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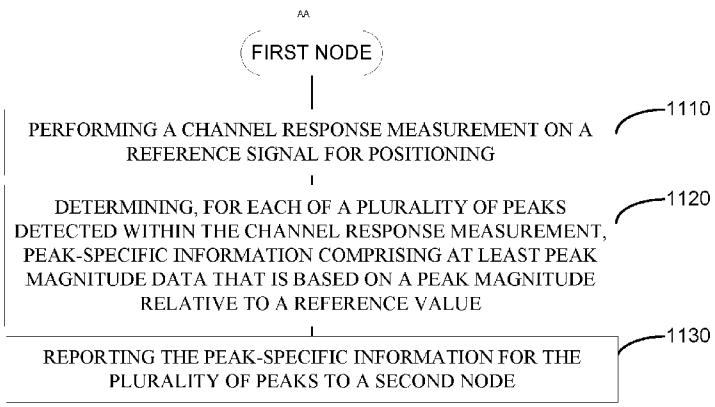


FIG. 11

(57) Abstract: In an embodiment, a first node (e.g., a UE or a BS) performs a channel response measurement on a reference signal for positioning (e.g., UL reference signal such as SRS for positioning, or a DL PRS). The first node determines, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value. The first node reports the peak-specific information for the plurality of peaks to a second node (e.g., a BS, UE, or LMF). The second node receives the peak-specific information, and determines a positioning estimate for a UE based on the peak-specific information.

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COMMUNICATING PEAK MAGNITUDE DATA ASSOCIATED WITH A REFERENCE SIGNAL FOR POSITIONING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present Application for Patent claims the benefit of U.S. Provisional Application No. 63/025,000, entitled "COMMUNICATING PEAK MAGNITUDE DATA ASSOCIATED WITH A REFERENCE SIGNAL FOR POSITIONING", filed May 14, 2020, and U.S. Non-Provisional Application No. 17/319,339, entitled "COMMUNICATING PEAK MAGNITUDE DATA ASSOCIATED WITH A REFERENCE SIGNAL FOR POSITIONING", filed May 13, 2021, both of which are assigned to the assignee hereof and hereby expressly incorporated by reference herein in their entirety.

BACKGROUND OF THE DISCLOSURE

1. Field of the Disclosure

[0002] Aspects of the disclosure relate generally to wireless communications, and more particularly to communicating peak magnitude data associated with a reference signal for positioning.

2. Description of the Related Art

[0003] Wireless communication systems have developed through various generations, including a first-generation analog wireless phone service (1G), a second-generation (2G) digital wireless phone service (including interim 2.5G networks), a third-generation (3G) high speed data, Internet-capable wireless service and a fourth-generation (4G) service (e.g., LTE or WiMax). There are presently many different types of wireless communication systems in use, including cellular and personal communications service (PCS) systems. Examples of known cellular systems include the cellular analog advanced mobile phone system (AMPS), and digital cellular systems based on code division multiple access (CDMA), frequency division multiple access (FDMA), time division multiple access (TDMA), the Global System for Mobile access (GSM) variation of TDMA, etc.

[0004] A fifth generation (5G) wireless standard, referred to as New Radio (NR), enables higher data transfer speeds, greater numbers of connections, and better coverage, among

other improvements. The 5G standard, according to the Next Generation Mobile Networks Alliance, is designed to provide data rates of several tens of megabits per second to each of tens of thousands of users, with 1 gigabit per second to tens of workers on an office floor. Several hundreds of thousands of simultaneous connections should be supported in order to support large wireless sensor deployments. Consequently, the spectral efficiency of 5G mobile communications should be significantly enhanced compared to the current 4G standard. Furthermore, signaling efficiencies should be enhanced and latency should be substantially reduced compared to current standards.

SUMMARY

[0005] The following presents a simplified summary relating to one or more aspects disclosed herein. Thus, the following summary should not be considered an extensive overview relating to all contemplated aspects, nor should the following summary be considered to identify key or critical elements relating to all contemplated aspects or to delineate the scope associated with any particular aspect. Accordingly, the following summary has the sole purpose to present certain concepts relating to one or more aspects relating to the mechanisms disclosed herein in a simplified form to precede the detailed description presented below.

[0006] In an aspect, a method of operating a first node includes performing a channel response measurement on a reference signal for positioning; determining, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and reporting the peak-specific information for the plurality of peaks to a second node.

[0007] In some aspects, the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[0008] In some aspects, the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[0009] In some aspects, the first node corresponds to a user equipment (UE) and the

second node corresponds to a base station (BS) or a location management function (LMF).

[0010] In some aspects, the second node corresponds to a user equipment (UE) or a location management function (LMF) and the first node corresponds to a base station (BS).

[0011] In some aspects, a number of the plurality of peaks is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[0012] In some aspects, the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[0013] In some aspects, the peak magnitude threshold and/or the reference value are configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[0014] In some aspects, the plurality of peaks excludes peaks outside of a defined time window.

[0015] In some aspects, the defined time window is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[0016] In some aspects, the defined time window is defined relative to a reference timing.

[0017] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[0018] In some aspects, the method includes peak timing data that is based on a peak timing relative to a reference timing.

[0019] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[0020] In some aspects, the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[0021] In an aspect, a method of operating a second node includes receiving, from a first node, peak-specific information associated with a plurality of peaks within a channel response measurement on a reference signal for positioning, the peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and determining a positioning estimate for a user equipment (UE) based

on the peak-specific information.

[0022] In some aspects, the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[0023] In some aspects, the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[0024] In some aspects, the first node corresponds to the UE and the second node corresponds to a base station (BS) or a location management function (LMF).

[0025] In some aspects, the second node corresponds to the UE or an location management function (LMF) and the first node corresponds to a base station (BS).

[0026] In some aspects, a number of the plurality of peaks is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[0027] In some aspects, the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[0028] In some aspects, the peak magnitude threshold and/or the reference value are configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[0029] In some aspects, the plurality of peaks excludes peaks outside of a defined time window.

[0030] In some aspects, the defined time window is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[0031] In some aspects, the defined time window is defined relative to a reference timing.

[0032] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[0033] In some aspects, the method includes peak timing data that is based on a peak timing relative to a reference timing.

[0034] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[0035] In some aspects, the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[0036] In an aspect, a first node includes a memory; at least one transceiver; and at least one processor communicatively coupled to the memory and the at least one transceiver, the at least one processor configured to: perform a channel response measurement on a reference signal for positioning; determine, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and report the peak-specific information for the plurality of peaks to a second node.

[0037] In some aspects, the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[0038] In some aspects, the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[0039] In some aspects, the first node corresponds to a user equipment (UE) and the second node corresponds to a base station (BS) or a location management function (LMF).

[0040] In some aspects, the second node corresponds to a user equipment (UE) or a location management function (LMF) and the first node corresponds to a base station (BS).

[0041] In some aspects, a number of the plurality of peaks is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[0042] In some aspects, the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[0043] In some aspects, the peak magnitude threshold and/or the reference value are configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[0044] In some aspects, the plurality of peaks excludes peaks outside of a defined time window.

[0045] In some aspects, the defined time window is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[0046] In some aspects, the defined time window is defined relative to a reference timing.

[0047] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[0048] In some aspects,

[0049] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[0050] In some aspects, the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[0051] In an aspect, a second node includes a memory; at least one transceiver; and at least one processor communicatively coupled to the memory and the at least one transceiver, the at least one processor configured to: receive, via the at least one transceiver, from a first node, peak-specific information associated with a plurality of peaks within a channel response measurement on a reference signal for positioning, the peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and determine a positioning estimate for a user equipment (UE) based on the peak-specific information.

[0052] In some aspects, the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[0053] In some aspects, the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[0054] In some aspects, the first node corresponds to the UE and the second node corresponds to a base station (BS) or a location management function (LMF).

[0055] In some aspects, the second node corresponds to the UE or an location management function (LMF) and the first node corresponds to a base station (BS).

[0056] In some aspects, a number of the plurality of peaks is configured by the UE, a base

station (BS), or a core network component based on a UE capability indication.

[0057] In some aspects, the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[0058] In some aspects, the peak magnitude threshold and/or the reference value are configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[0059] In some aspects, the plurality of peaks excludes peaks outside of a defined time window.

[0060] In some aspects, the defined time window is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[0061] In some aspects, the defined time window is defined relative to a reference timing.

[0062] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[0063] In some aspects,

[0064] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[0065] In some aspects, the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[0066] In an aspect, a first node includes means for performing a channel response measurement on a reference signal for positioning; means for determining, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and means for reporting the peak-specific information for the plurality of peaks to a second node.

[0067] In some aspects, the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[0068] In some aspects, the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival

associated with the peak at a base station (BS).

[0069] In some aspects, the first node corresponds to a user equipment (UE) and the second node corresponds to a base station (BS) or a location management function (LMF).

[0070] In some aspects, the second node corresponds to a user equipment (UE) or a location management function (LMF) and the first node corresponds to a base station (BS).

[0071] In some aspects, a number of the plurality of peaks is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[0072] In some aspects, the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[0073] In some aspects, the peak magnitude threshold and/or the reference value are configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[0074] In some aspects, the plurality of peaks excludes peaks outside of a defined time window.

[0075] In some aspects, the method includes means for peaking timing data that is based on a peak timing relative to a reference timing.

[0076] In some aspects, the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[0077] In an aspect, The first node of claim 69, wherein the defined time window is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[0078] In some aspects, the defined time window is defined relative to a reference timing.

[0079] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[0080] In an aspect, The first node of claim 73, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[0081] In an aspect, a second node includes means for receiving, from a first node, peak-

specific information associated with a plurality of peaks within a channel response measurement on a reference signal for positioning, the peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and means for determining a positioning estimate for a user equipment (UE) based on the peak-specific information.

[0082] In some aspects, the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[0083] In some aspects, the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[0084] In some aspects, the first node corresponds to the UE and the second node corresponds to a base station (BS) or a location management function (LMF).

[0085] In some aspects, the second node corresponds to the UE or an location management function (LMF) and the first node corresponds to a base station (BS).

