

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

TOGAIL TECHNOLOGIES LTD.,
Patent Owner.

IPR2023-00644
U.S. Patent No. 11,115,165

**DECLARATION OF DR. ZHI DING, PH.D.,
UNDER 37 C.F.R. § 1.68 IN SUPPORT OF PETITION FOR
INTER PARTES REVIEW**

TABLE OF CONTENTS

I.	Introduction	4
II.	Qualifications and Professional Experience.....	6
III.	Level of Ordinary Skill in the Art	12
IV.	Relevant Legal Standards.....	13
V.	Overview of the '165 Patent	15
VI.	Prosecution History of the '165 Patent	18
VII.	Technology Background -- Tutorial Background on QCL Assumptions, Reference Signals, Antenna Ports, and Demodulation	20
VIII.	Claim Construction	28
IX.	Identification of how the Claims are Unpatentable.....	29
A.	Ground 1: Claims 1-3, 5-9, 11, and 12 are obvious under 35 U.S.C. § 103 over Vilaipornsawai combined with Shin and Grant.....	30
1.	Summary of Vilaipornsawai	30
2.	Summary of Shin.....	35
3.	Reasons to Combine Vilaipornsawai and Shin	37
4.	Summary of Grant.....	42
5.	Reasons to Combine Vilaipornsawai, Shin, and Grant	45
6.	Claim 1	50
7.	Claim 2	76
8.	Claim 3	77
9.	Claim 5	80
10.	Claim 6	82
11.	Claim 7	84
12.	Claim 8	86

13.	Claim 9	86
14.	Claim 11	86
15.	Claim 12	87
B.	Ground 2: Claims 4 and 10 are obvious under 35 U.S.C. § 103 over Vilaipornsawai, Shin, and Grant combined with Xue.	87
1.	Summary of Xue	87
2.	Reasons to Combine Grant and Xue	89
3.	Claim 4	91
4.	Claim 10	93
X.	Conclusion.....	95

I, Dr. Zhi Ding, do hereby declare as follows:

I. INTRODUCTION

1. I am making this declaration at the request of Apple Inc. in the matter of the *Inter Partes* Review of U.S. Patent No. 11,115,165 (“the ’165 patent”) to Meister, *et al.*

2. I am being compensated for my work on this matter and for reasonable and customary expenses associated with my work and testimony in this investigation. My compensation is not contingent on the outcome of this matter or the specifics of my testimony, and I have no other interest in this case or the parties thereto.

3. I have been asked to provide my opinions regarding whether claims 1-12 (“the Challenged Claims”) of the ’165 patent are patentable, or whether they would have been obvious to a person having ordinary skill in the art (“POSITA”) at the time of the alleged invention, in light of the prior art. It is my opinion that all of the limitations of the challenged claims would have been obvious to a POSITA.

4. In the preparation of this declaration, I have studied:

- a. the ’165 patent, Ex.1001;
- b. the prosecution history of the ’165 patent (“’165 File History”),

Ex.1002;

c. International Publication No WO 2018/141246 by U. Vilaipornsawai et al. (“**Vilaipornsawai**”), Ex. 1005; and

d. U.S. Application Publication No. 2019/0068308 to C. Shin et al. (“**Shin**”), Ex. 1006;

e. U.S. Application Publication No. 2020/0280409 to S. Grant et al. (“**Grant**”), Ex.1007;

f. U.S. Patent No. 9,596,061 to A. Wallen et al., Ex.1008;

g. U.S. Patent No. 9,788,310 to W. Chen et al., Ex.1009;

h. U.S. Application Publication No. 2015/0349855 to S. Sesia et al., Ex.1010;

i. U.S. Application Publication No. 2019/0074880 to M. Frenne et al., Ex.1011;

j. U.S. Application Publication No. 2020/02601418 to Y. Xue et al. (“**Xue**”), Ex.1012;

k. International Publication No. WO 2020/118686 to Y. Gao et al.; Ex.1013;

l. U.S. Patent No. 8,897,253, Ex.1014; and

m. U.S. Patent No. 8,964,632, Ex.1016.

5. In forming the opinions expressed below, I have considered:

the documents listed above;

the relevant legal standards, including the standard for obviousness, and any additional authoritative documents as cited in the body of this declaration; and

my own knowledge and experience based upon my work in the field of networking as described below, as well as the following materials.

6. Unless otherwise noted, all emphasis in any quoted material has been added.

II. QUALIFICATIONS AND PROFESSIONAL EXPERIENCE

7. I presently hold the title of Distinguished Professor in the Department of Electrical and Computer Engineering at the University of California, Davis. Since my appointment on July 1, 2000, I have held the position of professor for the past 22 years and have served as a faculty member at several US universities for over 30 years. I am also a private technical consultant on various technologies related to information systems. I have more than three decades of research experience on a wide range of topics related data communications and signal processing.

7. I earned my Bachelor of Science degree in 1982 in wireless engineering from the Nanjing Institute of Technology (later renamed as Southeast University) in Nanjing, China. I earned my Master of Science degree in 1987 in electrical engineering from the University of Toronto in Toronto, Canada. I earned my

Ph.D. in 1990 in electrical engineering from Cornell University in Ithaca, New York.

8. My responsibilities as a Professor at University of California, Davis, include classroom instruction on various topics of communication systems and signal analysis, as well as mentoring undergraduate students and supervising graduate students in their research and development efforts on various topics related to digital communications. I have directly supervised such research and development works ranging from signal detection to wireless networking. As the chief academic advisor, I have also directly supervised the completion of over 20 Masters theses and 30 Ph.D. dissertations on various topics related to digital communications. I have served full time as a faculty member at three major research universities in the United States over the past 30 years, including Auburn University from 1990 to 1998, University of Iowa from 1999 to 2000, and University of California, Davis, from 2000 to present.

9. Since 1990, I have been selected as the principal investigator of multiple highly competitive federal and local research grants, including more than twenty major research projects supported by the National Science Foundation and two research projects funded by the U.S. Army Research Office. These competitive research projects focused on developing more efficient and effective digital communication transceivers, networks, and signal processing tools. I

have also participated in several large-scale projects supported by the Defense Advanced Research Projects Agency (DARPA) with teams of researchers. I have applied for, and received support from, other federal, state, and industry sponsors.

10. I have published over 210 peer-reviewed research articles in premier international journals, in addition to over 240 refereed technical articles at top international conferences on communications and information technologies. According to Google Scholar, my published works have been cited by over 13,000 times by peers. I also authored two books on communications technologies. My most recent book, coauthored with B.P. Lathi, is entitled, “Modern Digital and Analog Communication Systems,” 5th edition, and was published by the Oxford University Press in 2018. The 4th edition of this book (published in 2009) had been widely adopted as an introductory textbook to communication systems.

11. In addition to the over 450 published technical papers that have been cited over 15,000 times according to Google Scholar¹, I am also co-inventor of 4 issued U.S. patents on communication technologies.

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

¹ <https://scholar.google.com>

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

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

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

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

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

15. I have also served as a technical consultant for the telecommunication industry. For example, in 1995 I consulted for Analog Devices, Inc., on the development of the first generation DOCSIS cable modem systems. I have also

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

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

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

18. My complete qualifications and professional experience are described in my *Curriculum Vitae*, a copy of which can be found in Exhibit 1004.

III. LEVEL OF ORDINARY SKILL IN THE ART

19. I understand there are multiple factors relevant to determining the level of ordinary skill in the pertinent art, including (1) the levels of education and experience of persons working in the field at the time of the invention; (2) the sophistication of the technology; (3) the types of problems encountered in the field; and (4) the prior art solutions to those problems.

20. It is my understanding that the earliest possible priority date for the '165 patent is Nov. 2, 2018. I am familiar with the wireless communications art pertinent to the '165 Patent. I am also aware of the state of the art at the time of the alleged priority date. Based on the technologies disclosed in the '165 patent, a person of ordinary skill in the art ("POSITA") in the field of the '165 patent, as of the earliest possible priority date of Nov. 2, 2018, would include someone who had a master's degree from an accredited program in electrical engineering, computer engineering, computer science, or a related field, and three years of relevant experience in mobile communications or wireless networks; or a Ph.D. degree in one of the disciplines listed above and one year of relevant experience. Moreover, I recognize that someone with more technical education, but less experience could have also met this standard. I believe that I possessed and exceeded such

experience and knowledge before and at the priority date and that I am qualified to opine on the '165 Patent.

21. For purposes of this Declaration, in general, and unless otherwise noted, my statements and opinions, such as those regarding my experience and the understanding of a POSITA generally (and specifically related to the references I consulted herein), reflect the knowledge that existed in the field as of the earliest alleged priority date of the '165 patent (i.e., Nov. 2, 2018). Unless otherwise stated, when I provide my understanding and analysis below, it is consistent with the level of a POSITA as of the alleged priority date of the '165 patent.

IV. RELEVANT LEGAL STANDARDS

22. I am not an attorney. In preparing and expressing my opinions and considering the subject matter of the '165 patent, I am relying on certain basic legal principles that counsel have explained to me. These principles are discussed below.

23. I understand that prior art to the '165 patent includes patents and printed publications in the relevant art that predate the priority date of the alleged invention recited in the '165 patent.

24. I have been informed that a claim preamble may or may not limit the claim scope. For the purposes of this *Inter Partes* Review, I have been informed by counsel to include the preamble in the analysis for obviousness in order to follow a

conservative approach.

25. I have been informed that a claimed invention is unpatentable under 35 U.S.C. § 103 if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains. I have also been informed by counsel that the obviousness analysis takes into account factual inquiries including the level of ordinary skill in the art, the scope and content of the prior art, and the differences between the prior art and the claimed subject matter.

26. I have been informed that a threshold inquiry as to whether a reference can be considered in the obvious analysis is whether the reference is analogous art to the claimed invention. A reference is analogous art to the claimed invention if: (1) the reference is from the same field of endeavor as the claimed invention (even if it addresses a different problem); or (2) the reference is reasonably pertinent to the problem faced by the inventor (even if it is not in the same field of endeavor as the claimed invention).

27. I have been informed by counsel that the Supreme Court has recognized several rationales for combining references or modifying a reference to show obviousness of claimed subject matter. Some of these rationales include the following: (a) combining prior art elements according to known methods to yield

predictable results; (b) simple substitution of one known element for another to obtain predictable results; (c) use of a known technique to improve a similar device (method, or product) in the same way; (d) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results; (e) choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; and (f) some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

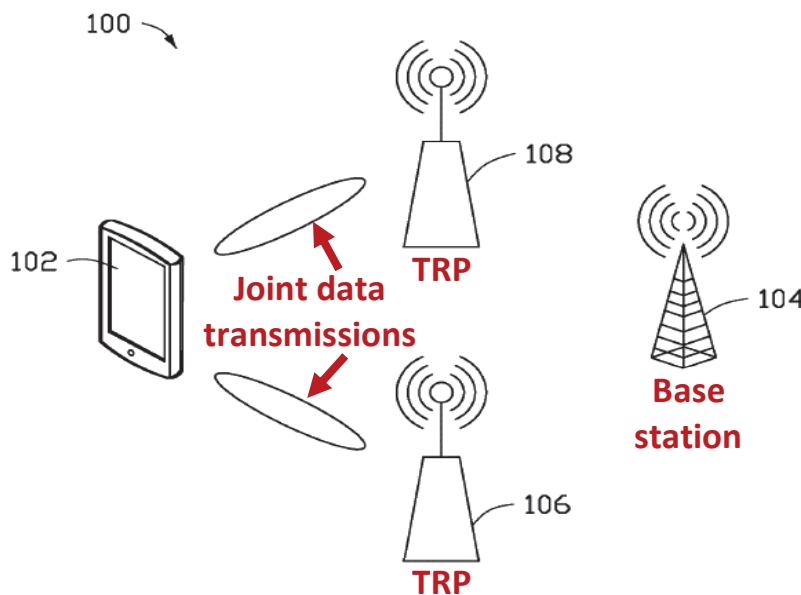
28. Also, I have been informed and understand that obviousness does not require physical combination or bodily incorporation but rather consideration of what the combined teachings of prior art references would have suggested to a POSITA at the time of the alleged invention.

V. OVERVIEW OF THE '165 PATENT

29. The '165 patent generally relates to “wireless communications, and more particularly, to methods and apparatuses for multiple Transmit/Receive Point (TRP) operations.” '165 patent, 1:18-20. According to the '165 patent, there was a purported “need in the art for an improved communication mechanism for multiple TRP operation.” '165 patent, 1:40-41.

30. FIG. 1 presents a multi-TRP system, having multiple TRPs 106 and

108 and a base station (BS) 104.



'165 patent, Figure 1

The TRPs 106 and 108 may be macro-cells, small-cells, pico-cells, femto-cells, Remote Radio Heads (RRHs), relay nodes or antenna panels, which may be deployed anywhere such as in the interior of a room, in/on a building, on top of a house or streetlamps. The UE 102 may connect to the BS 104 through the TRPs 106 and 108.

'165 patent, 5:8-13. The TRPs 106 and 108 may provide “directional beams towards the UE 102” and “may be jointly used in the data transmissions to the UE.” '165 patent, 5:14-18.

31. The '165 patent uses the terms “QCL assumptions” and “DMRS port groups,” with little by way of background explanation, thus assuming that a POSITA is familiar with these concepts. For example, the '165 patent recites:

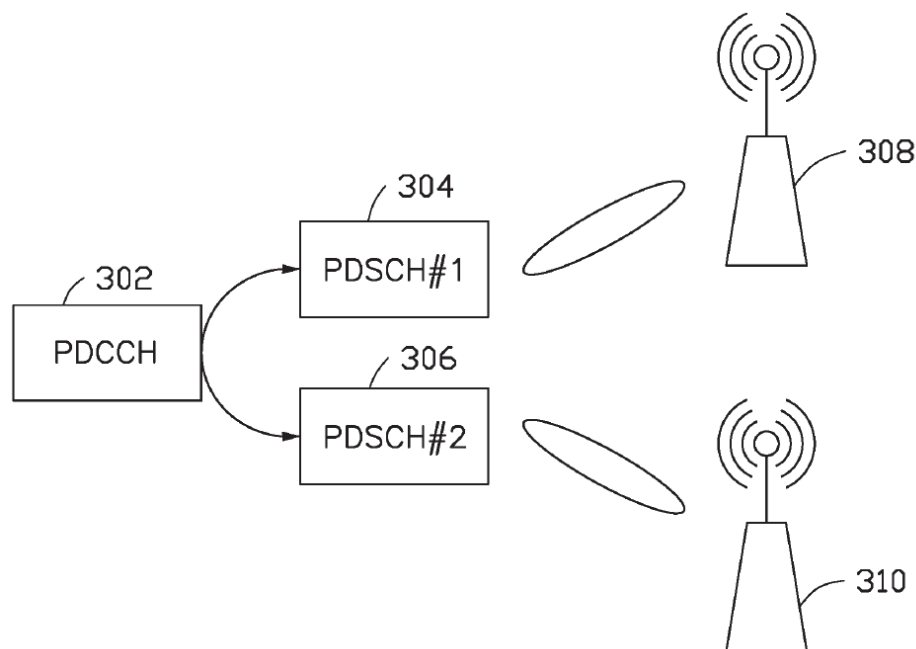
FIG. 2 is a flowchart for a process of multi-TRP operations, in accordance with example implementations of the present application. In action 202, the UE may receive TCI [Transmission Configuration Indicator] state data in a PDCCH determining multiple PDSCHs. The TCI state data may be associated with multiple **DMRS port groups**. In action 204, the UE may obtain multiple **QCL assumptions** for receiving the PDSCHs based on the **DMRS port groups** associated with the TCI state data.

