g.*, SPS period) "**regarding resources of the SPS**," and information regarding a physical uplink control channel (PUCCH) resource for the SPS configuration. APPLE-1006, [0022]. Takahashi also determines a size of a "HARQ-ACK codebook including the HARQ-ACK corresponding to the

downlink shared channel (PDSCH) of the SPS based on the number of set SPS settings.” *Id.*, [0210].

122. Based upon my knowledge and experience in this field, a POSITA would have recognized that Takahashi’s “**resources** of the SPS” (and Fakoorian-1’s SPS PDSCH) include specific radio resource allocations (*e.g.*, SPS PDSCH resources), comprising time slots and frequencies, that are configured at the UE, through RRC signaling, for a certain time duration. In particular, a POSITA would have known that the resources associated with the first SPS configuration includes, for example, SPS PDSCH resources to be released based on a “SPS release DCI” received by Takahashi’s UE.

[2b] deactivating: [...] a second plurality of resources associated with the second SPS configuration.

123. The Fakoorian-1-Takahashi combination renders obvious deactivating (*i.e.*, releasing) resources associated with the first and second SPS configurations. Additionally, the Fakoorian-1-Takahashi combination renders obvious Limitation [2b] for at least the reasons I discuss above at Limitations [1h], [2a], which are incorporated here.

3) Claim 3

[3a] The wireless device of claim 2, wherein: the DCI comprises a physical downlink shared channel (PDSCH)-to-HARQ feedback timing field; and

124. The Fakoorian-1-Takahashi combination renders obvious a DCI comprising the PDSCH-to-HARQ feedback timing field. Additionally, the Fakoorian-1-Takahashi combination renders obvious Limitation [3a] for at least the reasons I discuss above at Limitation [1g], which are incorporated here.

125. In the combination, Takahashi provides the PDSCH-to-HARQ feedback timing field that would have been included in Fakoorian-1's DCI received at the combination's UE. For example, Takahashi's "PDSCH-to-HARQ feedback timing corresponds to a timing indicating field for a HARQ corresponding to the PDSCH." APPLE-1006, [0053]. For example, Takahashi explicitly discloses a **"PDSCH-to-HARQ feedback timing indicator included in"** its DCI. *Id.*, [0055]. Further, Takahashi states that the **"PDSCH-to-HARQ feedback timing indicator"** is **"included in the DCI format 1_1."** *Id.*

126. In my opinion, modifying Fakoorian-1's DCI to include Takahashi's PDSCH-to-HARQ feedback timing field would have merely involved application of known techniques (Takahashi's "timing indicating field for a HARQ corresponding to the PDSCH") to a known layer 1 control channel messaging (Fakoorian-1's DCI) ready for improvement to yield predictable results. Indeed, a POSITA would have recognized that Fakoorian-1 describes timing concepts that correspond to Takahashi's PDSCH-to-HARQ feedback timing field. For example, Fakoorian-1 teaches "PDCCH signaling may indicate specific transmission

resource allocations in the **time**/frequency domain and transmission attributes (*e.g.*, **periodicity**, modulation and control scheme (MCS), **time offset**, [and] transmit power.” APPLE-1004/APPLE-1008, [0038]/[0037].

[3b] a value of the PDSCH-to-HARQ feedback timing field indicates a time duration between the DCI and the acknowledgement.

127. The Fakoorian-1-Takahashi combination renders obvious a value of the timing field indicates a time duration between the DCI and the acknowledgement. Additionally, the Fakoorian-1-Takahashi combination renders obvious Limitation [3b] for at least the reasons I discuss above at Limitations [3a], which are incorporated here.

128. In the combination, Takahashi provides the value of the PDSCH-to-HARQ feedback timing field, which indicates the time duration between when the combination’s UE receives the DCI and transmits the acknowledgement. For example, Takahashi’s “**PDSCH-to-HARQ feedback timing, K_1** ,” is “**specified by the [] DCI.**” APPLE-1006, [0050]. Takahashi describes that “PDSCH-to-HARQ feedback timing corresponds to a **timing indication field** for a HARQ corresponding to the PDSCH” and “[w]hen **the last slot** that has received the PDSCH is **defined as n** , the UE may **transmit the HARQ-ACK corresponding to the PDSCH in an $n+K_1$ slot.** *Id.*, [0050]. It is my opinion that Takahashi’s value of the K_1 field in the DCI provides the claimed “value of the PDSCH-to-

HARQ feedback timing field.” And, more specifically, I believe Takahashi’s “n+K1 slot” indicates a time duration between the DCI and the acknowledgement (*i.e.*, HARQ-ACK), as stated in Limitation [3b].

4) Claim 4

[4] The wireless device of claim 3, wherein the instructions, when executed by the one or more processors, further cause the wireless device to determine a timing of the acknowledgement based on a first timing of the DCI and the value of the PDSCH-to-HARQ feedback timing field.

129. The Fakoorian-1-Takahashi combination discloses determining a timing of the acknowledgement based on a first timing of the DCI and the value of the PDSCH-to-HARQ feedback timing field. Additionally, the Fakoorian-1-Takahashi combination renders obvious Claim [4] for at least the reasons I discuss above at Limitations [3a], [3b], which are incorporated here.

130. In the combination, Takahashi provides the instruction and processor-based UE function of determining a timing of the acknowledgement based on a first timing of the DCI and the value of the PDSCH-to-HARQ feedback timing field received at the combination’s UE. See APPLE-1006, Fig. 19, Fig. 20, [0220], [0222], [0225] (“processor 1001 reads programs (program code), software modules, data, etc.” “and executes various types of processing according to these”). For example, Takahashi’s discloses that “[w]hen the last slot that has

received the PDSCH is defined as n , the UE may transmit the HARQ-ACK corresponding to the PDSCH in an $n + K_1$ slot.” APPLE-1006, [0053].

131. Takahashi’s “PDSCH in [the] $n + K_1$ slot” teaches the claimed “first timing of the DCI.” And Takahashi’s “PDSCH-to-HARQ feedback timing may be referred to as the PDSCH-to-HARQ-ACK feedback timing,” which corresponds to the determined timing of the acknowledgement. *Id.* Indeed, Takahashi’s Fig. 4 embodiment (reproduced below) discloses a timing of the acknowledgement based on a first timing of the DCI corresponding to the release of SPS PDSCH #1.

APPLE-1006, Fig. 4.

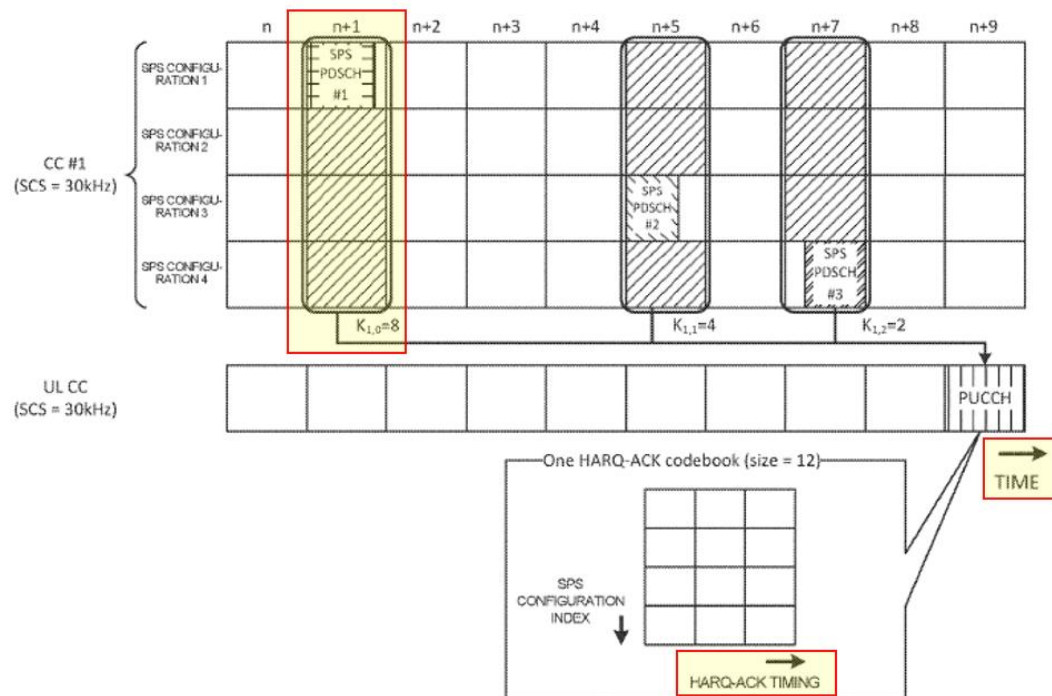


FIG. 4

APPLE-1006, Fig.4 (annotated)

5) Claim 5

[5a] The wireless device of claim 2, wherein: the first HARQ codebook identifier indicates a first HARQ feedback codebook for transmission of an acknowledgement associated with releasing the first SPS configuration or a HARQ feedback for a transport block received via a resource associated with the first SPS configuration;

132. The Fakoorian-1-Takahashi combination's first HARQ codebook identifier indicates a first HARQ feedback codebook for transmission of an acknowledgement associated with releasing the first SPS configuration.

Additionally, the Fakoorian-1-Takahashi combination renders obvious Limitation [5a] for at least the reasons I discuss above at Limitations [1d], [1e], [1h], [1i], which are incorporated here.

133. Fakoorian-1 describes that, for “an SPS configuration” that is released, the UE “acknowledge[s] the release by transmitting the acknowledgement in a codebook.” APPLE-1004/APPLE-1008, [0058]/[0057]. Fakoorian-1 notes that different techniques can “be used to transmit the acknowledgement and/or the location of the acknowledgement bit in the codebook” when “multiple SPS configurations” are jointly released. *Id.*, [0059]/[0058].

[5b] the second HARQ codebook identifier indicates a second HARQ feedback codebook for transmission of an acknowledgement associated with releasing the second SPS configuration or a HARQ feedback for a transport block received via a resource associated with the second SPS configuration; and

134. The Fakoorian-1-Takahashi combination's second HARQ codebook identifier indicates a second HARQ feedback codebook for transmission of an acknowledgement associated with releasing the second SPS configuration. Additionally, the Fakoorian-1-Takahashi combination renders obvious Limitation [5b] for at least the reasons I discuss above at Limitations [1e], [5a], which are incorporated here.

135. For example, Takahashi's "HARQ-ACK codebook" transmitted using the PUCCH can include "a HARQ-ACK bit" that is "disposed between a HARQ-ACK bit corresponding to one SPS PDSCH and a HARQ-ACK bit corresponding to another SPS PDSCH." APPLE-1006, [0146]. Takahashi confirms that each HARQ-ACK bit can be a "HARQ-ACK bit corresponding to [an] SPS release." *Id.* Thus, in this example, the "one SPS PDSCH" is a first SPS configuration to be released, whereas the "another SPS PDSCH" is a second SPS configuration to be released.

136. For clarity, Takahashi notes that "**the SPS, an SPS PDSCH, the SPS setting, an SPS occasion, SPS reception, SPS PDSCH reception, SPS scheduling, etc.**" generally refer to the same overall SPS configuration concept and may be used interchangeably. APPLE-1006, [0015]; *see* Analysis at §VII.C ("Takahashi's SPS settings disclose/include at least the SPS configurations, and corresponding configuration parameters, of the Challenged Claims").

[5c] the first HARQ feedback codebook is the same as the second HARQ feedback codebook based on the first HARQ codebook identifier being the same as the second HARQ codebook identifier.

137. Based upon my knowledge and experience in this field, the Fakoorian-1-Takahashi combination renders obvious the first HARQ feedback codebook being the same as the second HARQ feedback codebook based on the first HARQ codebook identifier being the same as the second HARQ codebook identifier. For example, the combination renders obvious Limitation [5c] for at least the reasons I discuss above at Limitations [1e], [5a], [5b], which are incorporated here.

6) Claim 6

[6] The wireless device of claim 2, wherein the state is associated with a plurality of configuration indexes comprising a first configuration index, of the first SPS configuration, and a second configuration index of the second SPS configuration.

138. The Fakoorian-1-Takahashi combination's state is associated with multiple configuration indexes comprising a configuration index of the first SPS configuration and a configuration index of the second SPS configuration. Additionally, the Fakoorian-1-Takahashi combination renders obvious Claim [6] for at least the reasons I discuss above at Limitation [1f], which are incorporated here.

139. In the Fakoorian-1-Takahashi combination, Fakoorian-1 provides state that is associated with multiple configuration indexes. For example,

Fakoorian-1 describes a “state” that corresponds to a “bit sequence” or “bitmap” in a DCI message. APPLE-1004/APPLE-1008, [0048]/[0047], [0052]/[0051]. For example, Fakoorian-1’s UE “identif[ies] a codepoint from the bit sequence in the single DCI message.” APPLE-1004/APPLE-1008, [0048]/[0047]. The codepoint “correspond[s] to a **configuration index**,” or multiple configuration indexes, associated with a particular SPS configuration to be released. *Id.* Thus, Fakoorian-1 describes the claimed “plurality of configuration indexes.” Fakoorian-1’s UE may **jointly release each “SPS configuration that is a member of the same set as the particular ... SPS configuration corresponding to the codepoint indicated in the bit sequence of the single DCI message.”** *Id.*

140. Additionally, Fakoorian-1 discloses a “bitmap” with “4 bits to represent four individual configuration sets, each of which may have one or more members.” APPLE-1004/APPLE-1008, Fig., 3, [0052]/[0051]. In Fakoorian-1’s Fig. 3, the bitmap includes the bit sequence ‘0101’ to indicate that the second and fourth configuration sets are to be” released, *e.g.*, based on the second and fourth bits being set to ‘1’. *Id.* The UE can identify: i) all “SPS configurations that are members of the second configuration set” and ii) all “SPS configurations that are members of the fourth configuration set.” APPLE-1004/APPLE-1008, Fig., 3, [0052]/[0051]. The identified SPS configurations are jointly “released based on the bitmap in the single DCI message.” *Id.*

141. This describes that the state (*e.g.*, release) is associated with a plurality of configuration indexes, as claimed.

7) Claim 7

[7] The wireless device of claim 2, wherein transmitting the acknowledgement is in response to the DCI indicating release of the first SPS configuration and the second SPS configuration.

142. The Fakoorian-1-Takahashi combination provides transmitting the acknowledgement in response to the DCI indicating release (or deactivation) of the first and second SPS configurations. Additionally, the Fakoorian-1-Takahashi combination renders obvious Claim [7] for at least the reasons I discuss above at Limitation [1i], which are incorporated here.

143. In the combination, Fakoorian-1's UE receives a DCI message that indicates release of the SPS configurations and, in response to receiving the DCI, transmits the acknowledgement, *e.g.*, via a codebook that includes an acknowledgement bit that indicates the SPS configurations to be released. See APPLE-1004/APPLE-1008, [0058]-[0063]/[0057]-[0062]. For example, Fakoorian-1's "UE may transmit, to the BS, a message to jointly **acknowledge** all" "SPS configurations that were" "**released by the single DCI message.**" APPLE-1004/APPLE-1008, [0058]/[0057]. For an SPS configuration that is released, the UE "**acknowledge[s] the ... release by transmitting the acknowledgement** in a codebook through a physical uplink control channel (PUCCH) resource." *Id.*

144. Further, Fakoorian-1 describes an example embodiment where the PUCCH resource used to transmit the acknowledgement is “indicated by a PUCCH resource indicator (PRI) of a **last (e.g., preceding or most recent) DCI message** and the location of **the acknowledgement bit** in the codebook may be **given by the single DCI message** that was **used to activate or release the** one or more **SPS configurations.**” *Id.*, [0061]/[0060]. A POSITA would have readily recognized that Fakoorian-1’s transmitting of the acknowledgement would have been in response to its UE receiving the DCI, which is the indicator of the SPS configurations to be released.

8) Claim 8

[8] The wireless device of claim 2, wherein the one or more RRC messages further comprise a fourth configuration parameter indicating a configured scheduling radio network temporary identifier, wherein the DCI is associated with the configured scheduling radio network temporary identifier.

145. Fakoorian-1 discloses a fourth configuration parameter indicating a configured scheduling radio network temporary identifier (CS-RNTI).

146. In the combination, Fakoorian-1 provides the fourth configuration parameter indicating a CS-RNTI. For example, Fakoorian-1 describes that “with a downlink SPS configuration, RRC may define a periodicity of the configured downlink assignments while a PDCCH addressed to the CS-RNTI can activate and/or **release the configured downlink assignment** (e.g., a PDCCH addressed to

the CS-RNTI may indicate that the **downlink assignment can be implicitly reused according to the periodicity defined by RRC until released**)." APPLE-1004/APPLE-1008, [0053]/[0052].

147. Additionally, Fakoorian-1's DCI is associated with the CS-RNTI. For example, Fakoorian-1's "UE may be associated with multiple CS-RNTIs, and each CS-RNTI may correspond to a particular configuration set that contains one or more multiple configurations that can be jointly activated or released. In this way, with multiple different CS-RNTIs, **the bit sequence in the DCI** that is used to jointly activate or release uplink CG configurations, downlink SPS configurations, and/or the like may be reduced, thus achieving greater reliability." *Id.*, [0054]/[0053]. Fakoorian-1 therefore describes that its DCI is associated with the CS-RNTI.

9) Claim 9

[9a] The wireless device of claim 2, wherein the instructions, when executed by the one or more processors, further cause the wireless device to: receive a first activation DCI indicating activation of a first plurality of resources associated with the first SPS configuration;

148. The Fakoorian-1-Takahashi combination receives, and renders obvious, a first activation DCI indicating activation of resources associated with the first SPS configuration. Additionally, the Fakoorian-1-Takahashi combination

renders obvious Limitation [9a] for at least the reasons I discuss above at Limitations [1a], [1b], which are incorporated here.

149. Each of Fakoorian-1 and Takahashi discloses a UE that receives an activation DCI. APPLE-1004/APPLE-1008, [0040]/[0039] (“DCI message activates ... the downlink SPS configuration”); APPLE-1006, [0016] (“[t]he DCI for activating ... the SPS setting may be referred to as SPS activation DCI”). And each of Fakoorian-1 and Takahashi discloses that activation of resources associated with an SPS configuration involves activation of DL SPS resources of that configuration, including SPS PDSCH and PUSCH/PUCCH (*e.g.*, UL grant). APPLE-1004/APPLE-1008, [0058]/[0057]-[0061]/[0060]; APPLE-1006, [0066], [0167] (“the DCI for scheduling the PDSCH may be referred to as DL assignment” and “the DCI for scheduling the PUSCH may be referred to as UL grant”).

150. In the Fakoorian-1-Takahashi combination, Takahashi’s “SPS PDSCH associated with the activation DCI” means “the first SPS PDSCH to be activated (triggered) by the activation DCI.” APPLE-1006, [0026]. Takahashi notes that “**SPS PDSCH**,” “**SPS setting**,” and “**SPS PDSCH reception**” refer to the same overall SPS configuration concept and may be used interchangeably. *Id.*, [0015]; *see* Analysis at §VII.C (“Takahashi’s SPS settings disclose/include at least the SPS configurations, and corresponding configuration parameters, of the Challenged Claims”).