[0086] In some aspects, a number of the plurality of peaks is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[0087] In some aspects, the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[0088] In some aspects, the peak magnitude threshold and/or the reference value are configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[0089] In some aspects, the plurality of peaks excludes peaks outside of a defined time window.

[0090] In some aspects, the defined time window is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[0091] In some aspects, the defined time window is defined relative to a reference timing.

[0092] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[0093] In some aspects, the method includes means for peaking timing data that is based

on a peak timing relative to a reference timing.

[0094] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[0095] In some aspects, the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[0096] In an aspect, a non-transitory computer-readable medium storing computer-executable instructions that, when executed by a first node, cause the first node to: perform a channel response measurement on a reference signal for positioning; determine, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and report the peak-specific information for the plurality of peaks to a second node.

[0097] In some aspects, the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[0098] In some aspects, the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[0099] In some aspects, the first node corresponds to a user equipment (UE) and the second node corresponds to a base station (BS) or a location management function (LMF).

[00100] In some aspects, the second node corresponds to a user equipment (UE) or a location management function (LMF) and the first node corresponds to a base station (BS).

[00101] In some aspects, a number of the plurality of peaks is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00102] In some aspects, the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[00103] In some aspects, the peak magnitude threshold and/or the reference value are

configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00104] In some aspects, the plurality of peaks excludes peaks outside of a defined time window.

[00105] In some aspects, the defined time window is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00106] In some aspects, the defined time window is defined relative to a reference timing.

[00107] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00108] In some aspects,

[00109] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00110] In some aspects, the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[00111] In an aspect, a non-transitory computer-readable medium storing computer-executable instructions that, when executed by a second node, cause the second node to: receive, from a first node, peak-specific information associated with a plurality of peaks within a channel response measurement on a reference signal for positioning, the peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and determine a positioning estimate for a user equipment (UE) based on the peak-specific information.

[00112] In some aspects, the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[00113] In some aspects, the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[00114] In some aspects, the first node corresponds to the UE and the second node corresponds to a base station (BS) or a location management function (LMF).

[00115] In some aspects, the second node corresponds to the UE or an location management function (LMF) and the first node corresponds to a base station (BS).

[00116] In some aspects, a number of the plurality of peaks is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00117] In some aspects, the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[00118] In some aspects, the peak magnitude threshold and/or the reference value are configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00119] In some aspects, the plurality of peaks excludes peaks outside of a defined time window.

[00120] In some aspects, the defined time window is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00121] In some aspects, the defined time window is defined relative to a reference timing.

[00122] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00123] In some aspects,

[00124] In some aspects, the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00125] In some aspects, the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[00126] Other objects and advantages associated with the aspects disclosed herein will be apparent to those skilled in the art based on the accompanying drawings and detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[00127] The accompanying drawings are presented to aid in the description of various aspects of the disclosure and are provided solely for illustration of the aspects and not limitation thereof.

[00128] FIG. 1 illustrates an exemplary wireless communications system, according to various aspects.

[00129] FIGS. 2A and 2B illustrate example wireless network structures, according to various aspects.

[00130] FIGS. 3A to 3C are simplified block diagrams of several sample aspects of components that may be employed in wireless communication nodes and configured to support communication as taught herein.

[00131] FIGS. 4A and 4B are diagrams illustrating examples of frame structures and channels within the frame structures, according to aspects of the disclosure.

[00132] FIG. 5 illustrates an exemplary PRS configuration for a cell supported by a wireless node.

[00133] FIG. 6 illustrates an exemplary wireless communications system according to various aspects of the disclosure.

[00134] FIG. 7 illustrates an exemplary wireless communications system according to various aspects of the disclosure.

[00135] FIG. 8A is a graph showing the RF channel response at a receiver over time according to aspects of the disclosure.

[00136] FIG. 8B is a diagram illustrating this separation of clusters in AoD.

[00137] FIG. 9 illustrates a channel response at a UE receiver in accordance with another embodiment of the disclosure.

[00138] FIG. 10 illustrates a channel response at a UE receiver in accordance with another embodiment of the disclosure.

[00139] FIGS. 11-12 illustrate methods of wireless communication, according to aspects of the disclosure.

[00140] FIG. 13 illustrates a channel response at a UE receiver in accordance with another embodiment of the disclosure.

[00141] FIG. 14 illustrates a channel response at a UE receiver in accordance with another embodiment of the disclosure.

[00142] FIG. 15 illustrates a channel response at a UE receiver in accordance with another embodiment of the disclosure.

DETAILED DESCRIPTION

[00143] Aspects of the disclosure are provided in the following description and related drawings directed to various examples provided for illustration purposes. Alternate aspects may be devised without departing from the scope of the disclosure. Additionally,

well-known elements of the disclosure will not be described in detail or will be omitted so as not to obscure the relevant details of the disclosure.

[00144] The words "exemplary" and/or "example" are used herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" and/or "example" is not necessarily to be construed as preferred or advantageous over other aspects. Likewise, the term "aspects of the disclosure" does not require that all aspects of the disclosure include the discussed feature, advantage or mode of operation.

[00145] Those of skill in the art will appreciate that the information and signals described below may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description below may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof, depending in part on the particular application, in part on the desired design, in part on the corresponding technology, etc.

[00146] Further, many aspects are described in terms of sequences of actions to be performed by, for example, elements of a computing device. It will be recognized that various actions described herein can be performed by specific circuits (e.g., application specific integrated circuits (ASICs)), by program instructions being executed by one or more processors, or by a combination of both. Additionally, the sequence(s) of actions described herein can be considered to be embodied entirely within any form of non-transitory computer-readable storage medium having stored therein a corresponding set of computer instructions that, upon execution, would cause or instruct an associated processor of a device to perform the functionality described herein. Thus, the various aspects of the disclosure may be embodied in a number of different forms, all of which have been contemplated to be within the scope of the claimed subject matter. In addition, for each of the aspects described herein, the corresponding form of any such aspects may be described herein as, for example, "logic configured to" perform the described action.

[00147] As used herein, the terms "user equipment" (UE) and "base station" are not intended to be specific or otherwise limited to any particular radio access technology (RAT), unless otherwise noted. In general, a UE may be any wireless communication device (e.g., a mobile phone, router, tablet computer, laptop computer, tracking device, wearable (e.g., smartwatch, glasses, augmented reality (AR) / virtual reality (VR) headset, etc.), vehicle (e.g., automobile, motorcycle, bicycle, etc.), Internet of Things (IoT) device,

etc.) used by a user to communicate over a wireless communications network. A UE may be mobile or may (e.g., at certain times) be stationary, and may communicate with a radio access network (RAN). As used herein, the term "UE" may be referred to interchangeably as an "access terminal" or "AT," a "client device," a "wireless device," a "subscriber device," a "subscriber terminal," a "subscriber station," a "user terminal" or UT, a "mobile terminal," a "mobile station," or variations thereof. Generally, UEs can communicate with a core network via a RAN, and through the core network the UEs can be connected with external networks such as the Internet and with other UEs. Of course, other mechanisms of connecting to the core network and/or the Internet are also possible for the UEs, such as over wired access networks, wireless local area network (WLAN) networks (e.g., based on IEEE 802.11, etc.) and so on.

[00148] A base station may operate according to one of several RATs in communication with UEs depending on the network in which it is deployed, and may be alternatively referred to as an access point (AP), a network node, a NodeB, an evolved NodeB (eNB), a New Radio (NR) Node B (also referred to as a gNB or gNodeB), etc. In addition, in some systems a base station may provide purely edge node signaling functions while in other systems it may provide additional control and/or network management functions. A communication link through which UEs can send signals to a base station is called an uplink (UL) channel (e.g., a reverse traffic channel, a reverse control channel, an access channel, etc.). A communication link through which the base station can send signals to UEs is called a downlink (DL) or forward link channel (e.g., a paging channel, a control channel, a broadcast channel, a forward traffic channel, etc.). As used herein the term traffic channel (TCH) can refer to either an UL / reverse or DL / forward traffic channel.

[00149] The term "base station" may refer to a single physical transmission-reception point (TRP) or to multiple physical TRPs that may or may not be co-located. For example, where the term "base station" refers to a single physical TRP, the physical TRP may be an antenna of the base station corresponding to a cell of the base station. Where the term "base station" refers to multiple co-located physical TRPs, the physical TRPs may be an array of antennas (e.g., as in a multiple-input multiple-output (MIMO) system or where the base station employs beamforming) of the base station. Where the term "base station" refers to multiple non-co-located physical TRPs, the physical TRPs may be a distributed antenna system (DAS) (a network of spatially separated antennas connected to a common source via a transport medium) or a remote radio head (RRH) (a

remote base station connected to a serving base station). Alternatively, the non-co-located physical TRPs may be the serving base station receiving the measurement report from the UE and a neighbor base station whose reference RF signals the UE is measuring. Because a TRP is the point from which a base station transmits and receives wireless signals, as used herein, references to transmission from or reception at a base station are to be understood as referring to a particular TRP of the base station.

[00150] An "RF signal" comprises an electromagnetic wave of a given frequency that transports information through the space between a transmitter and a receiver. As used herein, a transmitter may transmit a single "RF signal" or multiple "RF signals" to a receiver. However, the receiver may receive multiple "RF signals" corresponding to each transmitted RF signal due to the propagation characteristics of RF signals through multipath channels. The same transmitted RF signal on different paths between the transmitter and receiver may be referred to as a "multipath" RF signal.

[00151] According to various aspects, **FIG. 1** illustrates an exemplary wireless communications system 100. The wireless communications system 100 (which may also be referred to as a wireless wide area network (WWAN)) may include various base stations 102 and various UEs 104. The base stations 102 may include macro cell base stations (high power cellular base stations) and/or small cell base stations (low power cellular base stations). In an aspect, the macro cell base station may include eNBs where the wireless communications system 100 corresponds to an LTE network, or gNBs where the wireless communications system 100 corresponds to a NR network, or a combination of both, and the small cell base stations may include femtocells, picocells, microcells, etc.