'165 patent, 5:22-25. A POSITA's understanding of DMRS port groups, QCL assumptions, reference signals, and other items is presented in Section VII (Technology Background). "PDCCH" as used in the context of the '165 patent, as well as the prior art herein, is a well-known acronym of Physical Downlink Control Channel. Similarly, "PDSCH" is a well-known acronym of Physical Downlink Shared Channel.

32. The '165 patent describes control messages sent to a UE in a PDCCH to facilitate data communication with a UE using multiple PDSCHs from different TRPs. A control message may include Transmission Configuration Indicator (TCI) state data that is associated with multiple DMRS port groups.

33. For example, "FIG. 3 is a schematic diagram illustrating multiple PDSCHs determined from a single PDCCH." '165 patent, 6:4-5. "As shown in FIG. 3, the UE may receive DCI that contains a TCI state data ... from the PDCCH 302." '165 patent, 6:6-8. "For example, each TCI state may contain parameters for

configuring the QCL relationship between the DL/UL RS(s) [Reference Signal(s)] and the DM-RS port(s) of a corresponding PDSCH.” ’165 patent, 6:11-14. “In the example implementation, the UE may derive multiple PDSCHs based on the DMRS port groups associated with the TCI state data in the DCI, because each DMRS port group may correspond to one PDSCH.” ’165 patent, 6:23-26. “As shown in FIG. 3, the PDSCH #1 304 and PDSCH #2 306 may be associated with TRPs 308 and 310, respectively.” ’165 patent, 6:34-36.



’165 patent, Figure 3

VI. PROSECUTION HISTORY OF THE ’165 PATENT

34. The application that led to the ’165 patent was filed on November 4, 2019 and included original claims 1, 3, and 6 as follows (claim 1 was ultimately amended to include subject matter of claims 3 and 6 and independent claim 9 was

similarly amended):

1. A user equipment (UE) comprising:

one or more non-transitory computer-readable media having computer-executable instructions embodied thereon; and

at least one processor coupled to the one or more non-transitory computer-readable media, and configured to execute the computer-executable instructions to:

receive, in a Physical Download Control Channel (PDCCH), Transmission Configuration Indicator (TCI) state data for determining a plurality of Physical Downlink Shared Channels (PDSCHs), the TCI state data being associated with a plurality of Demodulation Reference Signal (DMRS) port groups; and

obtain a plurality of Quasi Co-Location (QCL) assumptions for receiving the plurality of PDSCHs based on the plurality of DMRS port groups associated with the TCI state data.

3. The UE of claim 1, wherein each of the plurality of QCL assumptions corresponds to one of the plurality of DMRS port groups.

6. The UE of claim 1, wherein the TCI state data corresponds to a TCI state configuration that includes a plurality of QCL Reference Signal (RS) sets, and each of the plurality of QCL RS sets corresponds to one of the plurality of DMRS port groups.

Ex.1002, 397-398.

35. A non-final rejection issued on April 2, 2021, in which independent claims 1 and 9 were rejected based on a combination of references including U.S. Patent Pub. No. 2020/0015200 to Vilaipornsawai et al. (Ex.1015), which is unrelated to Vilaipornsawai used herein (Ex.1005). Ex.1002, 182-184. Claims 3-6 were indicated as having allowable subject matter. Ex.1002, 187.

36. In response, Applicant amended claim 1 “to incorporate the allowable subject matter in dependent claim 3” and similarly amended independent claim 9

“to incorporate the allowable subject matter of dependent claim 11.” Ex.1002, 176.

37. The Notice of Allowance, received on June 16, 2021, includes an Examiner’s amendment in which claim 1 was amended to also include the subject matter of claim 6 and claim 9 was similarly amended to also included the subject matter of original claim 14. Ex.1002, 151-152. The ’165 subsequently issued on September 7, 2021.

VII. TECHNOLOGY BACKGROUND -- TUTORIAL BACKGROUND ON QCL ASSUMPTIONS, REFERENCE SIGNALS, ANTENNA PORTS, AND DEMODULATION

38. The ’165 patent introduces the term “Quasi Co-Location (QCL) assumptions” in the Detailed Description with little additional context, assuming that a POSITA is familiar with the term. For example, the ’165 Patent states:

In action 204, the UE may obtain multiple **QCL assumptions** for receiving the PDSCHs based on the DMRS port groups associated with the TCI state data.

The **QCL assumptions** may include different parameters, such as the spatial-domain QCL parameters (e.g., QCL TypeD parameter), or other QCL parameters such as, at least one of the average delay, the delay spread, the Doppler shift, and the Doppler spread. For example, each QCL assumption may include at least one of a time-domain QCL parameter, a frequency-domain QCL parameter, and a spatial-domain QCL parameter.

’165 patent, 5:24-35.

39. A POSITA would have been familiar with the concept of QCL assumptions in the context of well-known Long-Term Evolution (LTE or 4G) and 5G wireless systems. The concept of Quasi Co-Location (QCL) assumptions was introduced in LTE to simplify and enhance channel estimation used for demodulation. Thus, before discussing QCL assumptions, demodulation and channel estimation are discussed.

40. Fundamentally, “[d]emodulation of sent data requires estimation of the radio channel, which is done by using transmitted reference symbols (RS), i.e., symbols known a priori by the receiver.” U.S. Patent Pub. 2015/0349855 (Ex.1010), [0007]. There are various reference signals defined for the purpose of channel estimation, including a demodulation reference signal (DMRS) and a Channel State Information Reference Signal (CSI-RS):

LTE also supports UE-specific RS aimed only for assisting channel estimation for demodulation purposes, referred to as demodulation reference symbols (DMRS). Because the DMRS is precoded, in MIMO operations, with the same precoding matrix as that used for the PDSCH transmission, the DMRS cannot be used to generate Channel Quality Indicator (CQI), Precoding Matrix Index (PMI), or Rank Indicator (RI) feedback values. Accordingly, another reference signal, referred to as the Channel State Information Reference Signal (CSI-RS), is cell-specific and used by UEs 30 to generate CQI, PMI, and RI.

U.S. 2015/0349855, [0007]. A DMRS is specifically intended for a certain UE

(“UE-specific”), whereas a CSI-RS is specific to a cell (“cell-specific”) and can be used by all UEs in a cell. CSI-RS and DMRS signals were well-known signals that were a pre-existing part of LTE cellular systems, as discussed above.

41. A “DMRS port” generally refers to an antenna port used for DMRS transmission (and also for PDSCH transmission). For example, the prior art refers to an “antenna port mapping” for DMRS reference signals, and illustrates an example mapping in Figure 4B, where each square is a time-frequency resource element (U.S. Patent No. 9,596,061 (Ex.1008), 7:1-10):

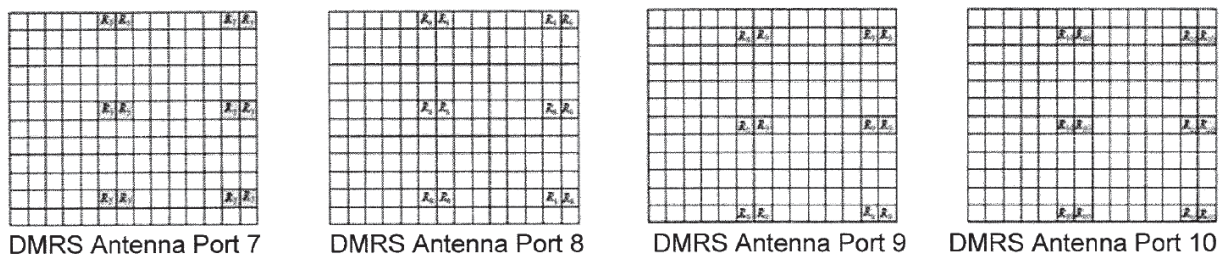


FIG. 4B

Ex.1008, Figure 4B

The shaded time-frequency resource elements represent time-frequency resource elements allocated for transmitting DMRS from each antenna port. A first pattern of time-frequency resource elements is allocated to transmit DMRS from antenna ports 7 and 8 and a second pattern of time-frequency resource elements is allocated to transmit DMRS from antenna ports 9 and 10.

Ex.1008, 7:4-10.

42. An “antenna port” was a well-known concept. It was known that

reference signals may be mapped to antenna ports, such that an antenna port may be designated as a type of antenna port, such as a DMRS port:

Reference signals 135 may be mapped to and transmitted from antenna ports. Antenna ports may represent logical antennas. An antenna port may map to one or more physical antenna. In multi-antenna transmission schemes, such as transmit diversity and Multiple-Input Multiple-Output (MIMO), multiple antenna ports may transmit multiple types of reference signals.

U.S. Patent No. 9,596,061 (Ex.1008), 5:53-59; *see also* Ex.1016, 11:17-19 (“The antenna port types correspond to types of reference signals transmitted by the ports. Some examples of antenna port types are DMRS...”). In 4G and 5G cellular systems, transmitters and receivers may be equipped with multiple antennas to increase reliability and/or throughput. *See, e.g.*, Ex.1010, [0004] (“LTE additionally supports Multiple-input multiple-output (MIMO) operation, in which both transmitter and receiver are equipped with multiple antenna ports, allowing for transmit diversity and closed-loop spatial multiplexing.”).

43. Furthermore, antenna ports may be grouped according to whether the ports share some mutual dependence with respect to associated channel parameters, yielding benefits for channel estimation:

Some embodiments disclosed herein provide the UE with selected information about RS ports grouping, in order to allow channel estimator implementations to exploit common channel properties

for different RS ports and/or RS types within a group. The information comprises e.g. of signaling which reference signals may be assumed to be used in combination with each other to form a channel estimate corresponding to a certain antenna port. Similarly but stated differently, which antenna ports may be assumed to have channels that can be utilized for inferring properties of the channel over which symbols for the antenna port of interest is conveyed. That is, the UE may be signaled that it is allowed to assume that reference signals on some antenna ports may be used to assist in the channel estimation of a channel for another antenna port.

The antenna ports whose channels exhibit such mutual dependence can be said to form a group. In practice, this assumption would allow the UE to assume that at least some statistical properties of the channels are similar over different antenna ports. **Such information allows the UE to jointly estimate channel properties and to achieve increased estimation accuracy for the corresponding channels estimates.** Thus, particular embodiments **enable improved channel estimation** by enabling joint channel parameters when it is applicable.

Ex.1016, 6:56-7:12.

44. Thus, providing the flexibility in a wireless system to designate a set of antenna ports as a “group,” if they share common channel properties, and also associating a type of reference signal with the set of ports is beneficially used to simplify channel estimation.

45. A “transmission/reception point,” or TRP, is also a term of art used in

LTE and 5G, referring to a set of antenna ports covering a geographic area. For example:

The concept of a transmission point is heavily used in CoMP. In this context, a transmission point (or simply a point) corresponds to a set of antenna ports covering essentially the same geographical area in a similar manner. ... Stated differently, a transmission point is a set of antenna ports that are geographically collocated.

U.S. Patent Pub. No. 2015/0349855 (Ex.1010), [0009].

The network node 101 may include one or more antenna ports 103 (e.g., antenna array, **transmission/reception points (TRP)**, or the like) that may transmit a first reference signal 111 (e.g., a broadcasted reference signal such as an SS² block).

U.S. Patent Pub. No. 2019/0074880 (Ex.1011), [0065].

46. DMRS signals are particularly useful in coordinated multipoint (CoMP) scenarios. The use of DMRS signals allows “flexible transmission schemes to be used from the network side,” such as data being transmitted from different TRPs, so that a UE may estimate channels for data transmission from each TRP.

DMRS or UE-specific RS are employed for demodulation of data channels and possibly certain control channels (ePDCCH). Data may be transmitted from different points [e.g., transmission points] than

² SS is acronym of synchronization signal.

other information (e.g. control signaling). This is one of the main drivers behind the use of UE-specific RS, which relieves the UE from having to know many of the properties of the transmission and thus allows flexible transmission schemes to be used from the network side. This is referred to as transmission transparency (with respect to the UE).

Ex.1016, 4:45-59.

47. Returning to QCL³ assumptions, QCL assumptions are used to simplify and enhance channel estimation. For example, different antenna ports may be said to be quasi co-located with respect to certain channel properties if they share these same properties. Also, the network may recognize that certain repeating/recurring cell-specific reference signals, such as CSI-RS, are QCL with certain UE-specific reference signals, such as DMRS, that are transmitted less often.

According to the LTE terminology, it is said that two antenna ports are **quasi co-located (QCL)** with respect to a certain long term channel property X when such long term channel property X may be assumed to be the same for both ports by the UE 30. ...

UEs 30 may exploit knowledge of the QCL assumptions in a number of ways. For example, the complexity of channel estimation algorithms

³ “QCL” may refer to “quasi co-location” or “quasi co-located,” depending on the context. “Quasi co-located” is also sometimes abbreviated as “QCLed.”

may be reduced by avoiding individual estimation of channel properties that are QCLed between different antenna ports. Another advantage is the possibility of extracting channel properties from certain ports which allow accurate estimation and applying them to other QCLed ports that do not allow equally good estimation. Other applications are also possible, one example being the indication of QCL assumptions between DMRS and CSI-RS. Since estimation of long term channel properties from DMRS is challenging, the DMRS QCL assumptions in LTE allow estimating selected long term channel properties from a signaled CSI-RS resource and applying them to DMRS, to aid DMRS estimation. Other UE 30 implementations might exploit QCL between CSI-RS and DMRS by jointly exploiting certain channel properties from both RS types, and applying them to aid estimation of either or both such RS types.

U.S. 2015/0349855 (Ex.1010), [0013]-[0014]. As recited above, an important and known advantage of QCL assumptions among antenna ports is “the possibility of extracting channel properties from certain ports which allow accurate estimation and applying them to other QCLed ports that do not allow equally good estimation.” And an advantage of QCL assumptions between DMRS signals and other reference signals (e.g., CSI-RS) is allowing “estimating selected long term channel properties from a signaled CSI-RS resource and applying them to DMRS, to aid DMRS estimation.”

48. Also, different reference signals also may be said to be quasi co-

located with respect to certain channel properties if they share the same properties, such as the same frequency shift, Doppler spread, received timing, and/or delay spread. For example:

Two reference signals that are transmitted from the same or from different cells can be said to be **quasi-co-located (QCL)** if they have at least the same frequency shift, Doppler spread, received timing, and/or delay spread from the UE perspective. CoMP operation may require certain PDSCH resource element (RE) mapping, and QCL of channel state information reference signals (CSI-RS) and user equipment reference signals (UE-RS) (also known as demodulation reference signals (DMRS)).

U.S. 9,788,310 (Ex.1009), 9:56-64.

49. In summary, antenna ports may be recognized by the network as being quasi co-located (QCL) such that the ports form a group, and different reference signals may also be recognized by the network as being QCL. Examples of “QCL assumptions” are assumptions that a UE could use regarding antenna ports, reference signals, and/or associated channel estimation parameters to perform channel estimation more efficiently and accurately. And channel estimates are subsequently used to receive data, such as in a PDSCH.

VIII. CLAIM CONSTRUCTION

50. It is my understanding that in order to properly evaluate the ’165 patent, the terms of the claims must first be interpreted. It is my understanding that

for the purposes of this *inter partes* review, the claims are to be construed under the so-called *Phillips* standard, under which claim terms are given their ordinary and customary meaning as would be understood by one of ordinary skill in the art in light of the specification and prosecution history, unless the inventor has set forth a special meaning for a term. For the purposes of my analysis below, I do not believe any claim terms require explicit construction.