[9b] receive a second activation DCI indicating activation of a second plurality of resources associated with the second SPS configuration.

151. The Fakoorian-1-Takahashi combination receives a second activation DCI indicating activation of resources associated with the second SPS configuration. Additionally, the Fakoorian-1-Takahashi combination renders obvious Limitation [9b] for at least the reasons I discuss above at Limitation [9a] which are incorporated here.

152. In the combination, Takahashi provides the instruction and processor-based UE function of receiving a second activation DCI indicating activation of a second plurality of resources associated with the second SPS configuration. For example, Takahashi's express disclosure of its **“second and subsequent SPS PDSCHs activated by the activation DCI”** provides the second activation DCI indicating activation of resources associated with the second SPS configuration. APPLE-1006, [0027].

10) Claim 10

[10] The wireless device of claim 2, wherein the one or more RRC messages further comprise fourth configuration parameters of a bandwidth part of a cell, wherein the first SPS configuration and the second SPS configuration are for the bandwidth part.

153. The Fakoorian-1-Takahashi combination renders obvious RRC messages that comprise fourth configuration parameters of a bandwidth part of a cell, where the first and second SPS configurations are for the bandwidth part.

Additionally, the Fakoorian-1-Takahashi combination renders obvious Claim [10] for at least the reasons I discuss above at Limitations [1c]-[1f], which are incorporated here.

154. In the combination, Fakoorian-1 provides RRC messages comprising fourth configuration parameters of a bandwidth part of a cell. For example, Fakoorian-1's **"UE can be provided with multiple downlink SPS configurations for a given bandwidth part (BWP) of a serving cell."** This provides express disclosure that Fakoorian-1's first and second SPS configurations, which would have been among its multiple downlink SPS configuration, are for the bandwidth part of a cell, as claimed.

155. Further, in my opinion, a POSITA would have readily recognized that Fakoorian-1's multiple downlink SPS configurations that are provided to its UE **for a given BWP of a serving cell** would have included configuration parameters (*e.g.*, fourth configuration parameters) of the given BWP of that serving cell. For example, the configuration parameters would have been included with one or more of the multiple SPS configurations for the given BWP. *See* §VIII.B.1.c-e, Analysis of Limitations [1c]-[1e] (Ground 1). And Fakoorian-1 describes that these downlink SPS configurations are **"initially indicated in an RRC configuration,"** which is conveyed to the UE via one or more RRC messages. APPLE-

1004/APPLE-1008, [0040]/[0039]. This provides the RRC configuration messages that further comprise fourth configuration parameters, as claimed.

11) Claim 11

[11a] The wireless device of claim 1, wherein: the DCI comprises a physical downlink shared channel (PDSCH)-to-HARQ feedback timing field;

156. The Fakoorian-1-Takahashi combination renders obvious Limitation [11a] for at least the reasons I discuss above at Limitation [3a], which are incorporated here.

[11b] a value of the PDSCH-to-HARQ feedback timing field indicates a time duration between the DCI and the acknowledgement.

157. The Fakoorian-1-Takahashi combination renders obvious Limitation [11b] for at least the reasons I discuss above at Limitation [3b], which are incorporated here.

12) Claim 12

[12] The wireless device of claim 11, further comprising determining a timing of the acknowledgement based on a first timing of the DCI and the value of the PDSCH-to-HARQ feedback timing field.

158. The Fakoorian-1-Takahashi combination renders obvious Claim [12] for at least the reasons I discuss above at Claim [4], which are incorporated here.

13) Claim 13

[13] The wireless device of claim 12, wherein the one or more RRC messages further comprise fourth configuration parameters of a bandwidth part of a cell,

wherein the first SPS configuration and the second SPS configuration are for the bandwidth part.

159. The Fakoorian-1-Takahashi combination renders obvious Claim [13] for at least the reasons I discuss above at Claim [10], which are incorporated here.

14) Claim 14

[14a] The wireless device of claim 1, wherein: the first HARQ codebook identifier indicates a first HARQ feedback codebook for transmission of an acknowledgement associated with releasing the first SPS configuration or a HARQ feedback for a transport block received via a resource associated with the first SPS configuration;

160. The Fakoorian-1-Takahashi combination renders obvious Limitation [14a] for at least the reasons I discuss above at Limitation [5a], which are incorporated here.

[14b] the second HARQ codebook identifier indicates a second HARQ feedback codebook for transmission of an acknowledgement associated with releasing the second SPS configuration or a HARQ feedback for a transport block received via a resource associated with the second SPS configuration; and

161. The Fakoorian-1-Takahashi combination renders obvious Limitation [14b] for at least the reasons I discuss above at Limitation [5b], which are incorporated here.

[14c] the first HARQ feedback codebook is the same as the second HARQ feedback codebook based on the first HARQ codebook identifier being the same as the second HARQ codebook identifier.

162. The Fakoorian-1-Takahashi combination renders obvious Limitation [14c] for at least the reasons I discuss above at Limitation [5c], which are incorporated here.

15) Claim 15

[15] The wireless device of claim 14, wherein the one or more RRC messages further comprise fourth configuration parameters of a bandwidth part of a cell, wherein the first SPS configuration and the second SPS configuration are for the bandwidth part.

163. The Fakoorian-1-Takahashi combination renders obvious Claim [15] for at least the reasons I discuss above at Claim [10], which are incorporated here.

16) Claim 16

[16] The wireless device of claim 1, wherein the state is associated with a plurality of configuration indexes comprising a first configuration index, of the first SPS configuration, and a second configuration index of the second SPS configuration.

164. The Fakoorian-1-Takahashi combination renders obvious Claim [16] for at least the reasons I discuss above at Claim [6], which are incorporated here.

17) Claim 17

[17] The wireless device of claim 1, wherein transmitting the acknowledgement is in response to the DCI indicating release of the first SPS configuration and the second SPS configuration.

165. The Fakoorian-1-Takahashi combination renders obvious Claim [17] for at least the reasons I discuss above at Claim [7], which are incorporated here.

18) Claim 18

[18] The wireless device of claim 1, wherein the one or more RRC messages further comprise a fourth configuration parameter indicating a configured scheduling radio network temporary identifier, wherein the DCI is associated with the configured scheduling radio network temporary identifier.

166. The Fakoorian-1-Takahashi combination renders obvious Claim [18] for at least the reasons I discuss above at Claim [8], which are incorporated here.

19) Claim 19

[19a]The wireless device of claim 1, wherein the instructions, when executed by the one or more processors, further cause the wireless device to: receive a first activation DCI indicating activation of a first plurality of resources associated with the first SPS configuration;

167. The Fakoorian-1-Takahashi combination renders obvious Limitation [19a] for at least the reasons I discuss above at Limitation [9a], which are incorporated here.

[19b]receive a second activation DCI indicating activation of a second plurality of resources associated with the second SPS configuration.

168. The Fakoorian-1-Takahashi combination renders obvious Limitation [19b] for at least the reasons I discuss above at Limitation [9b], which are incorporated here.

20) Claim 20

[20] The wireless device of claim 1, wherein the one or more RRC messages further comprise fourth configuration parameters of a bandwidth part of a cell, wherein the first SPS configuration and the second SPS configuration are for the bandwidth part.

169. The Fakoorian-1-Takahashi combination renders obvious Claim [20] for at least the reasons I discuss above at Claim [10], which are incorporated here.

IX. GROUND 2A: CLAIMS 1-20 ARE OBVIOUS OVER FAKOORIAN-2

A. Application to Challenged Claims

170. For the reasons I describe in detail below, and based on my review of the '639 Patent, its file history, and the prior art references cited in this declaration, a POSITA would have plainly understood that the teachings of Fakoorian-2, in combination with the knowledge of a POSITA, render obvious all elements of claims 1-20.

1) Claim 1

p) *Limitation [1pre] A wireless device comprising:*

171. Fakoorian-2 discloses a wireless device. For example, Fakoorian-2 relates to a “wireless communication system” that includes “a user equipment (UE).” APPLE-1005, 1:19-23, Abstract/APPLE-1009, [0001] (“wireless communication systems”), [0006] (“user equipment (UE)”). Fakoorian-2’s UE “may also be referred to as ... a wireless device” or “a wireless communications device.” *Id.*, 8:39-46/*Id.*, [0031]. In Fakoorian-2 “[e]xamples of UEs [] include a cellular phone, a smart phone,” or “multimedia device.” *Id.*, 8:28-31/*Id.*, [0031].

a) ***Limitation [1a] one or more processors; and***

172. Fakoorian-2 discloses one or more processors. For example, Fakoorian-2's UE is a "wireless communication device" that includes "at least one modem," "**at least one processor**," and "at least one **memory communicatively coupled with the at least one processor**." *Id.*, 3:1-5, cl. 15/*Id.*, Fig. 3, Fig. 13, cl. 24, [0019] ("one or more processors").

b) ***Limitation [1b] memory storing instructions that, when executed by the one or more processors, cause the wireless device to:***

173. Fakoorian-2 discloses a memory storing instructions that are executable by the one or more processors. For example, Fakoorian-2's "memory **may store instructions that, when executed by the at least one processor ...**, causes the wireless communication device to perform operations," such as operations for jointly releasing multiple SPS configurations. APPLE-1005, 3:5-8/APPLE-1009, *see* [0019], [0020], [00107]; cl. 25.

c) ***Limitation [1c] receive one or more radio resource control (RRC) messages comprising⁸:***

⁸ The "comprising" element is addressed more fully with reference to limitations **[1d]** and **[1e]**.

174. Fakoorian-2's UE receives one or more RRC messages. For example, Fakoorian-2 configures SPS resources at its UE via RRC signaling, which includes the UE receiving one or more RRC messages from a base station. In Fakoorian-2, "[t]o configure SPS resources" at its UE, "radio **resource control (RRC) signaling** may indicate an interval at with which the radio resources are periodically assigned." APPLE-1005, 12:59-62/APPLE-1009, [0048]. It is my opinion that a POSITA would have recognized that RRC signaling conveys RRC messages.

175. Fakoorian-2's "[d]ownload SPS resources ... are **configured by the RRC**," and it would have been apparent and obvious to a POSITA that an RRC message received by the UE would have been used to facilitate configuring the SPS resources at the UE. APPLE-1005, 13:23-24/APPLE-1009, [0050]. The UE's "controller/processor 359 provides **RRC layer functionality** associated with system information ... **acquisition, [and] RRC connections**." *Id.*, 12:12-15/*Id.*, [0044]. This corresponds to the UE receiving one or more RRC messages and an example system that facilitates this is indicated at Fakoorian-2's Fig. 3 embodiment (reproduced below).

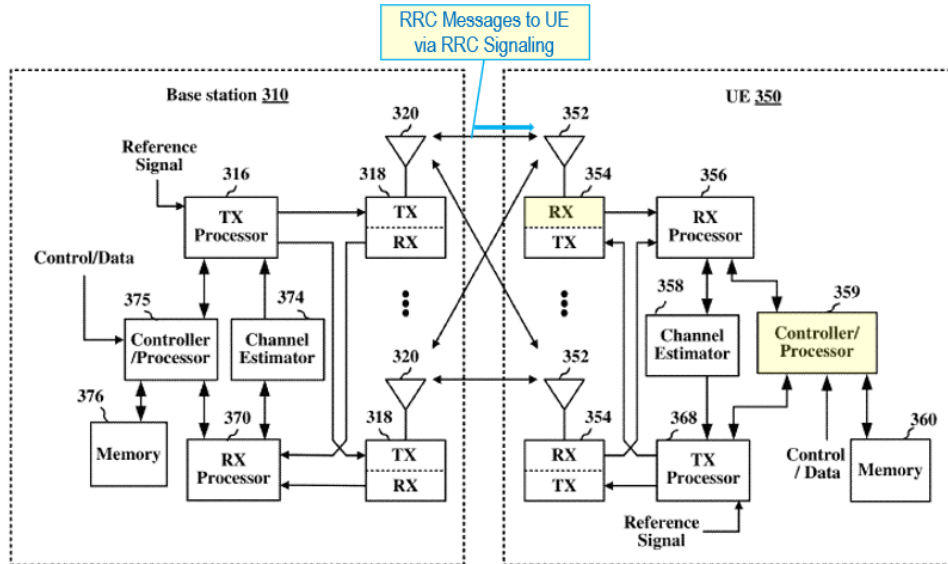


Figure 3
APPLE-1005/APPLE-1009, Fig. 3 (annotated)

176. Additionally, Fakoorian-2 renders obvious Limitation [1c] for at least the reasons I discuss below at Limitations [1d] and [1e], which are incorporated here.

d) *Limitation [1d] a first configuration parameter, of a first semi-persistent scheduling (SPS) configuration, indicating a first hybrid automatic repeat request (HARQ) codebook identifier;*

177. Fakoorian-2 renders obvious a first configuration parameter of a first semi-persistent scheduling (SPS) configuration that indicates a first HARQ codebook identifier. Additionally, Fakoorian-2 renders obvious Limitation [1d] for at least the reasons I discuss below at Limitations [1e], [1i] and above at Limitation [1c] (Ground 2A), which are incorporated here.

A first configuration parameter of a first SPS configuration

178. Fakoorian-2's Fig. 4 (reproduced below), and related descriptions, teaches a configuration parameter (*e.g.*, transmission parameter) of at least a first SPS configuration. APPLE-1005, Fig. 4/APPLE-1009, Fig. 4.

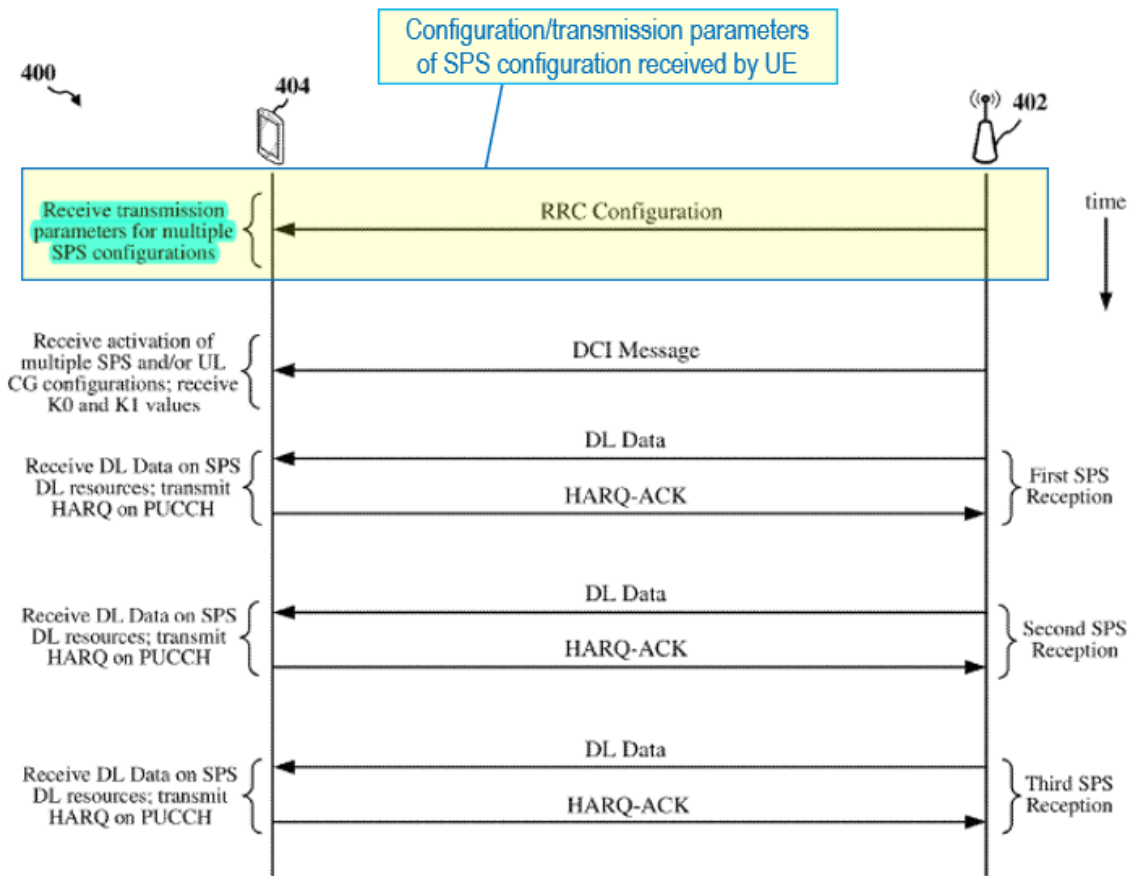


Figure 4

APPLE-1005, Fig. 4/APPLE-1009, Fig. 4 (annotated)

179. For example, as shown, Fakoorian-2's "UE 404" receives an "RRC Configuration" message comprising "transmission **parameters for multiple SPS configurations.**" APPLE-1005, Fig. 4/APPLE-1009, Fig. 4. For example, in

Fakoorian-2's Fig. 5 the "SPS1" represents a first SPS configuration. *Id.*, Fig. 5;/*Id.*, Fig. 5. Indeed, it would have been apparent and obvious to a POSITA that Fakoorian-2's "transmission parameters" include (or correspond to) the claimed first and second "configuration parameter." See §IX.A.1.e, Analysis of Limitation [1e] (Ground 2A).

First configuration parameter indicating a first HARQ codebook identifier

180. Fakoorian-2 discloses "the CS-RNTI, the periodicity, **the number of HARQ processes**, [and] the PUCCH resources ... **for the SPS configuration are [] indicated to the UE via RRC configuration.**" APPLE-1005, 13:40-43/APPLE-1009, [0051]. It is my opinion that, any one of Fakoorian-2's **CS-RNTI, periodicity, and number of HARQ processes** can represent a first configuration parameter, a second configuration parameter, or both (*e.g.*, across first and second SPS configurations). As described in the '639 Patent, each of these items represent a configuration parameter of an SPS configuration. APPLE-1001, 33:12-15 ("DL SPS configuration may comprise **a first parameter indicating a periodicity, a second parameter indicating a number of HARQ processes associated with the DL SPS configurations**").

181. In my opinion, it would have been apparent and obvious to a POSITA that "**the number of HARQ processes**" is at least one configuration parameter that indicates a HARQ codebook identifier (ID). For example, Fakoorian-2's

HARQ “processes may be used to acknowledge reception of UL data and DL data **transmitted on SPS resources.**” APPLE-1005, 12:67-13:1/APPLE-1009, [0048].

Thus, a POSITA would have recognized that information about the HARQ processes would include at least an identifier for the HARQ codebook to be used by the UE to transmit the acknowledgment. See §IX.A.1.i, Analysis of Limitation [1i] (incorporated here).

182. Additionally, or alternatively, Fakoorian-2’s base station “RRC may periodically transmit DCI messages to activate **downlink SPS configurations**” at the UE. APPLE-1005, 13:27-29/APPLE-1009, [0050]. The DCI message that activates an SPS configuration can also “indicate[] the resource assignments and timing information **for the SPS configuration.**” *Id.*, 13:38-40/*Id.*, [0051]. Thus, the DCI message can be an example RRC message that includes configuration parameters that indicate a HARQ codebook identifier.