[00152] The base stations 102 may collectively form a RAN and interface with a core network 170 (e.g., an evolved packet core (EPC) or next generation core (NGC)) through backhaul links 122, and through the core network 170 to one or more location servers 172. In addition to other functions, the base stations 102 may perform functions that relate to one or more of transferring user data, radio channel ciphering and deciphering, integrity protection, header compression, mobility control functions (e.g., handover, dual connectivity), inter-cell interference coordination, connection setup and release, load balancing, distribution for non-access stratum (NAS) messages, NAS node selection, synchronization, RAN sharing, multimedia broadcast multicast service (MBMS), subscriber and equipment trace, RAN information management (RIM), paging, positioning, and delivery of warning messages. The base stations 102 may communicate

with each other directly or indirectly (e.g., through the EPC / NGC) over backhaul links 134, which may be wired or wireless.

[00153] The base stations 102 may wirelessly communicate with the UEs 104. Each of the base stations 102 may provide communication coverage for a respective geographic coverage area 110. In an aspect, one or more cells may be supported by a base station 102 in each coverage area 110. A "cell" is a logical communication entity used for communication with a base station (e.g., over some frequency resource, referred to as a carrier frequency, component carrier, carrier, band, or the like), and may be associated with an identifier (e.g., a physical cell identifier (PCI), a virtual cell identifier (VCI)) for distinguishing cells operating via the same or a different carrier frequency. In some cases, different cells may be configured according to different protocol types (e.g., machine-type communication (MTC), narrowband IoT (NB-IoT), enhanced mobile broadband (eMBB), or others) that may provide access for different types of UEs. Because a cell is supported by a specific base station, the term "cell" may refer to either or both the logical communication entity and the base station that supports it, depending on the context. In some cases, the term "cell" may also refer to a geographic coverage area of a base station (e.g., a sector), insofar as a carrier frequency can be detected and used for communication within some portion of geographic coverage areas 110.

[00154] While neighboring macro cell base station 102 geographic coverage areas 110 may partially overlap (e.g., in a handover region), some of the geographic coverage areas 110 may be substantially overlapped by a larger geographic coverage area 110. For example, a small cell base station 102' may have a coverage area 110' that substantially overlaps with the coverage area 110 of one or more macro cell base stations 102. A network that includes both small cell and macro cell base stations may be known as a heterogeneous network. A heterogeneous network may also include home eNBs (HeNBs), which may provide service to a restricted group known as a closed subscriber group (CSG).

[00155] The communication links 120 between the base stations 102 and the UEs 104 may include UL (also referred to as reverse link) transmissions from a UE 104 to a base station 102 and/or downlink (DL) (also referred to as forward link) transmissions from a base station 102 to a UE 104. The communication links 120 may use MIMO antenna technology, including spatial multiplexing, beamforming, and/or transmit diversity. The communication links 120 may be through one or more carrier frequencies. Allocation of

carriers may be asymmetric with respect to DL and UL (e.g., more or less carriers may be allocated for DL than for UL).

[00156] The wireless communications system 100 may further include a wireless local area network (WLAN) access point (AP) 150 in communication with WLAN stations (STAs) 152 via communication links 154 in an unlicensed frequency spectrum (e.g., 5 GHz). When communicating in an unlicensed frequency spectrum, the WLAN STAs 152 and/or the WLAN AP 150 may perform a clear channel assessment (CCA) or listen before talk (LBT) procedure prior to communicating in order to determine whether the channel is available.

[00157] The small cell base station 102' may operate in a licensed and/or an unlicensed frequency spectrum. When operating in an unlicensed frequency spectrum, the small cell base station 102' may employ LTE or NR technology and use the same 5 GHz unlicensed frequency spectrum as used by the WLAN AP 150. The small cell base station 102', employing LTE / 5G in an unlicensed frequency spectrum, may boost coverage to and/or increase capacity of the access network. NR in unlicensed spectrum may be referred to as NR-U. LTE in an unlicensed spectrum may be referred to as LTE-U, licensed assisted access (LAA), or MulteFire.

[00158] The wireless communications system 100 may further include a millimeter wave (mmW) base station 180 that may operate in mmW frequencies and/or near mmW frequencies in communication with a UE 182. Extremely high frequency (EHF) is part of the RF in the electromagnetic spectrum. EHF has a range of 30 GHz to 300 GHz and a wavelength between 1 millimeter and 10 millimeters. Radio waves in this band may be referred to as a millimeter wave. Near mmW may extend down to a frequency of 3 GHz with a wavelength of 100 millimeters. The super high frequency (SHF) band extends between 3 GHz and 30 GHz, also referred to as centimeter wave. Communications using the mmW/near mmW radio frequency band have high path loss and a relatively short range. The mmW base station 180 and the UE 182 may utilize beamforming (transmit and/or receive) over a mmW communication link 184 to compensate for the extremely high path loss and short range. Further, it will be appreciated that in alternative configurations, one or more base stations 102 may also transmit using mmW or near mmW and beamforming. Accordingly, it will be appreciated that the foregoing illustrations are merely examples and should not be construed to limit the various aspects disclosed herein.

[00159] Transmit beamforming is a technique for focusing an RF signal in a specific direction. Traditionally, when a network node (e.g., a base station) broadcasts an RF signal, it broadcasts the signal in all directions (omni-directionally). With transmit beamforming, the network node determines where a given target device (e.g., a UE) is located (relative to the transmitting network node) and projects a stronger downlink RF signal in that specific direction, thereby providing a faster (in terms of data rate) and stronger RF signal for the receiving device(s). To change the directionality of the RF signal when transmitting, a network node can control the phase and relative amplitude of the RF signal at each of the one or more transmitters that are broadcasting the RF signal. For example, a network node may use an array of antennas (referred to as a "phased array" or an "antenna array") that creates a beam of RF waves that can be "steered" to point in different directions, without actually moving the antennas. Specifically, the RF current from the transmitter is fed to the individual antennas with the correct phase relationship so that the radio waves from the separate antennas add together to increase the radiation in a desired direction, while cancelling to suppress radiation in undesired directions.

[00160] Transmit beams may be quasi-collocated, meaning that they appear to the receiver (e.g., a UE) as having the same parameters, regardless of whether or not the transmitting antennas of the network node themselves are physically collocated. In NR, there are four types of quasi-collocation (QCL) relations. Specifically, a QCL relation of a given type means that certain parameters about a second reference RF signal on a second beam can be derived from information about a source reference RF signal on a source beam. Thus, if the source reference RF signal is QCL Type A, the receiver can use the source reference RF signal to estimate the Doppler shift, Doppler spread, average delay, and delay spread of a second reference RF signal transmitted on the same channel. If the source reference RF signal is QCL Type B, the receiver can use the source reference RF signal to estimate the Doppler shift and Doppler spread of a second reference RF signal transmitted on the same channel. If the source reference RF signal is QCL Type C, the receiver can use the source reference RF signal to estimate the Doppler shift and average delay of a second reference RF signal transmitted on the same channel. If the source reference RF signal is QCL Type D, the receiver can use the source reference RF signal to estimate the spatial receive parameter of a second reference RF signal transmitted on the same channel.

[00161] In receive beamforming, the receiver uses a receive beam to amplify RF signals detected on a given channel. For example, the receiver can increase the gain setting

and/or adjust the phase setting of an array of antennas in a particular direction to amplify (e.g., to increase the gain level of) the RF signals received from that direction. Thus, when a receiver is said to beamform in a certain direction, it means the beam gain in that direction is high relative to the beam gain along other directions, or the beam gain in that direction is the highest compared to the beam gain in that direction of all other receive beams available to the receiver. This results in a stronger received signal strength (e.g., reference signal received power (RSRP), reference signal received quality (RSRQ), signal-to-interference-plus-noise ratio (SINR), etc.) of the RF signals received from that direction.

[00162] Receive beams may be spatially related. A spatial relation means that parameters for a transmit beam for a second reference signal can be derived from information about a receive beam for a first reference signal. For example, a UE may use a particular receive beam to receive a reference downlink reference signal (e.g., synchronization signal block (SSB)) from a base station. The UE can then form a transmit beam for sending an uplink reference signal (e.g., sounding reference signal (SRS)) to that base station based on the parameters of the receive beam.

[00163] Note that a "downlink" beam may be either a transmit beam or a receive beam, depending on the entity forming it. For example, if a base station is forming the downlink beam to transmit a reference signal to a UE, the downlink beam is a transmit beam. If the UE is forming the downlink beam, however, it is a receive beam to receive the downlink reference signal. Similarly, an "uplink" beam may be either a transmit beam or a receive beam, depending on the entity forming it. For example, if a base station is forming the uplink beam, it is an uplink receive beam, and if a UE is forming the uplink beam, it is an uplink transmit beam.

[00164] In 5G, the frequency spectrum in which wireless nodes (e.g., base stations 102/180, UEs 104/182) operate is divided into multiple frequency ranges, FR1 (from 450 to 6000 MHz), FR2 (from 24250 to 52600 MHz), FR3 (above 52600 MHz), and FR4 (between FR1 and FR2). In a multi-carrier system, such as 5G, one of the carrier frequencies is referred to as the "primary carrier" or "anchor carrier" or "primary serving cell" or "PCell," and the remaining carrier frequencies are referred to as "secondary carriers" or "secondary serving cells" or "SCells." In carrier aggregation, the anchor carrier is the carrier operating on the primary frequency (e.g., FR1) utilized by a UE 104/182 and the cell in which the UE 104/182 either performs the initial radio resource

control (RRC) connection establishment procedure or initiates the RRC connection re-establishment procedure. The primary carrier carries all common and UE-specific control channels, and may be a carrier in a licensed frequency (however, this is not always the case). A secondary carrier is a carrier operating on a second frequency (e.g., FR2) that may be configured once the RRC connection is established between the UE 104 and the anchor carrier and that may be used to provide additional radio resources. In some cases, the secondary carrier may be a carrier in an unlicensed frequency. The secondary carrier may contain only necessary signaling information and signals, for example, those that are UE-specific may not be present in the secondary carrier, since both primary uplink and downlink carriers are typically UE-specific. This means that different UEs 104/182 in a cell may have different downlink primary carriers. The same is true for the uplink primary carriers. The network is able to change the primary carrier of any UE 104/182 at any time. This is done, for example, to balance the load on different carriers. Because a "serving cell" (whether a PCell or an SCell) corresponds to a carrier frequency / component carrier over which some base station is communicating, the term "cell," "serving cell," "component carrier," "carrier frequency," and the like can be used interchangeably.