IX. IDENTIFICATION OF HOW THE CLAIMS ARE UNPATENTABLE

51. I have been asked to provide my opinion as to whether the Challenged Claims of the '165 patent would have been obvious in view of the prior art. The discussion below provides a detailed analysis of how the prior art references identified below teach the limitations of the Challenged Claims of the '165 patent.

52. As part of my analysis, I have considered the scope and content of the prior art and any differences between the alleged invention and the prior art. I describe in detail below the scope and content of the prior art, as well as differences between the alleged invention and the prior art, on an element-by-element basis for each Challenged Claims of the '165 patent.

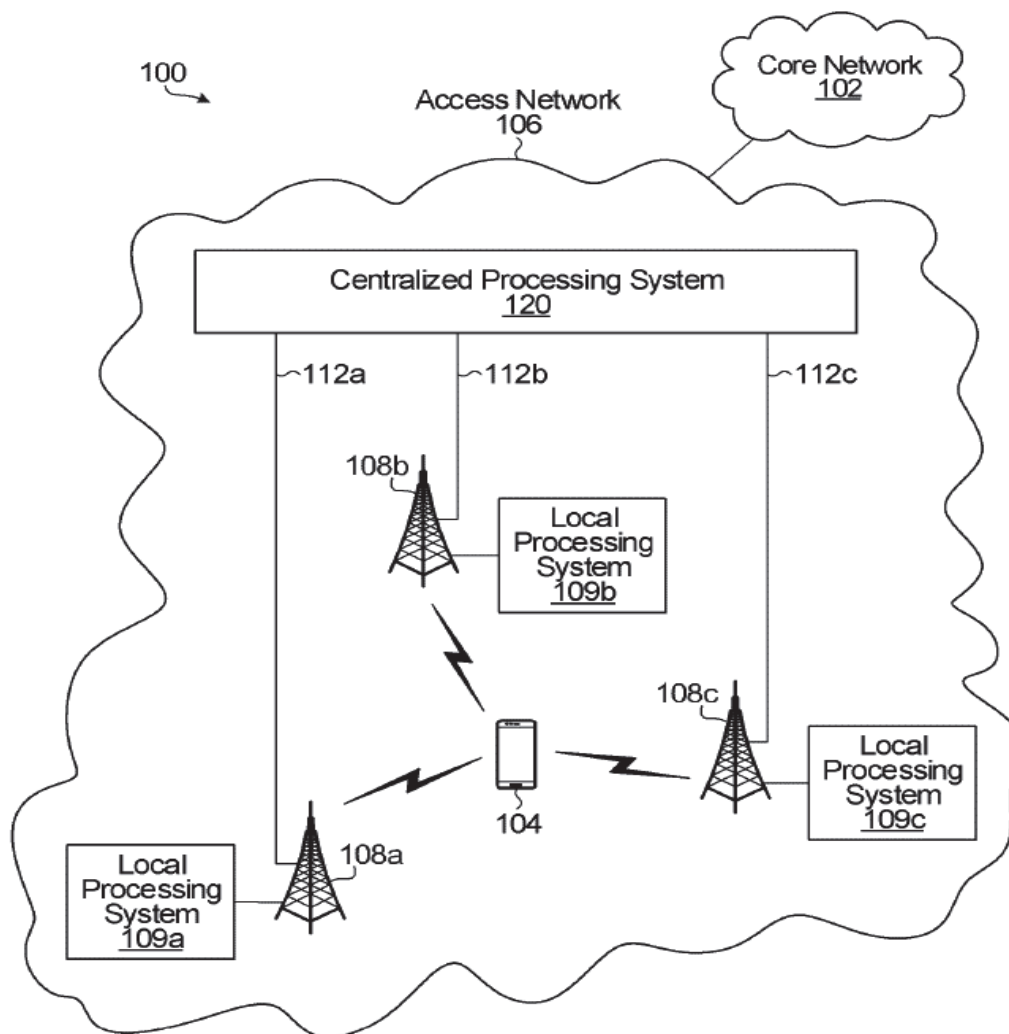
53. As described in detail below, the alleged invention of the Challenged Claims would have been obvious in view of the teachings of the identified prior art references as well as the knowledge of a POSITA.

A. Ground 1: Claims 1-3, 5-9, 11, and 12 are obvious under 35 U.S.C. § 103 over Vilaipornsawai combined with Shin and Grant.

1. Summary of Vilaipornsawai

54. Vilaipornsawai recognizes that many wireless networks include “data channels” and “control channels.” Vilaipornsawai, [0050]. For example, LTE networks include downlink channels: “data channels such as Physical Downlink Shared Channel (PDSCH) ... and control channels such as PDCCH (Physical Downlink Control Channel).” Vilaipornsawai, [0050].

55. Figure 1 illustrates a “communication system 100” that “includes a core network 102 and an access network 106.” Vilaipornsawai, [0054]. Furthermore, “the network elements 108a-c may be configured to serve UE 104 in accordance with one or more CoMP [Coordinated Multi-Point] transmission schemes, such as Dynamic Point Selection (DPS) or Non-Coherent Joint Transmission. In these network coordination schemes, the same or different downlink PDSCH data stream (s) can be transmitted to a UE from multiple TRPs.” Vilaipornsawai, [0061].

**FIG. 1**

Villaipornsawai, Figure 1

56. Vilaipornsawai is concerned with providing “mechanisms to support one or more PDCCH (s) for network coordination schemes such as those being

contemplated for NR⁴ to support the delivery of the same or different PDSCH data stream (s) to a UE from multiple TRPs.” Vilaipornsawai, [0052]; *see also* [0005].

57. Vilaipornsawai addresses a scenario in which a UE receives different PDSCHs from multiple transmission-reception points (TRPs):

For the NC-JT scenario in which multiple PDSCHs, e.g. multiple TBs are transmitted from multiple TRPs, either single or multiple PDDCH [sic]⁵ messages are required to convey the DCI for the multiple PDSCHs from the multiple TRPs.

Vilaipornsawai, [0067]; *see also* [0068], [0114], [0116], [0159], [0166], [0170], [0188] (Example Embodiments 1 and 2).

58. In a section entitled “DCI [Downlink Control Information] content,” Vilaipornsawai discloses “a single PDCCH message” that has one or more “resource assignment fields” for scheduling “multiple PDSCHs.” Vilaipornsawai, [0116].

59. Vilaipornsawai also discloses that the DCI of a PDCCH carries “DMRS information” for UEs to use to perform channel estimation and receive multiple PDSCH(s). Vilaipornsawai, [0113]-[0114] (“**[T]he content of the DCI**

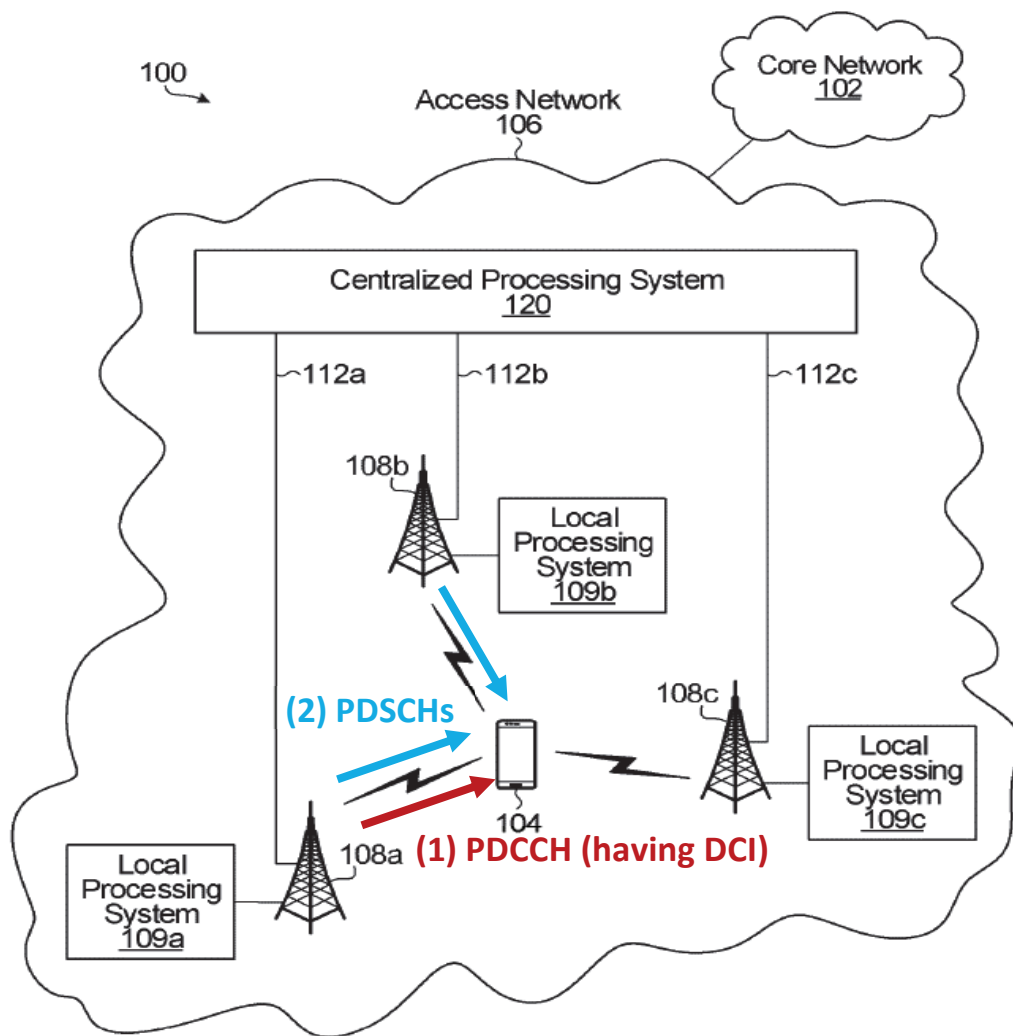
⁴ “NR” refers to “New Radio,” another term for certain 5G cellular networks. *See*, e.g., Vilaipornsawai, [0003]; *see also* ’165 patent, 1:24-27.

⁵ “PDDCH” is a typo and should instead be “PDCCH.”

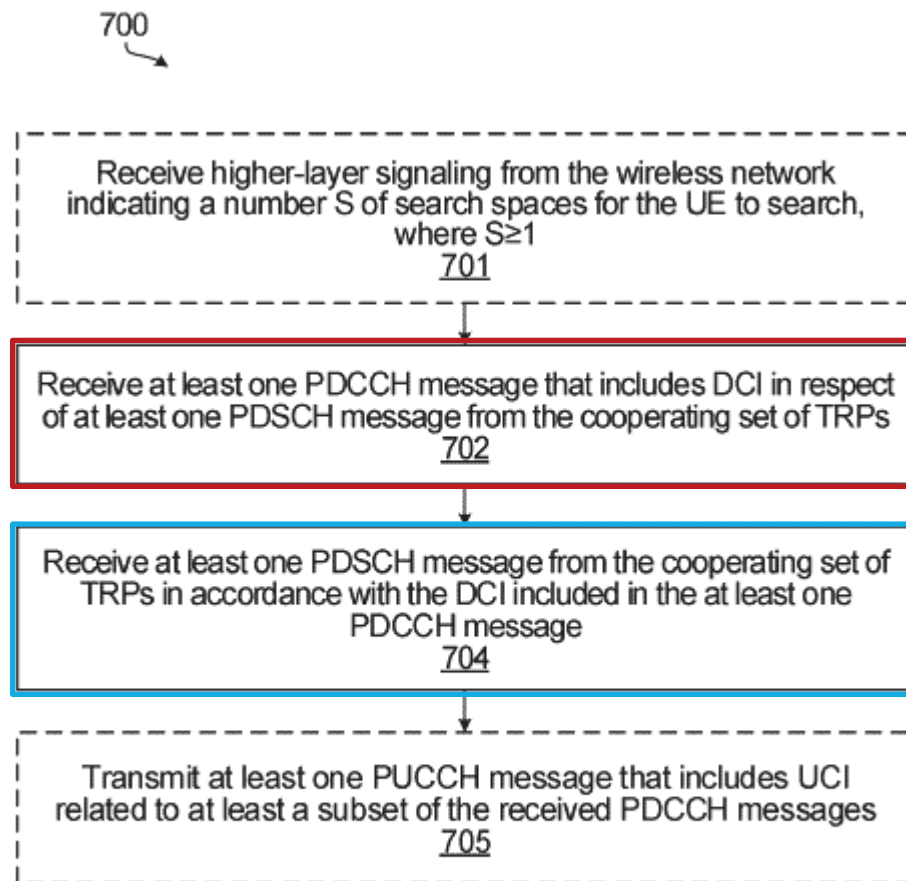
carried in PDCCH messages may include, in addition to the LTE DCI content for different DCI formats, **additional content such as one or more of DMRS information for PDSCH(s).**”); [0115] (“From the UE perspective, upon receiving ... multiple DMRSs, a UE can obtain channel estimate (s) for decoding ... multiple PDSCHs.”).

60. Thus, Vilaipornsawai describes a system in which different TRPs (transmission-reception points) transmit different PDSCHs to a UE in a joint transmission (JT) scenario, and a single TRP transmits downlink control information (DCI) information in a PDCCH for scheduling the multiple PDSCHs, with the DCI including “DMRS information” for the transmissions.

Vilaipornsawai’s transmission of a (1) PDCCH (having DCI including scheduling information for multiple PDSCHs and also DMRS information) followed by (2) joint transmission of PDSCHs from “a cooperating set of TRPs” is illustrated below in Figures 1 and 16 (in which the color coding annotation is coordinated).

**FIG. 1**

Villaipornsawai, Figure 1 (annotated in color)

**FIG. 16**

Villaipornsawai, Figure 16 (annotated in color)

2. Summary of Shin

61. Shin is directed to cellular wireless communications, such as LTE and 5G/NR systems. Shin, [0008] (“An aspect of the disclosure provides a DMRS port grouping and signaling method in a 5G wireless communication system supporting non-coherent joint transmission (NC-JT).”). The communication system may

support joint transmission from multiple TRPs to a single UE. *Id.*, [0008], [0200], Figure 11 (illustrating transmission from multiple transmission points to a UE). Furthermore, the “radio resources are allocated for transmitting different signals,” including “DMRS ... PDSCH [and] control channels [such as] PDCCH.” *Id.*, [0050]-[0052].

62. Shin provides examples of DMRS information, such as DMRS port groups, that would have been beneficial to include in the DCI of a PDCCH in systems such as Vilaipornsawai. Shin provides detailed examples of “DMRS information” communicated to a UE in NR (New Radio)/5G systems, recognizing that the use of “DMRS port grouping” would be beneficial in multi-TRP networks that employ joint transmission (JT):

When supporting the downlink/uplink common DMRS structure, it is important to consider DMRS information signaling efficiency. **In the NR system, the DMRS information may include information as follows:**

...

DMRS port grouping information

Shin, [0062].

The DMRS port grouping information is used for the NC-JT or phase tracking reference signal (PTRS) transmission, and the signaling method thereof is described with respect to a fourth embodiment of the disclosure.

Shin, [0071].

The DMRS port grouping may be performed for various purposes. The **DMRS port grouping may be performed for NC-JT**. As a CoMP technique for multiple TP [transmission points] to transmit different data simultaneously, the NC-JT assumes different QCLs for different TPs to receive the data transmitted by the different TPs and estimate channels accurately.