- e) ***Limitation [1e] a second configuration parameter, of a second SPS configuration, indicating a second HARQ codebook identifier, wherein the second HARQ codebook identifier is the same as the first HARQ codebook identifier; and:***

183. Based upon my knowledge and experience in this field, I believe Fakoorian-2 renders obvious a second configuration parameter of a second SPS configuration, with the second configuration parameter indicating a second HARQ codebook identifier that is the same as the first HARQ codebook identifier.

Additionally, Fakoorian-2 renders obvious Limitation [1e] for at least the reasons I discuss above at Limitations [1c], [1d] (Ground 2A), which are incorporated here.

A second configuration parameter of a second SPS configuration

184. In Fakoorian-2's Fig. 4, the UE receives an "RRC Configuration" message comprising "transmission **parameters for multiple SPS configurations.**" APPLE-1005, Fig. 4/APPLE-1009, Fig. 4. For example, in Fakoorian-2's Fig. 5 the "SPS2" can indicate a second SPS configuration. *Id.*, Fig. 5/*Id.*, Fig. 5. Fakoorian-2's UE is provided with "**up to sixteen (16) different downlink SPS configurations,**" which are conveyed to the UE via one or more "RRC Configuration" messages. APPLE-1005, 13:65-14:3, *see* Fig. 4/APPLE-1009, [0052], *see* Fig. 4. Thus, Fakoorian-2 discloses at least a "first SPS configuration" and "second SPS configuration."

Second configuration parameter indicating a second HARQ codebook identifier that is the same as the first HARQ codebook identifier

185. As noted above with reference to Limitation [1d] (Ground 2A), any one of Fakoorian-2's **CS-RNTI, the periodicity, the number of HARQ processes** can represent a first and/or second configuration parameter. For example, Fakoorian-2's "**number of HARQ processes**" represent a configuration parameter (*e.g.*, a second configuration parameter) of a second SPS configuration received by the UE via the RRC Configuration message. APPLE-1005, 13:40-

43/APPLE-1009, [0051]. Again, this is consistent with the descriptions of “configuration parameters” established in the ’639 Patent. APPLE-1001, 37:33-37 (“Configuration parameters of a DL SPS may indicate **periodicity** and/or **number of HARQ processes** and/or **configuration index** and/or a group (*e.g.*, group of DL SPS configurations) identifier, etc.”).

186. In my opinion, it would have been apparent and obvious to a POSITA that “**the number of HARQ processes**” is a configuration parameter that indicates a HARQ codebook identifier (ID). *See*, §IX.A.1.d, Analysis of Limitation [1d] (Ground 2A); APPLE-1001, 47:63-66 (“first HARQ codebook identifier may indicate a first HARQ codebook ... for transmission of HARQ feedback (HARQ ACK/NACK)”). Fakoorian-2’s UE “**may multiplex the HARQ feedback information for the first and second SPS configurations**” with **one codebook**. APPLE-1005, 21:44-46/APPLE-1009, [0084]. Reviewing Fakoorian-2, I believe it would have been apparent and obvious to a POSITA that the second HARQ codebook identifier indicated by the second configuration parameter would have been the same as the first HARQ codebook identifier indicated by the first configuration parameters.

- f) ***Limitation [1f] a third configuration parameter indicating a state that is mapped to the first SPS configuration and the second SPS configuration;***

187. Fakoorian-2 renders obvious a third configuration parameter indicating **a state** that is mapped to at least two (*e.g.*, first and second) SPS configurations. Additionally, Fakoorian-2 renders obvious Limitation [1f] for at least the reasons I discuss below at Limitation [1g], which are incorporated here.

188. Fakoorian-2 configures SPS resources at its UE via RRC signaling, which defines a configuration parameter (*e.g.*, a third configuration parameter) represented by “CS-RNTI.” Specifically, Fakoorian-2’s “CS-RNTI” that is “associated with multiple downlink SPS configurations” provides the third configuration parameter. APPLE-1005, 15:4-5/APPLE-1009, [0055]. For example, Fakoorian-2 provides one CS-RNTI (*e.g.*, a single CS-RNTI) that corresponds to a unique identification for the UE that is used to manage resources associated with downlink SPS configurations. *Id.*, 15:6-9/*Id.*, [0055]. It is my opinion that at least this aspect of Fakoorian-2’s CS-RNTI establishes it as a third configuration parameter that indicates “a state” (*i.e.*, a single state) that is mapped to first and second DL SPS configurations.

189. Fakoorian-2’s CS-RNTI is also included in an RRC configuration message received by its UE. *Id.*, 15:9-10/*Id.*, [0055] (“RRC may define ... a CS-RNTI” indicating one (or a single) CS-RNTI in RRC messaging to the UE). For example, Fakoorian-2’s RRC “define[s] a periodicity of a downlink SPS

configuration, and a PDCCH **addressed to the CS-RNTI** can” “**release the downlink SPS configuration.**” *Id.*, 15:10-12/*Id.*, [0055].

190. In Fakoorian-2, one or more configuration sets “can be associated with different CS-RNTIs,” and **the SPS configurations that are jointly “released may be constrained to those configurations that are associated with the same CS-RNTI.”** APPLE-1005, 15:17-21/APPLE-1009, [0056]. For example, Fakoorian-2’s “UE may be associated with multiple CS-RNTIs, and each CS-RNTI may correspond to a particular configuration set that contains one or more multiple [SPS] configurations that can be jointly” “released.” *Id.*, 15:22-26/*Id.*, [0056]. These aspects of Fakoorian-2 indicate “a state” (*i.e.*, **release**) that is mapped to the multiple SPS configurations (*e.g.*, the first & second SPS configurations) in the configuration set, as claimed.

191. Additionally, or alternatively, I observed that Fakoorian-2 discloses a “bit sequence” (*e.g.*, a single bit sequence) comprising a “codepoint that indicates an index associated with a particular SPS configuration” to be released, “and all SPS configurations ... that are members of the set that includes the particular SPS configuration” can be jointly “released.” APPLE-1005, 14:36-42/APPLE-1009, [0053]. In my opinion, a POSITA would have recognized that Fakoorian-2’s bit sequence is associated with the **HARQ process number**, which can also represent a third configuration. It is my opinion that a binary value of the bit sequence that

indicates the SPS configurations (*e.g.*, a first and second SPS configuration) to be jointly released also “indicat[es] a state that is mapped” to those SPS configurations, as claimed in the ’639 Patent.

192. Further, Fakoorian-2’s “bit sequence may include a bitmap” and an individual bit of the bitmap can correspond to a particular configuration set that includes at least the first and second SPS configurations. APPLE-1005, 26:58-61/APPLE-1009, [00109]. I believe Fakoorian-2’s “bit sequence” would have been recognized by a POSITA as a third configuration parameter with a bitmap “indicating a state that is mapped” the first and second SPS configurations, as claimed in the ’639 Patent.

g) *Limitation [1g] receive a downlink control information (DCI), wherein a value of one or more bits of a HARQ process number field of the DCI indicates the state;*

193. Fakoorian-2 renders obvious a wireless device (or UE) that receives a DCI, wherein a value of one or more bits of a HARQ process number field of the DCI indicates the state mapped to the SPS configurations. Additionally, Fakoorian-2 renders obvious Limitation [1g] for at least the reasons I discuss below at Limitation [1h] and above at Limitation [1f] (Ground 2A), which are incorporated here.

194. Fakoorian-2’s UE “**receiv[es] the DCI message**” and determines, for each SPS configuration, a number of time slots associated with “**the received DCI**”

message” based on a first value contained in the DCI message. APPLE-1005, Abstract/APPLE-1009, [0089], [0093], [0094], cl. 1. Fakoorian-2’s single DCI message includes “**an existing DCI field (e.g., a HARQ process number)**” that is “used to indicate which [SPS] configurations” are to be released, thereby avoiding a need to introduce a new DCI field to indicate which configurations are to be released. *Id.*, 14:66-15:3, *see* 27:46-50/*Id.*, [0054], *see* [00112].

195. Additionally, Fakoorian-2’s different SPS configurations “associated with a UE may be divided or otherwise grouped into different sets, and a bit sequence in a single DCI message can be used to indicate multiple SPS configurations” that are to be jointly released. *Id.*, 14:30-35/*Id.*, [0053]. A POSITA would have readily recognized the bit sequence is associated with the **HARQ process number**, and one or more binary values of the bit sequence indicating SPS configurations to be jointly released also “indicates the state” mapped to those SPS configurations, as claimed.

196. Limitation [1h] deactivate the first SPS configuration and the second SPS configuration in response to receiving the DCI; and Fakoorian-2 renders obvious a wireless device (or UE) that deactivates the first and second SPS configurations in response to receiving the DCI. Additionally, Fakoorian-2 renders obvious Limitation [1h] for at least the reasons I discuss above at Limitation [1g] (Ground 2A), which are incorporated here.

197. Fakoorian-2’s “[d]ownlink SPS resources” may be “**released using downlink control information (DCI) messages** transmitted on the PDCCH.” APPLE-1005, 13:23-25/APPLE-1009, [0050]. Indeed, aspects of Fakoorian-2’s disclosure “**allow a single DCI message to ... jointly release multiple downlink SPS configurations.**” *Id.*, 14:27-29/*Id.*, [0053]. Fakoorian-2 describes “**jointly releasing multiple downlink SPS configurations ... using a single DCI message,**” which “may conserve **network resources, base station resources,** and UE resources.” *Id.*, 26:61-66/*Id.*, [00109].

h) *Limitation [1i] transmit an acknowledgment.*

198. It is my opinion that Fakoorian-2 renders obvious a UE that transmits an acknowledgment.

199. Fakoorian-2’s UE “**transmit[s] a hybrid automatic repeat request acknowledgement (HARQ-ACK)**” based on the DCI message. APPLE-1005, Abstract/APPLE-1009, [00108], [0051], [0057], [0063], [0064], Fig. 8, cl. 1. For example, the UE “transmit[s] a message (to the base station 402) that jointly **acknowledges** all SPS configurations” that were released by the DCI message. *Id.*, 16:66-17:3/*Id.*, [0063]. For an SPS configuration that is released, the UE **acknowledges** the “release by transmitting the acknowledgement in a codebook through a PUCCH resource.” *Id.*, 17:3-7/*Id.*, [0063]. Fakoorian-2 also discloses “transmitting [a] plurality of HARQ-ACKs corresponding to the plurality of SPS

configurations on the PUCCH at the determined instances in time.” APPLE-1005, cl. 19/APPLE-1009, cl. 1, cl. 5, cl. 7.

2) Claim 2

[2a] The wireless device of claim 1, wherein deactivating the first SPS configuration and the second SPS configuration comprises deactivating: a first plurality of resources associated with the first SPS configuration; and

200. Fakoorian-2 discloses deactivating (*i.e.*, releasing) resources associated with the first and second SPS configurations. Additionally, Fakoorian-2 renders obvious Limitation [2a] for at least the reasons I discuss above at Limitation [1h] (Ground 2A), which are incorporated here.

201. For example, Fakoorian-2 discloses that jointly “releasing multiple downlink SPS configurations” using a single DCI message “conserve[s] network **resources**, base station **resources**, UE resources” relative to current approaches that use multiple DCIs to release the multiple downlink SPS configurations. APPLE-1005, 14:51-55/APPLE-1009, [0054].

[2b] deactivating: [...] a second plurality of resources associated with the second SPS configuration.

202. Fakoorian-2 discloses deactivating (*i.e.*, releasing) resources associated with the first and second SPS configurations. Additionally, Fakoorian-2 renders obvious Limitation [2b] for at least the reasons I discuss above at Limitations [1h], [2a] (Ground 2A), which are incorporated here.

3) Claim 3

[3a] The wireless device of claim 2, wherein: the DCI comprises a physical downlink shared channel (PDSCH)-to-HARQ feedback timing field; and

203. Fakoorian-2 discloses a DCI comprising the PDSCH-to-HARQ feedback timing field. Additionally, Fakoorian-2 renders obvious Limitation [3a] for at least the reasons I discuss above at Limitation [1g] (Ground 2A) and below at Limitation [3b] and Claim [4], which are incorporated here.

204. For example, Fakoorian-2's "DCI message typically includes a frequency domain resource assignment (FDRA), a time domain resource assignment (FDRA), and a **PDSCH-to-HARQ feedback timer** for the single SPS configuration." APPLE-1005, 13:44-47/APPLE-1009, [0051]. It would have been apparent and obvious to a POSITA that Fakoorian-2's "PDSCH-to-HARQ feedback timer" corresponds to a PDSCH-to-HARQ feedback **timing field** of the DCI message, *e.g.*, where that timing field indicates a value for the PDSCH-to-HARQ feedback timer.

[3b] a value of the PDSCH-to-HARQ feedback timing field indicates a time duration between the DCI and the acknowledgement.

205. Fakoorian-2 renders obvious a value of the timing field that indicates a time duration between the DCI and the acknowledgement. Additionally, Fakoorian-2 renders obvious Limitation [3b] for at least the reasons I discuss above at Limitations [3a] (Ground 2A), which are incorporated here. For example,

Fakoorian-2's "**PDSCH-to-HARQ feedback timer** may be used **to determine a K1 value that indicates the number of slots between the end of the PDSCH and a beginning of the PUCCH upon which the HARQ-ACK is transmitted** (*e.g.*, the time period between the instance at which the UE received the last symbol of the DL data on the PDSCH **and the instance at which the UE is to begin transmitting HARQ feedback information on the PUCCH**)."

APPLE-1005, 13:57-64/APPLE-1009, [0051].

206. The "K1 value" determined from Fakoorian-2's "PDSCH-to-HARQ feedback timer" along with Fakoorian-2's "instance at which the UE **is to begin transmitting HARQ feedback**" provides the indication of a time duration between the DCI and the acknowledgement, as stated in Limitation [3b]. In particular, Fakoorian-2's UE "may use **values carried in the DCI message (such as K0 and K1 values) to determine timing information** for receiving DL data on the PDSCH and **for transmitting HARQ feedback information**" (*e.g.*, ACKs). *Id.*, 17:12-19/*Id.*, [0064]. This provides that Fakoorian-2's K1 value indicates a time duration between its DCI and the acknowledgement, as stated in Limitation [3b].

4) Claim 4

[4] The wireless device of claim 3, wherein the instructions, when executed by the one or more processors, further cause the wireless device to determine a

timing of the acknowledgement based on a first timing of the DCI and the value of the PDSCH-to-HARQ feedback timing field.

207. Fakoorian-2 renders obvious determining a timing of the acknowledgement based on a first timing of the DCI and the value of the PDSCH-to-HARQ feedback timing field. Additionally, Fakoorian-2 renders obvious Claim [4] for at least the reasons I discuss above at Limitations [1a], [1b], [3a], [3b] (Ground 2A), which are incorporated here.

208. For example, Fakoorian-2's UE "may use values carried in the DCI message (such as K0 and K1 values) **to determine timing information for receiving DL data on the PDSCH and for transmitting HARQ feedback information** (e.g., ACKs and NACKs) on the PUCCH for each of the activated SPS configurations." APPLE-1005, 17:15-20/APPLE-1009, [0064].

209. Fakoorian-2's **transmitting HARQ feedback information** corresponds to transmitting an acknowledgment. Thus, Fakoorian-2's discloses that its UE can "determine timing information" for transmitting HARQ feedback and, therefore, teaches that instructions executed by a processor of the UE cause the UE to determine the timing of the acknowledgement, as claimed. APPLE-1005, cl. 19, cl. 21/APPLE-1009, cl. 1, cl. 5, cl. 7.

5) Claim 5

[5a] The wireless device of claim 2, wherein: the first HARQ codebook identifier indicates a first HARQ feedback codebook for transmission of an

acknowledgement associated with releasing the first SPS configuration or a HARQ feedback for a transport block received via a resource associated with the first SPS configuration;

210. Fakoorian-2's first HARQ codebook identifier indicates a first HARQ feedback codebook for transmission of an acknowledgement associated with releasing the first SPS configuration. Additionally, Fakoorian-2 renders obvious Limitation [5a] for at least the reasons I discuss above at Limitations [1d], [1e], [1h], [1i] (Ground 2A), which are incorporated here.

211. For the first SPS configuration, Fakoorian-2's "**HARQ process number**" represents a first configuration parameter that indicates the first HARQ codebook identifier. See, §IX.A.1.d, Analysis of Limitation [1d] (Ground 2A). A POSITA would have recognized that Fakoorian-2's "**HARQ process number**" corresponds to the first HARQ codebook identifier, which indicates (or identifies) a first HARQ feedback codebook. Based upon my knowledge and experience in this field, a POSITA would have recognized the HARQ feedback codebook generally defines a format used to signal a set of HARQ acknowledgements to a base station (*e.g.*, gNB).

212. Fakoorian-2's first HARQ feedback codebook is for transmission of an acknowledgement associated with releasing its first SPS configuration. For example, Fakoorian-2's UE "**transmit[s]** a message (to the base station 402) that jointly **acknowledges all SPS configurations**" that were **released** by the DCI

message. APPLE-1005, 16:66-17:3/APPLE-1009, [0063]. Fakoorian-2 describes that, for an SPS configuration that is released, its UE **acknowledges the “release by transmitting the acknowledgement in a codebook.”** *Id.*, 17:3-7/*Id.*, [0063].

Notably, Fakoorian-2’s “HARQ process number” can also indicate the SPS configurations to be released. *Id.*, 14:66-15:3 (“an existing DCI field (*e.g.*, a **HARQ process number**) may be **used to indicate** which **[SPS] configurations are to be ... released**”), *see* 27:46-50/*Id.*, [0054], *see* [00112].

[5b] the second HARQ codebook identifier indicates a second HARQ feedback codebook for transmission of an acknowledgement associated with releasing the second SPS configuration or a HARQ feedback for a transport block received via a resource associated with the second SPS configuration; and

213. Fakoorian-2’s second HARQ codebook identifier indicates a second HARQ feedback codebook for transmission of an acknowledgement associated with releasing the second SPS configuration. Additionally, Fakoorian-2 renders obvious Limitation [5b] for at least the reasons I discuss above at Limitations [1e], [5a] (Ground 2A), which are incorporated here.

214. For its second SPS configuration, Fakoorian-2’s “**HARQ process number**” represents a second configuration parameter that indicates the first HARQ codebook identifier. *See*, §IX.A.1.d, Analysis of Limitation [1d] (Ground 2A). It is my opinion that a POSITA would have recognized that Fakoorian-2’s “**HARQ process number**” corresponds to the first HARQ codebook identifier,

which indicates (or identifies) a first HARQ feedback codebook. Indeed, I believe it would have been apparent to a POSITA that the HARQ feedback codebook generally defines a format used to signal a set of HARQ acknowledgements to a base station (e.g., gNB).

[5c] the first HARQ feedback codebook is the same as the second HARQ feedback codebook based on the first HARQ codebook identifier being the same as the second HARQ codebook identifier.

215. Based upon my knowledge and experience in this field, Fakoorian-2 renders obvious the first HARQ feedback codebook being the same as the second HARQ feedback codebook based on the first HARQ codebook identifier being the same as the second HARQ codebook identifier. For example, Fakoorian-2 renders obvious Limitation [5c] for at least the reasons I discuss above at Limitations [1e], [5a], [5b] (Ground 2A), which are incorporated here.