[00165] For example, still referring to FIG. 1, one of the frequencies utilized by the macro cell base stations 102 may be an anchor carrier (or "PCell") and other frequencies utilized by the macro cell base stations 102 and/or the mmW base station 180 may be secondary carriers ("SCells"). The simultaneous transmission and/or reception of multiple carriers enables the UE 104/182 to significantly increase its data transmission and/or reception rates. For example, two 20 MHz aggregated carriers in a multi-carrier system would theoretically lead to a two-fold increase in data rate (i.e., 40 MHz), compared to that attained by a single 20 MHz carrier.

[00166] The wireless communications system 100 may further include one or more UEs, such as UE 190, that connects indirectly to one or more communication networks via one or more device-to-device (D2D) peer-to-peer (P2P) links. In the example of FIG. 1, UE 190 has a D2D P2P link 192 with one of the UEs 104 connected to one of the base stations 102 (e.g., through which UE 190 may indirectly obtain cellular connectivity) and a D2D P2P link 194 with WLAN STA 152 connected to the WLAN AP 150 (through which UE 190 may indirectly obtain WLAN-based Internet connectivity). In an example, the D2D P2P links 192 and 194 may be supported with any well-known D2D RAT, such as LTE Direct (LTE-D), WiFi Direct (WiFi-D), Bluetooth®, and so on.

[00167] The wireless communications system 100 may further include a UE 164 that may communicate with a macro cell base station 102 over a communication link 120 and/or the mmW base station 180 over a mmW communication link 184. For example, the macro cell base station 102 may support a PCell and one or more SCells for the UE 164 and the mmW base station 180 may support one or more SCells for the UE 164.

[00168] According to various aspects, **FIG. 2A** illustrates an example wireless network structure 200. For example, an NGC 210 (also referred to as a "5GC") can be viewed functionally as control plane functions 214 (e.g., UE registration, authentication, network access, gateway selection, etc.) and user plane functions 212, (e.g., UE gateway function, access to data networks, IP routing, etc.) which operate cooperatively to form the core network. User plane interface (NG-U) 213 and control plane interface (NG-C) 215 connect the gNB 222 to the NGC 210 and specifically to the control plane functions 214 and user plane functions 212. In an additional configuration, an eNB 224 may also be connected to the NGC 210 via NG-C 215 to the control plane functions 214 and NG-U 213 to user plane functions 212. Further, eNB 224 may directly communicate with gNB 222 via a backhaul connection 223. In some configurations, the New RAN 220 may only have one or more gNBs 222, while other configurations include one or more of both eNBs 224 and gNBs 222. Either gNB 222 or eNB 224 may communicate with UEs 204 (e.g., any of the UEs depicted in FIG. 1). Another optional aspect may include location server 230, which may be in communication with the NGC 210 to provide location assistance for UEs 204. The location server 230 can be implemented as a plurality of separate servers (e.g., physically separate servers, different software modules on a single server, different software modules spread across multiple physical servers, etc.), or alternately may each correspond to a single server. The location server 230 can be configured to support one or more location services for UEs 204 that can connect to the location server 230 via the core network, NGC 210, and/or via the Internet (not illustrated). Further, the location server 230 may be integrated into a component of the core network, or alternatively may be external to the core network.

[00169] According to various aspects, **FIG. 2B** illustrates another example wireless network structure 250. For example, an NGC 260 (also referred to as a "5GC") can be viewed functionally as control plane functions, provided by an access and mobility management function (AMF) / user plane function (UPF) 264, and user plane functions, provided by a session management function (SMF) 262, which operate cooperatively to

form the core network (i.e., NGC 260). User plane interface 263 and control plane interface 265 connect the eNB 224 to the NGC 260 and specifically to SMF 262 and AMF/UPF 264, respectively. In an additional configuration, a gNB 222 may also be connected to the NGC 260 via control plane interface 265 to AMF/UPF 264 and user plane interface 263 to SMF 262. Further, eNB 224 may directly communicate with gNB 222 via the backhaul connection 223, with or without gNB direct connectivity to the NGC 260. In some configurations, the New RAN 220 may only have one or more gNBs 222, while other configurations include one or more of both eNBs 224 and gNBs 222. Either gNB 222 or eNB 224 may communicate with UEs 204 (e.g., any of the UEs depicted in FIG. 1). The base stations of the New RAN 220 communicate with the AMF-side of the AMF/UPF 264 over the N2 interface and the UPF-side of the AMF/UPF 264 over the N3 interface.

[00170] The functions of the AMF include registration management, connection management, reachability management, mobility management, lawful interception, transport for session management (SM) messages between the UE 204 and the SMF 262, transparent proxy services for routing SM messages, access authentication and access authorization, transport for short message service (SMS) messages between the UE 204 and the short message service function (SMSF) (not shown), and security anchor functionality (SEAF). The AMF also interacts with the authentication server function (AUSF) (not shown) and the UE 204, and receives the intermediate key that was established as a result of the UE 204 authentication process. In the case of authentication based on a UMTS (universal mobile telecommunications system) subscriber identity module (USIM), the AMF retrieves the security material from the AUSF. The functions of the AMF also include security context management (SCM). The SCM receives a key from the SEAF that it uses to derive access-network specific keys. The functionality of the AMF also includes location services management for regulatory services, transport for location services messages between the UE 204 and the location management function (LMF) 270, as well as between the New RAN 220 and the LMF 270, evolved packet system (EPS) bearer identifier allocation for interworking with the EPS, and UE 204 mobility event notification. In addition, the AMF also supports functionalities for non-3GPP access networks.

[00171] Functions of the UPF include acting as an anchor point for intra-/inter-RAT mobility (when applicable), acting as an external protocol data unit (PDU) session point

of interconnect to the data network (not shown), providing packet routing and forwarding, packet inspection, user plane policy rule enforcement (e.g., gating, redirection, traffic steering), lawful interception (user plane collection), traffic usage reporting, quality of service (QoS) handling for the user plane (e.g., UL/DL rate enforcement, reflective QoS marking in the DL), UL traffic verification (service data flow (SDF) to QoS flow mapping), transport level packet marking in the UL and DL, DL packet buffering and DL data notification triggering, and sending and forwarding of one or more "end markers" to the source RAN node.

[00172] The functions of the SMF 262 include session management, UE Internet protocol (IP) address allocation and management, selection and control of user plane functions, configuration of traffic steering at the UPF to route traffic to the proper destination, control of part of policy enforcement and QoS, and downlink data notification. The interface over which the SMF 262 communicates with the AMF-side of the AMF/UPF 264 is referred to as the N11 interface.

[00173] Another optional aspect may include a LMF 270, which may be in communication with the NGC 260 to provide location assistance for UEs 204. The LMF 270 can be implemented as a plurality of separate servers (e.g., physically separate servers, different software modules on a single server, different software modules spread across multiple physical servers, etc.), or alternately may each correspond to a single server. The LMF 270 can be configured to support one or more location services for UEs 204 that can connect to the LMF 270 via the core network, NGC 260, and/or via the Internet (not illustrated).

[00174] **FIGS. 3A, 3B, and 3C** illustrate several sample components (represented by corresponding blocks) that may be incorporated into a UE 302 (which may correspond to any of the UEs described herein), a base station 304 (which may correspond to any of the base stations described herein), and a network entity 306 (which may correspond to or embody any of the network functions described herein, including the location server 230 and the LMF 270) to support the file transmission operations as taught herein. It will be appreciated that these components may be implemented in different types of apparatuses in different implementations (e.g., in an ASIC, in a system-on-chip (SoC), etc.). The illustrated components may also be incorporated into other apparatuses in a communication system. For example, other apparatuses in a system may include components similar to those described to provide similar functionality. Also, a given

apparatus may contain one or more of the components. For example, an apparatus may include multiple transceiver components that enable the apparatus to operate on multiple carriers and/or communicate via different technologies.

[00175] The UE 302 and the base station 304 each include wireless wide area network (WWAN) transceiver 310 and 350, respectively, configured to communicate via one or more wireless communication networks (not shown), such as an NR network, an LTE network, a GSM network, and/or the like. The WWAN transceivers 310 and 350 may be connected to one or more antennas 316 and 356, respectively, for communicating with other network nodes, such as other UEs, access points, base stations (e.g., eNBs, gNBs), etc., via at least one designated RAT (e.g., NR, LTE, GSM, etc.) over a wireless communication medium of interest (e.g., some set of time/frequency resources in a particular frequency spectrum). The WWAN transceivers 310 and 350 may be variously configured for transmitting and encoding signals 318 and 358 (e.g., messages, indications, information, and so on), respectively, and, conversely, for receiving and decoding signals 318 and 358 (e.g., messages, indications, information, pilots, and so on), respectively, in accordance with the designated RAT. Specifically, the transceivers 310 and 350 include one or more transmitters 314 and 354, respectively, for transmitting and encoding signals 318 and 358, respectively, and one or more receivers 312 and 352, respectively, for receiving and decoding signals 318 and 358, respectively.

[00176] The UE 302 and the base station 304 also include, at least in some cases, wireless local area network (WLAN) transceivers 320 and 360, respectively. The WLAN transceivers 320 and 360 may be connected to one or more antennas 326 and 366, respectively, for communicating with other network nodes, such as other UEs, access points, base stations, etc., via at least one designated RAT (e.g., WiFi, LTE-D, Bluetooth®, etc.) over a wireless communication medium of interest. The WLAN transceivers 320 and 360 may be variously configured for transmitting and encoding signals 328 and 368 (e.g., messages, indications, information, and so on), respectively, and, conversely, for receiving and decoding signals 328 and 368 (e.g., messages, indications, information, pilots, and so on), respectively, in accordance with the designated RAT. Specifically, the transceivers 320 and 360 include one or more transmitters 324 and 364, respectively, for transmitting and encoding signals 328 and 368, respectively, and one or more receivers 322 and 362, respectively, for receiving and decoding signals 328 and 368, respectively.