Shin, [0200].

3. Reasons to Combine Vilaipornsawai and Shin

63. As a threshold matter, Vilaipornsawai and Shin are analogous art to the '165 patent, as all three documents are directed to cellular wireless communications, such as LTE and 5G/NR systems. '165 patent, 3:37-48 (“A radio communication network architecture (e.g., a Long Term Evolution (LTE) system, an LTE-Advanced (LTE-A) system, an LTE-Advanced Pro system, or a 5G New Radio (NR) Radio Access Network (RAN)) typically includes at least one Base Station (BS), at least one User Equipment (UE), and one or more optional network elements that provide connection towards a network.”); Vilaipornsawai, [0003] (“Coordinated MultiPoint (CoMP) or Joint Transmission (JT) CoMP” has been considered for “5G”/“NR” “wireless networks”); Shin, [0008] (“An aspect of the disclosure provides a DMRS port grouping and signaling method in a 5G wireless communication system supporting non-coherent joint transmission (NC-JT).”).

64. In addition, all three documents are related to methods and

apparatuses relating to cellular communication involving data transmission to the UE from multiple TRPs. *See, e.g.*, '165 patent, 1:18-20 and Figure 1; Vilaipornsawai, [0005] (“Aspects of this disclosure provide mechanisms to support one or more PDCCH (s) for network coordination schemes such as those being contemplated for NR to support the delivery of the same or different PDSCH data stream (s) to a UE from multiple TRPs.”); Shin, [0200] (“The DMRS port grouping may be performed for various purposes. The DMRS port grouping may be performed for NC-JT. As a CoMP [Cooperative MultiPoint] technique for multiple TP [transmission points] to transmit different data simultaneous, the NC-JT assumes different QCLs for different TPs to receive the data transmitted by the different TPs and estimate channels accurately.”); Fig. 11 (illustrating transmission from multiple transmission points to a UE); Grant, [0006] (describing “[d]ifferent [indicator] states [that] may correspond to different TRP pairs, supporting, e.g., non-coherent joint transmission (NC-JT) from a pair of TRPs to the UE.”).

65. Turning to reasons to combine Vilaipornsawai and Shin, it is my opinion that it would have been obvious for a POSITA to combine Vilaipornsawai and Shin to provide the obvious, beneficial, and predictable result of including Shin’s DMRS port grouping information in Vilaipornsawai’s “DMRS information” in Vilaipornsawai’s multi-TRP system, in which each TRP may beneficially have multiple antennas. *See, e.g.*, Vilaipornsawai, [0164] (“Although a single antenna

614 is shown in Figure 15, a TRP could include multiple antennas. Separate receive and transmit antennas or sets of multiple antennas could be provided at 614...”).

66. Vilaipornsawai does not specify the details of its “DMRS information,” beyond that “the same or different DMRSs” can be used by the network and this “DMRS information” is specified in the DCI. Vilaipornsawai, [0114]. A POSITA implementing Vilaipornsawai’s system for joint transmission from multiple TRPs, each having multiple antennas, would have been motivated to specify “DMRS information” in such a way as to provide the system the flexibility to group antenna ports together into port groups (and indicate those groups to a UE) for the purpose of simplifying and improving channel estimation and also to be able to associate various reference signals, such as DMRS signals, with those grouped ports, to form DMRS port groups, as taught in Shin, also to simplify and improve channel estimation.

67. Shin provides detailed examples of “DMRS information” communicated to a UE as “DMRS port grouping information” in joint transmission (JT) scenarios:

When supporting the downlink/uplink common DMRS structure, it is important to consider DMRS information signaling efficiency. **In the NR system, the DMRS information may include information as follows:**

...

DMRS port grouping information

Shin, [0062]; [0071] (“The DMRS port grouping information is used for the NC-JT...”), [199] (“A DMRS grouping configuration method is provided herein... If it is determined at step h11 that the number of the number of DMRS port groups is two or more...”); [0200] (“The DMRS port grouping may be performed...for NC-JT.”).

68. For multi-TRP scenarios (e.g., NC-JT), according to Shin, it is “necessary to transmit the DMRS port grouping information to the UE for NC-JT.” Shin, [0200]. For example, there may be different DMRS port groups for different TPs (Shin uses the term “TP” or transmission point, whereas Vilaipornsawai uses TRP⁶). As an example, “[f]or 3-layer NC-JT with 1-layer transmission from TP1 and 2-layer transmission from TP2, it may be possible to select DMRS port 0 for TP1 and DMRS ports 2 and 3 for TP2.” Shin, [0204]. And, as discussed previously, the QCL assumptions among different DMRS ports in a DMRS port group (and different DMRS port groups, each having different QCL assumptions, for different TPs) may be used to facilitate improved channel estimation. In other

⁶ Regardless of whether Shin’s TP also includes a receiver, the relevant teachings as applied to the claims of the ’165 patent relate only to transmitting by the TP and corresponding receiving by a UE (the claims relate to a UE receiving certain information). Nonetheless, Shin’s TP would have been understood as performing two-way communication with a UE such that a TP also receives wireless signals.

words, providing the flexibility in a wireless system to designate a set of antenna ports as a “group,” if they share common channel properties, and also associating a type of reference signal with a group of ports are beneficially used to improve or simplify channel estimation. Ex.1016, 6:56-7:10 (A UE is provided “selected information about RS ports grouping, in order to allow channel estimator implementations to exploit common channel properties for different RS ports and/or RS types within a group. ... Such information allows the UE to jointly estimate channel properties and to achieve increased estimation accuracy for the corresponding channels estimates.”); 11:17-19 (“The antenna port types correspond to types of reference signals transmitted by the ports,” such as “DMRS”).

69. There would have been a reasonable expectation of success in combining Vilaipornsawai and Shin. Vilaipornsawai contemplates the use of multiple antennas at each TRP, referring to TRPs having “beams” and “panels,” which was well-known circuitry referring to multiple antennas per panel. Vilaipornsawai, [0068] (“To support DL cooperation from multiple TRPs/beams/panels, single or multiple PDCCH message (s) can be transmitted from a single TRP.”); [0164] (“Although a single antenna 614 is shown in Figure 15, a TRP could include multiple antennas. Separate receive and transmit antennas or sets of multiple antennas could be provided at 614, or the same antenna or set of

multiple antennas could be used for both receiving and transmitting communication signals.”) Thus, at least in some examples, Vilaipornsawai’s TRPs would have had multiple antennas and therefore multiple antenna ports. As explained in Section VII (Technology Background), a POSITA would have understood that “[a]ntenna ports may represent logical antennas. An antenna port may map to one or more physical antenna[s].” Ex.1008, 5:53-59. And a POSITA would have understood that a “DMRS port” generally refers to an antenna port used for DMRS transmission. Thus, Shin presents an example of “DMRS information” that would have been beneficial for a UE to use to receive information from TRPs having multiple antennas (such as in Vilaipornsawai).

70. Combining Vilaipornsawai with Shin represents combining prior art elements, namely, further specifying the DMRS information carried by bits or fields in Vilaipornsawai’s DCI as Shin’s DMRS port groups, according to known methods (using bits to represent and signal DMRS port groups) to yield the predictable result of Vilaipornsawai’s DCI communicating or indicating DMRS port group information to a UE in a multi-TRP system in which each TRP employs multiple antennas.

4. Summary of Grant

71. Grant is directed to cellular wireless communications, such as LTE and 5G/NR systems. Ex.1007, [0092]. The communication system may support

joint transmission from multiple TRPs to a single UE. *Id.*, [0006] (describing “[d]ifferent [indicator] states [that] may correspond to different TRP pairs, supporting, e.g., non-coherent joint transmission (NC-JT) from a pair of TRPs to the UE.”). Grant also involves “transmission of a channel (e.g., ... PDSCH, PDCCH) or reference signal,” such as “DMRS.” *Id.*, [0157], [0007], [0181].

72. Grant uses the term “Transmission Configuration Indicator (TCI)” to refer to an N-bit indicator in the DCI (of a PDCCH). Grant, [0008] (“Throughout this disclosure the following generic name for the N-bit indicator is used: Transmission Configuration Indicator (TCI).”); [0271], [0283] (“The UE is signaled the N-bit TCI field in DCI...”). The TCI value indicates two reference signal (RS) sets and a QCL relationship for a DMRS port group per RS set, wherein each RS set refers to one or more RSs which are QCLeD with DMRS ports within corresponding DM-RS group. Ex.1007, [0005]-[0009], [0168]-[0170].

73. Consistent with Shin’s techniques, the signaling of DMRS port groups in DCI is confirmed by Grant, which describes the use of an “N-bit indicator” transmitted via “DCI signaling.” Grant, [0005]. Grant refers to an “agreement” at a

3GPP standards meeting⁷ that “establishes that an N-bit indicator field in DCI provides at least a spatial QCL reference to a downlink reference signal (DL RS) (either CSI-RS or SSB) to aid in the demodulation of PDSCH.” Grant, [0003]-[0004]. Furthermore, Grant explains that in the “same 3GPP meeting, an agreement for facilitating “multi-TRP operation” was reached about the “N-bit indicator,” in which

each indicator state [i.e., TCI state] is associated with one or two RS [reference signal] sets, where each RS set refers to one or two downlink DMRS port groups, respectively. This facilitates QCL indication in the case of that multi-TRP operation (DL CoMP) is configured. Different states may correspond to different TRP pairs supporting, e.g., non-coherent joint transmission (NC-JT) from a pair of TRPs to the UE.

Grant, [0006]. Furthermore, “[e]ach [indicator] state refers to one or two RS sets, which indicates a QCL relationship for one or two DMRS port group(s), respectively,” and “[e]ach RS set refers to one or more RS(s) which are QCLeD with DM-RS ports within corresponding DM-RS group.” Grant, [0005]; *see also* Grant, [0269]. Finally, Grant specifies a name for its N-bit indicator transmitted in

⁷ 3GPP is a standards body responsible for LTE and 5G/NR standardization. Much of what is relied upon from Grant was apparently previously agreed upon at a 3GPP standards meeting, further reflecting the desirability of Grant’s teachings.

DCI: “**Transmission Configuration Indicator (TCI).**” Grant, [0008], [0271], [0283].

5. Reasons to Combine Vilaipornsawai, Shin, and Grant

74. As a threshold matter, Grant is analogous art to the ’165 patent, as all documents (’165 patent, Vilaipornsawai, Shin, and Grant) are directed to cellular wireless communications, such as LTE and 5G/NR systems. ’165 patent, 3:37-48; Grant, [0092] (“[P]articular embodiments of the wireless network may implement communication standards, such as Global System for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS), Long Term Evolution (LTE), and/or other suitable 2G, 3G, 4G, or 5G standards.”).

75. In addition, all documents are related to methods and apparatuses relating to cellular communication involving multiple TRPs. *See, e.g.*, ’165 patent, 1:18-20 and Figure 1; Vilaipornsawai, [0005] (“Aspects of this disclosure provide mechanisms to support one or more PDCCH (s) for network coordination schemes such as those being contemplated for NR to support the delivery of the same or different PDSCH data stream (s) to a UE from multiple TRPs.”); Shin, [0200] (“The DMRS port grouping may be performed for various purposes. The DMRS port grouping may be performed for NC-JT. As a CoMP [Cooperative MultiPoint] technique for multiple TP [transmission points] to transmit different data simultaneous, the NC-JT assumes different QCLs for different TPs to receive the

data transmitted by the different TPs and estimate channels accurately.”); Grant, [0006] (describing “[d]ifferent [indicator] states [that] may correspond to different TRP pairs, supporting, e.g., non-coherent joint transmission (NC-JT) from a pair of TRPs to the UE.”).

76. It is my opinion that it would have been obvious to a POSITA to combine Grant with the previously-discussed teachings of Vilaipornsawai and Shin to provide the obvious, beneficial, and predictable result of including Grant’s TCI in the DCI of Vilaipornsawai and Shin to indicate QCL relationships among DMRS port groups (e.g., Shin’s DMRS port groups) and other, cell-specific, reference signals to improve channel estimation and the reception of DMRS signals, thereby improving reception of the corresponding PDSCH messages in a multi-TRP system.

77. Grant uses the term “Transmission Configuration Indicator (TCI)” to refer to an N-bit indicator in the DCI (of a PDCCH). The TCI value indicates two reference signal (RS) sets and a QCL relationship for a DMRS port group per RS set, wherein each RS set refers to one or more RSs which are QCLed with DMRS ports within corresponding DMRS group.

78. Consistent with Shin’s techniques, the signaling of DMRS port groups in DCI is confirmed by Grant, which describes the use of an “N-bit indicator” transmitted via “DCI signaling.” Grant, [0005]. Grant refers to an “agreement” at a

3GPP meeting that “**establishes that an N-bit indicator field in DCI provides at least a spatial QCL reference to a downlink reference signal (DL RS) (either CSI-RS or SSB) to aid in the demodulation of PDSCH.**” Grant, [0004].

Furthermore, Grant explains that in the “same 3GPP meeting, an agreement for facilitating “multi-TRP operation” was reached about the “N-bit indicator,” in which

each indicator state [i.e., TCI state] is associated with one or two RS [reference signal] sets, where each RS set refers to one or two downlink DMRS port groups, respectively. This facilitates QCL indication in the case of that multi-TRP operation (DL CoMP) is configured. Different states may correspond to different TRP pairs supporting, e.g., non-coherent joint transmission (NC-JT) from a pair of TRPs to the UE.

Grant, [0005]-[0006]. Furthermore, “[e]ach [indicator] state refers to one or two RS sets, which indicates a QCL relationship for one or two DMRS port group(s),” and “[e]ach RS set refers to one or more RS(s) which are QCLeD with DM-RS ports within corresponding DM-RS group.” Grant, [0005]; *see also* Grant, [0269].

Finally, Grant specifies a name for its N-bit indicator transmitted in DCI:

“**Transmission Configuration Indicator (TCI).**” Grant, [0008], [0271].

79. An RS, such as a CSI-RS, can be a cell-specific reference signal as was understood in the art. By contrast, it was known that a DMRS is a UE-specific reference signal. CSI-RS and DMRS signals were well-known signals that were

(and are) a pre-existing part of wireless cellular systems, such as LTE systems. By indicating a QCL relationship between an “RS set” (e.g., indicating CSI-RS) and a “DMRS port group(s),” long term channel properties gleaned by the UE from receiving CSI-RS can be used in conjunction with information gleaned from receiving DMRS signals on DMRS ports to aid DMRS-based channel estimation. As explained in elsewhere in the art, “[o]ther applications are also possible, one example being the indication of QCL assumptions between DMRS and CSI-RS. Since estimation of long term channel properties from DMRS is challenging, the DMRS QCL assumptions in LTE allow estimating selected long term channel properties from a signaled CSI-RS resource and applying them to DMRS, **to aid DMRS estimation.**” U.S. Patent Publication No. 2015/0349855 (Ex.1010), [0014].

Thus, it would have been obvious to a POSITA to combine Grant with Vilaipornsawai and Shin to yield the obvious, predictable, and beneficial result of including Grant’s TCI in the DCI of Vilaipornsawai and Shin (combining prior art elements) to indicate QCL relationships among DMRS port groups (e.g., Shin’s DMRS port groups) and other, cell-specific, reference signals to improve channel estimation and the reception of DMRS signals in the case of multi-TRP operation.