6) Claim 6

[6] The wireless device of claim 2, wherein the state is associated with a plurality of configuration indexes comprising a first configuration index, of the first SPS configuration, and a second configuration index of the second SPS configuration.

216. Fakoorian-2's "state" is associated with multiple configuration indexes comprising a configuration index of the first SPS configuration and a configuration index of the second SPS configuration. Additionally, Fakoorian-2

renders obvious Claim [6] for at least the reasons I discuss above at Limitation [1f] (Ground 2A), which are incorporated here.

217. Fakoorian-2's SPS configurations received by its UE may be "grouped into different sets, and a bit sequence in a single DCI message can be used to indicate multiple SPS configurations" to be jointly released. APPLE-1005, 14:30-35/APPLE-1009, [0053]. Fakoorian-2's **"bit sequence" includes a "codepoint that indicates an index associated with a particular SPS configuration" to be released**, "and all SPS configurations ... that are members of the set that includes the particular SPS configuration" can be jointly "released by the single DCI message." *Id.*, 14:36-42/*Id.*, [0053]. Fakoorian-2's "index" and multiple different configuration sets that correspond to the state (*e.g.*, release") discloses the state as being associated with a plurality of configuration indexes.

218. The "bit sequence may include a bitmap" where "each individual bit" of the bitmap "corresponds to a particular configuration set, which can be used to indicate **multiple sets** that are to be jointly ... released." *Id.*, 14:42-46/*Id.*, [0053]. It is my opinion that, from Fakoorian-2's disclosure, a POSITA would have readily understood that the SPS configurations of each configuration set is represented by the configuration index. And Fakoorian-2's teaching of "multiple sets" corresponds to a plurality of configuration indexes, comprising at least a first and a second configuration index, as stated in claim 6. Fakoorian-2 also explains that

“different configurations may be associated with different sets,” and an SPS configuration(s) may be “released” based on bitmap indications about all of the sets. *Id.*, 14:27-50/*Id.*, [0053].

7) Claim 7

[7] The wireless device of claim 2, wherein transmitting the acknowledgement is in response to the DCI indicating release of the first SPS configuration and the second SPS configuration.

219. Fakoorian-2 discloses the acknowledgement is transmitted in response to the DCI indicating release (or deactivation) of the first and second SPS configurations. Additionally, Fakoorian-2 renders obvious Claim [7] for at least the reasons I discuss above at Limitation [1i] (Ground 2A), which are incorporated here.

220. Fakoorian-2’s UE receives a DCI message that indicates release of the SPS configurations and, in response to receiving the DCI, transmits the acknowledgement, *e.g.*, via a codebook that includes an acknowledgement bit that indicates the SPS configurations to be released. See APPLE-1005, Abstract, 16:66-17:3, Fig. 8/APPLE-1009, [0051], [0057], [0063], [0064], [00108], Fig. 8, cl. 1. For example, Fakoorian-2’s UE “transmit[s] a hybrid automatic repeat request **acknowledgement** (HARQ-ACK) based on a [] value carried in the DCI message.” *Id.*, Fig. 8, cl. 1/ *Id.*, Fig. 8 (“based on a [] value *contained* in the DCI message”), cl. 1. A POSITA would have readily recognized that Fakoorian-2’s

transmitting of the acknowledgement would have been in response to its UE receiving the DCI, which is the indicator of the SPS configurations to be released.

8) Claim 8

[8] The wireless device of claim 2, wherein the one or more RRC messages further comprise a fourth configuration parameter indicating a configured scheduling radio network temporary identifier, wherein the DCI is associated with the configured scheduling radio network temporary identifier.

221. It is my opinion that Fakoorian-2 discloses a fourth configuration parameter indicating a Configured Scheduling Radio Network Temporary Identifier (“CS-RNTI”).

222. Fakoorian-2’s UE is “provided with multiple downlink SPS configurations” that are conveyed to the UE via one or more RRC messages. APPLE-1005, 13:65-14:3/APPLE-1009, [0052]. Like “the number of HARQ processes,” Fakoorian-2’s “CS-RNTI” can represent a configuration parameter (*e.g.*, a fourth configuration parameter) of an SPS configuration received by the UE via the RRC Configuration message. APPLE-1005, 13:40-43/APPLE-1009, [0051]; *see* Analysis of Limitation [1e] (Ground 2A).

223. As an example, I observed that Fakoorian-2’s “CS-RNTI” is “associated with multiple downlink SPS configurations” and “generally corresponds to a unique identification for the UE that is used to manage resources associated with downlink SPS configurations.” APPLE-1005, 15:4-9/APPLE-

1009, [0055]. Fakoorian-2's "RRC may define a periodicity of a downlink SPS configuration, and a PDCCH addressed to the CS-RNTI can" "release the downlink SPS configuration." APPLE-1005, 15:10-12/APPLE-1009, [0055].

224. Fakoorian-2's "UE may be associated with" a CS-RNTI, which "correspond[s] to a particular configuration set that contains" multiple SPS configurations that can be "jointly activated or released." *Id.*, 15:17-26/*Id.*, [0056]. In this example, the multiple SPS configurations to be jointly released "may be constrained to" the particular configuration set corresponding the CS-RNTI. *Id.* Fakoorian-2's teaches **"a bit sequence in a single DCI message can be used to indicate multiple SPS configurations" to be jointly released.** APPLE-1005, 26:55-58/APPLE-1009, [00109].

225. The "bit sequence may include a bitmap," an individual bit of the bitmap can correspond to the particular configuration set. I believe the bitmap can be used to indicate multiple configuration sets to be jointly released in response to receiving the single DCI message. *Id.*, 26:58-61/*Id.*, [00109]. Referencing the above example, Fakoorian-2's multiple configuration sets can include the particular configuration set corresponding to the CS-RNTI. *See id.*, 15:26-30/*See id.*, [0056]. Thus, based upon my knowledge and experience in this field, the DCI message that includes the bit sequence (and bitmap) is associated with the CS-RNTI, as claimed in the '639 Patent.

9) Claim 9

[9a] The wireless device of claim 2, wherein the instructions, when executed by the one or more processors, further cause the wireless device to: receive a first activation DCI indicating activation of a first plurality of resources associated with the first SPS configuration;

226. Based upon my knowledge and experience in this field, Fakoorian-2 receives, and renders obvious, a first activation DCI indicating activation of resources associated with the first SPS configuration. Additionally, Fakoorian-2 renders obvious Limitation [9a] for at least the reasons I discuss above at Limitations [1a], [1b] (Ground 2A), which are incorporated here.

227. Fakoorian-2's "[d]ownlink **SPS resources**" "may be **activated** and released **using downlink control information (DCI) messages transmitted on the PDCCH**" and received by the UE. APPLE-1005, 13:23-26/APPLE-1009, [0050]. Based upon my knowledge and experience in this field, Fakoorian-2's "[d]ownlink **SPS resources**" are a plurality of resources, and these **resources** are associated with a first and/or second SPS configuration. And Fakoorian-2's DCI message that activates an SPS configuration is an activation DCI.

228. It should be noted that Fakoorian-2 describes transmitting/receiving multiple DCI messages and multiple SPS configurations. See APPLE-1005, 13:27-28 ("the RRC may periodically transmit **DCI messages to activate downlink SPS configurations**")/See APPLE-1009, [0050]. I believe it would have been obvious to a POSITA that Fakoorian-2's descriptions of multiple DCI

messages provide at least a first activation DCI activating a first SPS configuration and a second activation DCI activating a second SPS configuration.

229. When the “UE receives a DCI that activates a downlink SPS configuration, the UE may receive DL data from the base station on the PDSCH according to the activated downlink SPS configuration.” APPLE-1005, 13:30-33/APPLE-1009, [0050]. It is my opinion that Fakoorian-2’s PDSCH represents a first plurality of resources associated with the downlink SPS configuration being activated. Fakoorian-2 also describes an example configuration type where **“activation by a DCI message is needed for the UE [] to use the SPS resources.”** *Id.*, 16:45-47/*Id.*, [0061].

230. [9b] receive a second activation DCI indicating activation of a second plurality of resources associated with the second SPS configuration. Fakoorian-2 receives a second activation DCI indicating activation of resources associated with the second SPS configuration. Additionally, Fakoorian-2 renders obvious Limitation [9b] for at least the reasons I discuss above at Limitation [9a] (Ground 2A), which are incorporated here.

231. Fakoorian-2’s gNB “transmits a DCI message” “that *jointly* **activates a first SPS configuration (SPS1) and a second SPS configuration (SPS2).**” APPLE-1005, 17:60-62/APPLE-1009, [0068]. Relatedly, Fakoorian-2 describes that, in an example prior art embodiment, **“to activate a number *N* of SPS**

configurations, the base station needs to send the same **number N of DCI messages to a UE.**” APPLE-1005, 14:9-13/APPLE-1009, [0052]. It is my opinion that, from these descriptions, a POSITA would have recognized that Fakoorian-2’s UE receives at least: i) a first activation DCI to activate resources associated with a first SPS configuration, and ii) a second activation DCI to activate resources associated with a second SPS configuration.

10) Claim 10

[10] The wireless device of claim 2, wherein the one or more RRC messages further comprise fourth configuration parameters of a bandwidth part of a cell, wherein the first SPS configuration and the second SPS configuration are for the bandwidth part.

232. Fakoorian-2 renders obvious RRC messages that comprise fourth configuration parameters of a bandwidth part of a cell, where the first and second SPS configurations are for the bandwidth part. Additionally, Fakoorian-2 renders obvious Claim [10] for at least the reasons I discuss above at Limitations [1c]-[1f] (Ground 2A), which are incorporated here.

233. It is my opinion that Fakoorian-2 provides RRC messages comprising fourth configuration parameters of a bandwidth part of a cell. For example, Fakoorian-2’s **“UE may be provided with multiple downlink SPS configurations ... for a given bandwidth part (BWP) of a serving cell.”**

APPLE-1005, 13:65-14:1/APPLE-1009, [0052]. This provides express disclosure

that Fakoorian-2's first and second SPS configurations, which would have been among its multiple downlink SPS configuration, are for the bandwidth part of a cell, as claimed.

234. Further, in my opinion, a POSITA would have readily recognized that Fakoorian-2's multiple downlink SPS configurations that are provided to its UE **for a given BWP of a serving cell** would have included configuration parameters (e.g., fourth configuration parameters) of the given BWP of that serving cell. For example, the configuration parameters would have been included with one or more of the multiple SPS configurations for the given BWP. See Analysis of Limitations [1c]-[1e] (Ground 2A). Fakoorian-2's downlink **"SPS configurations"** are indicated to its UE **in an "RRC Configuration,"** which is conveyed to the UE via one or more RRC messages. APPLE-1005, 13:40-43/APPLE-1009, [0051]. This provides the RRC messages that further comprise fourth configuration parameters, as claimed.

11) Claim 11

[11a] The wireless device of claim 1, wherein: the DCI comprises a physical downlink shared channel (PDSCH)-to-HARQ feedback timing field;

235. Fakoorian-2 renders obvious Limitation [11a] for at least the reasons I discuss above at Limitation [3a] (Ground 2A), which are incorporated here.

[11b] a value of the PDSCH-to-HARQ feedback timing field indicates a time duration between the DCI and the acknowledgement.

236. Fakoorian-2 renders obvious Limitation [11b] for at least the reasons I discuss above at Limitation [3b] (Ground 2A), which are incorporated here.

12) Claim 12

[12] The wireless device of claim 11, further comprising determining a timing of the acknowledgement based on a first timing of the DCI and the value of the PDSCH-to-HARQ feedback timing field.

237. Fakoorian-2 renders obvious Claim [12] for at least the reasons I discuss above at Claim [4] (Ground 2A), which are incorporated here.

13) Claim 13

[13] The wireless device of claim 12, wherein the one or more RRC messages further comprise fourth configuration parameters of a bandwidth part of a cell, wherein the first SPS configuration and the second SPS configuration are for the bandwidth part.

238. Fakoorian-2 renders obvious Claim [13] for at least the reasons I discuss above at Claim [10] (Ground 2A), which are incorporated here.

14) Claim 14

[14a] The wireless device of claim 1, wherein: the first HARQ codebook identifier indicates a first HARQ feedback codebook for transmission of an acknowledgement associated with releasing the first SPS configuration or a HARQ feedback for a transport block received via a resource associated with the first SPS configuration;

239. Fakoorian-2 renders obvious Limitation [14a] for at least the reasons I discuss above at Limitation [5a] (Ground 2A), which are incorporated here.

[14b] the second HARQ codebook identifier indicates a second HARQ feedback codebook for transmission of an acknowledgement associated with releasing the second SPS configuration or a HARQ feedback for a transport block received via a resource associated with the second SPS configuration; and

240. Fakoorian-2 renders obvious Limitation [14b] for at least the reasons I discuss above at Limitation [5b] (Ground 2A), which are incorporated here.

[14c] the first HARQ feedback codebook is the same as the second HARQ feedback codebook based on the first HARQ codebook identifier being the same as the second HARQ codebook identifier.

241. Fakoorian-2 renders obvious Limitation [14c] for at least the reasons I discuss above at Limitation [5c] (Ground 2A), which are incorporated here.

15) Claim 15

[15] The wireless device of claim 14, wherein the one or more RRC messages further comprise fourth configuration parameters of a bandwidth part of a cell, wherein the first SPS configuration and the second SPS configuration are for the bandwidth part.

242. Fakoorian-2 renders obvious Claim [15] for at least the reasons I discuss above at Claim [10] (Ground 2A), which are incorporated here.

16) Claim 16

[16] The wireless device of claim 1, wherein the state is associated with a plurality of configuration indexes comprising a first configuration index, of the first SPS configuration, and a second configuration index of the second SPS configuration.

243. Fakoorian-2 renders obvious Claim [16] for at least the reasons I discuss above at Claim [6] (Ground 2A), which are incorporated here.

17) Claim 17

[17] The wireless device of claim 1, wherein transmitting the acknowledgement is in response to the DCI indicating release of the first SPS configuration and the second SPS configuration.

244. Fakoorian-2 renders obvious Claim [17] for at least the reasons I discuss above at Claim [7] (Ground 2A), which are incorporated here.

18) Claim 18

[18] The wireless device of claim 1, wherein the one or more RRC messages further comprise a fourth configuration parameter indicating a configured scheduling radio network temporary identifier, wherein the DCI is associated with the configured scheduling radio network temporary identifier.

245. Fakoorian-2 renders obvious Claim [18] for at least the reasons I discuss above at Claim [8] (Ground 2A), which are incorporated here.

19) Claim 19

[19a]The wireless device of claim 1, wherein the instructions, when executed by the one or more processors, further cause the wireless device to: receive a first activation DCI indicating activation of a first plurality of resources associated with the first SPS configuration;

246. Fakoorian-2 renders obvious Limitation [19a] for at least the reasons I discuss above at Limitation [9a] (Ground 2A), which are incorporated here.

[19b]receive a second activation DCI indicating activation of a second plurality of resources associated with the second SPS configuration.

247. Fakoorian-2 renders obvious Limitation [19b] for at least the reasons I discuss above at Limitation [9b] (Ground 2A), which are incorporated here.

20) Claim 20

[20] The wireless device of claim 1, wherein the one or more RRC messages further comprise fourth configuration parameters of a bandwidth part of a cell, wherein the first SPS configuration and the second SPS configuration are for the bandwidth part.

248. Fakoorian-2 renders obvious Claim [20] for at least the reasons I discuss above at Claim [10] (Ground 2A), which are incorporated here.

X. GROUND 2B: CLAIMS 1-20 ARE OBVIOUS OVER FAKOORIAN-2 IN VIEW OF TAKAHASHI

249. For the reasons I describe in detail below, and based on my review of the '639 Patent, its file history, and the prior art references cited herein, a POSITA would have plainly understood that the teachings of Fakoorian-2 (Ground 2A) and Takahashi (Ground 1), each provide all elements of claims 1-20, as I discuss in more detail below.

250. Takahashi provides a UE acknowledgement technique that can be used when “more than one set of delivery acknowledgement information (for example, hybrid automatic repeat request acknowledgement (HARQ-ACK))” “for multiple SPSs” is required “to be included in **one HARQ-ACK codebook.**” APPLE-1006, [0008]. Takahashi notes that “if the HARQ-ACK codebook for multiple SPSs *is not clearly defined,*” then “appropriate HARQ control cannot be performed when multiple SPSs are used, and communication throughput may deteriorate.” *Id.* Thus, Takahashi provides a UE and wireless communication

method that allows for appropriate feedback of acknowledgements (HARQ-ACK) when **multiple SPSs** are used. *Id.*

251. In Ground 2B, I thus explain an additional manner in which the prior art renders obvious claims 1-20 with respect to the “HARQ codebook identifier” and “configuration index” features of the Challenged Claims. I first explain the combination of Fakoorian-2 and Takahashi, and then how the combinations address the elements of the claims. To be clear, a POSITA would have been motivated to combine Takahashi with either of Fakoorian-1 or Fakoorian-2 for similar reasons, as I discuss below, which include the reasons I discuss above at §VIII.A.

A. Predictable Combination of Fakoorian-2 & Takahashi: Reasons to Combine & Reasonable Expectation of Success

252. A POSITA would have been motivated to combine Fakoorian-2 and Takahashi to utilize first and second configuration parameters of corresponding first and second SPS configurations, where the first and second configuration parameters indicate the same HARQ codebook identifier, as suggested by Takahashi. A POSITA would have been motivated to look to Takahashi when implementing techniques for efficient release of multiple SPS configurations consistent with Fakoorian-2’s teachings. APPLE-1006, [0028]-[0046].

253. For example, each of Fakoorian-2 and Takahashi provides SPS configurations to its UE via RRC signaling that convey RRC configuration messages to the UE. APPLE-1005, 13:23-24/APPLE-1009, [0050] (“SPS configurations” “initially indicated to the UE in an RRC configuration”); APPLE-1006, [0019]-[0020] (“SPS setting” “set in the UE” “using higher layer signaling,” *e.g.*, “radio resource control (RRC) signaling”). Takahashi’s “HARQ-ACK codebook” “may be set in the UE by using a higher layer **parameter**” *e.g.*, a configuration parameter. APPLE-1006, [0031]. Indeed, Takahashi’s “UE may **determine which codebook to use based on**” “**the RRC parameter.**” *Id.*, [0059].

254. It is my belief that a POSITA would have been motivated to combine the teachings of Fakoorian-2 and Takahashi to achieve common advantages articulated by each of Fakoorian-2 and Takahashi. For example, a POSITA would have predictably combined Fakoorian-2’s joint release of multiple SPS configurations in a single DCI with Takahashi’s techniques for transmitting acknowledgements (HARQ-ACK) of the released SPS configurations using one codebook.

255. In my opinion, a POSITA would have been motivated to combine Fakoorian-2 and Takahashi to achieve the benefit of reduced network overhead at least by using the one (*i.e.*, the same) HARQ codebook to transmit HARQ

acknowledgements (ACK) for at least two SPS configurations, as taught by Takahashi. APPLE-1006, [0045] (“more than one set of HARQ-ACK information for multiple SPSs” can be “included in one HARQ-ACK codebook.”); APPLE-1005, 14:62-65/APPLE-1009, [0054] (“avoid incurring additional overhead by ensuring” “joint release of multiple SPS configurations” “do not increase the size of the DCI message”).