[00177] Transceiver circuitry including a transmitter and a receiver may comprise an integrated device (e.g., embodied as a transmitter circuit and a receiver circuit of a single communication device) in some implementations, may comprise a separate transmitter device and a separate receiver device in some implementations, or may be embodied in other ways in other implementations. In an aspect, a transmitter may include or be coupled to a plurality of antennas (e.g., antennas 316, 336, and 376), such as an antenna array, that permits the respective apparatus to perform transmit "beamforming," as described herein. Similarly, a receiver may include or be coupled to a plurality of antennas (e.g., antennas 316, 336, and 376), such as an antenna array, that permits the respective apparatus to perform receive beamforming, as described herein. In an aspect, the transmitter and receiver may share the same plurality of antennas (e.g., antennas 316, 336, and 376), such that the respective apparatus can only receive or transmit at a given time, not both at the same time. A wireless communication device (e.g., one or both of the transceivers 310 and 320 and/or 350 and 360) of the apparatuses 302 and/or 304 may also comprise a network listen module (NLM) or the like for performing various measurements.

[00178] The apparatuses 302 and 304 also include, at least in some cases, satellite positioning systems (SPS) receivers 330 and 370. The SPS receivers 330 and 370 may be connected to one or more antennas 336 and 376, respectively, for receiving SPS signals 338 and 378, respectively, such as global positioning system (GPS) signals, global navigation satellite system (GLONASS) signals, Galileo signals, Beidou signals, Indian Regional Navigation Satellite System (NAVIC), Quasi-Zenith Satellite System (QZSS), etc. The SPS receivers 330 and 370 may comprise any suitable hardware and/or software for receiving and processing SPS signals 338 and 378, respectively. The SPS receivers 330 and 370 request information and operations as appropriate from the other systems, and performs calculations necessary to determine the apparatus' 302 and 304 positions using measurements obtained by any suitable SPS algorithm.

[00179] The base station 304 and the network entity 306 each include at least one network interfaces 380 and 390 for communicating with other network entities. For example, the network interfaces 380 and 390 (e.g., one or more network access ports) may be configured to communicate with one or more network entities via a wire-based or wireless backhaul connection. In some aspects, the network interfaces 380 and 390 may be implemented as transceivers configured to support wire-based or wireless signal

communication. This communication may involve, for example, sending and receiving: messages, parameters, or other types of information.

[00180] The apparatuses 302, 304, and 306 also include other components that may be used in conjunction with the operations as disclosed herein. The UE 302 includes processor circuitry implementing a processing system 332 for providing functionality relating to, for example, false base station (FBS) detection as disclosed herein and for providing other processing functionality. The base station 304 includes a processing system 384 for providing functionality relating to, for example, FBS detection as disclosed herein and for providing other processing functionality. The network entity 306 includes a processing system 394 for providing functionality relating to, for example, FBS detection as disclosed herein and for providing other processing functionality. In an aspect, the processing systems 332, 384, and 394 may include, for example, one or more general purpose processors, multi-core processors, ASICs, digital signal processors (DSPs), field programmable gate arrays (FPGA), or other programmable logic devices or processing circuitry.

[00181] The apparatuses 302, 304, and 306 include memory circuitry implementing memory components 340, 386, and 396 (e.g., each including a memory device), respectively, for maintaining information (e.g., information indicative of reserved resources, thresholds, parameters, and so on). In some cases, the apparatuses 302, 304, and 306 may include positioning measurement modules 342, 388 and 389, respectively. The positioning measurement modules 342, 388 and 389 may be hardware circuits that are part of or coupled to the processing systems 332, 384, and 394, respectively, that, when executed, cause the apparatuses 302, 304, and 306 to perform the functionality described herein. Alternatively, the positioning measurement modules 342, 388 and 389 may be memory modules (as shown in FIGS. 3A-C) stored in the memory components 340, 386, and 396, respectively, that, when executed by the processing systems 332, 384, and 394, cause the apparatuses 302, 304, and 306 to perform the functionality described herein.

[00182] The UE 302 may include one or more sensors 344 coupled to the processing system 332 to provide movement and/or orientation information that is independent of motion data derived from signals received by the WWAN transceiver 310, the WLAN transceiver 320, and/or the GPS receiver 330. By way of example, the sensor(s) 344 may include an accelerometer (e.g., a micro-electrical mechanical systems (MEMS) device),

a gyroscope, a geomagnetic sensor (e.g., a compass), an altimeter (e.g., a barometric pressure altimeter), and/or any other type of movement detection sensor. Moreover, the sensor(s) 344 may include a plurality of different types of devices and combine their outputs in order to provide motion information. For example, the sensor(s) 344 may use a combination of a multi-axis accelerometer and orientation sensors to provide the ability to compute positions in 2D and/or 3D coordinate systems.

[00183] In addition, the UE 302 includes a user interface 346 for providing indications (e.g., audible and/or visual indications) to a user and/or for receiving user input (e.g., upon user actuation of a sensing device such a keypad, a touch screen, a microphone, and so on). Although not shown, the apparatuses 304 and 306 may also include user interfaces.

[00184] Referring to the processing system 384 in more detail, in the downlink, IP packets from the network entity 306 may be provided to the processing system 384. The processing system 384 may implement functionality for an RRC layer, a packet data convergence protocol (PDCP) layer, a radio link control (RLC) layer, and a medium access control (MAC) layer. The processing system 384 may provide RRC layer functionality associated with broadcasting of system information (e.g., master information block (MIB), system information blocks (SIBs)), RRC connection control (e.g., RRC connection paging, RRC connection establishment, RRC connection modification, and RRC connection release), inter-RAT mobility, and measurement configuration for UE measurement reporting; PDCP layer functionality associated with header compression/decompression, security (ciphering, deciphering, integrity protection, integrity verification), and handover support functions; RLC layer functionality associated with the transfer of upper layer packet data units (PDUs), error correction through ARQ, concatenation, segmentation, and reassembly of RLC service data units (SDUs), re-segmentation of RLC data PDUs, and reordering of RLC data PDUs; and MAC layer functionality associated with mapping between logical channels and transport channels, scheduling information reporting, error correction, priority handling, and logical channel prioritization.

[00185] The transmitter 354 and the receiver 352 may implement Layer-1 functionality associated with various signal processing functions. Layer-1, which includes a physical (PHY) layer, may include error detection on the transport channels, forward error correction (FEC) coding/decoding of the transport channels, interleaving, rate matching, mapping onto physical channels, modulation/demodulation of physical channels, and

MIMO antenna processing. The transmitter 354 handles mapping to signal constellations based on various modulation schemes (e.g., binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-quadrature amplitude modulation (M-QAM)). The coded and modulated symbols may then be split into parallel streams. Each stream may then be mapped to an orthogonal frequency division multiplexing (OFDM) subcarrier, multiplexed with a reference signal (e.g., pilot) in the time and/or frequency domain, and then combined together using an Inverse Fast Fourier Transform (IFFT) to produce a physical channel carrying a time domain OFDM symbol stream. The OFDM stream is spatially precoded to produce multiple spatial streams. Channel estimates from a channel estimator may be used to determine the coding and modulation scheme, as well as for spatial processing. The channel estimate may be derived from a reference signal and/or channel condition feedback transmitted by the UE 302. Each spatial stream may then be provided to one or more different antennas 356. The transmitter 354 may modulate an RF carrier with a respective spatial stream for transmission.

[00186] At the UE 302, the receiver 312 receives a signal through its respective antenna(s) 316. The receiver 312 recovers information modulated onto an RF carrier and provides the information to the processing system 332. The transmitter 314 and the receiver 312 implement Layer-1 functionality associated with various signal processing functions. The receiver 312 may perform spatial processing on the information to recover any spatial streams destined for the UE 302. If multiple spatial streams are destined for the UE 302, they may be combined by the receiver 312 into a single OFDM symbol stream. The receiver 312 then converts the OFDM symbol stream from the time-domain to the frequency domain using a fast Fourier transform (FFT). The frequency domain signal comprises a separate OFDM symbol stream for each subcarrier of the OFDM signal. The symbols on each subcarrier, and the reference signal, are recovered and demodulated by determining the most likely signal constellation points transmitted by the base station 304. These soft decisions may be based on channel estimates computed by a channel estimator. The soft decisions are then decoded and de-interleaved to recover the data and control signals that were originally transmitted by the base station 304 on the physical channel. The data and control signals are then provided to the processing system 332, which implements Layer-3 and Layer-2 functionality.

[00187] In the UL, the processing system 332 provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, and control signal processing to recover IP packets from the core network. The processing system 332 is also responsible for error detection.

[00188] Similar to the functionality described in connection with the DL transmission by the base station 304, the processing system 332 provides RRC layer functionality associated with system information (e.g., MIB, SIBs) acquisition, RRC connections, and measurement reporting; PDCP layer functionality associated with header compression/decompression, and security (ciphering, deciphering, integrity protection, integrity verification); RLC layer functionality associated with the transfer of upper layer PDUs, error correction through ARQ, concatenation, segmentation, and reassembly of RLC SDUs, re-segmentation of RLC data PDUs, and reordering of RLC data PDUs; and MAC layer functionality associated with mapping between logical channels and transport channels, multiplexing of MAC SDUs onto transport blocks (TBs), demultiplexing of MAC SDUs from TBs, scheduling information reporting, error correction through HARQ, priority handling, and logical channel prioritization.

[00189] Channel estimates derived by the channel estimator from a reference signal or feedback transmitted by the base station 304 may be used by the transmitter 314 to select the appropriate coding and modulation schemes, and to facilitate spatial processing. The spatial streams generated by the transmitter 314 may be provided to different antenna(s) 316. The transmitter 314 may modulate an RF carrier with a respective spatial stream for transmission.

[00190] The UL transmission is processed at the base station 304 in a manner similar to that described in connection with the receiver function at the UE 302. The receiver 352 receives a signal through its respective antenna(s) 356. The receiver 352 recovers information modulated onto an RF carrier and provides the information to the processing system 384.

[00191] In the UL, the processing system 384 provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover IP packets from the UE 302. IP packets from the processing system 384 may be provided to the core network. The processing system 384 is also responsible for error detection.

[00192] For convenience, the apparatuses 302, 304, and/or 306 are shown in FIGS. 3A-C as including various components that may be configured according to the various examples described herein. It will be appreciated, however, that the illustrated blocks may have different functionality in different designs.