80. As explained in Section VII (Technology Background), an advantage of QCL assumptions among antenna ports is the possibility of extracting channel properties from certain ports which allow accurate channel estimation and applying

them to other QCLed ports that do not allow equally good estimation. Ex.1010, [0013]-[0014]. And an advantage of QCL assumptions between DMRS signals and other reference signals (e.g., CSI-RS) is to allow estimating selected long term channel properties from a signaled CSI-RS resource and applying them to DMRS, to aid DMRS estimation. Ex.1010, [0013]-[0014].

81. Different reference signals also may be said to be quasi co-located (QCL or QCLed) with respect to certain channel properties if they share the same properties, such as frequency shift, Doppler spread, received timing, and/or delay spread. U.S. 9,788,310 (Ex.1009), 9:56-64.

82. And Grant further clarifies the different QCL connections that may exist between reference signals, in that the PDSCH DMRS could be configured to be QCL with CSI-RS/SSB with respect to spatial parameters, but QCL with Tracking Reference Signal (TRS) with respect to non-spatial (time/frequency) parameters:

In any case, an RS set contains one or more DL RSs. ... In the case of more than one DL RS ... the PDSCH DMRS could be configured to be QCL with CSI-RS/SSB with respect to spatial parameters, but QCL with TRS with respect to non-spatial (time/frequency) parameters.

Grant, [0007].

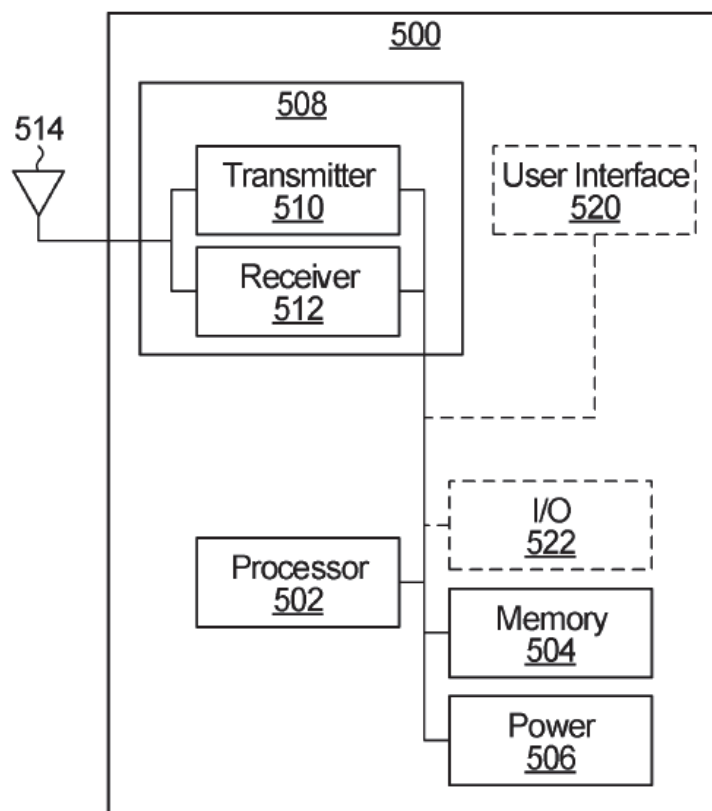
83. Owing to the advantages provided by the use of TCI that includes RS sets and QCL information as applied to a UE receiving PDSCH messages in a

multi-TRP scenario, and the fact that Vilaipornsawai, Shin, and Grant all involve similar multi-TRP (multi-TP) wireless communication systems communicating PDSCH messages based on 5G/NR concepts, a POSITA would have had a reasonable expectation of success in including Grant's TCI (indicating RS sets and QCL information) in the DCI of Vilaipornsawai-Shin.

6. Claim 1

[1.0] *A user equipment (UE) comprising:*

84. Vilaipornsawai discloses a UE: "Figure 14 is a block diagram of a UE according to an embodiment of the present disclosure." Vilaipornsawai, [0041].

**FIG. 14**

Ex.1001, Figure 14

Thus, Vilaipornsawai discloses “*user equipment (UE).*”

[1.1] *one or more non-transitory computer-readable media having computer-executable instructions embodied thereon; and*

85. Vilaipornsawai discloses or renders obvious claim element [1.1]. For example, Vilaipornsawai recites:

Moreover, it will be appreciated that any module, component, or device disclosed herein that executes instructions may include or otherwise have access to a non-transitory computer/processor readable storage medium or media for storage of information, such as computer/

processor readable instructions, data structures, program modules, and/or other data. A non-exhaustive list of examples of non-transitory computer/processor readable storage media includes magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, optical disks such as compact disc read-only memory (CD-ROM) , digital video discs or digital versatile discs (i.e. DVDs) , Blu-ray Disc TM, or other optical storage, volatile and non-volatile, removable and non-removable media implemented in any method or technology, random-access memory (RAM) , read-only memory (ROM) , electrically erasable programmable read-only memory (EEPROM) , flash memory or other memory technology.

Vilaipornsawai, [0047]. Vilaipornsawai's UE in Figure 14 includes a "memory 504." Vilaipornsawai, [0160]. Furthermore, "[t]he memory 504 may store programming and/or instructions for the processor 502 including instructions for sending, receiving, processing and supporting different services and types of data, such as but not limited to video, VoIP calls, web browsing data, email and other text communications." Vilaipornsawai, [0160].

86. Thus, Vilaipornsawai's disclosure of a UE having a memory storing instructions, with such a memory understood as an example of a "*non-transitory computer-readable media*," discloses or renders obvious "*one or more non-transitory computer-readable media having computer-executable instructions embodied thereon.*"

[1.2] *at least one processor coupled to the one or more non-transitory computer-readable media, and configured to execute the computer-executable instructions to:*

87. Vilaipornsawai discloses or renders obvious claim element [1.2].

88. Vilaipornsawai's UE in Figure 14 includes a "processor 502" ("processor") coupled to a "memory 504" ("*non-transitory computer-readable media*") for processing instructions, thereby disclosing [1.2]:

The memory 504 may store programming and/or instructions for the **processor 502** including instructions for sending, receiving, processing and supporting different services and types of data, such as but not limited to video, VoIP calls, web browsing data, email and other text communications.

Vilaipornsawai, [0160].

[1.3] *receive, in a Physical Downlink Control Channel (PDCCH), Transmission Configuration Indicator (TCI) state data for determining a plurality of Physical Downlink Shared Channels (PDSCHs), the TCI state data being associated with a plurality of Demodulation Reference Signal (DMRS) port groups; and*

89. Vilaipornsawai combined with Shin renders obvious claim element [1.3]. Vilaipornsawai combined with Shin and Grant also renders obvious claim element [1.3].

Vilaipornsawai combined with Shin

90. **First**, Vilaipornsawai describes a system in which different TRPs (transmission-reception points) transmit different PDSCHs to a UE in a joint transmission (JT) scenario, and a single TRP transmits downlink control

information (DCI) information in a PDCCH for scheduling the multiple PDSCHs, with the DCI including “DMRS information” for the transmissions.

91. Vilaipornsawai recognizes that many wireless networks include “data channels” and “control channels.” Vilaipornsawai, [0050]. For example, LTE networks include “data channels such as Physical Downlink Shared Channel (PDSCH) ... and control channels such as PDCCH (Physical Downlink Control Channel).” Vilaipornsawai, [0050].

92. And the PDCCH carries DCI:

The PDCCH carries control information that is referred to as Downlink Control Information (DCI). The DCI may include control information such as resource allocation of PDSCH (which may be referred to as Downlink (DL) grant, because it identifies the time-frequency resource element (s) allocated/granted for downlink data transmissions) In other words, the DCI carried by PDCCH instructs a User Equipment (UE) where and how to find and decode its downlink data in PDSCH.

Vilaipornsawai, [0051].

Embodiments of the present disclosure provide mechanisms to support one or more PDCCH (s) for network coordination schemes such as those being contemplated for NR to support the delivery of the same or **different PDSCH data stream (s) to a UE from multiple TRPs.**

Vilaipornsawai, [0052]. “NR” refers to “fifth generation (5G) or New Radio (NR) wireless networks” being developed. Vilaipornsawai, [0053].

93. Vilaipornsawai contemplates a joint transmission (JT) scheme that in which a single PDCCH message is used to convey the DCI for multiple PDSCHs:

NC-JT [noncoherent-joint transmission] schemes may involve transmitting the same or **different data/codewords from different TRPs** and the resource allocation on different TRPs may be the same or different. For example, in one scenario, different data/codewords are transmitted to a UE from different TRPs, with each TRP performing adaptive precoding independently.

...

For the NC-JT scenario in which **multiple PDSCHs**, e.g. multiple TBs [transport blocks] are transmitted from multiple TRPs, either **single** or multiple **PDDCH [sic] messages** are required to convey the DCI for the **multiple PDSCHs** from the multiple TRPs.

Vilaipornsawai, [0065]-[0067].

94. In a section called “DCI content,” Vilaipornsawai discloses “a single PDCCH message” that has one or more resource assignment fields for scheduling multiple PDSCHs:

For transmission of a **single PDCCH message for multiple PDSCHs**, **DCI carried by a PDCCH message** can have either a single resource assignment field or multiple resource assignment fields. For a single resource assignment field, the resources of multiple PDSCHs are fully overlapped. With multiple fields for resource assignments with one-to-one or one-to-many correspondence to PDSCHs, then the assigned

resource for multiple PDSCHs can be partially overlapped, fully overlapped, or non-overlapped.

Vilaipornsawai, [0116].

95. Vilaipornsawai addresses a scenario in which a UE receives different PDSCHs from multiple transmission-reception points (TRPs):

For the NC-JT scenario in which multiple PDSCHs, e.g., multiple TBs are transmitted from multiple TRPs, either single or multiple PDCCH [*sic*] messages are required to convey the DCI for the multiple PDSCHs from the multiple TRPs.

Vilaipornsawai, [0067].

To support DL cooperation from multiple TRPs/beams/panels, single or multiple PDCCH message (s) can be transmitted from a single TRP. ... However, if a single PDCCH message is transmitted from a single TRP for multiple PDSCHs from multiple TRPs, and the single PDCCH message only conveys one resource assignment, then multiple TBs will have overlapped time-frequency resources, because each PDSCH has the same resource assignment conveyed in the DCI of the single PDCCH message.”

Vilaipornsawai, [0068]; *see also* [0114], [0116], [0159], [0166], [0170], [0188] (Example Embodiments 1 and 2).

96. Thus, Vilaipornsawai discloses that the DCI in a PDCCH from a single TRP informs a UE about the resource assignments (time/frequency resources) so that the UE is informed on when and where (in time and frequency)

to receive different PDSCHs from different TRPs (e.g., PDSCHs from different TRPs can occupy the same or different resources).

97. As was understood in the art, because of dynamic wireless channel distortions on PDSCH signals, UEs would have to perform channel estimation for a PDSCH in order to successfully or more accurately receive the PDSCH data. A demodulation reference signal (DMRS) is a UE-specific reference signal used by the UE for demodulating the associated channel (e.g., used with PDSCH). *See* U.S. 2015/0349855 (Ex.1010), [0007] (“LTE also supports UE-specific RS aimed only for assisting channel estimation for demodulation purposes, referred to as demodulation reference symbols (DMRS).”).

98. Vilaipornsawai also discloses that the DCI of a PDCCH carries “DMRS information” for UEs to use to perform channel estimation for, and receive, multiple PDSCHs:

“In some embodiments, the content of the DCI carried in PDCCH messages may include, in addition to the LTE DCI content for different DCI formats, additional content such as **one or more of DMRS information for PDSCH(s)**...”

With respect to **DMRS information** for PDSCH(s):

...

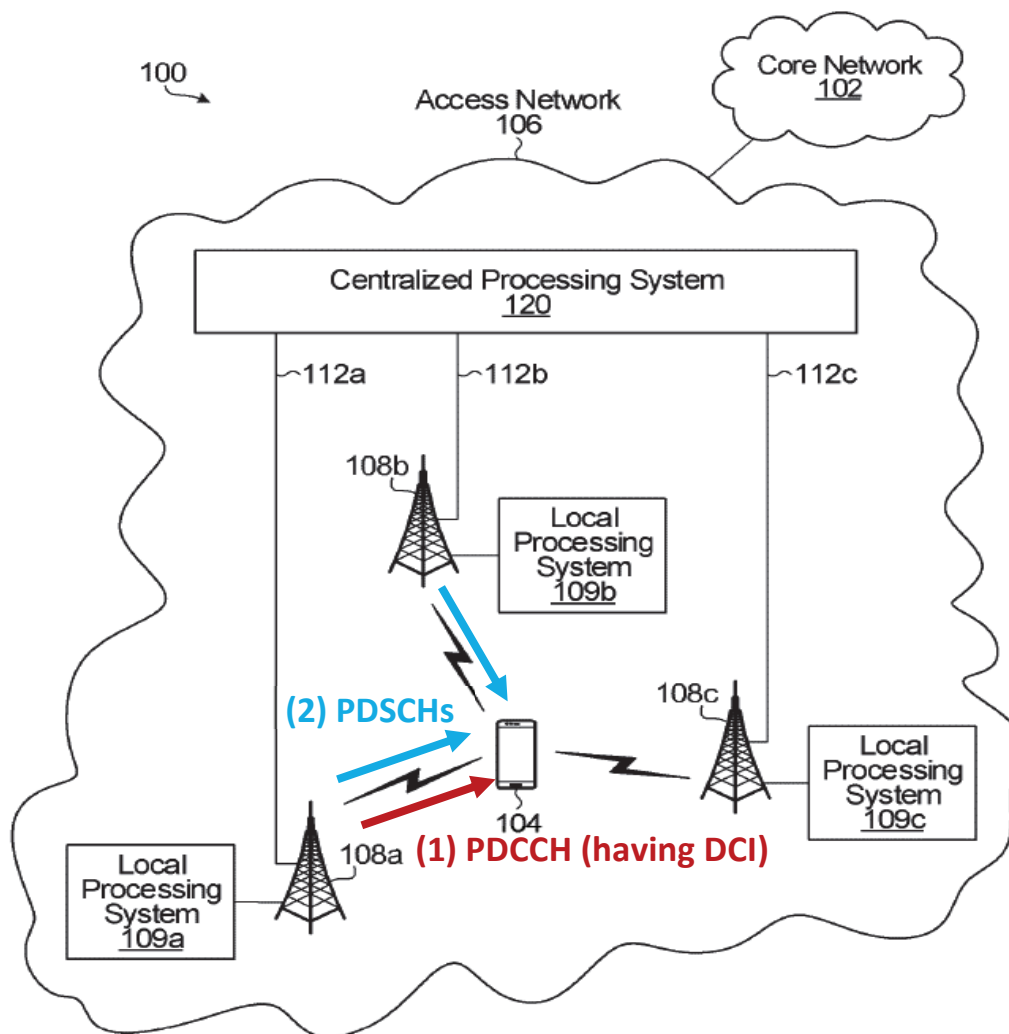
- For transmission of a single PDCCH message corresponding to multiple PDSCHs from multiple TRPs/beams/panels, resource assignment in PDSCH can be non-overlapping, partial or fully

overlapping. Non-overlapping or partial overlapping is only possible if the PDCCH message contains multiple resource assignment fields. In case of partial or fully overlapping resources, there should be **different DMRSs for different PDSCHs**.