256. It would have been apparent to a POSITA, based on Takahashi’s disclosure, that Fakoorian-2’s HARQ feedback (*e.g.*, HARQ-ACK) for multiple SPS configurations, including SPS PDSCH release, may be transmitted using the same HARQ feedback codebook, as taught by Takahashi. For example, Takahashi discloses that **“more than one set of HARQ-ACK information for multiple SPSs”** can be **“included in one HARQ-ACK codebook.”** APPLE-1006, [0045]. Fakoorian-2 and Takahashi are analogous art given the extensive overlap in subject matter between, a POSITA would have had reason to consult Takahashi when assessing Fakoorian-2, and would have had a reasonable expectation of success in making the proposed modifications.

B. Application to Challenged Claims

257. Based upon my knowledge and experience in this field, I believe a POSITA would have plainly understood that the teachings of Fakoorian-2 and Takahashi (“Fakoorian-2-Takahashi” or “the Fakoorian-2-Takahashi

combination”) render obvious all elements of claims 1-20. The reasoning and basis for my opinion is explained in more detail below.

[1e] a second configuration parameter, of a second SPS configuration, indicating a second HARQ codebook identifier, wherein the second HARQ codebook identifier is the same as the first HARQ codebook identifier; and:

258. The Fakoorian-2-Takahashi combination provides a second configuration parameter, of a second SPS configuration, indicating a second HARQ codebook identifier that is the same as the first HARQ codebook identifier.

A second configuration parameter of a second SPS configuration

259. As discussed at [1e], (Ground 2A), in the Fakoorian-2-Takahashi combination any one of Fakoorian-2’s **CS-RNTI, periodicity, number of HARQ processes** provides a first and/or second configuration parameter. See APPLE-1005, 13:40-43/APPLE-1009, [0051]. For example, Fakoorian-2’s “**periodicity**” is a second configuration parameter of a second SPS configuration received by the combination’s UE via RRC signaling (e.g., message).

Second configuration parameter indicating a second HARQ codebook identifier that is the same as the first HARQ codebook identifier

260. In the combination, Fakoorian-2’s “**periodicity**” is a configuration parameter indicating a HARQ codebook identifier, and is also received at the combination’s UE via an RRC message. Fakoorian-2’s “RRC may define a **periodicity** of a downlink SPS configuration,” which establishes the periodicity as

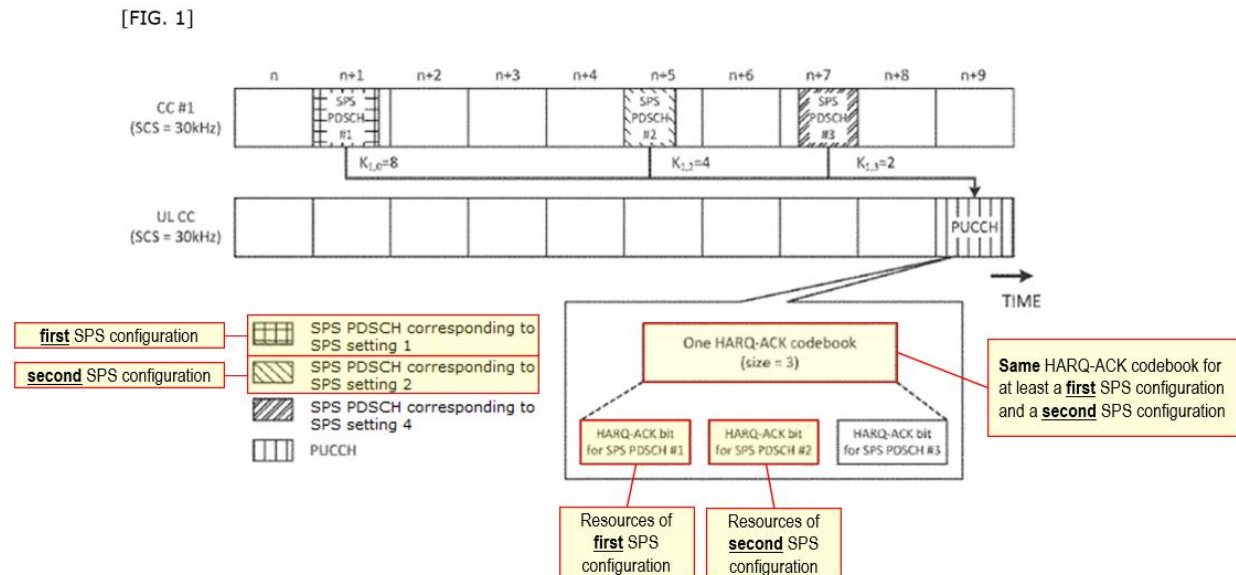
a configuration parameter received and defined at the UE via an RRC message.

APPLE-1005, 15:10-11/APPLE-1009, [0055].

261. For example, Fakoorian-2's SPS configuration with "the longest **periodicity**" can be a reference for "determin[ing] **transmit times for HARQ feedback information**. *Id.* 20:66-21:2, */Id.*, [0082]. This establishes Fakoorian-2's periodicity as a configuration parameter indicating a HARQ codebook identifier. In the combination, Fakoorian-2's UE receives, "from a radio resource controller (RRC)," "**periodicity for each SPS configuration**," and this would include at least a first periodicity (first configuration parameter) of a first SPS configuration and a second periodicity (second configuration parameter) of a second SPS configuration. APPLE-1005, cl. 12 /APPLE-1009, cl. 19].

262. In addition to Fakoorian-2's disclosure, which provides the claimed feature, Limitation [1e] is additionally provided in the combination's UE based on Takahashi's teachings. Takahashi provides "multiple SPS settings" and describes that "[p]arameters (the SPS **period**, etc.) of each SPS setting **may be the same**." APPLE-1006, [0063]. In the combination, Takahashi's UE determines which "**HARQ-ACK codebook to use**" "based on at least one of an SPS index, the **SPS period**, etc.," where "SPS period" is a configuration parameter corresponding to periodicity. *Id.*, [0062]. In particular, Takahashi provides that "more than one set

of HARQ-ACK information **for multiple SPSs**” are “**included in one HARQ-ACK codebook.**” APPLE-1006, [0045]; Fig. 1 (reproduced below).



APPLE-1006, Fig. 1 (annotated)

This describes that HARQ-ACK information for at least a first **and** second SPS configuration is included in one (*i.e.*, the **same**) HARQ codebook.

[1f] a third configuration parameter indicating a state that is mapped to the first SPS configuration and the second SPS configuration;

263. The Fakoorian-2-Takahashi combination renders obvious a third configuration parameter (*e.g.*, Fakoorian-2’s HARQ process number) indicating a **state** that is mapped to at least two (*e.g.*, first and second) SPS configurations.

APPLE-1005, 14:66-17:1/APPLE-1009, [0054] (“a HARQ process number” “used to indicate which [SPS] configurations are to be activated **and/or** released”).

[6] The wireless device of claim 2, wherein the state is associated with a plurality of configuration indexes comprising a first configuration index, of the first SPS

configuration, and a second configuration index of the second SPS configuration.

264. The Fakoorian-2-Takahashi combination's UE provides a "state" associated with multiple configuration indexes comprising a first configuration index of the first SPS configuration and a second configuration index of the second SPS configuration. In the combination Takahashi's "setting information for the SPS" can be "an 'SPS-Config' information element for RRC" and may include **an index (SPS index)** for identifying the SPS. APPLE-1006, [0022], [0015].

265. Takahashi's "SPS-Config" is an SPS configuration that "include[s] **an index (SPS index).**" *Id.* This provides at least the first configuration index of the first SPS configuration, as stated in claim [6]. Takahashi also describes multiple examples of a configuration index with reference to its "HARQ-ACK bits for the SPS PDSCH occasions," which can be "arranged in ascending order **of the SPS setting index**" *Id.*, [0120]. This provides at least one instance of a second configuration index of the second SPS configuration, as stated in claim [6].

XI. CONCLUSION

266. For the reasons I explain above, all of the Challenged Claims of the '639 Patent are rendered obvious by the prior art at issue.

267. In signing this declaration, I recognize that the 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 also recognize that I may be subject to

cross examination in the 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 as mutually agreed between the parties.

268. I currently hold the opinions expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations. Therefore, I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information that becomes available to me and on my continuing analysis of the materials already provided.

APPENDIX A

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Narayan B. Mandayam is a Distinguished Professor and Chair of Electrical and Computer Engineering at Rutgers University, where he also serves as Associate Director of the Wireless Information Network Laboratory (WINLAB). Using constructs from game theory, communications and networking, his work has focused on system modeling, information processing as well as resource management for enabling cognitive wireless technologies to support various applications. His recent interests include enabling privacy in IoT, building resilience in smart city infrastructures, machine learning for enhancing physics based models, as well as modeling and analysis of trustworthy knowledge creation on the internet. His recent work has also focused on the use of prospect theory in understanding the psychophysics of end-user behavior in wireless data networks as well as the smart grid. Dr. Mandayam is a recipient of the *2015 IEEE Communications Society Advances in Communications Award* (given to the most impactful paper in the preceding 15 calendar years) for his work on power control and pricing, the *2014 IEEE Donald G. Fink Award* for his IEEE Proceedings paper titled Frontiers of Wireless and Mobile Communications and the *2009 Fred W. Ellersick Prize* from the IEEE Communications Society for his work on dynamic spectrum access models and spectrum policy. He is also a recipient of the Peter D. Cherasia Faculty Scholar Award from Rutgers University (2010), the National Science Foundation CAREER Award (1998), the Institute Silver Medal from the Indian Institute of Technology, Kharagpur (1989) and its Distinguished Alumnus Award (2018). He is an IEEE Fellow and Distinguished Lecturer.

EDUCATION:

Ph. D in Electrical Engineering, May 1994
Rice University, Houston, Texas
M.S. in Electrical Engineering, May 1991
Rice University, Houston, Texas
B. Tech (Hons.) in Electrical Engineering, May 1989
Indian Institute of Technology, Kharagpur, India

EXPERIENCE:

Dept. of ECE, Rutgers University, Piscataway, New Jersey
Department Chair, July 2016 - present
Distinguished Professor, July 2014- present
Peter D. Cherasia Endowed Faculty Scholar, June 2010 - June 2014
Professor, July 2003 - June 2014
Associate Professor, July 2001 - June 2003
Assistant Professor, July 1996 - June 2001

WINLAB, Dept. of ECE, Rutgers University, Piscataway, New Jersey
Interim Director, January 2001 - July 2001
Associate Director, December 1999 - present
Research Associate, Sep. 1994 - June 1996

Princeton University, Princeton, New Jersey
Faculty Fellow in Dept. of EE, Sep. 2002 - Dec. 2002

Indian Institute of Science, Bangalore, India
Visiting Faculty in Dept. of ECE, Jan. 2003 - Jun. 2003

AWARDS AND HONORS:

- *Distinguished Alumnus Award* from the Indian Institute of Technology (IIT), Kharagpur (2018)
- *Big Ten Academic Alliance (BTAA) Department Executive Officers (DEO) Fellow* – one of 5 Department Chairs selected from over a 100 at Rutgers (2017)
- *Advances in Communication Award* from the IEEE Communications Society (2015) – highest (“test of time”) paper award of IEEE COMSOC; awarded to the most impactful paper in any IEEE COMSOC publication over the preceding 15 calendar years
- *Donald G. Fink Award* from the IEEE (2014) - highest paper award across all IEEE Publications in the preceding calendar year
- *National Academies Keck Futures Initiative (NAKFI) Grant Award* (2013)- “From Informed Human Brains to Society-Scale Silicon Brains: Uncovering the DNA of Social Knowledge”
- Invitee to *National Academies Keck Futures Initiative (NAKFI) Informed Brain in a Digital World* (one of 100 invitees in the U.S. selected by the National Academy of Engineering (NAE), National Academy of Sciences (NAS), and Institute of Medicine (IOM)) (2012)
- *Distinguished Lecturer* of the IEEE (2012-15)
- *Peter D. Cherasia Faculty Scholar Award*, Rutgers University (2010)
- Technical Program Co-Chair, WiOPT (2011)
- Briefer to JASON (an elite advisory group to the U.S. government) study on Cognitive Radio Networks (2010)
- *Fred W. Ellersick Prize* from the IEEE Communications Society (2009) for the best paper in a IEEE Communications Society Magazine in the preceding 3 calendar years
- Fellow, IEEE for contributions to “Wireless Data Transmission” (2009)
- Guest Editor, IEEE JSAC - Game Theory in Communications and Networking (2008)
- Guest Editor, IEEE JSAC - Spectrum Agile Cognitive Radio Networks (2007)
- Editor, IEEE Transactions on Wireless Communications (2002-2005)
- Outstanding Engineering Faculty Recognition, Rutgers University (2000)
- Associate Editor, IEEE Communications Letters (1999-2003)
- Invitee to *Annual Symposium on Frontiers of Engineering*, National Academy of Engineering (NAE) (one of hundred engineers in the U.S. selected by the NAE) (1999)
- National Science Foundation (NSF) CAREER Award (1998)
- *Outstanding Branch Counselor and Advisor Award Nominee*, IEEE (1998-99)
- *William Marsh Rice Fellowship*, Rice University (1989-1990)
- *Institute Silver Medal*, Indian Institute of Technology (I.I.T.), Kharagpur (Awarded to the graduating student with the highest G.P.A. in Electrical Engineering) (1989)
- *National Talent Search Scholarship* Awarded by the National Council of Educational Research and Training, New Delhi, India (1983-1989)

CURRENT RESEARCH INTERESTS:

- Machine Learning for Enhancing Physics Based Models
- Resilience in Smart Cities
- 5G and Beyond 5G Networks
- Reality Aware Networks
- Prospect Theory in the Design of Cyberphysical Systems
- Privacy and Security for Internet of Things
- Resource Allocation in Wireless Networks using Non Radio Attributes
- Energy Efficient Internet of Things
- End-User Behavior and the Smart Grid
- Microeconomics of Information Centric Networks
- Noncontiguous Spectrum Access and Software Defined Networks
- Modeling of Social Knowledge Creation

GRANTS: (PI or co-PI on ~ \$42M funding from Federal, State and Industry Sources)

1. “Standalone Mobile Core Network (SA-MCN) Architecture and Enabling Technologies- Phase II,” US Department of Defense Contract (\$1,315,000), October 2020; PI: Narayan Mandayam, co-PI: Dipankar Raychaudhuri, Ivan Seskar
2. “EAGER: SARE: Directional Modulation Non-Contiguous OFDM Retrodirective Communication for Secure IoT,” National Science Foundation Grant (\$300,000), September 2020; PI: Chung-Tse Michael Wu, co-PI: Narayan Mandayam, Waheed Bajwa
3. “SII Planning: ARIES: Center for Agile, Reliable, Scalable Spectrum,” National Science Foundation Grant (\$300,000), August 2020; PI: Walid Saad, co-PI: Narayan Mandayam, Douglas Sicker, Andreas Molisch, Harpreet Dhillon
4. “Standalone Mobile Core Network (SA-MCN) Architecture and Enabling Technologies,” US Department of Defense Contract (\$450,000), August 2019; PI: Narayan Mandayam, co-PI: Dipankar Raychaudhuri, Ivan Seskar
5. “Reality-Aware Networks” National Science Foundation Grant (\$800,000), April 2018; PI: Marco Gruteser, co-PI: Kristin Dana, Narayan Mandayam (Rutgers is the lead institution in collaboration with Old Dominion University and Georgia State University).
6. “COSMOS: Cloud Enhanced Open Software Defined Mobile Wireless Testbed for City-Scale Deployment” National Science Foundation Grant (\$12.5M), April 2018; PI: Dipankar Raychaudhuri, co-PI: Marco Gruteser, Narayan Mandayam, Thu Nguyen, Ivan Seskar (Rutgers is the lead institution in collaboration with Columbia University and NYU)
7. “EAGER: SSDIM: Simulated and Synthetic Data for Interdependent Communications and Energy Critical Infrastructures” National Science Foundation Grant (\$100,000), September 2017; PI: Narayan Mandayam, co-PI: Arnold Glass, Janne Lindqvist
8. “TWC: PERMIT: Privacy-Enabled Resource Management for IoT Networks” National Science Foundation (NSF) Grant No.1617849 (\$500,000), September 2016; - PI: Anand Sarwate, co-PI: Narayan Mandayam
9. “Towards Resilient Smart Cities” National Science Foundation CRISP Grant No. 1541069 (\$900,000), January 2016; PI: Narayan Mandayam, co-PI: Janne Lindqvist, Arnold Glass
10. “EAGER: Renewables: Foundations of Prosumer-Centric Grid Energy Management” National Science Foundation Grant (\$100,000), October 2015; PI: Narayan Mandayam, co-PI: Arnold Glass
11. “A Software Defined Framework for Opportunistic Networking and Spectrum Management” Office of Naval Research (ONR) Grant (\$1,000,000), January 2015; PI: Narayan Mandayam, co-PI: Ivan Seskar, S. Kompella (NRL)
12. “NeTS: End-User Behavior and Prospect Pricing in Wireless Data Networks” National Science Foundation (NSF) Grant No. 1421961 (\$500,000), October 2014; - PI: Narayan Mandayam, co-PI: Arnold Glass (Rutgers Psychology)
13. “NeTS: Transmit Only: Green Communication for Dense Wireless Systems” National Science Foundation (NSF) Grant No.1423020 (\$498,000), October 2014; - PI: Yanyong Zhang, co-PI: Narayan Mandayam
14. “From Informed Human Brains to Society-Scale Silicon Brains: Uncovering the DNA of Social Knowledge” NAKFI Grant Award (\$ 50,000), May 2013, PI: Oded Nov, co-PI: Narayan Mandayam, Ofer Arazy
15. “NeTS: Visual MIMO Networks” National Science Foundation (NSF) Grant No. CNS-1065463 (\$ 685,000), April 2011; - PI: Marco Gruteser, co-PI: Narayan Mandayam, Kristin Dana
16. “Bandwidth Exchange: A Framework for Enhancing the Performance of Cognitive Radio Networks” Office of Naval Research (ONR) (\$ 300,000), February 2011; - PI: Narayan Mandayam
17. “DEDI: A New Framework for the Practice of Wireless Network Coding” National Science Foundation (NSF) CIF Grant (\$ 427,000), September 2010; - PI: Narayan Mandayam