[00193] The various components of the apparatuses 302, 304, and 306 may communicate with each other over data buses 334, 382, and 392, respectively. The components of FIGS. 3A-C may be implemented in various ways. In some implementations, the components of FIGS. 3A-C may be implemented in one or more circuits such as, for example, one or more processors and/or one or more ASICs (which may include one or more processors). Here, each circuit may use and/or incorporate at least one memory component for storing information or executable code used by the circuit to provide this functionality. For example, some or all of the functionality represented by blocks 310 to 346 may be implemented by processor and memory component(s) of the UE 302 (e.g., by execution of appropriate code and/or by appropriate configuration of processor components). Similarly, some or all of the functionality represented by blocks 350 to 389 may be implemented by processor and memory component(s) of the base station 304 (e.g., by execution of appropriate code and/or by appropriate configuration of processor components). Also, some or all of the functionality represented by blocks 390 to 396 may be implemented by processor and memory component(s) of the network entity 306 (e.g., by execution of appropriate code and/or by appropriate configuration of processor components). For simplicity, various operations, acts, and/or functions are described herein as being performed "by a UE," "by a base station," "by a positioning entity," etc. However, as will be appreciated, such operations, acts, and/or functions may actually be performed by specific components or combinations of components of the UE, base station, positioning entity, etc., such as the processing systems 332, 384, 394, the transceivers 310, 320, 350, and 360, the memory components 340, 386, and 396, the positioning measurement modules 342, 388, 389, etc.

[00194] **FIG. 4A** is a diagram 400 illustrating an example of a DL frame structure, according to aspects of the disclosure. **FIG. 4B** is a diagram 430 illustrating an example of channels within the DL frame structure, according to aspects of the disclosure. Other wireless communications technologies may have a different frame structures and/or different channels.

[00195] LTE, and in some cases NR, utilizes OFDM on the downlink and single-carrier frequency division multiplexing (SC-FDM) on the uplink. Unlike LTE, however, NR has an option to use OFDM on the uplink as well. OFDM and SC-FDM partition the system bandwidth into multiple (K) orthogonal subcarriers, which are also commonly referred to as tones, bins, etc. Each subcarrier may be modulated with data. In general, modulation symbols are sent in the frequency domain with OFDM and in the time domain with SC-FDM. The spacing between adjacent subcarriers may be fixed, and the total number of subcarriers (K) may be dependent on the system bandwidth. For example, the spacing of the subcarriers may be 15 kHz and the minimum resource allocation (resource block) may be 12 subcarriers (or 180 kHz). Consequently, the nominal FFT size may be equal to 128, 256, 512, 1024, or 2048 for system bandwidth of 1.25, 2.5, 5, 10, or 20 megahertz (MHz), respectively. The system bandwidth may also be partitioned into subbands. For example, a subband may cover 1.08 MHz (i.e., 6 resource blocks), and there may be 1, 2, 4, 8, or 16 subbands for system bandwidth of 1.25, 2.5, 5, 10, or 20 MHz, respectively.

[00196] LTE supports a single numerology (subcarrier spacing, symbol length, etc.). In contrast NR may support multiple numerologies, for example, subcarrier spacing of 15 kHz, 30 kHz, 60 kHz, 120 kHz and 204 kHz or greater may be available. Table 1 provided below lists some various parameters for different NR numerologies.

Subcarrier spacing (kHz)	Symbols / slot	slots / subframe	slots / frame	slot (ms)	Symbol duration (μs)	Max. nominal system BW (MHz) with 4K FFT size
15	14	1	10	1	66.7	50
30	14	2	20	0.5	33.3	100
60	14	4	40	0.25	16.7	100
120	14	8	80	0.125	8.33	400
240	14	16	160	0.0625	4.17	800

Table 1

[00197] In the examples of FIGS. 4A and 4B, a numerology of 15 kHz is used. Thus, in the time domain, a frame (e.g., 10 ms) is divided into 10 equally sized subframes of 1 ms each, and each subframe includes one time slot. In FIGS. 4A and 4B, time is represented horizontally (e.g., on the X axis) with time increasing from left to right, while frequency

is represented vertically (e.g., on the Y axis) with frequency increasing (or decreasing) from bottom to top.

[00198] A resource grid may be used to represent time slots, each time slot including one or more time concurrent resource blocks (RBs) (also referred to as physical RBs (PRBs)) in the frequency domain. The resource grid is further divided into multiple resource elements (REs). An RE may correspond to one symbol length in the time domain and one subcarrier in the frequency domain. In the numerology of FIGS. 4A and 4B, for a normal cyclic prefix, an RB may contain 12 consecutive subcarriers in the frequency domain and 7 consecutive symbols (for DL, OFDM symbols; for UL, SC-FDMA symbols) in the time domain, for a total of 84 REs. For an extended cyclic prefix, an RB may contain 12 consecutive subcarriers in the frequency domain and 6 consecutive symbols in the time domain, for a total of 72 REs. The number of bits carried by each RE depends on the modulation scheme.

[00199] As illustrated in FIG. 4A, some of the REs carry DL reference (pilot) signals (DL-RS) for channel estimation at the UE. The DL-RS may include demodulation reference signals (DMRS) and channel state information reference signals (CSI-RS), exemplary locations of which are labeled "R" in FIG. 4A.

[00200] FIG. 4B illustrates an example of various channels within a DL subframe of a frame. The physical downlink control channel (PDCCH) carries DL control information (DCI) within one or more control channel elements (CCEs), each CCE including nine RE groups (REGs), each REG including four consecutive REs in an OFDM symbol. The DCI carries information about UL resource allocation (persistent and non-persistent) and descriptions about DL data transmitted to the UE. Multiple (e.g., up to 8) DCIs can be configured in the PDCCH, and these DCIs can have one of multiple formats. For example, there are different DCI formats for UL scheduling, for non-MIMO DL scheduling, for MIMO DL scheduling, and for UL power control.

[00201] A primary synchronization signal (PSS) is used by a UE to determine subframe/symbol timing and a physical layer identity. A secondary synchronization signal (SSS) is used by a UE to determine a physical layer cell identity group number and radio frame timing. Based on the physical layer identity and the physical layer cell identity group number, the UE can determine a PCI. Based on the PCI, the UE can determine the locations of the aforementioned DL-RS. The physical broadcast channel (PBCH), which carries an MIB, may be logically grouped with the PSS and SSS to form

an SSB (also referred to as an SS/PBCH). The MIB provides a number of RBs in the DL system bandwidth and a system frame number (SFN). The physical downlink shared channel (PDSCH) carries user data, broadcast system information not transmitted through the PBCH such as system information blocks (SIBs), and paging messages.

[00202] In some cases, the DL RS illustrated in FIG. 4A may be positioning reference signals (PRS). **FIG. 5** illustrates an exemplary PRS configuration 500 for a cell supported by a wireless node (such as a base station 102). FIG. 5 shows how PRS positioning occasions are determined by a system frame number (SFN), a cell specific subframe offset (Δ_{PRS}) 552, and the PRS periodicity (T_{PRS}) 520. Typically, the cell specific PRS subframe configuration is defined by a "PRS Configuration Index" I_{PRS} included in observed time difference of arrival (OTDOA) assistance data. The PRS periodicity (T_{PRS}) 520 and the cell specific subframe offset (Δ_{PRS}) are defined based on the PRS configuration index I_{PRS}, as illustrated in Table 2 below.

PRS configuration Index I_{PRS}	**PRS periodicity T_{PRS} (subframes)**	**PRS subframe offset Δ_{PRS} (subframes)**
0 – 159	160	I_{PRS}
160 – 479	320	$I_{PRS} - 160$
480 – 1119	640	$I_{PRS} - 480$
1120 – 2399	1280	$I_{PRS} - 1120$
2400 – 2404	5	$I_{PRS} - 2400$
2405 – 2414	10	$I_{PRS} - 2405$
2415 – 2434	20	$I_{PRS} - 2415$
2435 – 2474	40	$I_{PRS} - 2435$
2475 – 2554	80	$I_{PRS} - 2475$
2555-4095	Reserved	

Table 2

[00203] A PRS configuration is defined with reference to the SFN of a cell that transmits PRS. PRS instances, for the first subframe of the N_{PRS} downlink subframes comprising a first PRS positioning occasion, may satisfy:

$$(10 \times n_f + \lfloor n_s / 2 \rfloor - \Delta_{PRS}) mod\ T_{PRS} = 0,$$

where n_f is the SFN with $0 \leq n_f \leq 1023$, n_s is the slot number within the radio frame defined by n_f with $0 \leq n_s \leq 19$, T_{PRS} is the PRS periodicity 520, and Δ_{PRS} is the cell-specific subframe offset 552.

[00204] As shown in FIG. 5, the cell specific subframe offset Δ_{PRS} 552 may be defined in terms of the number of subframes transmitted starting from system frame number 0 (Slot 'Number 0', marked as slot 550) to the start of the first (subsequent) PRS positioning occasion. In the example in FIG. 5, the number of consecutive positioning subframes (N_{PRS}) in each of the consecutive PRS positioning occasions 518a, 518b, and 518c equals 4. That is, each shaded block representing PRS positioning occasions 518a, 518b, and 518c represents four subframes.

[00205] In some aspects, when a UE receives a PRS configuration index I_{PRS} in the OTDOA assistance data for a particular cell, the UE may determine the PRS periodicity T_{PRS} 520 and PRS subframe offset Δ_{PRS} using Table 2. The UE may then determine the radio frame, subframe, and slot when a PRS is scheduled in the cell (e.g., using equation (1)). The OTDOA assistance data may be determined by, for example, the location server (e.g., location server 230, LMF 270), and includes assistance data for a reference cell, and a number of neighbor cells supported by various base stations.

[00206] Typically, PRS occasions from all cells in a network that use the same frequency are aligned in time and may have a fixed known time offset (e.g., cell-specific subframe offset 552) relative to other cells in the network that use a different frequency. In SFN-synchronous networks, all wireless nodes (e.g., base stations 102) may be aligned on both frame boundary and system frame number. Therefore, in SFN-synchronous networks, all cells supported by the various wireless nodes may use the same PRS configuration index for any particular frequency of PRS transmission. On the other hand, in SFN-asynchronous networks, the various wireless nodes may be aligned on a frame boundary, but not system frame number. Thus, in SFN-asynchronous networks the PRS configuration index for each cell may be configured separately by the network so that PRS occasions align in time.