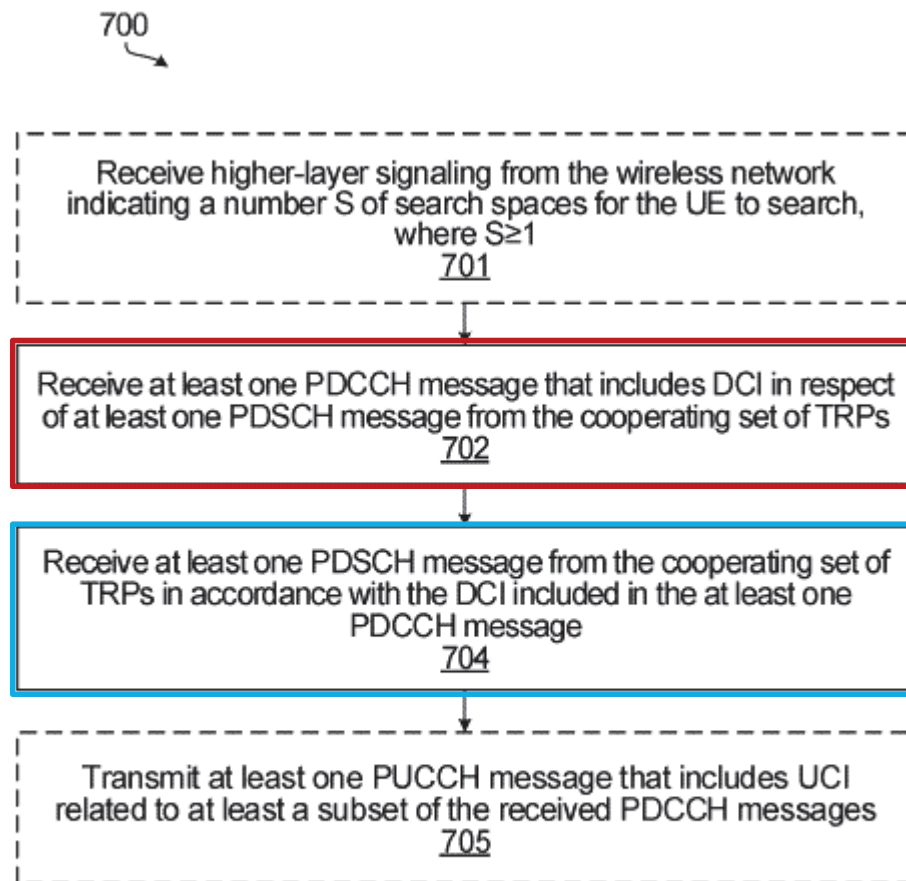
Vilaipornsawai, [0113]-[0114]. In other words, if different PDSCHs use “fully overlapping” resources (e.g., sent in the same time/frequency resources from different TRPs) or partially overlapping resources, different DMRSs (i.e., DMRS information) for different PDSCHs are needed to demodulate the PDSCHs from the different TRPs.

99. Thus, Vilaipornsawai describes a system in which different TRPs (transmission-reception points) transmit different PDSCHs to a UE in a joint transmission (JT) scenario, and a single TRP transmits downlink control information (DCI) information in a PDCCH for scheduling the multiple PDSCHs, with the DCI including “DMRS information” for the transmissions.

100. Vilaipornsawai’s transmission of a (1) PDCCH (having DCI including scheduling information for multiple PDSCHs and also DMRS information) followed by (2) joint transmission of PDSCHs from different TRPs is illustrated below.

**FIG. 1**

Villaipornsawai, Figure 1 (annotated in color)

**FIG. 16**

Villaipornsawai, Figure 16 (annotated in color)

101. Second, Shin provides examples of the “DMRS information,” such as DMRS port groups, that would have been included in the DCI of a PDCCH.

102. Vilaipornsawai does not specify the detailed structure of its “DMRS information,” beyond that “the same or different DMRS’s can be used by different TRPs” and this “DMRS information” is specified in the DCI. A POSITA

implementing Vilaipornsawai's system for joint transmission from multiple TRPs would have been motivated to specify the details of the "DMRS information" structure communicated to a UE, particularly in such a way to simplify and improve channel estimation for TRPs having multiple antennas (see Reasons to Combine Vilaipornsawai and Shin, Section IX.A.3). Shin provides detailed examples of "DMRS information" communicated to a UE in such a scenario:

When supporting the downlink/uplink common DMRS structure, it is important to consider DMRS information signaling efficiency. **In the NR system, the DMRS information may include information as follows:**

...

DMRS port grouping information

Shin, [0062].

The DMRS port grouping information is used for the NC-JT or phase tracking reference signal (PTRS) transmission, and the signaling method thereof is described with respect to a fourth embodiment of the disclosure.

Shin, [0071].

103. The "fourth embodiment" referenced above is described in paragraphs [0194]-[0223] of Shin, which includes the following disclosure:

The fourth embodiment is directed to a method for **signaling DMRS port grouping information as part of the DMRS signaling**

information and a UE operation. The NR system supports DMRS grouping, which is defined as follows:

The NR system supports DMRS grouping, which is defined as follows: DMRS ports within one DMRS port group are QCL-ed, and DMRS ports in different groups are non-QCL-ed; and

Two antenna ports are QCL-ed (quasi co-located) if the large-scale properties of the channel over which a symbol on one antenna port is conveyed can be inferred from the channel over which a symbol on the other antenna port is conveyed. The large-scale properties include one or more of delay spread, Doppler spread, Doppler shift, average gain, average delay, and spatial reception parameters.

Shin, [0194]-[0196].

DMRS port grouping information may be configured ... via ... DCI.

Shin, [0198].

DMRS port grouping configuration method is provided herein... If it is determined at step h11 that the number of DMRS port groups is two or more, the UE checks the configured DMRS type at step h30... [T]he UE performs channel estimation based on the RS at the DMRS port locations and QCL information at step h40.

Shin, [0199].

Accordingly, it is necessary to transmit the DMRS port grouping information to the UE for NC-JT. As described above, the DMRS port grouping information may be transmitted in a hybrid form of RRC/MAC-CE/DCI or only via DCI.

Shin, [0200].

104. Thus, for multi-TRP scenarios (e.g., NC-JT), according to Shin, it is “necessary to transmit the DMRS port grouping information to the UE for NC-JT.” Shin, [0200]. For example, there may be different DMRS port groups for different TPs (e.g., TRPs). As an example, “[f]or 3-layer NC-JT with 1-layer transmission from TP1 and 2-layer transmission from TP2, it may be possible to select DMRS port 0 for TP1 and DMRS ports 2 and 3 for TP2.” Shin, [0204]. The QCL assumptions among different DMRS ports in a DMRS port group (and different DMRS port groups, each having different QCL assumptions, for different TPs or TRPs) may be used to assist UE channel estimation.

105. Without explicitly using the term “Transmission Configuration Indicator (TCI),” Vilaipornsawai combined with Shin discloses a UE receiving DCI (in a single PDCCH) that carries resource assignment fields for scheduling multiple PDSCHs from different TRPs and also carries “DMRS information” for the different PDSCHs (Vilaipornsawai), and discloses “DMRS information” as representing different DMRS port groups (Shin), thereby rendering obvious *receive, in a Physical Downlink Control Channel (PDCCH), Transmission Configuration Indicator (TCI) state data for determining a plurality of Physical Downlink Shared Channels (PDSCHs), the TCI state data being associated with a plurality of Demodulation Reference Signal (DMRS) port groups.*

Vilaipornsawai combined with Shin and Grant

106. Vilaipornsawai combined with Shin and Grant also renders obvious claim element [1.3], as shown below.

107. Grant uses the term “Transmission Configuration Indicator (TCI)” to refer to an N-bit indicator within the DCI (of a PDCCH). Each of the N-bit indicator state is associated with at least one index of a DL RS (CRI or SSB index) and is associated with one or two reference signal (RS) set(s) where each RS set refers to one or two downlink DMRS port groups, respectively. The received TCI value indicates one or two RS set(s) and a QCL relationship for a DMRS port group per RS set, wherein each RS set refers to one or more RSs which are QCLed with DM-RS ports within corresponding DM-RS group.

108. Consistent with Shin’s techniques, the signaling of DMRS port groups in DCI is confirmed by Grant, which describes the use of an “N-bit indicator” transmitted via “DCI signaling.” Grant, [0005]. Grant refers to an “agreement” at a 3GPP meeting that “establishes that an N-bit indicator field in DCI provides at least a spatial QCL reference to a downlink reference signal (DL RS) (either CSI-RS or SSB) to aid in the demodulation of PDSCH.” Grant, [0004]. Furthermore, Grant explains that in the “same 3GPP meeting, an agreement for facilitating “multi-TRP operation” was reached about the “N-bit indicator,” in which

each indicator state [i.e., TCI state] is associated with one or two RS [reference signal] sets, where each RS set refers to one or two downlink DMRS port groups, respectively. This facilitates QCL indication in the

case of that multi-TRP operation (DL CoMP) is configured. Different states may correspond to different TRP pairs supporting, e.g., non-coherent joint transmission (NC-JT) from a pair of TRPs to the UE.

Grant, [0005]-[0006]. Furthermore, “[e]ach [indicator] state refers to one or two RS sets, which indicates a QCL relationship for one or two DMRS port group(s),” and “[e]ach RS set refers to one or more RS(s) which are QCLeD with DM-RS ports within corresponding DM-RS group.” Grant, [0005] (also shown below); *see also* Grant, [0269].

Agreement #2

Support the QCL indication of DM-RS for PDSCH via DCI signaling:

The N-bit indicator field in the agreed WF R1-1714885 is extended to support:

Each state refers to one or two RS sets, which indicates a QCL relationship for one or two DMRS port group (s), respectively

Each RS set refers to one or more RS(s) which are QCLeD with DM-RS ports within corresponding DM-RS group

Note: The RSs within a RS set may be of different types
If there are more than one RS per RS set, each of them may be associated with different QCL parameters, e.g. one RS may be associated with spatial QCL while another RS may be associated with other QCL parameters, etc

Configuration of RS set for each state can be done via higher layer signaling

E.g., RRC/RRC + MAC CE

FFS the timing when the QCL is applied relative to the time of the QCL indication

Grant, [0005] (highlighted)

Finally, Grant specifies a name for its N-bit indicator transmitted in DCI:

“Transmission Configuration Indicator (TCI).” Grant, [0008], [0271].

109. An RS, such as a CSI-RS, can be a cell-specific reference signal as was understood by a POSITA in the art. By contrast, it was known that DMRS is a UE-specific reference signal. *See* Section VII (Technology Overview). By indicating a QCL relationship between an “RS set” (e.g., indicating CSI-RS) and a “DMRS port group(s),” long term channel properties gleaned from receiving CSI-RS by the UE can be used in conjunction with information gleaned from receiving DMRS signals on DMRS ports to aid DMRS based channel estimation. As explained in elsewhere in the art, “[o]ther applications are also possible, one example being the indication of QCL assumptions between DMRS and CSI-RS. Since estimation of long term channel properties from DMRS is challenging, the DMRS QCL assumptions in LTE allow estimating selected long term channel properties from a signaled CSI-RS resource and applying them to DMRS, to aid DMRS estimation.” U.S. Patent Publication No. 2015/0349855 (Ex.1010), [0014]. Thus, it would have been beneficial to include Grant’s TCI in the DCI of Vilaipornsawai and Shin in order to indicate QCL relationships among DMRS port groups (e.g., Shin’s DMRS port groups) and other, cell-specific, reference signals to improve channel estimation and the reception of DMRS signals, thereby providing a motivation to combine the teachings of Vilaipornsawai and Shin

regarding DCI and multiple PDSCHs and Grant's teachings regarding an N-bit TCI indicator in DCI.

110. Because Vilaipornsawai explicitly relates to different PDSCH transmissions from different TRPs in a joint transmission scenario, it would have been obvious to a POSITA that the application of different DMRS port groups of Grant to Vilaipornsawai's teachings regarding different PDSCH transmissions from different TRPs would have implied that the network can assign different DMRS port groups to different PDSCH transmissions. For example, Vilaipornsawai provides an example with "different DMRSs for different PDSCHs." Vilaipornsawai, [0114].

111. Grant provides an example in which an RS set "could contain, for example, an index to either CSI-RS or SSB⁸ [synchronization signal block] and a configured TRS [tracking RS]. In this case, the PDSCH DMRS could be configured [e.g., by the network] to be QCL with CSI-RS/SSB with respect to spatial parameters, but QCL with TRS with respect to non-spatial (time/frequency) parameters." Grant, [0007].

112. In summary:

- **Vilaipornsawai** discloses a UE receiving DCI (in a single PDCCH)

⁸ See Grant, [0320] (Abbreviations).

(claimed “*PDCCH*”) that carries resource assignment fields for scheduling multiple PDSCHs (“*plurality of PDSCHs*”) from different TRPs and also carries “DMRS information” for performing channel estimation and receiving/determining the different PDSCHs;

- **Shin** discloses exemplary “DMRS information” received in DCI (of a PDCCH) in a multi-TRP scenario, wherein the DMRS information represents different DMRS port groups for different TRPs (“*plurality of DMRS port groups*”); and
- **Grant** discloses the use of an N-bit indicator, referred to as a TCI (“*TCI state data*”), received in the DCI (of a PDCCH) for indicating QCL information between RS sets and DMRS port groups, where “each RS set refers to one or two downlink DMRS port groups,” to support multi-TRP operation. Grant’s TCI provides a connection (QCL assumptions) between DMRS port groups and RS sets, used for channel estimation in PDSCH reception.

113. In combination, Grant’s TCI state (“*TCI state data*”), received in a PDCCH (“*PDCCH*”), would have been associated with Vilaipornsawai-Shin’s “*plurality of DMRS port groups*” by the UE, so that QCL assumptions indicated by the TCI could be used in channel estimation for receiving Vilaipornsawai’s multiple PDSCHs (“*for determining a plurality of PDSCHs*”), thereby rendering

obvious “receive, in a Physical Download Control Channel (PDCCH), Transmission Configuration Indicator (TCI) state data for determining a plurality of Physical Downlink Shared Channels (PDSCHs), the TCI state data being associated with a plurality of Demodulation Reference Signal (DMRS) port groups.”

114. The '165 patent confirms that these teachings of Vilaipornsawai, Shin, and Grant disclose claim element [1.3]. For example, the '165 patent explains that “if the TCI state data is associated with DMRS port group #1 and DMRS port group #2 ... the UE may then determine the QCL assumptions for PDSCH #1 304 and PDSCH #2 306 based on the DMRS port group #1 and DMRS port group #2, respectively.” '165 patent, 6:26-32; see also claim element [1.4] (“receiving the plurality of PDSCHs based on the plurality of DMRS port groups associated with the TCI state data.”).

[1.4] obtain a plurality of Quasi Co-Location (QCL) assumptions for receiving the plurality of PDSCHs based on the plurality of DMRS port groups associated with the TCI state data, wherein:

115. The '165 patent uses the term “Quasi Co-Location (QCL) assumptions” with little in the way of context or background explanation, assuming that a POSITA is familiar with the term. See Section VII (Technology Background). As discussed in Section VII, antenna ports may be recognized by the network as being quasi co-located (QCL), and different reference signals may also

be recognized by the network as being QCL. Examples of “QCL assumptions” are assumptions that a UE should consider with respect to antenna ports, reference signals, and/or associated channel estimation parameters in performing channel estimation, which is subsequently used to receive data, such as in a PDSCH.