18. "MIAMI: Mobile Infrastructures for Advancing Military Information Technologies" US Army-TACOM-ARDEC (\$ 659,401), September 2009; - PI: Wade Trappe, co-PI: Narayan Mandayam, D. Raychaudhuri, I. Seskar
19. "RF Equipment Upgrades to Enable Scalable Crosslayer Protocol Experimentation on the ORBIT Radio Grid Testbed" Army Research Office (\$ 65,000), September 2008; - PI: Wade Trappe, co-PI: Narayan Mandayam
20. "NeTS-WN: A Joule for your Byte: Barter-Exchange Incentive Mechanisms for Wireless Networks" National Science Foundation (NSF) Grant No. CNS-0721826 (\$ 450,000), September 2007; - PI: Roy Yates, co-PI: Narayan Mandayam
21. "Cooperation and Conflict - Coalitional Games in Spectrum Sharing" National Science Foundation (NSF) Theoretical Foundations Grant, CCF-0634973(\$ 100,000), September 2006; - PI: Narayan Mandayam
22. "Fingerprints in the Ether - Exploiting the Radio Channel to Enhance Wireless Security" National Science Foundation (NSF) NeTS-ProWiN Grant (\$581,332), September 2006; - PI: Wade Trappe, co-PI: Narayan Mandayam, Larry Greenstein
23. "Cog-Net- An Experimental Protocol Stack for Cognitive Radio Networks and its Interaction with the Future Internet" National Science Foundation (NSF) NeTS-FIND Grant (\$450,000), September 2006; - PI: Dipankar Raychaudhuri, co-PI: Narayan Mandayam, Predrag Spasojevic
24. "NeTS-Cognitive Radios for Enabling Open Access to Spectrum" National Science Foundation (NSF) Grant No. NeTS-0434854 (\$ 670,000), September 2004; - PI: Narayan Mandayam, Co-PI : Chris Rose, Predrag Spasojevic, Roy Yates
25. "FMF-Unquantized and Uncoded Channel State Feedback in Multiple Antenna Multiuser Wireless Systems" National Science Foundation (NSF) Grant No. 0429724(\$ 200,000), September 2004; - PI: Narayan Mandayam
26. "Center for Multimodal Wireless Integrated Sensor-On-Silicon (MUSE) Technology" New Jersey Commission on Science and Technology (\$2,820,000)) September 2002; - PI: Dipankar Raychaudhuri, Co-PIs : Yicheng Lu, Narayan Mandayam, John Li, Joseph Kadem
27. "Wireless Instructional Lab and Curriculum Development" Intel Corporation (\$ 240,000) September 2002; -PI: Narayan Mandayam, Co-PI : Dipankar Raychaudhuri, Badri Nath
28. "Achieving Innovative and Reliable Services in Unlicensed Spectrum" National Science Foundation (NSF) ITR Grant No. 0205362(\$ 886,411), September 2002; - PI: Roy Yates, Co-PI : Narayan Mandayam, Dipankar Raychaudhuri, Chris Rose, Predrag Spasojevic
29. "'Free Bits" : The Real Challenge of the Wireless Internet" National Science Foundation (NSF) ITR Grant No. 0085986 (\$ 860,000), September 2000; - PI: Roy Yates, Co-PI : Narayan Mandayam, Chris Rose
30. "CAREER: Radio Resource Management for Wireless Data Networks" National Science Foundation (NSF) Career Grant CCR-9874976 (\$ 200,001) September 1, 1999; - PI : Narayan Mandayam
31. "Media Access Control (MAC) Protocols for Wireless Multimedia CDMA Systems" Telcordia Technologies (\$ 10,000) September 1, 1999; -PI: Narayan Mandayam
32. "Performance Analysis of Interference Cancellation for WCDMA Systems in Multicell Environments" NTT DoCoMo, Japan (\$ 90,000) September 1, 1999; - PI: Roy Yates, Co-PI : Narayan Mandayam
33. "KDI: Multimodal Collaboration Across Wired and Wireless Networks" National Science Foundation (NSF) IIS-98-72995 (\$ 2,196,006) September 1, 1998; - PI: Jim Flanagan, Co-PIs : Narayan Mandayam, David Goodman, Casimir A. Kulikowski, Sven J. Dickinson, Ivan Marsic, Peter Meer, Manish Parashar
34. "Digital Radio as Enabling Technology for Computing, Communications and Information Systems" New Jersey Commission on Science and Technology (\$1,218,405) July 1998; - PI: Roy Yates, Co-PIs : Richard Frenkiel, Narayan Mandayam and Chris Rose

35. "Parallel Computing For Wireless Networking Research" National Science Foundation (NSF) NCR 97-29863 (\$ 170,000) November 1, 1997; - PI: David Goodman, Co-PIs : Narayan Mandayam, Andrew Ogielski, Christopher Rose and Roy Yates
36. "Capacity and Protocols for Integrated Voice/Data CDMA Systems" National Science Foundation (NSF) NCR 97-06036 (\$ 328,057) October 1, 1997; - PI : Narayan Mandayam
37. "Scalable Self-Organizing Simulations S3" DARPA ITO Order No. AOD 812, Contract No. N66001-96-C-8530 (Contract Issued by -: Naval Command Control and Ocean Surveillance Center (NCCOSC)) 1997-1999 (Rutgers Internal Grant (\$ 504,225) administered by Center for Discrete Mathematics and Theoretical Computer Science (DIMACS)) - PI : Narayan Mandayam, Co-PI: Roy Yates
38. "Subspace-based Approaches for Signal Quality Estimation and Interference Cancellation in Wireless Systems" Texas Instruments Inc. (\$ 33,500) September 1, 1997; - PI: Narayan Mandayam, Co-PI : Roy Yates
39. "Interference Cancellation Prototyping and ASIC Development for Wireless CDMA Communication" National Science Foundation (NSF), NSF IUCRC for Wireless Information Networks : TIE Program between University of California San Diego and The State University of New Jersey (\$50,000) August 15, 1997; Rutgers University (PI: Narayan Mandayam) UC San Diego (PI: Paul Chau)
40. "A Testbed for Multiuser Detection" Office of Naval Research (ONR) (\$ 119,000) January 1, 1997; PI : Narayan Mandayam
41. "Capacity and Protocols for Multimedia Wireless Systems" AT & T Foundation Grant, (\$ 23,400) January 1, 1997; PI : Narayan Mandayam, Co-PI: David Goodman

INVITED TALKS:

- "*Resilience in Smart Cities*" Stevens Institute of Technology, NJ, October 2020
- "*Resilience in Smart Cities*" Lehigh University, PA, February 2020
- "*Resilience in Smart Cities*" Indian Institute of Technology (IIT)-Hyderabad, India, January 2020
- "*Resilience in Smart Cities*" Drexel University, Philadelphia, PA, March 2019
- "*Resilience in Smart Cities*" IEEE Princeton Jersey Section, Princeton, NJ, December 2018
- "*Resilience in Smart Cities*" University of Electronics Science and Technology (UESTC), Chengdu, China, July 2018
- "*Resilience in Smart Cities*" Keynote at 60th Anniversary of Computer Science at Tsinghua University, Beijing, China, July 2018
- "*Resilience in Smart Cities*" Keynote at IEEE Sarnoff Symposium, NJ September 2017
- "*Dynamic Spectrum Access in 5G: What's new?*" ECE Colloquium, University of Illinois at Urbana-Champaign, November 2016
- "*Backhauling in TV White Space using LTE-U*" IEEE Distinguished Lecture, NJ Coast Section, Holmdel, NJ, November 2015
- "*Game Theoretic Modeling of Online Knowledge Creation in Wikipedia*" ITA Workshop, San Diego, CA, February 2015
- "*Backhauling in TV White Space*" New Jersey Advanced Communications Symposium, Hoboken, NJ September 2014
- "*Towards Uncovering the DNA of Silicon Brains*" SEEDS Seminar, University of Miami, Miami, FL, April 2014
- "*Forces and Strategies that Shaped the Wireless Revolution*" Bell Labs, Alcatel-Lucent, Bangalore, July 2013
- "*Backhauling in TV White Spaces*" IEEE Distinguished Lecture, Indian Institute of Science (IISc.), Bangalore, India, July 2013
- "*When Users Interfere with Protocols - Prospect Theory in Wireless Networks*" IEEE Communication Theory Workshop, Phuket, Thailand, June 2013
- "*Towards Green Techniques for Wireless Networks*" IEEE Distinguished Lecture, University of Technology, Kingston, Jamaica, May 2013

- “*Network Coding as a Dynamical System*” IEEE Distinguished Lecture, IEEE COMSOC, Orlando, FL, May 2013
- “*Backhauling in TV White Spaces*” IEEE Distinguished Lecture, Adtran Corp., Huntsville, AL, May 2013
- “*Forces and Strategies that Shaped the Wireless Revolution*” IEEE Distinguished Lecture, AT&T, Birmingham, AL, May 2013
- “*Backhauling in TV White Spaces*” IEEE Distinguished Lecture, Georgia Tech., Atlanta, GA, May 2013
- “*Backhauling in TV White Spaces*” IEEE Distinguished Lecture, IEEE COMSOC, Charleston, SC, May 2013
- “*Backhauling in TV White Spaces*” IEEE Distinguished Lecture, National Electronic Museum, Washington D.C., May 2013
- “*Network Coding as a Dynamical System*” IEEE Distinguished Lecture, Syracuse University, April 2013
- “*Towards Green Techniques for Wireless Networks*” IEEE Distinguished Lecture, Madras Institute of Technology Anna University-KBC, Chennai, India, October 2012
- “*Network Coding as a Dynamical System*” IEEE Distinguished Lecture, Indian Institute of Science (IISc.), Bangalore, India, September 2012
- “*Network Coding as a Dynamical System*” IEEE Distinguished Lecture, Indraprastha Institute of Information Technology (IIIT) Delhi, New Delhi, India, September 2012
- “*Network Coding as a Dynamical System*” IEEE Distinguished Lecture, Osmania University, Hyderabad, India, September 2012
- “*Towards Green Techniques for Wireless Networks*” IEEE Distinguished Lecture, HelloSoft Inc., Hyderabad, India, September 2012
- “*Towards Green Techniques for Wireless Networks*” IEEE Distinguished Lecture, AirTight Networks Inc., Pune, India, September 2012
- “*Towards Green Techniques for Wireless Networks*” IEEE Distinguished Lecture, Institute of Electronics and Telecommunications Engineers (IETE), Pune, India, September 2012
- “*Network Coding as a Dynamical System*” IEEE Distinguished Lecture, Pune University, Pune, India, September 2012
- “*Towards Green Techniques for Wireless Networks*” IEEE Distinguished Lecture, Center for Development of Advanced Computing (C-DAC), Pune, India, September 2012
- “*Enabling Cognitive Radio Networks*” IEEE Distinguished Lecture, Drexel University, Philadelphia, April 2012
- “*Enabling Cognitive Radio Networks*” NSF Workshop on Beyond Cognitive Radio, University of Illinois, Urbana-Champaign, June 2011
- “*Bandwidth Exchange: A Framework for Enhancing the Performance of Cognitive Radio Networks*” Naval Research Laboratories (NRL), Washington D.C., May 2011
- “*Towards Green Techniques for Wireless*” Keynote Address at MedHocNet 2010, Juan-Les-Pins, France, June 2010
- “*Resource Allocation in Cognitive Radio Networks*” JASON Study on Cognitive Radio Networks, San Diego, CA, June 2010
- “*Communicating in TV White Space*” Panel Leader at IEEE Communication Theory Workshop, Cancun, Mexico, May 2010
- “*Towards Green Wireless*” Panelist at IEEE Saranoff Symposium, Princeton, NJ, April 2010
- “*Cognitive Radios in Wireless Ecosystems*” “Workshop on Views on Cognitive Radio: Key Issues and Long-term Development”, Huawei Technologies, San Diego, CA, April 2009
- “*Coalitions and Incentives in Cognitive Radio Networks*” New York Metro Area Networking Workshop, Columbia University, New York, March 2009
- “*Coexistence in Cognitive Radio Networks*” NSF Workshop on the Future of Cognitive Radio, Arlington, VA, March 2009
- “*Coalitions and Incentives in Cognitive Radio Networks*” Center for Multimedia Communications Seminar, Rice University, Houston, TX, February 2009
- “*Coalitions and Incentives in Cognitive Radio Networks*” ECE Colloquium, Indian Institute of Science (IISc.), Bangalore, India, October 2008
- “*Coalitions and Incentives in Cognitive Radio Networks*” Illinois Center for Wireless Systems, University of Illinois @ Urbana-Champaign, IL, May 2008

- “*Coalitions and Incentives in Cognitive Radio Networks*” Information Sciences and Systems Seminar, Princeton University, Princeton, NJ, May 2008
- “*Cognitive Radio Networks*” Princeton ACM/IEEE Computer Society Lecture Series, Princeton, NJ, January 2008
- “*Cognitive Radio Networks*” InterDigital Distinguished Lecture, King of Prussia, PA, January 2008
- “*Cognitive Radio Networks*” IEEE Princeton/Central Jersey Communications and Consumer Electronics Lecture Series, Princeton NJ, December 2007
- “*Cognitive Radio Networks*” Electrical Engineering Seminar, Columbia University, New York, September 2007
- “*Cognitive Radio Networks*” National Science Foundation (NSF) Workshop on Bridging Physical Layer and Networking, Reston VA, August 2007
- “*Cognitive Radio Networks*” DIMACS Tutorial on Algorithms for Next Generation Networks, Rutgers University, NJ, August 2007
- “*Cognitive Radio Networks*” ECE Colloquium, Indian Institute of Science (IISc.), Bangalore, India, July 2007
- “*Cognitive Radio Networks- Overview, Challenges and Directions*” Keynote Address at The Frequency Resource Development Symposium, Association of Radio Industries and Businesses, Tokyo, Japan, June 2007
- “*Cognitive Radio Networks- Overview, Challenges and Directions*” National Institute of Information Technology (NICT), Yokosuka, Japan, June 2007
- “*Cognitive Algorithms and Architectures for Open Access to Spectrum*” The Royal Institute of Technology (KTH), Stockholm, Sweden, April 2005
- “*Cognitive Radios for Enabling Open Access to Spectrum*” National Science Foundation (NSF) Wireless Networking PI Meeting, Nashua, NH, October 2004
- “*Freebits: The Real Challenge of the Wireless Internet*” Intel, Bangalore, India, June 2003
- “*Freebits: The Real Challenge of the Wireless Internet*” IEEE Colloquim Series, Bangalore, India, May 2003
- “*Freebits: The Real Challenge of the Wireless Internet*” Defense Research Development Organization (DRDO), Bangalore, India, May 2003
- “*Radio Resource Management for Wireless Data*” Golden Jubilee ECE Colloquim, Indian Institute of Science, Bangalore, India, February 2003
- “*Radio Resource Management for Wireless Data*” Drexel University, Philadelphia, PA January 2002
- “*Radio Resource Management for Wireless Data*” University of California at Irvine, Irvine, July 2001
- “*Free Bits: The Real Challenge of the Wireless Internet*” 3G and Beyond Technology Workshop, Nokia Research Center, Beijing, China, June 2001
- “*Radio Resource Management for Wireless Data*” University of Texas at Dallas, Dallas, May 2001
- “*Radio Resource Management for Wireless Data*” Southern Methodist University, Dallas, April 2001
- “*Power Control for Wireless Data: Static and Dynamic Policies*” IEEE Vehicular Technology Society, North Jersey Chapter Seminar, October 24, 2000
- “*Software Defined Radio Architectures for Interference Cancellation in CDMA Systems*” Morphics Technologies, Campbell, CA, October 13, 2000
- “*Blind Interference Cancellation for CDMA Systems*” Motorola, Piscataway, NJ, September 21, 2000
- “*Power Control for Wireless Data: Static and Dynamic Policies*” Crawford Hill Wireless Coffee Hour Seminar, Bell Labs, Lucent Technologies, August 24, 2000
- “*Power Control for Wireless Data: Static and Dynamic Policies*” Polytechnic University, February 24, 2000
- “*Power Control for Wireless Data: Games, Utility and Pricing*” Newman Springs Seminar, AT & T Research Labs, January 5, 2000
- “*Power Control for Wireless Data: Games, Utility and Pricing*” Princeton University, October 28, 1999
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- “*Software Defined Radio Architectures for Interference Cancellation in CDMA Systems*” University of California, San Diego, May 18, 1999
- “*A New Framework for Radio Resource Management in Wireless Data Networks: Games, Utility and Pricing*” New Jersey Institute of Technology, Newark, April 19, 1999
- “*Introduction to Spread Spectrum*” (Short Course) Wireless Symposium & Exhibition, Santa Clara, California, February 13, 1998
- “*Wireless Staffing*” Wireless Engineering Roundtable Forum, International Engineering Consortium, Chicago, November 10, 1997
- “*Capacity and Protocols for Integrated Voice/Data CDMA Systems*” Crawford Hill Wireless Coffee Hour Seminar, Bell Labs, Lucent Technologies, November 26, 1996
- “*Wireless Simulation Scenarios*” DARPA PI Meeting (Scalable Self-Organizing Simulations S3 Project), Center for Discrete Mathematics & Theoretical Computer Science (DIMACS), Rutgers University, November 8, 1996
- “*Capacity and Protocols for Integrated Voice/Data CDMA Systems*” Harvard University, April 24, 1996
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105. L. Sankaranarayanan, G. Kramer, N. B. Mandayam, "Hierarchical Wireless Networks: Capacity theorems using the constrained multiple-access relay channel model" in 38th Annual Asilomar Conf. Signals, Systems, and Computers, November 2004, Pacific Grove CA
106. L. Sankaranarayanan, G. Kramer, N. B. Mandayam, "Hierarchical Sensor Networks: Capacity theorems and cooperative strategies using the multiple-access relay channel model" in First IEEE Conference on Sensor and Ad Hoc Communications and Networks, October 2004, Santa Clara CA
107. L. Sankaranarayanan, G. Kramer, N. B. Mandayam, "Capacity theorems for the multiple-access relay channel" in 42nd Annual Allerton Conf. on Commun., Control, and Computing, September 2004, Allerton, IL