[00207] A UE may determine the timing of the PRS occasions of the reference and neighbor cells for OTDOA positioning, if the UE can obtain the cell timing (e.g., SFN) of at least one of the cells, e.g., the reference cell or a serving cell. The timing of the other cells may then be derived by the UE based, for example, on the assumption that PRS occasions from different cells overlap.

[00208] 3GPP Rel. 16 introduced various NR positioning aspects directed to increase location accuracy of positioning schemes that involve measurement(s) associated with one or more UL or DL PRSs (e.g., higher bandwidth (BW), FR2 beam-sweeping, angle-

based measurements such as Angle of Arrival (AoA) and Angle of Departure (AoD) measurements, multi-cell Round-Trip Time (RTT) measurements, etc.). If latency reduction is a priority, then UE-based positioning techniques (e.g., DL-only techniques without UL location measurement reporting) are typically used. However, if latency is less of a concern, then UE-assisted positioning techniques can be used, whereby UE-measured data is reported to a network entity (e.g., location server 230, LMF 270, etc.). Latency associated UE-assisted positioning techniques can be reduced somewhat by implementing the LMF in the RAN.

[00209] Layer-3 (L3) signaling (e.g., RRC or Location Positioning Protocol (LPP)) is typically used to transport reports that comprise location-based data in association with UE-assisted positioning techniques. L3 signaling is associated with relatively high latency (e.g., above 100 ms) compared with Layer-1 (L1, or PHY layer) signaling or Layer-2 (L2, or MAC layer) signaling. In some cases, lower latency (e.g., less than 100 ms, less than 10 ms, etc.) between the UE and the RAN for location-based reporting may be desired. In such cases, L3 signaling may not be capable of reaching these lower latency levels. L3 signaling of positioning measurements may comprise any combination of the following:

- One or multiple TOA, TDOA, RSRP or Rx-Tx measurements,
- One or multiple AoA/AoD (e.g., currently agreed only for gNB->LMF reporting DL AoA and UL AoD) measurements,
- One or multiple Multipath reporting measurements, e.g., per-path ToA, RSRP, AoA/AoD (e.g., currently only per-path ToA allowed in LTE)
- One or multiple motion states (e.g., walking, driving, etc.) and trajectories (e.g., currently for UE), and/or
- One or multiple report quality indications.

[00210] More recently, L1 and L2 signaling has been contemplated for use in association with PRS-based reporting. For example, L1 and L2 signaling is currently used in some systems to transport CSI reports (e.g., reporting of Channel Quality Indications (CQIs), Precoding Matrix Indicators (PMIs), Layer Indicators (Lis), L1-RSRP, etc.). CSI reports may comprise a set of fields in a pre-defined order (e.g., defined by the relevant standard). A single UL transmission (e.g., on PUSCH or PUCCH) may include multiple reports, referred to herein as 'sub-reports', which are arranged according to a pre-defined priority (e.g., defined by the relevant standard). In some designs, the pre-defined order may be based on an associated sub-report periodicity (e.g., aperiodic/semi-persistent/periodic

(A/SP/P) over PUSCH/PUCCH), measurement type (e.g., L1-RSRP or not), serving cell index (e.g., in carrier aggregation (CA) case), and *reportconfigID*. With 2-part CSI reporting, the part 1s of all reports are grouped together, and the part 2s are grouped separately, and each group is separately encoded (e.g., part 1 payload size is fixed based on configuration parameters, while part 2 size is variable and depends on configuration parameters and also on associated part 1 content). A number of coded bits/symbols to be output after encoding and rate-matching is computed based on a number of input bits and beta factors, per the relevant standard. Linkages (e.g., time offsets) are defined between instances of RSs being measured and corresponding reporting. In some designs, CSI-like reporting of PRS-based measurement data using L1 and L2 signaling may be implemented.

[00211] FIG. 6 illustrates an exemplary wireless communications system 600 according to various aspects of the disclosure. In the example of FIG. 6, a UE 604, which may correspond to any of the UEs described above with respect to FIG. 1 (e.g., UEs 104, UE 182, UE 190, etc.), is attempting to calculate an estimate of its position, or assist another entity (e.g., a base station or core network component, another UE, a location server, a third party application, etc.) to calculate an estimate of its position. The UE 604 may communicate wirelessly with a plurality of base stations 602a-d (collectively, base stations 602), which may correspond to any combination of base stations 102 or 180 and/or WLAN AP 150 in FIG. 1, using RF signals and standardized protocols for the modulation of the RF signals and the exchange of information packets. By extracting different types of information from the exchanged RF signals, and utilizing the layout of the wireless communications system 600 (i.e., the base stations locations, geometry, etc.), the UE 604 may determine its position, or assist in the determination of its position, in a predefined reference coordinate system. In an aspect, the UE 604 may specify its position using a two-dimensional coordinate system; however, the aspects disclosed herein are not so limited, and may also be applicable to determining positions using a three-dimensional coordinate system, if the extra dimension is desired. Additionally, while FIG. 6 illustrates one UE 604 and four base stations 602, as will be appreciated, there may be more UEs 604 and more or fewer base stations 602.

[00212] To support position estimates, the base stations 602 may be configured to broadcast reference RF signals (e.g., Positioning Reference Signals (PRS), Cell-specific Reference Signals (CRS), Channel State Information Reference Signals (CSI-RS),

synchronization signals, etc.) to UEs 604 in their coverage areas to enable a UE 604 to measure reference RF signal timing differences (e.g., OTDOA or RSTD) between pairs of network nodes and/or to identify the beam that best excite the LOS or shortest radio path between the UE 604 and the transmitting base stations 602. Identifying the LOS/shortest path beam(s) is of interest not only because these beams can subsequently be used for OTDOA measurements between a pair of base stations 602, but also because identifying these beams can directly provide some positioning information based on the beam direction. Moreover, these beams can subsequently be used for other position estimation methods that require precise ToA, such as round-trip time estimation based methods.

[00213] As used herein, a "network node" may be a base station 602, a cell of a base station 602, a remote radio head, an antenna of a base station 602, where the locations of the antennas of a base station 602 are distinct from the location of the base station 602 itself, or any other network entity capable of transmitting reference signals. Further, as used herein, a "node" may refer to either a network node or a UE.

[00214] A location server (e.g., location server 230) may send assistance data to the UE 604 that includes an identification of one or more neighbor cells of base stations 602 and configuration information for reference RF signals transmitted by each neighbor cell. Alternatively, the assistance data can originate directly from the base stations 602 themselves (e.g., in periodically broadcasted overhead messages, etc.). Alternatively, the UE 604 can detect neighbor cells of base stations 602 itself without the use of assistance data. The UE 604 (e.g., based in part on the assistance data, if provided) can measure and (optionally) report the OTDOA from individual network nodes and/or RSTDs between reference RF signals received from pairs of network nodes. Using these measurements and the known locations of the measured network nodes (i.e., the base station(s) 602 or antenna(s) that transmitted the reference RF signals that the UE 604 measured), the UE 604 or the location server can determine the distance between the UE 604 and the measured network nodes and thereby calculate the location of the UE 604.

[00215] The term "position estimate" is used herein to refer to an estimate of a position for a UE 604, which may be geographic (e.g., may comprise a latitude, longitude, and possibly altitude) or civic (e.g., may comprise a street address, building designation, or precise point or area within or nearby to a building or street address, such as a particular entrance to a building, a particular room or suite in a building, or a landmark such as a

town square). A position estimate may also be referred to as a "location," a "position," a "fix," a "position fix," a "location fix," a "location estimate," a "fix estimate," or by some other term. The means of obtaining a location estimate may be referred to generically as "positioning," "locating," or "position fixing." A particular solution for obtaining a position estimate may be referred to as a "position solution." A particular method for obtaining a position estimate as part of a position solution may be referred to as a "position method" or as a "positioning method."

[00216] The term "base station" may refer to a single physical transmission point or to multiple physical transmission points that may or may not be co-located. For example, where the term "base station" refers to a single physical transmission point, the physical transmission point may be an antenna of the base station (e.g., base station 602) corresponding to a cell of the base station. Where the term "base station" refers to multiple co-located physical transmission points, the physical transmission points may be an array of antennas (e.g., as in a MIMO system or where the base station employs beamforming) of the base station. Where the term "base station" refers to multiple non-co-located physical transmission points, the physical transmission points may be a Distributed Antenna System (DAS) (a network of spatially separated antennas connected to a common source via a transport medium) or a Remote Radio Head (RRH) (a remote base station connected to a serving base station). Alternatively, the non-co-located physical transmission points may be the serving base station receiving the measurement report from the UE (e.g., UE 604) and a neighbor base station whose reference RF signals the UE is measuring. Thus, FIG. 6 illustrates an aspect in which base stations 602a and 602b form a DAS / RRH 620. For example, the base station 602a may be the serving base station of the UE 604 and the base station 602b may be a neighbor base station of the UE 604. As such, the base station 602b may be the RRH of the base station 602a. The base stations 602a and 602b may communicate with each other over a wired or wireless link 622.

[00217] To accurately determine the position of the UE 604 using the OTDOAs and/or RSTDs between RF signals received from pairs of network nodes, the UE 604 needs to measure the reference RF signals received over the LOS path (or the shortest NLOS path where an LOS path is not available), between the UE 604 and a network node (e.g., base station 602, antenna). However, RF signals travel not only by the LOS / shortest path between the transmitter and receiver, but also over a number of other paths as the RF

signals spread out from the transmitter and reflect off other objects such as hills, buildings, water, and the like on their way to the receiver. Thus, FIG. 6 illustrates a number of LOS paths 610 and a number of NLOS paths 612 between the base stations 602 and the UE 604. Specifically, FIG. 6 illustrates base station 602a transmitting over an LOS path 610a and an NLOS path 612a, base station 602b transmitting over an LOS path 610b and two NLOS paths 612b, base station 602c transmitting over an LOS path 610c and an NLOS path 612c, and base station 602d transmitting over two NLOS paths 612d. As illustrated in FIG. 6, each NLOS path 612 reflects off some object 630 (e.g., a building). As will be appreciated, each LOS path 610 and NLOS path 612 transmitted by a base station 602 may be transmitted by different antennas of the base station 602 (e.g., as in a MIMO system), or may be transmitted by the same antenna of a base station 602 (thereby illustrating the propagation of an RF signal). Further, as used herein, the term "LOS path" refers to the shortest path between a transmitter and receiver, and may not be an actual LOS path, but rather, the shortest NLOS path.