116. Vilaipornsawai combined with Shin and Grant renders obvious claim element [1.4].

117. As discussed in the analysis of claim element [1.3], Grant’s “TCI” state received by a UE in DCI can refer to “**two RS sets**, wherein “[e]ach RS set refers to one or more RS(s) which are QCLed with DM-RS ports within corresponding DM-RS group.” Grant, [0005]. Therefore, Grant’s disclosure of multiple RS sets, in which each RS set refers to a corresponding DMRS port group of DMRS ports that are QCL-ed, discloses a “*plurality of Quasi Co-Location (QCL) assumptions.*”

118. Similarly, Shin discloses a “*plurality of Quasi Co-Location (QCL) assumptions*”:

The fourth embodiment is directed to a method for signaling DMRS port grouping information as part of the DMRS signaling information and a UE operation. The NR system supports DMRS grouping, which is defined as follows:

DMRS ports within one DMRS port group are QCL-ed, and DMRS ports in different groups are non-QCL-ed

Shin, [0194]-[0195]. It would have been understood or obvious that when Grant's TCI is used in the context of Vilaipornsawai and Shin, the different PDSCHs of Vilaipornsawai and Shin may use different DMRS port groups (*"receiving the plurality of PDSCHs based on the plurality of DMRS port groups"*), with Grant's TCI indicator value providing QCL assumptions for receiving the different data in different PDSCHs from different TRPs (*"plurality of PDSCHs"*) (*"obtain a plurality of QCL assumptions"* according to *"the plurality of DMRS port groups associated with the TCI state data"*), thereby rendering obvious a UE *"obtain[ing] a plurality of Quasi Co-Location (QCL) assumptions for receiving the plurality of PDSCHs based on the plurality of DMRS port groups associated with the TCI state data."*

[1.5] each of the plurality of QCL assumptions corresponds to one of the plurality of DMRS port groups,

119. First, as discussed in [1.3], Vilaipornsawai's UE receives "DMRS information" for performing channel estimation and receiving/determining different PDSCHs from different TRPs, and Shin discloses exemplary "DMRS information" for Vilaipornsawai's UE as different DMRS port groups for different TRPs (*"plurality of DMRS port groups"*). And as discussed in [1.3] and [1.4], Grant's TCI received by a UE associates QCL assumptions with DMRS port groups, yielding *"a plurality of QCL assumptions."*

120. Second, as shown below, Grand and Shin each disclose a one-to-one

correspondence between QCL assumptions and DMRS port groups.

121. As discussed in the analysis of claim element [1.3], Grant's "TCI" state received by a UE in DCI can refer to "two RS sets," wherein "[e]ach RS set refers to one or more RS(s) which are QCLed with DM-RS ports within corresponding DM-RS group." Grant, [0005]. Therefore, Grant discloses a "plurality of Quasi Co-Location (QCL) assumptions," and each of the QCL assumptions refers to a corresponding DMRS port group.

122. Similarly, Shin discloses:

The fourth embodiment is directed to a method for signaling DMRS port grouping information as part of the DMRS signaling information and a UE operation. The NR system supports DMRS grouping, which is defined as follows:

DMRS ports within one DMRS port group are QCL-ed, and DMRS ports in different groups are non-QCL-ed

Shin, [0194]-[0195]. There is a one-to-one correspondence between DMRS port groups and QCL assumptions ("DMRS ports within one DMRS port group are QCL-ed, and DMRS ports in different groups are non-QCL-ed").

123. Thus, Shin's disclosure of exemplary DMRS information for Vilapornsawai's UE as DMRS port groups, in view of Grant and Shin's disclosure of a one-to-one correspondence between QCL assumptions and DMRS port groups, renders obvious claim element [1.5].

[1.6] the TCI state data corresponds to a TCI state configuration that includes a plurality of QCL Reference Signal (RS) sets, and

124. First, the '165 Patent uses the terms "RS set" only three times in the specification (and only in the context of a "QCL RS set"):

In some of the present implementations, the TCI state of a DL channel (e.g., a PDCCH or a PDSCH) may include multiple **QCL Reference Signal (RS) sets**, and each **QCL RS set** may correspond to one DMRS port group. For example, the TCI state data may correspond to a TCI state configuration that includes multiple QCL RS sets, and each of the **QCL RS sets** may correspond to one of the DMRS port groups associated with the TCI state data.

'165 Patent, 5:63-6:3. There is no further explanation of a "QCL RS set" in the '165 Patent.

125. A POSITA would have understood that the terms "RS set" and "QCL RS set" were being used synonymously in the art and, particularly, in the claim, when RS set(s) were presented in the context of QCL assumptions, as confirmed by other contemporaneous references:

In some embodiments, each of the TRPs 130 may be associated with a Transmission Configuration Indication (TCI) state, which indicates Quasi-Co-Location (QCL) relationships between **one or more RSs in a corresponding RS set (also referred to as 'TCI RS set' or 'QCL RS set') and one or more DMRS ports in a corresponding DMRS port group.**

WO 2020/118686 (Ex.1013), [0054].

126. Second, as discussed in [1.3], Grant discloses the use of an N-bit indicator, referred to as a TCI (“*TCI state data*”), received in control information for indicating QCL information between RS sets and DMRS port groups.

127. Third, Grant refers to “two RS sets” in the context of indicating QCL relationships, such as in the following disclosure, which is an example of “*a plurality of QCL RS sets*” as claimed.

Each [TCI] state refers to one or two RS sets, which indicates a QCL relationship for one or two DMRS port group(s), respectively

Each RS set refers to one or more RS(s) which are QCLeD with DM-RS ports within corresponding DM-RS group.

Grant, [0005]. In fact, Grant’s disclosure is substantively the same as the ’165 Patent’s specification presented above (e.g., compare Grant’s “the TCI state data may correspond to a TCI state configuration that includes multiple QCL RS sets, and each of the QCL RS sets may correspond to one of the DMRS port groups associated with the TCI state data” with the ’165 Patent’s “the TCI state data may correspond to a TCI state configuration that includes multiple QCL RS sets, and each of the QCL RS sets may correspond to one of the DMRS port groups associated with the TCI state data”).

128. Grant’s Table 3 (below) shows various TCI state values (“*TCI state data*”) corresponding to TCI state configurations (“*a TCI state configuration*”)

having two RS sets (“a plurality of QCL Reference Signal (RS) sets”), such as TCI State values of 3 and higher.

TABLE 3

a TCI state configuration that includes a plurality of QCL Reference Signal (RS) sets



TCI states used for QCL indication for PDSCH and PDCCH			
TCI State	RS Set(s)	Used for PDCCH QCL Indication	Used for PDSCH QCL Indication
0 (default state)	{Set1 ₀ }	Y	Y
1	{Set1 ₀ }	Y	Y
2	{Set1 ₀ }	Y	Y
3	{Set1 ₃ , Set2 ₃ }		Y
⋮	⋮		⋮
⋮	⋮		⋮
⋮	⋮		⋮
2 ^N -1	{Set1 _{2^N-1} , Set2 _{2^N-1} }		Y

Grant, [0009]

129. Thus, Grant discloses an N-bit TCI state indicator transmitted in DCI to a UE, wherein the TCI state refers to two RS sets and indicates a QCL relationship between each RS set and DMRS ports in a corresponding DMRS port group, thereby disclosing or rendering obvious “the TCI state data corresponds to a TCI state configuration that includes a plurality of QCL Reference Signal (RS) sets.”

[1.7] each of the plurality of QCL RS sets corresponds to one of the plurality of DMRS port groups.

130. First, as discussed in the analysis of claim element [1.6], Grant discloses that a TCI state value refers to two RS sets (see, e.g., Table 3, TCI states

indexed with values greater than or equal to three, i.e., from 3 to 2^N-1), wherein “each [TCI] state refers to one or two RS sets, which indicates a QCL relationship for one or two DMRS port group(s), respectively” (“*plurality of QCL RS sets*”). Grant, [0005]. Second, as discussed in the analysis of claim element [1.3], Vilaipornsawai-Shin discloses exemplary DMRS information for Vilaipornsawai’s UE as different DMRS port groups for different TRPs (“*plurality of DMRS port groups*”). Third, “[e]ach RS set refers to one or more RS(s) which are QCLeD with DM-RS ports within corresponding DM-RS group,” Grant, [0005]. In other words, Grant discloses a one-to-one correspondence between two QCL RS sets and two DMRS port groups, which, in view of Vilaipornsawai-Shin’s teachings, discloses or renders obvious claim element [1.7].

7. Claim 2

The UE of claim 1, wherein the at least one processor is further configured to execute the computer-executable instructions to:
[2.1] identify a plurality of Transmit/Receive Points (TRPs) based on the plurality of QCL assumptions.

131. First, as discussed in [1.4], both Grant and Shin disclose multiple DMRS port groups, each having associated QCL assumptions (“*plurality of QCL assumptions*”).

132. Second, Grant discloses associating QCL assumptions with TRP pairs. For example, Grant recites:

With this extension, each indicator state is associated with one or two RS sets, where each RS set refers to one or two downlink DMRS port groups, respectively. **This facilitates QCL indication in the case of that multi-TRP operation (DL CoMP) is configured. Different states may correspond to different TRP pairs** supporting, e.g., non-coherent joint transmission (NC-JT) from a pair of TRPs to the UE.

Grant, [0006]. As recited above, TCI indicator states associated with two RS sets may “correspond to different TRP pairs.” In other words, the QCL assumptions associated with a particular TCI state are used by a UE to receive information transmitted from a specific pair of TRPs. By associating a TCI indicator state, which has a plurality of QCL assumptions (per Shin and Grant in the analysis of [1.4])), with a TRP pair/two TRPs (per the teachings of Grant), renders obvious *identify a plurality of Transmit/Receive Points (TRPs) based on the plurality of QCL assumptions.*

8. Claim 3

The UE of claim 1, wherein the at least one processor is further configured to execute the computer-executable instructions to:

[3.1] receive an instruction for indicating a relationship between the plurality of QCL assumptions and the plurality of DMRS port groups via Medium Access Control (MAC) Control Element (CE) signaling.

133. As discussed in [1.3], Vilaipornsawai’s UE receives “DMRS information” for performing channel estimation and receiving/determining different PDSCHs from different TRPs, and Shin discloses exemplary “DMRS

information” for Vilaipornsawai’s UE as different DMRS port groups for different TRPs (“*plurality of DMRS port groups*”). And as discussed in [1.3] and [1.4], Grant’s TCI received by a UE indicates QCL assumptions connecting DMRS port groups and other reference signals (RSs), yielding “*a plurality of QCL assumptions.*”

134. Grant describes “[p]rocedures for defining/updating TCI states.” Grant, [0283]. These procedures are for defining or updating the information associated with each TCI state value. In other words, Grant addresses how the information in a table of TCI configurations (corresponding to TCI state values) is established or communicated from the network.

135. Grant addresses how the information in a table of TCI configurations (corresponding to TCI state values) is established or communicated from the network. For example, Grant discloses:

Configuration of RS set for each state can be done via higher layer signaling E.g., RRC/RRC + MAC CE
--

Grant, [0005]. In context, Grant’s mention of “each state” is a reference to each TCI state represented by an N-bit indicator, e.g., in a table of TCI state values. Grant, [0005] (“The N-bit indicator field...is extended to support: Each state...”; [0008] (“Throughout this disclosure the following generic name for the N-bit indicator is used: Transmission Configuration Indicator (TCI).”); [0009] (“TABLE

3 (below) shows an exemplary set of TCI states...). “MAC CE” (MAC control element, per Grant, [0325]) is a message transmitted via “higher layer signaling.” And Grant explains that “different TCI states may be used for QCL indication referring to different RS types.” Grant, [0009]. By changing the “[c]onfiguration of RS set” for each TCI state, the QCL relationships between RS sets and DMRS port groups are changed.

136. Furthermore, a POSITA would have understood that an RRC message and a MAC-CE message, as referenced in Grant, [0005], are different options for communicating configuration information. For example, Grant discloses:

For example, in one aspect there is provided a UE being configured to receive a message comprising configuration information, CI, indicating that a reference signal, RS, is quasi-co-located, QCL, with a transmission, and adjust a spatial Tx configuration for the transmission based on an RS associated with the received CI.

In some embodiments, the message is a layer 2 message, MAC-CE message, RRC message, or DCI message.

Grant, [0027]-[0028].

137. Thus, Vilaipornsawai-Shin’s disclosure of a UE receiving a plurality of DMRS port groups, in view of Grant’s disclosure of TCI received by a UE indicates QCL assumptions connecting DMRS port groups and RSs and that the “[c]onfiguration of each RS set” for each TCI state can be indicated via “MAC CE” signaling” discloses or renders obvious “*receive an instruction for indicating*

a relationship between the plurality of QCL assumptions and the plurality of DMRS port groups via Medium Access Control (MAC) Control Element (CE) signaling.”

9. Claim 5

5. The UE of claim 1, wherein the at least one processor is further configured to execute the computer-executable instructions to:

[5.1] receive the plurality of DMRS port groups via Radio Resource Control (RRC) signaling, wherein the plurality of DMRS port groups is associated with the plurality of PDSCHs.

138. Vilaipornsawai combined with Shin renders obvious claim element [5.1].

139. As explained in the analysis of claim element [1.3], Vilaipornsawai provides an example in which a UE receives “DMRS information” via DCI in a PDCCH for UEs to be able to receive multiple PDSCHs. For example, Vilaipornsawai discloses:

In some embodiments, the content of the DCI carried in PDCCH messages may include, in addition to the LTE DCI content for different DCI formats, **additional content such as one or more of DMRS information for PDSCH(s)**, resource assignment information and HARQ/retransmission assignment information.

Vilaipornsawai, [0113]; see also [0114] (“there should be different DMRSs for different PDSCHs”).

140. As further explained in the analysis of [1.3], Shin describes example

DMRS information as DMRS port groups. Shin explains that DMRS port grouping may be configured via RRC signaling:

DMRS port grouping information may be configured in a semi-static manner via RRC signaling or dynamically via a media access control (MAC) CE or DCI.

Shin, [0198].

141. In summary, Vilaipornsawai discloses communicating DMRS information to a UE for receiving a plurality of PDSCHs, and Shin discloses communicating DMRS information (namely, DMRS port group information) via RRC signaling, thereby rendering obvious “*receive the plurality of DMRS port groups via Radio Resource Control (RRC) signaling, wherein the plurality of DMRS port groups is associated with the plurality of PDSCHs.*”

Additional Reasons to Combine Vilaipornsawai and Shin

142. Reasons to combine Vilaipornsawai and Shin are provided previously in Section IX.A.3. Additional reasons to combine these references are presented here. It is not necessary to indicate DMRS port grouping information in DCI messages, which are transmitted via PDCCH as taught in Vilaipornsawai. Instead, DMRS port group information may be conveyed to a UE “in a semi-static manner via RRC signaling,” as taught in Shin (at [0198]). A POSITA would have understood that Shin’s description of a “semi-static manner via RRC signaling” refers to signaling that does not take place as often as DCI messages. *See* Shin,

[0198] (contrast between “semi-static” and “dynamically”); *see also, e.g.*, U.S. Patent No. 8,897,253 (Ex.1014), 23:39-43 (“Control signaling for resource allocation may be **flexible (e.g., dynamic)** by relying on physical layer signaling (e.g., PDCCH and/or DCI format extensions) or may rely on at least a number of **semi-statically** configured parameters (e.g., by RRC configuration).”). Thus, the use of RRC signaling instead of DCI signaling represents a well-known tradeoff between reducing the number of times and the amount of resource used with which control and/or configuration parameters are conveyed to a UE (a benefit, because fewer resources are dedicated to control signaling) at the expense of not being able to update the DMRS port group information as often (a drawback). Thus, a POSITA more interested in conserving resources used to convey DMRS port group information than being able to update DMRS port group information rapidly (see tradeoff above) would have been motivated to modify Vilaipornsawai so that DMRS port grouping information is communicated using RRC signaling.