108. F. Meshkati, D. Guo, H. V. Poor, S. C. Schwartz, N.B. Mandayam, "A Unified Approach to Power Control for Multiuser Detectors" in 2nd International Workshop on Signal Processing for Wireless Communications, June 2004, London, U.K.
109. D. Samardzija, N. B. Mandayam, "Uncoded Unquantized CSI Feedback in Correlated Wireless Channels" in CISS'2004, March 2004, Princeton NJ
110. D. Samardzija, D. Chizhik, N. B. Mandayam "Downlink Multiple Antenna Transmitter Optimization on Spatially and Temporally Correlated Channels with Delayed Channel State Information" in CISS'2004, March 2004, Princeton NJ
111. O. Ilieri, S. Mau, N. B. Mandayam "Pricing for Enabling Forwarding in Wireless Adhoc Networks" in Proceedings of WCNC'2004, March 2004, Atlanta, GA
112. D. Samardzija, N. B. Mandayam, "Downlink Transmitter Optimization Schemes for Multiple Antenna Systems" in IEEE VTC'03 (Fall), Orlando, FL, October, 2003
113. F. Meshkati, H. V. Poor, S. Schwartz, N. Mandayam "A Game Theoretic Approach to Power Control and Receiver Design in Wireless Data Networks with Multiple Antennas" in *Proceedings of 41st Annual Allerton Conference on Communication, Control, and Computing*, Allerton, IL, September, 2003
114. F. Meshkati, H. V. Poor, S. Schwartz, N. Mandayam "Linear Multiuser Receivers and Power Control: A Game Theoretic Approach" in Proceedings of CISS'2003, Johns Hopkins University, Baltimore, MD, March, 2003
115. D. Samardzija, N. B. Mandayam, "Pilot Assisted MIMO Channel Estimation and Achievable Rates" in DIMACS Workshop on Signal Processing for Wireless Transmission, October 2002, NJ (Invited Paper)
116. A. Domazetovic, L. Greenstein, N. Mandayam, I. Seskar "A New Modelling Approach for Wireless Channels with Predictable Path Geometries" in IEEE VTC'02 Fall, September 2002, Vancouver, Canada
117. H. Wang, N. B. Mandayam "Opportunistic Transmission for Wireless Data under Energy and Delay Constraints" in IEEE International Symposium on Advances in Wireless Communications (ISWC'02), September 2002, Victoria, British Columbia, Canada (Invited Paper)
118. H. Wang, N. B. Mandayam "A Simple Packet Scheduling Scheme for Wireless Data over Fading Channels", in CISS'2002, Princeton, NJ, March, 2002
119. S. Mau, N. Feng, N. B. Mandayam "Pricing and Power Control for Joint User-centric and Network-centric Resource Allocation" in CISS'2002, Princeton, NJ, March, 2002
120. C. Comaniciu, N. B. Mandayam "Integrated Access Control and Multiuser Detection for CDMA Systems" in CISS'2002, Princeton, NJ, March, 2002
121. D. Samardzija, N. B. Mandayam, "Estimation of Fading Channel Response and System Capacity Considerations" in CISS'2002, Princeton, NJ, March, 2002
122. H. Wang, N. B. Mandayam "Energy Constrained Power Control" in *Proceedings of GLOBE-COM 2001*, San Antonio, TX, November 2001
123. H. Wang, N. B. Mandayam "Energy and Delay Constrained Power Control for File Transfers over fading Channels" in *Proceedings of Asilomar*, Monterrey, CA, , November 2001
124. S. Mau, N. Feng, N. B. Mandayam "Pricing and Power Control for Joint User-centric and Network-centric Resource Allocation" in *Proceedings of 39th Annual Allerton Conference on Communication, Control, and Computing*, Allerton, IL, September, 2001
125. S. Mau, N. Feng, N.B. Mandayam "Pricing Resources for Utility Maximization in the Context of Capacity Region Per Unit Cost" in *Proceedings of IEEE International Symposium on Information Theory*, Washington D.C., June 2001
126. D. J. Goodman, N. B. Mandayam, "Network Assisted Power Control for Wireless Data ", in *Proceedings of VTC 2001*, Greece, Spring 2001
127. D. Samardzija, N. B. Mandayam "Multistage Blind Interference Cancellation and Channel Estimation for DS-CDMA Systems" in CISS'2001, Johns Hopkins University, Baltimore, MD, March, 2001

128. C. Comaniciu, N. B. Mandayam, D. Famolari and P. Agrawal "QoS Guarantees for Third Generation (3G) CDMA Systems via Admission and Flow Control" in VTC'2000 (Fall), Boston, MA, September 2000
129. D. Samardzija, N. B. Mandayam, I. Seskar "Blind Successive Interference Cancellation" in VTC'2000 (Fall), Boston, MA, September 2000
130. C. Saraydar, N. B. Mandayam, D. J. Goodman, "Multicell Pricing and Power Control in Wireless Data Networks" in VTC'2000 (Fall), Boston, MA, September 2000
131. C. Comaniciu, N. B. Mandayam, D. Famolari and P. Agrawal "Admission and Flow Control in Multimedia CDMA", in *Proceedings of IEEE Multimedia Conference*, New York, NY, July 2000
132. L. Song, N. B. Mandayam "Hierarchical SIR and Rate Control for the Downlink of CDMA Systems", in ICC'2000, New Orleans, L.A., June, 2000
133. H. Wang, N. B. Mandayam "Dynamic Utility Maximization for Mobile Data Communications under Delay Constraints" in VTC'2000 (Spring), Tokyo, Japan, May 2000
134. L. Song, N. B. Mandayam "Hierarchical SIR and Rate Control for CDMA Data Users", in CISS'2000, Princeton, NJ, March, 2000
135. D. Samardzija, N. B. Mandayam, I. Seskar "Blind Interference Cancellation for the CDMA Downlink" in CISS'2000, Princeton, NJ, March, 2000
136. D. J. Goodman, N. B. Mandayam, "Power Control for Wireless Data", To Appear in *Proceedings of IEEE International Workshop on Mobile Multimedia Communications Workshop MoMuC'99*, San Diego, November 15-17, 1999
137. S. Manji, G. Djuknic, N. B. Mandayam, "Variable Rate Channel Coding for Image Transmission using an Outage Criterion", in IEEE Wireless Communications and Networking Conference (WCNC'99), New Orleans, Louisiana, Sept. 21-24, 1999
138. C. Saraydar, N. B. Mandayam, D. J. Goodman, "Pareto Efficiency of Pricing based Power Control in Wireless Data Networks" in IEEE Wireless Communications and Networking Conference (WCNC'99), New Orleans, Louisiana, Sept. 21-24, 1999
139. L. Song, N. B. Mandayam, Z. Gajic "Analysis of an Up/Down Power Control Algorithm in CDMA Reverse Link under Fading Condition", in *Proceedings of 37th Annual Allerton Conference on Communication, Control, and Computing*, Allerton, IL, September, 1999
140. C. Comaniciu, N. B. Mandayam, "Prediction based Access Control in Integrated Voice/Data CDMA Systems", in *Proceedings of IEEE ICC'99*, pp. 1447-1451, Vancouver, British Columbia, June 1999
141. C. Comaniciu, N. B. Mandayam, "Analysis of a Prediction based Access Control Mechanism for Short Message Data Service in an Integrated Voice/Data CDMA System", in *Proceedings of IEEE VTC'99*, pp. 128-132, Houston, TX, May 1999
142. K. Medapalli, N. B. Mandayam, "Combined Equalization and Cochannel Interference Cancellation for the Downlink using Tentative Decisions" in *Proceedings of IEEE VTC'99*, pp. 637-641, Houston, TX, May 1999
143. Z. Lei, D. J. Goodman, N. B. Mandayam, "Location Dependent Other-Cell Interference and Its Effect on the Uplink Capacity of a Cellular CDMA System" in *Proceedings of IEEE VTC'99*, pp. 2164-2168, Houston, TX, May 1999
144. Z. Lei, C. Saraydar, N. B. Mandayam, "Dynamic Paging Area Design by Interval Estimation", in the 2nd IEEE Signal Processing Workshop on Signal Processing Advances in Wireless Communications, Annapolis, MD, May, 1999
145. N. Feng, N. B. Mandayam, D. J. Goodman, "Joint Power and Rate Optimization for Wireless Data Services Based on Utility Functions", in *Proceedings of Conference on Information Sciences and Systems, CISS'99*, pp.109-114, The Johns Hopkins University, Baltimore, MD, March 1999

146. J. Lai , N. B. Mandayam, "Performance of Reed-Solomon Codes for Hybrid-ARQ over Rayleigh Fading Channels under Imperfect Interleaving", in *Proceedings of Conference on Information Sciences and Systems, CISS'99*, The Johns Hopkins University, Baltimore, MD, March 1999
147. L. Song, N. B. Mandayam, Z. Gajic "Analysis of an Up/Down Power Control Algorithm for the CDMA Reverse Link: A Nonlinear Control Systems Approach", in *Proceedings of Conference on Information Sciences and Systems, CISS'99*, pp. 119-124, The Johns Hopkins University, Baltimore, MD, March 1999
148. D. Famolari, N. B. Mandayam, D. J. Goodman, "A New Framework for Power Control in Wireless Data Networks: Games, Utility and Pricing", *Proceedings of 36th Annual Allerton Conference on Communication, Control, and Computing*, pp. 546-555, Allerton, IL, September, 1998
149. V. Shah, N.B. Mandayam, D.J. Goodman, "Power Control for Wireless Data based on Utility and Pricing", *Proceedings of PIMRC 1998*, pp. 1427-1432, Boston, September 1998
150. J. Panchal, O. E. Kelly, J. Lai, N. B. Mandayam, A. T. Ogielski, R. D. Yates, " Scalable Parallel Simulations of Wireless Networks with WiPPET: Modeling of Radio Propagation, Mobility and Protocols" *Proceedings of MASCOTS 1998*, Montreal, July 1998
151. I. Seskar, N.B. Mandayam "Reconfigurable Testbed for Linear Multiuser Detection", in *Proceedings of International Conference on Telecommunications (ICT'98)*, Chalkidiki, Greece, June, 1998
152. J. Panchal, O. E. Kelly, J. Lai, N. B. Mandayam, A. T. Ogielski, R. D. Yates, " WiPPET, A Virtual Testbed for Parallel Simulations of Wireless Networks", in *SIGSIM, IEEE-TCSIM, SCS Parallel and Distributed Simulation (PADS'98)*, pp. 162-169, Banff, Canada, May 1998.
153. S. Manji, N.B. Mandayam "Outage Probability for a Zero Forcing Multiuser Detector with Random Signature Sequences" in *Proceedings of IEEE VTC'98*, vol. 1, pp. 174-178, Ottawa, Canada, May, 1998
154. J. Lai, N.B. Mandayam "Packet Error Rate for Burst-Error-Correcting Codes in Rayleigh Fading Channels" in *Proceedings of IEEE VTC'98*, vol. 2, pp. 1568-1572, Ottawa, Canada, May, 1998
155. J. Borras, P. Hatrack, N.B. Mandayam "A Decision Theoretic Framework for NLOS Identification" in *Proceedings of IEEE VTC'98*, vol. 2, pp. 1583-1587, Ottawa, Canada, May, 1998
156. L. Song, N.B. Mandayam "A QoS Based Adaptive Power Control Algorithm for the CDMA Forward Link", in *Proceedings of Conference on Information Sciences and Systems (CISS'98)*, vol. 1, p. 180, Princeton University, Princeton, NJ, March 1998
157. I. Seskar, N.B. Mandayam "A Software Radio Architecture for Linear Multiuser Detection", in *Proceedings of Conference on Information Sciences and Systems (CISS'98)*, vol. 1, pp. 242-247, Princeton University, Princeton, NJ, March 1998
158. J. Lai, N.B. Mandayam "Fade Margins for Minimum Duration Outages in Log-Normal Shadow Fading and Rayleigh Fading" in *Proceedings of Asilomar*, pp. 609-613, Monterrey, CA, November, 1997
159. D. Ramakrishna, N.B. Mandayam, R. Yates "SIR Estimation in CDMA Cellular Systems using Subspace Tracking," in *Proceedings of Asilomar*, pp. 149-153, Monterrey, CA, November, 1997
160. N.B. Mandayam, J. Holtzman "Effect of Tracking Errors on the Coding-Spreading Tradeoff in CDMA Systems" in *Proceedings of ICUPC'97*, vol. 2, pp.366-370, San Diego, CA, October 1997
161. J. Lai, N.B. Mandayam "Minimum Duration Outage for a Cellular System with Rayleigh Fading" in *Proceedings of Conference on Information Sciences and Systems (CISS'97)*, pp. 281-286, The Johns Hopkins University, Baltimore, MD, March 1997

162. A. Sampath, N. B. Mandayam, J. Holtzman "Erlang Capacity of an Integrated Voice/Data CDMA System with Optimal Power Control" in *Proceedings of IEEE VTC'97*, vol. 3, pp. 1557-1561, Phoenix, AZ, May 1997
163. D. Ramakrishna, N.B. Mandayam, R. Yates "Subspace-based Estimation of the Signal-to-Interference Ratio for CDMA Cellular Systems" in *Proceedings of IEEE VTC'97*, vol. 2, pp. 735-739, Phoenix, AZ, May 1997
164. D.J. Goodman, J. Borras, N.B. Mandayam, R. Yates "INFOSTATIONS : A New System Model for Data and Messaging Services" in *Proceedings of IEEE VTC'97*, vol. 2, pp. 969-973, Phoenix, AZ, May 1997
165. D. Ramakrishna, N.B. Mandayam, R. Yates "Subspace based Techniques for Estimation of the Signal-to-Interference Ratio in CDMA Cellular Systems" in *Symposium on Interference Rejection and Signal Separation in Wireless Communications (IRSS'97)*, George Washington University, Washington D.C., March 18, 1997
166. N.B. Mandayam, J. Holtzman "Coding-Spreading Tradeoff in CDMA Systems with Tracking Errors" in *Proceedings of Conference on Information Sciences and Systems (CISS'97)*, pp. 954-959, The Johns Hopkins University, Baltimore, MD, March 1997
167. M. Saquib, R. Yates, N.B. Mandayam "Decision Feedback Decorrelating Detector for a Dual Rate Synchronous DS/CDMA Channel," in *Proceedings of IEEE GLOBECOM'96*, vol. 3, pp. 1804-1808, London, U.K., November, 1996
168. N.B. Mandayam, P.C. Chen, J. Holtzman "Time Dependent Outages in Cellular Systems : Minimum Duration Outages," in *Proceedings of the 34th Annual Allerton Conference on Communication, Control, and Computing*, pp. 835-844, Allerton, IL, October, 1996
169. P.C. Chen, N.B. Mandayam, J. Holtzman "Minimum Duration Outages for Cellular Systems with Reception Diversity", in *Proceedings of IEEE ICUPC'96*, vol. 1, pp. 245-249, Cambridge, September, 1996
170. A. Sampath, N.B. Mandayam, J. Holtzman "Analysis of an Access Control Mechanism for Data Traffic in an Integrated Voice/Data CDMA System," in *Proceedings of IEEE VTC'96*, vol. 3, pp. 1448-1452, Atlanta, May, 1996
171. N.B. Mandayam, P.C. Chen, J. Holtzman "Minimum Duration Outages for Cellular Systems : A Level Crossing Analysis", in *Proceedings of IEEE VTC'96*, vol. 2, pp. 879-883, Atlanta, May, 1996
172. M. Saquib, R. Yates, N.B. Mandayam "Decorrelating Detectors for a Dual Rate Synchronous DS/CDMA System," in *Proceedings of IEEE VTC'96*, vol. 1, pp. 377-381, Atlanta, May, 1996
173. M. Andersin, N.B. Mandayam, R. Yates "Subspace based SIR Estimation for Cellular Systems," in *Proceedings of IEEE VTC'96*, vol. 2, pp. 1155-1159, Atlanta, May 1996
174. A. Sampath, N.B. Mandayam, J. Holtzman "A Simple Model for Admission of Short Message Data in an Integrated Voice/Data CDMA System," *Proceedings of INFORMS (Operations Research Society of America)*, Washington D.C., May, 1996
175. N.B. Mandayam, J. Holtzman "Analysis of a Simple Protocol for Short Message Data Service in an Integrated Voice/Data CDMA System," *Proceedings of MILCOM, 1995*, vol. 3, pp. 1160-1164, San Diego, November, 1995
176. N.B. Mandayam, S. Verdú "Analysis of an Approximate Decorrelating Detector for CDMA Systems," *Proceedings of the 33rd Annual Allerton Conference on Communication, Control, and Computing*, pp. 1043-1052, Allerton, IL, October, 1995
177. N.B. Mandayam "Adaptive Interference Suppression for DS-CDMA with Impulsive Noise" *Proceedings of IEEE International Symposium on Information Theory*, p. 26, Whistler, B.C., September 1995
178. N.B. Mandayam, J. Holtzman, S. Barberis "Erlang Capacity of an Integrated Voice/Data Wireless CDMA System with Variable Bit Rate Sources," *Proceedings of PIMRC 1995*, vol. 3, pp. 1078-1082, Toronto, September 1995

179. N.B. Mandayam “Adaptive Linear Detection for DS-CDMA Communications in Impulsive Channels”, *Proceedings of IEEE International Conference on Vehicular Technology (VTC)*, pp. 699-703, Chicago, IL, June 1995
180. N.B. Mandayam, J. Holtzman, and S. Barberis “Performance and Capacity of an Integrated Voice/Data Wireless CDMA System with Variable Bit Rate Sources,” *Proceedings of International Workshop on Mobile Multimedia Communications MoMuc-2, 1995*, Bristol, U.K., April 1995
181. N.B. Mandayam, B. Aazhang, “ An Adaptive Multiuser Interference Rejection Algorithm for DS-CDMA Systems”, *Proceedings of IEEE International Symposium on Information Theory*, p. 135, Trondheim, Norway, June 1994
182. N.B. Mandayam, B. Aazhang, “ An Adaptive Single-User Detector for Optical Code Division Multiple Access Systems”, in *Proceedings of the 28th Annual Conference on Information Sciences and Systems (CISS’94)*, pp. 485-490, Princeton University, Princeton, March 1994
183. N.B. Mandayam, B. Aazhang, “Generalized Sensitivity Analysis of Optical Code Division Multiple Access Systems”, in *Proceedings of the 27th Annual Conference on Information Sciences and Systems (CISS’93)*, pp. 302-307, The Johns Hopkins University, Baltimore, MD, March 1993.
184. N.B. Mandayam, B. Aazhang, “Error Probabilities for Fiber-Optic Code Division Multiple Access System”, in *Proceedings of the International Symposium on Information Theory*, p. 43, San Antonio, TX, Jan 1993.
185. N.B. Mandayam, B. Aazhang, “Importance Sampling Simulation of Single User and Multi User Optical Communication Systems”, in *Proceedings of the 25th Annual Conference on Information Sciences and Systems (CISS’91)*, pp. 822-827, The Johns Hopkins University, Baltimore, MD, March 1991.
186. B. Chakravarty, N.B. Mandayam, S. Mukhopadhyay, A. Patra, G.P. Rao, “Real-Time Parameter Estimation via Block Pulse Functions”, In *28th Annual Conference of the Society of Instrument and Control Engineers (SICE)*, Matsuyama, Japan, pp. 1095-1098, July 1989.