10. Claim 6

6. The UE of claim 1,

[6.1] wherein each of the plurality of QCL assumptions includes at least one of a time-domain QCL parameter, a frequency-domain QCL parameter, and a spatial-domain QCL parameter.

143. As discussed in the analysis of claim element [1.4], Grant discloses a “*plurality of QCL assumptions*” and Shin also discloses a “*plurality of QCL assumptions.*” For example, Grant’s “TCI” state received by a UE in DCI can refer

to “two RS sets, wherein “[e]ach RS set refers to one or more RS(s) which are QCLed with DM-RS ports within corresponding DM-RS group.” Grant, [0005].

144. Turning to the contents of the QCL assumptions, Grant discloses each of the different claimed QCL parameters:

In any case, **an RS set contains one or more DL RSs**. In the case of a single DL RS, a set contains an index to either a CSI-RS or SSB. **In the case of more than one DL RS**, a set could contain, for example, an index to either CSI-RS or SSB and a configured TRS. **In this case, the PDSCH DMRS could be configured to be QCL with CSI-RS/SSB with respect to spatial parameters, but QCL with TRS with respect to non-spatial (time/frequency) parameters.**

Grant, [0007]. Thus, each of the plurality of Grant’s QCL assumptions (corresponding to different RS sets, each of which may have multiple RSs) may include “spatial parameters” (*a spatial-domain QCL parameter*) and “non-spatial (time/frequency) parameters” (*a time-domain QCL parameter [and] a frequency-domain QCL parameter*), thereby disclosing *wherein each of the plurality of QCL assumptions includes at least one of a time-domain QCL parameter, a frequency-domain QCL parameter, and a spatial-domain QCL parameter*.

145. I have been informed that the default assumption, in the absence of explicit evidence otherwise, is to interpret the phrase “at least one of A and B” as requiring at least one of A and at least one of B. However, the ’165 patent defines

the expression:

The expression “at least one of A, B and C” or “at least one of the following: A, B and C” means “only A, or only B, or only C, or any combination of A, B and C.”

’165 patent, 2:61-64. Thus, in light of the ’165 patent specification, claim element [6.1] requires only “*a time-domain QCL parameter*” or only “*a frequency-domain QCL parameter*” or only “*a spatial-domain QCL parameter,*” or any combination of the three. Regardless, Grant discloses all three.

11. Claim 7

[7.0] *A method of wireless communications by a user equipment (UE), the method comprising:*

146. As discussed in the analysis of claim elements [1.0]-[1.2], Vilaipornsawai discloses a UE having a memory and a processor for storing and processing instructions, respectively. *See* Vilaipornsawai, [0160] and Figure 14. And Vilaipornsawai relates generally to wireless communication: “The present disclosure relates generally to wireless communications and, in particular, to downlink control information design and associated methods and apparatus.” Vilaipornsawai, [0002]. Further, Vilaipornsawai discloses wireless communication of a PDCCH and PDSCHs to a UE. Vilaipornsawai, [0052]. Thus, Vilaipornsawai discloses “*a method of wireless communications by a user equipment (UE).*”

[7.1] receiving, in a Physical Download Control Channel (PDCCH) Transmission Configuration Indicator (TCI) state data for determining a plurality of Physical Downlink Shared Channels (PDSCHs), the TCI state data being associated with a plurality of Demodulation Reference Signal (DMRS) port groups

147. Claim element [7.1] is substantively the same as claim element [1.3].

Therefore, the prior art discloses or renders obvious claim element [7.1] for the reasons given in the analysis of [1.3].

[7.2] obtaining a plurality of Quasi Co-Location (QCL) assumptions for receiving the plurality of PDSCHs based on the plurality of DMRS port groups associated with the TCI state data, wherein:

148. Claim element [7.2] is substantively the same as claim element [1.4].

Therefore, the prior art discloses or renders obvious claim element [7.2] for the reasons given in the analysis of [1.4].

[7.3] each of the plurality of QCL assumptions corresponds to one of the plurality of DMRS port groups,

149. Claim element [7.3] is substantively the same as claim element [1.5].

Therefore, the prior art discloses or renders obvious claim element [7.3] for the reasons given in the analysis of [1.5].

[7.4] the TCI state data corresponds to a TCI state configuration that includes a plurality of QCL Reference Signal (RS) sets

150. Claim element [7.4] is substantively the same as claim element [1.6].

Therefore, the prior art discloses or renders obvious claim element [7.4] for the reasons given in the analysis of [1.6].

[7.5] *each of the plurality of QCL RS sets corresponds to one of the plurality of DMRS port groups.*

151. Claim element [7.5] is substantively the same as claim element [1.7].

Therefore, the prior art discloses or renders obvious claim element [7.5] for the reasons given in the analysis of [1.7].

12. Claim 8

The method of claim 7, further comprising:

[8.1] *identifying a plurality of Transmit/Receive Points (TRPs) based on the plurality of QCL assumptions.*

152. Claim element [8.1] is substantively the same as claim element [2.1].

Therefore, the prior art discloses or renders obvious claim element [2.1] for the reasons given in the analysis of [2.1].

13. Claim 9

The method of claim 7, further comprising:

[9.1] *receiving an instruction for indicating a relationship between the plurality of QCL assumptions and the plurality of DMRS port groups via Medium Access Control (MAC) Control Element (CE) signaling.*

153. Claim element [9.1] is substantively the same as claim element [3.1].

Therefore, the prior art discloses or renders obvious claim element [9.1] for the reasons given in the analysis of [3.1].

14. Claim 11

The method of claim 7, further comprising:

[11.1] *receiving the plurality of DMRS port groups via Radio Resource Control (RRC) signaling, wherein the plurality of DMRS port groups is associated with the plurality of PDSCHs.*

154. Claim element [11.1] is substantively the same as claim element [5.1].

Therefore, the prior art discloses or renders obvious claim element [11.1] for the reasons given in the analysis of [5.1].

15. Claim 12

The method of claim 7, [12.1] wherein each of the plurality of QCL assumptions includes at least one of a time-domain QCL parameter, a frequency-domain QCL parameter, and a spatial-domain QCL parameter.

155. Claim element [12.1] is substantively the same as claim element [6.1].

Therefore, the prior art discloses or renders obvious claim element [12.1] for the reasons given in the analysis of [6.1].

B. Ground 2: Claims 4 and 10 are obvious under 35 U.S.C. § 103 over Vilaipornsawai, Shin, and Grant combined with Xue.

1. Summary of Xue

156. Xue describes a UE that uses a timer to keep track of time periods in which it “monitors and receives a PDCCH” and when the UE “does not receive the PDCCH.” Xue, [0002]. For example, Xue describes a “DRX [discontinuous reception] deactivation timer” that keeps track of “a plurality of consecutive subframes.” Xue, [0003].

157. More generally, Xue describes a method in which “[a] terminal monitors downlink control information in a first time resource unit range according to a first rule.” Xue, [0108]. The “time resource unit range” may be a certain

number of slots. Xue, [0112] (“The **time resource unit is one or a combination of a slot**, a mini-slot, a symbol, and a subframe.”). “A slot is a basic time-frequency resource unit, and occupies L consecutive OFDM symbols in time domain, where L is a natural number greater than 0.” Xue, [0102]. To a person of ordinary skill in the art, a “slot” in LTE, for example, was understood as spanning a fixed amount of time (0.5 ms), equivalent to a certain number of OFDM symbols (e.g., 7). *See, e.g.*, Shin, [0045]-[0046] (“FIG. 1 is a diagram of a basic time-frequency resource structure for transmitting downlink data or control channels in the legacy LTE/LTE-A system. ... Each slot spans 0.5 ms, and each subframe spans 1.0 ms.”).

158. Further, “[i]n a possible design, the first time resource unit range is determined by using a first timer.” Xue, [0148]. For example, “the 1st time resource unit range is implemented by a timer 1,” “[a] start moment of the timer 1 is the same as a start moment of the 1st time resource unit range, and an effective period of the timer 1 is the same as a time length of the 1st time resource unit range,” and a time resource unit range may “include[] four consecutive slots.” Xue, [0159]-[160].

159. Thus, Xue discloses the use of a timer to keep track of the expiry of a certain number of slots, thereby confirming that a POSITA would have understood that a timer is one way keep track of the expiry of a certain number (d_1) of slots to

implement Grant's teaching of "[i]f the UE receives the signalling message in slot n , the first time that the UE may apply the updated QCL assumption for demodulation of PDSCH ... is in slot $n+d_1$." Grant, [0289].

2. Reasons to Combine Grant and Xue

160. As a threshold matter, Xue is analogous art to the '165 patent, as both documents are directed to cellular wireless communication systems, such as LTE and 5G/NR systems. '165 patent, 1:18-19 ("The present disclosure generally relates to wireless communications...") and 3:37-48 ("A radio communication network architecture (e.g., a Long Term Evolution (LTE) system, an LTE-Advanced (LTE-A) system, an LTE-Advanced Pro system, or a 5G New Radio (NR) Radio Access Network (RAN)) typically includes at least one Base Station (BS), at least one User Equipment (UE), and one or more optional network elements that provide connection towards a network."); Xue, [0095] ("This application is mainly applied to a long term evolution (Long Term Evolution, LTE for short)/5G new radio access technology (New RAT. NR for short) system.").

161. As explained in Section IX.A.4 (Summary of Grant), Grant uses the term "Transmission Configuration Indicator (TCI)" to refer to an N-bit indicator in the DCI (of a PDCCH). The TCI value indicates two reference signal (RS) sets and a QCL relationship for a DMRS port group per RS set, wherein each RS set refers to one or more RSs which are QCLED with DM-RS ports within corresponding

DM-RS group.

162. In Grant's Table 6, entitled "Proposal for Procedures for defining/updating TCI States," Grant describes "[e]xplicit update[s] of a TCI state," in which "[t]he UE receives a signalling message." Grant, [0289]. Furthermore, "[i]f the UE receives the signalling message in slot n , the first time that the UE may apply the updated QCL assumption for demodulation of PDSCH ... is in slot $n+d_1$." Grant, [0289]. Grant does not provide implementation detail for how its UE keeps track of time between "slot n " and "slot $n+d_1$." Thus, a POSITA seeking to implement Grant's teachings would have been motivated to specify this implementation detail to implement Grant's teachings. It would have been obvious to a POSITA that a timer is one way for a UE to keep track of whether the amount of time that has passed is equal to some integer (e.g., d_1) number of slots. Xue confirms this understanding of a POSITA, presenting use of such a timer in the context of wireless communications.

163. Combining Xue and Grant represents combining prior art elements (Xue's timer in Grant's UE) according to known methods to yield the obvious and predictable result of a timer keeping track of the expiry of a certain number of slots to implement Grant's teaching regarding the timing of applying updated QCL assumptions.

3. Claim 4

The UE of claim 1, wherein the at least one processor is further configured to execute the computer-executable instructions to:

[4.1] indicate a relationship between the plurality of QCL assumptions and the plurality of DMRS port groups when a timer configured for the UE expires.

164. As discussed in [1.3], Vilaipornsawai's UE receives "DMRS information" for performing channel estimation and receiving/determining different PDSCHs from different TRPs, and Shin discloses exemplary "DMRS information" for Vilaipornsawai's UE as different DMRS port groups for different TRPs ("*plurality of DMRS port groups*"). And as discussed in [1.3] and [1.4], Grant's TCI received by a UE indicates QCL assumptions connecting DMRS port groups and other reference signals (RSs), yielding "*a plurality of QCL assumptions.*"

165. Furthermore, in Grant's Table 6, entitled "Proposal for Procedures for defining/updating TCI States," Grant describes "[e]xplicit update[s] of a TCI state," in which "[t]he UE receives a signalling message." Grant, [0289]. Moreover, "the signalling can simultaneously update more than one TCI state." *Id.* Finally, "[i]f the UE receives the signalling message in slot n, the first time that the UE may apply the updated QCL assumption for demodulation of PDSCH ... is in slot $n+d_1$." Grant, [0289].

166. It would have been obvious to a POSITA that a timer is one way for a UE to keep track of whether the amount of time that has passed is equal to some

integer (e.g., d_1) number of slots. A “slot” would have been understood as a term of art referring to a time slot. For example, a “slot” in LTE was understood as spanning a fixed amount of time (0.5 ms), equivalent to a certain number of OFDM symbols. *See, e.g.*, Shin, [0045]-[0046] (“FIG. 1 is a diagram of a basic time-frequency resource structure for transmitting downlink data or control channels in the legacy LTE/LTE-A system. ... Each slot spans 0.5 ms, and each subframe spans 1.0 ms.”).

167. As described previously (Section IX.B.1), Xue confirms that it was common to determine the passage of a fixed number of slots using a timer. More generally, Xue describes a method in which “[a] terminal monitors downlink control information in a first time resource unit range according to a first rule.” Xue, [0108]. The “time resource unit range” may be a certain number of slots. Xue, [0112] (“The **time resource unit is one or a combination of a slot**, a mini-slot, a symbol, and a subframe.”).

168. Further, “[i]n a possible design, the first time resource unit range is determined by using a first timer.” Xue, [0148]. For example, “the 1st time resource unit range is implemented by a timer 1,” “[a] start moment of the timer 1 is the same as a start moment of the 1st time resource unit range, and an effective period of the timer 1 is the same as a time length of the 1st time resource unit range,” and a time resource unit range may “include[] four consecutive slots.” Xue,

[0159]-[160]. Thus, Xue discloses or renders obvious the use of a timer to keep track of the expiry of a certain number of slots, thereby confirming that a timer is one way keep track of the expiry of a certain number (d_1) of slots to implement Grant's teaching of "[i]f the UE receives the signalling message in slot n , the first time that the UE may apply the updated QCL assumption for demodulation of PDSCH ... is in slot $n+d_1$." Grant, [0289].

169. Thus, Grant discloses TCI values that indicates two RS sets and a QCL relationship for a DMRS port group per RS set, wherein each RS set refers to one or more RSs which are QCLeD with DM-RS ports within corresponding DM-RS group; Grant also discloses a UE waiting to apply updates to TCI states after waiting a certain number of slots; and Xue discloses the use of a timer to measure the passage of time equal to a certain number of slots. In view of Vilaipornsawai-Shin's teachings regarding "*plurality of DMRS port groups*," Grant's TCI values that provide QCL assumptions for the DMRS port groups and that are updated based on the expiration of Xue's timer, renders obvious *indicate a relationship between the plurality of QCL assumptions and the plurality of DMRS port groups when a timer configured for the UE expires.*

4. Claim 10

***The method of claim 7, further comprising:
[10.1] indicating a relationship between the plurality of QCL assumptions and the plurality of DMRS port groups when a timer configured for the UE expires.***

170. Claim element [10.1] is substantively the same as claim element [4.1]. Therefore, the prior art discloses or renders obvious claim element [10.1] for the reasons given in the analysis of [4.1].

X. CONCLUSION

171. This declaration and my opinions herein are made to the best of my knowledge and understanding, and based on the material available to me, at the time of signing this declaration. I declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 or Title 18 of the United States Code.

Mar. 2, 2023

Date: _____



Digitally signed by
Zhi Ding
Date: 2023.03.02
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Zhi Ding