POSTDOCTORAL ADVISEES:

- Kenza Hamidouche, Ph.D. CentraleSupélec, Gif-sur-Yvette, France, 2016
- S. Rasoul Etesami, Ph.D. University of Illinois at Urbana-Champaign, 2015
- Gokul Sridharan, Ph.D. University of Toronto, 2015
- Siun-Chuon Mau, Ph.D. Princeton University, 2000
- Paschalis Ligdas, Ph.D. University of Maryland, 1997

PAST ADVISEES:

- Ph.D. Students :
 1. Mohammad Yousefvand, Ph.D. February 2021, Thesis: “User Centric and Network Centric Approaches for Resources and Emergency Alert Optimization in Wireless Networks” (currently at Qualcomm)
 2. Tejashri Kuber, Ph.D. November 2020, Thesis: “Learning and Prediction using Radio and Non-Radio Attributes in Wireless Systems” (currently at Rutgers)
 3. Neelakantan Nurani Krishnan, Ph.D. November 2019, Thesis: “Pushing the Envelope of Wi-Fi Networks Using Distributed Multi-user MIMO” (currently at Qualcomm)
 4. Mohammad Hajimirsadeghi, Ph.D. September 2018, Thesis: “Game Theoretic Approaches for Design of Information Centric Networks (ICN) and Spectrum Sharing” (currently at Princeton University)

5. Ahmed Alabdel A. Abass, Ph.D. May 2018, Thesis: “Evolutionary Games: Applications to Security and Resource Allocation” (currently at University of Thi-Qar, Iraq)
6. Ratnesh Kumbhkar, Ph.D. December 2017, Thesis: “Opportunistic Access of Noncontiguous Spectrum - Exploring use of Noncontiguous OFDM transmission for Dynamic Spectrum Access” (currently at Marvell Semiconductors)
7. Kai Su, Ph.D. May 2016, Thesis: “Algorithms and Protocols for Efficient Multicast, Transport, and Congestion Control in Wireless Networks” (currently at VMware) (Co-advisor: D. Raychaudhuri)
8. Wenjia Yuan, Ph.D. September 2014, Thesis: “Computational Photography Methods for Visual MIMO” (currently at Google) (Co-advisors: K. Dana and M. Gruteser)
9. Muhammad Nazmul Islam, Ph.D. September 2014, Thesis: “Noncontiguous Spectrum Access and Small Cell Network Design” (currently at Qualcomm)
10. Ashwin Ashok, Ph.D. June 2014, Thesis: “Design, Modeling and Analysis of Visual MIMO Communication” (currently at CMU) (Co-advisor: M. Gruteser, K. Dana)
11. Narayanan Krishnan, Ph.D. September 2013, Thesis: “Bandwidth Sharing and Massive MIMO for Next Generation Cellular Systems” (currently at Qualcomm) (Co-advisor: R. Yates)
12. Tianming Li, Ph.D. September 2013, Thesis: “Cognitive Radio Networks: Resource Allocation and Effect of End-User Behavior” (currently at J. P. Morgan)
13. Dan Zhang, Ph.D. September 2012, Thesis: “On the Dynamics of Random Network Coding” (currently at Qualcomm)
14. Suhas Mathur, Ph.D. July 2010, Thesis: “Building Information-Theoretic Confidentiality and Traffic Privacy into Wireless Networks” (currently at AT&T), (Co-advisors: W. Trappe and L. Greenstein)
15. Chandrasekharan Raman, Ph.D. February 2010, Thesis: “Relaying and Scheduling in Interference Limited Wireless Networks” (currently at Alcatel-Lucent), (Co-advisors: R. Yates and G. Foschini)
16. Liang Xiao, Ph.D. March 2009, Thesis: “PHY-Techniques to Improve Higher-Layer Functions in Wireless Networks” (currently Associate Professor at Xiamen University), (Co-advisors: W. Trappe and L. Greenstein)
17. Zhuyu Lei, Ph.D. December 2008, Thesis: “Utility-based Power Control for Packet-Switched Wireless Networks” (currently at Alcatel-Lucent, IL)
18. Hongbo Liu, Ph.D. November 2007, Thesis: “Cross-layer Design for Reliable and Efficient Data Transmission over Multiple Antenna Mobile Infostation Networks” (currently at Spirent, NJ)
19. Omer Ileri, Ph.D. June 2007, Thesis: “Dynamic Spectrum Access Models: Towards an Engineering Perspective in the Spectrum Debate” (currently at Royal Institute of Technology (KTH))
20. Lalitha Sankaranarayanan, Ph.D. May 2007, Thesis: “Relay Cooperation in Multiaccess Networks” (currently Assistant Professor at Arizona State University, was a post-doc at Princeton University)
21. Hitesh Nama, Ph.D. February 2007, Thesis: “Resource Allocation in Cooperative and Non-cooperative Energy-constrained Wireless Networks” (currently at Marvel Semiconductor)
22. Salim Manji, Ph.D. September 2004, Thesis: “Rate Adaptation Strategies for Progressive Image Transmission over Fading Channels” (currently at Spirent Technologies, NJ)
23. Nan Feng, Ph.D. July 2004, Thesis: “User Centric and Network Centric Radio Resource Management” (currently at Alcatel-Lucent Technologies, NJ)
24. Dragan Samardzija, Ph.D. April 2004, Thesis: “Multiple Antenna Wireless Systems and Channel State Information” (currently at Bell Labs, Alcatel-Lucent Technologies, NJ)

25. Heng Wang, Ph.D. December 2002, Thesis: “Opportunistic Transmission for Wireless Data over Fading Channels under Energy and Delay Constraints” (currently at Qualcomm)
 26. Cristina Comaniciu, Ph.D., December 2001, Thesis: “Integrated Access Control and Detection for QoS in Multimedia CDMA Networks” (currently Associate Professor at Stevens Institute of Technology; was post-doc at Princeton University)
 27. Jie Lai, Ph.D., August 2001, Thesis: “Performance of Channel Coding on Temporally and Spatially Correlated Wireless Channels” (currently at Broadcom Inc.)
 28. Lei Song, Ph.D., August 2001, Thesis: “Resource Allocation Based on Hierarchical and Nonlinear Control in Wireless Networks” (currently at UTStar Telecom Inc.)
 29. Cem Saraydar, Ph.D., December 2000, Thesis: “Pricing and Power Control in Wireless Data Networks” (currently at GM Research)
- M.S. Students :
 1. Leonard Park, M. S. April 2016, Thesis: “Psychophysics Testbed and Experiments for Assessing End-User Perception of Video QoS over Wireless Channels”
 2. Cyrus Gerami, M.S. May 2011, Thesis: “Spatio-Spectral Mapping of TV White Space in NJ”
 3. Tejaswy Hari, M.S. October 2009, Thesis: “Implementation of an Adaptive MIMO-OFDM Cognitive Radio”
 4. Suhas Mathur, M. S. October 2006, Thesis: “Coalitional Games in Cooperative Networks”
 5. Omer Ileri, M. S. October 2003, Thesis: “Pricing for Enabling Forwarding in Wireless Adhoc Networks”
 6. Shrenik Patel, M.S., December 2002, Thesis: “Comparative Evaluation of OFDM and Single-Carrier Equalization Schemes for Infostation Channels” (currently at Time Domain Inc.)
 7. Andrej Domazetovic, M.S., September 2002, Thesis: “Propagation Models for Short-Range Wireless Channels with Predictable Path Geometries” (currently at Ibiquty Digital)
 8. Shaily Verma, M.S., July 2001, Thesis: “QoS Provisioning for Mobile Internet Access via GPRS/EDGE” (currently at Thomson Electronics)
 9. Dragan Samardzija, M.S., June 2000, Thesis: “Blind Interference Cancellation Schemes for DS-CDMA Systems” (currently at Lucent Technologies)
 10. Nan Feng, M.S., June 1999, Thesis: “Joint Power and Rate Optimization for Utility Maximization in Wireless Data Networks”, (currently pursuing Ph.D. at Rutgers)
 11. Kamesh Medapalli, M.S., December 1998, Thesis: “TDMA Interference Cancellation and Equalization using Tentative Decisions” (currently at Stanford University)
 12. Viral Shah, M.S., March 1998, Thesis: “Power Control for Wireless Data Services based on Utility and Pricing” (currently at Qualcomm, Inc.)
 13. Deepa Ramakrishna, M.S., June 1997, Thesis: “Subspace Based Estimation of the Signal to Interference Ratio for CDMA Cellular Systems”

CURRENT ADVISEES:

- Ph.D. & M.S. Students :
 1. Sijie Xiong, Ph.D. Thesis: Privacy and Resource Allocation in IoT (co-advisor with A. Sarwate)
 2. Mohsen Rajabpour, Ph.D. Thesis: Privacy and End-User Behavior with Applications to IoT and Smart Grid (co-advisor with A. Sarwate)

3. Alireza Nooraiepour, Ph.D. Thesis: Learning-Aided Physical Layer Security for IoT (co-advisor with W. Bajwa)
4. Nitya Sathyavageeswaran, Ph.D. Thesis: Privacy and Age of Information (co-advisor with A. Sarwate and R. Yates)
5. Zahra Aref, Ph.D. Thesis: Advanced Persistent Threats and End-User Behavior
6. Demetrios Lambropoulos, Ph.D. Thesis: Impact of End-User Behavior and Non Radio Attributes on Resource Allocation

UNDERGRADUATE RESEARCH INITIATIVES:

1. “Eagle Eye Multi UAV Reconnaissance,” Spring 2020. In this project, students designed and prototyped a multi UAV reconnaissance system for search and rescue operations when communications infrastructure is compromised. (Students: Kaavya Krishna-Kumar, Sagar Shah, Harmit Badyal, Abhishek Kondila)
2. “Tracking Rutgers Students for Traffic Optimization,” Spring 2015. In this project, students are designing a module that will use the Cisco CMX API to gather data, process it into useful metrics, and present it in a fashionable form to optimize transportation traffic across the Rutgers campuses. (Students: Jason Scatena, Dan Su, Samin Rahman, Peter Zhang)
3. “Resonance based Wireless Power Transfer,” Fall 2013. In this project, students designed a prototype device for remotely charging cell phones. (Students: Hiren Patel, Parth Patel, Nikunj Shah)
4. “Spectrum Sensing using GNU Radios” Fall 2006 and Spring 2007. In this project we use the GNU software defined radio toolkit to design a spectrum sensor which can sniff the spectrum of interest and identify transmitting devices (Student: Janani Kalyanam)
5. “Electrical Engineering Building WiFi Measurements & Analysis”, Spring 2007. A group of 6 undergraduate students conducting measurements, modeling and prediction of WiFi signal coverage in the EE building on Busch Campus at Rutgers University (Students: Rodney Gataeu, Daniel Austin, Francois M. Jean-Noel, Nandita Mitra, Shil Madiwala, Michael Kasmer)
6. “Wireless Networking Effects in Multistory Buildings using NetStumbler”, Spring 2007. A group of 7 undergraduate students conducting measurements, modeling and prediction of WiFi signal coverage in the coRe building on Busch Campus at Rutgers University (Students: Sunny Balwani, Tanya Busayadilok, Niharika Gajawelli, Janani Kalyanam, Rohan Panjwani, Priti Shah, Jerry Yick)
7. “Busch Campus Center WiFi Measurements & Analysis” Spring 2006. A group of 4 undergraduate students conducting measurements, modeling and prediction of WiFi signal coverage in the Busch Campus Center at Rutgers University (Students: Suhrid Bhatt, Smeet Modi, Jigar Pathak, Lakshmi Murthy)
8. “Implementation of a Blind Successive Interference Canceller for CDMA” Spring 2002. A group of 3 undergraduate students built an SPW system emulation for blindly cancelling CDMA encoded interference from CDMA encoded voice transmissions (Students : Ahmad Turk, John Youssuf, Pranav Amin)
9. “Simulations of Coding Spreading Tradeoffs in CDMA Systems” Fall 1999 and Spring 2000. One undergraduate student (Siamak Sorooshyari) worked on SPW simulations for understanding partitioning of bandwidth expansion in CDMA systems between channel coding and bandwidth spreading.
10. “Analysis and Design of an Infostation Testbed” (with Dr. I. Marsic): Fall 1999. A group of 7 undergraduate students building an infostation testbed including GUI and a rotating directional antenna to emulate drive-through and walk-through environments in an infostation setting (Students : Milton Cobo, Paul DiBenedetto, Phil Futernik, Michael Girone, Ulysses Gonzalez, Louis Lagonik, Nitish Sinha)

11. "Using Ad-Hoc Networks in Crisis Management" (with Dr. D. Goodman and Dr. I. Marsic): Spring 1999. A group of 15 undergraduate students built a demo including GUI and network support that facilitates multimodal collaboration across wired and wireless links in case of FIRE emergencies. (Students :S. Ali, E. Chen, O. Lewis, D. Mulato, M. Patel, A. Ogunshola, L. Rivera, A. Rowan, R. Sekhar, M. Shah, N. Shakir, D. Tabora, J. Tunis, K. Vapiwala, J. Vora)
12. "WCT: Wireless Collaborative Teleconferencing" (with Dr. D. Goodman): Fall 1998. A group of 13 undergraduate students worked on the creation of a concept that facilitates multimodal collaboration across wired and wireless links in case of FIRE emergencies. (Students :S. Ali, S. Chowdhury, C. Larson, G. Mittal, A. Ogunshola, T. Osinubi, L. Rivera, A. Rowan, R. Sekhar, N. Shakir, D. Tabora, J. Tunis, T. Zacharia)
13. "WISP-II: Wireless Internet Special Problems - Part II" (with Dr. D. Goodman): Spring 1998. A group of 10 undergraduate students worked on a prototype of the device "NaviDator" that provided location based mobile services including emergency and yellow page information. (Students: M. Anguin, A. Haidri, T. Holman, J. Ken-Kwofie, D. Ngo, A. Srivastava, R. Sharma, A. Tiwari, M. Vachharajani, A. Whittaker)
14. "WISP: Wireless Internet Special Problems" (with Dr. D. Goodman): Fall 1997. A group of 15 undergraduate students worked on the creation of a concept device called "NaviDator" that provided location based mobile services including emergency and yellow page information. (Students : M. Anguin, P. Boutros, M. Canuel, S. Ercilasun, A. Haidri, K. Harris, S. Ke, J. Ken-Kwofie, D. Ngo, A. Srivastava, R. Sharma, S. Tamhankar, A. Tiwari, M. Vachharajani, A. Whittaker)
15. "Bayesian Decision making in an AlterEgo server" : Spring 1997. Testing decision rules for message forwarding to mobile hosts in Email management servers (Student: Stephan Samuel)

UNDERGRADUATE CO-OP PROGRAM ADVISING:

1. Christopher Shin, Verizon Wireless (Jun-Dec 2001)
2. Swarna Gadiraju, Motorola (Aug-Dec 2001)

NEW COURSES

1. "Wireless Revolution" (14:332:301) (introduced in Fall 2008) This multidisciplinary course is intended for all undergraduate students (from engineering, science, arts, business, economics, and humanities) who have an interest in the strategic problems that emerge when companies and entrepreneurs set out to create successful new businesses. A primary objective of the course is to demonstrate (using wireless communications systems as an illustrative example) that students from all disciplines can understand a wide range of strategic issues at a basic, intuitive level, and can use this basic understanding to solve important real-world problems. Has been offered in Flip'd mode in 2020 and 2021.
2. "Wireless Instructional System Design" (introduced in Spring 2004): This instructional "hands-on" design course covers PHY, MAC, Networking and Application layers of wireless systems
3. "Wireless Communications Technologies" (introduced in Spring 1999): This course has since been adopted permanently into the graduate curriculum of the Department of Electrical & Computer Engineering, Rutgers University (Course No. 16:332:546)
4. "INFOSTATIONS- Challenges in the Creation of a New Wireless System" (Fall 1996). A multidisciplinary course involving graduate students from Electrical & Computer Engineering (ECE), Computer Science (CS), and School of Information and Library Studies (SCILS).

TEACHING

1. "Introduction to Computers for Engineers" - Fall 2015
2. "Wireless Revolution" - Spring 2021, 2020, 2019, 2018, 2017; Fall 2014, 2013, 2011, 2010, 2009, 2008

3. "Wireless Personal Communications Systems" - Spring 2007
4. "Probability and Random Processes" - Fall 2001,2000,1999
5. "Wireless System Design" - Spring 2004,2005
6. "Wireless Communication Technologies" - Spring 2015, 2013, 2011, 2009,2005, 2004,2002,2001,2000,1999
7. "Communications Engineering" - Fall 2007,2004,1998,1997
8. "Detection and Estimation Theory" - Spring 2014, 2012,2010,2008,2006,2003,1998,1997
9. "INFOSTATIONS- Challenges in the Creation of a New Wireless System" - Fall 1996

DEPARTMENT/SCHOOL/UNIVERSITY SERVICE AND ACTIVITIES:

1. University Network Infrastructure Steering Committee, 2020-21
2. School of Engineering, Distinguished Professor Promotion Committee, 2015-16
3. ECE Department Strategic Planning Committee, Rutgers University, 2006-present
4. ECE Undergraduate Curriculum Revision Committee, 2012-present
5. Member, Committee on Corporate Partnerships, Office of VP of Research and Economic Development, 2011-12
6. Chair, ECE Chair Search Committee, Rutgers University 2009-10
7. ECE Faculty Search Committee, Rutgers University 2006-2012
8. School of Engineering Academic Promotion and Tenure Committee, Rutgers University - 2007-2008, 2008-2009
9. Faculty Advisor, IEEE Student Branch, Rutgers University, Jan. 1997-December 2002
10. Engineering Orientation Lecture, Rutgers University - November 1996, November 1997, November 1998, December 2001, February 2002, Spring 2009, Fall 2012, Spring 2013,
11. Engineering Open House (led one ECE Department "Info-session" almost every year for the last several years)
12. Undergraduate and Graduate Student Advising
13. Graduate Committees: Scholastic Standing Committee, Graduate Admissions Committee
14. Undergraduate Committees: Scholastic Standing Committee
15. Marshall at School of Engineering Commencement Ceremonies, Rutgers University - 1996-1999, 2010,2011,2012

SOCIETY/TECHNICAL ACTIVITIES:

1. Distinguished Lecturer of the IEEE Communications Society (COMSOC), 2012-15
2. Technical Program Co-Chair, IEEE WiOPT 2011, Princeton NJ
3. Member, IEEE Technical Committee on Green Multimedia Communications (since 2010)
4. Guest Editor, IEEE JSAC Special Issue on Game Theory in Communications and Networking (September 2008)
5. Guest Editor, IEEE JSAC Special Issue on Spectrum Agile Cognitive Radio Networks (April 2007)
6. Editor, IEEE Transactions on Wireless Communications, 2002-2005
7. Associate Editor, IEEE Communications Letters, 1999-2002
8. IEEE Student Branch Counsellor, Rutgers University, Jan. 1997-Dec. 2002
9. Member of Technical Program Committees of several IEEE conferences over the last several years (e.g. ICC, Globecom, DySpaN, CrownComm, WiOPT)

10. Panel Leader and Organizer for “*Communicating in TV White Space*” at IEEE Communication Theory Workshop (CTW’2010), Cancun, Mexico, May 2010
11. Panelist for “*Towards Green Wireless*” at IEEE Saranoff Symposium, Princeton, NJ, April 2010
12. Session Chairman, ”Adhoc/Multihop Networks” IEEE International Symposium on Wireless Communications, ISWC’02, Victoria, British Columbia, Canada, September 2002
13. Session Chairman, ”MAC Performance” IEEE Vehicular Technology Conference, VTC’02 Fall, Vancouver, Canada, September 2002
14. Session Chairman, “CDMA”, Conference on Information Sciences and Systems, CISS’02, Princeton University, March 2002
15. Session Organizer and Chairman, “Multirate Spread Spectrum Techniques and Systems”, IEEE International Symposium on Spread Spectrum Techniques and Applications, ISSA’2000, Parsippany NJ, September 2000
16. Session Organizer and Chairman, “CDMA Performance Enhancements”, IEEE International Conference on Communications, ICC’98, Atlanta, GA, June 1998
17. Session Chairman, “Wireless Communications Systems” Conference on Information Sciences and Systems, CISS’99, The Johns Hopkins University, Baltimore, MD, March 1999.
18. Reviewer for IEEE Journals (Transactions on Communications, Transactions on Wireless Communications, Information Theory, Signal Processing, Vehicular Technology, Automatic Control and Selected Areas in Communications)
19. Panelist and Reviewer for National Science Foundation (NSF)