[00218] In an aspect, one or more of base stations 602 may be configured to use beamforming to transmit RF signals. In that case, some of the available beams may focus the transmitted RF signal along the LOS paths 610 (e.g., the beams produce highest antenna gain along the LOS paths) while other available beams may focus the transmitted RF signal along the NLOS paths 612. A beam that has high gain along a certain path and thus focuses the RF signal along that path may still have some RF signal propagating along other paths; the strength of that RF signal naturally depends on the beam gain along those other paths. An "RF signal" comprises an electromagnetic wave that transports information through the space between the transmitter and the receiver. As used herein, a transmitter may transmit a single "RF signal" or multiple "RF signals" to a receiver. However, as described further below, the receiver may receive multiple "RF signals" corresponding to each transmitted RF signal due to the propagation characteristics of RF signals through multipath channels.

[00219] Where a base station 602 uses beamforming to transmit RF signals, the beams of interest for data communication between the base station 602 and the UE 604 will be the beams carrying RF signals that arrive at UE 604 with the highest signal strength (as indicated by, e.g., the Received Signal Received Power (RSRP) or SINR in the presence of a directional interfering signal), whereas the beams of interest for position estimation will be the beams carrying RF signals that excite the shortest path or LOS path (e.g., an

LOS path 610). In some frequency bands and for antenna systems typically used, these will be the same beams. However, in other frequency bands, such as mmW, where typically a large number of antenna elements can be used to create narrow transmit beams, they may not be the same beams. As described below with reference to FIG. 7, in some cases, the signal strength of RF signals on the LOS path 610 may be weaker (e.g., due to obstructions) than the signal strength of RF signals on an NLOS path 612, over which the RF signals arrive later due to propagation delay.

[00220] FIG. 7 illustrates an exemplary wireless communications system 700 according to various aspects of the disclosure. In the example of FIG. 7, a UE 704, which may correspond to UE 604 in FIG. 6, is attempting to calculate an estimate of its position, or to assist another entity (e.g., a base station or core network component, another UE, a location server, a third party application, etc.) to calculate an estimate of its position. The UE 704 may communicate wirelessly with a base station 702, which may correspond to one of base stations 602 in FIG. 6, using RF signals and standardized protocols for the modulation of the RF signals and the exchange of information packets.

[00221] As illustrated in FIG. 7, the base station 702 is utilizing beamforming to transmit a plurality of beams 711 – 715 of RF signals. Each beam 711 – 715 may be formed and transmitted by an array of antennas of the base station 702. Although FIG. 7 illustrates a base station 702 transmitting five beams 711 – 715, as will be appreciated, there may be more or fewer than five beams, beam shapes such as peak gain, width, and side-lobe gains may differ amongst the transmitted beams, and some of the beams may be transmitted by a different base station.

[00222] A beam index may be assigned to each of the plurality of beams 711 – 715 for purposes of distinguishing RF signals associated with one beam from RF signals associated with another beam. Moreover, the RF signals associated with a particular beam of the plurality of beams 711 – 715 may carry a beam index indicator. A beam index may also be derived from the time of transmission, e.g., frame, slot and/or OFDM symbol number, of the RF signal. The beam index indicator may be, for example, a three-bit field for uniquely distinguishing up to eight beams. If two different RF signals having different beam indices are received, this would indicate that the RF signals were transmitted using different beams. If two different RF signals share a common beam index, this would indicate that the different RF signals are transmitted using the same beam. Another way to describe that two RF signals are transmitted using the same beam is to say that the

antenna port(s) used for the transmission of the first RF signal are spatially quasi-collocated with the antenna port(s) used for the transmission of the second RF signal.

[00223] In the example of FIG. 7, the UE 704 receives an NLOS data stream 723 of RF signals transmitted on beam 713 and an LOS data stream 724 of RF signals transmitted on beam 714. Although FIG. 7 illustrates the NLOS data stream 723 and the LOS data stream 724 as single lines (dashed and solid, respectively), as will be appreciated, the NLOS data stream 723 and the LOS data stream 724 may each comprise multiple rays (i.e., a "cluster") by the time they reach the UE 704 due, for example, to the propagation characteristics of RF signals through multipath channels. For example, a cluster of RF signals is formed when an electromagnetic wave is reflected off of multiple surfaces of an object, and reflections arrive at the receiver (e.g., UE 704) from roughly the same angle, each travelling a few wavelengths (e.g., centimeters) more or less than others. A "cluster" of received RF signals generally corresponds to a single transmitted RF signal.

[00224] In the example of FIG. 7, the NLOS data stream 723 is not originally directed at the UE 704, although, as will be appreciated, it could be, as are the RF signals on the NLOS paths 612 in FIG. 6. However, it is reflected off a reflector 740 (e.g., a building) and reaches the UE 704 without obstruction, and therefore, may still be a relatively strong RF signal. In contrast, the LOS data stream 724 is directed at the UE 704 but passes through an obstruction 730 (e.g., vegetation, a building, a hill, a disruptive environment such as clouds or smoke, etc.), which may significantly degrade the RF signal. As will be appreciated, although the LOS data stream 724 is weaker than the NLOS data stream 723, the LOS data stream 724 will arrive at the UE 704 before the NLOS data stream 723 because it follows a shorter path from the base station 702 to the UE 704.

[00225] As noted above, the beam of interest for data communication between a base station (e.g., base station 702) and a UE (e.g., UE 704) is the beam carrying RF signals that arrives at the UE with the highest signal strength (e.g., highest RSRP or SINR), whereas the beam of interest for position estimation is the beam carrying RF signals that excite the LOS path and that has the highest gain along the LOS path amongst all other beams (e.g., beam 714). That is, even if beam 713 (the NLOS beam) were to weakly excite the LOS path (due to the propagation characteristics of RF signals, even though not being focused along the LOS path), that weak signal, if any, of the LOS path of beam 713 may not be as reliably detectable (compared to that from beam 714), thus leading to greater error in performing a positioning measurement.

[00226] While the beam of interest for data communication and the beam of interest for position estimation may be the same beams for some frequency bands, for other frequency bands, such as mmW, they may not be the same beams. As such, referring to FIG. 7, where the UE 704 is engaged in a data communication session with the base station 702 (e.g., where the base station 702 is the serving base station for the UE 704) and not simply attempting to measure reference RF signals transmitted by the base station 702, the beam of interest for the data communication session may be the beam 713, as it is carrying the unobstructed NLOS data stream 723. The beam of interest for position estimation, however, would be the beam 714, as it carries the strongest LOS data stream 724, despite being obstructed.

[00227] FIG. 8A is a graph 800A showing the RF channel response at a receiver (e.g., UE 704) over time according to aspects of the disclosure. Under the channel illustrated in FIG. 8A, the receiver receives a first cluster of two RF signals on channel taps at time T1, a second cluster of five RF signals on channel taps at time T2, a third cluster of five RF signals on channel taps at time T3, and a fourth cluster of four RF signals on channel taps at time T4. In the example of FIG. 8A, because the first cluster of RF signals at time T1 arrives first, it is presumed to be the LOS data stream (i.e., the data stream arriving over the LOS or the shortest path), and may correspond to the LOS data stream 724. The third cluster at time T3 is comprised of the strongest RF signals, and may correspond to the NLOS data stream 723. Seen from the transmitter's side, each cluster of received RF signals may comprise the portion of an RF signal transmitted at a different angle, and thus each cluster may be said to have a different angle of departure (AoD) from the transmitter. FIG. 8B is a diagram 800B illustrating this separation of clusters in AoD. The RF signal transmitted in AoD range 802a may correspond to one cluster (e.g., "Cluster1") in FIG. 8A, and the RF signal transmitted in AoD range 802b may correspond to a different cluster (e.g., "Cluster3") in FIG. 8A. Note that although AoD ranges of the two clusters depicted in FIG. 8B are spatially isolated, AoD ranges of some clusters may also partially overlap even though the clusters are separated in time. For example, this may arise when two separate buildings at same AoD from the transmitter reflect the signal towards the receiver. Note that although FIG. 8A illustrates clusters of two to five channel taps (or "peaks"), as will be appreciated, the clusters may have more or fewer than the illustrated number of channel taps.

[00228] In some designs, the earliest channel tap of a RS, such as a PRS or a SRS for positioning, is used to determine its respective TOA. However, if the time synchronization between the UE and the network is misaligned, an error may occur in the TOA estimate at the UE, as depicted in FIG. 9. FIG. 9 illustrates a channel response 900 at a UE receiver in accordance with another embodiment of the disclosure. Due to a timing misalignment at the UE, a channel tap 902 associated with gNB_2 and a channel tap 904 associated with gNB_1 are received at the UE receiver. Due to a timing misalignment at the UE, the UE measures the time of arrival of channel taps 902 and 904 relative to an incorrect timing reference that is not aligned with the gNBs, which results in an error in the TOA estimate for the RS from gNB_1 and gNB_2. While not illustrated expressly, a similar timing misalignment may occur at the gNB with respect to measurements of an uplink reference signal for positioning, such as an SRS for positioning.

[00229] If the timing offset between the UE and the network is common for all the PRS signals from different gNBs, then the UE can remove the impact of this offset by considering differences between the TOA. For example, the UE may be configured to report the reference signal time difference (RSTD), which is the time difference of the arrival (TDOA) of PRS from two different gNBs.

[00230] Due to the multi-path nature of the channel, the channel estimated by the UE may contain several taps corresponding to the multiple signal paths. In some cases, the UE may need to balance the objective of identifying the earliest channel tap with the need to not falsely declare a noisy sample as the earliest channel tap. In some cases, if the direct path between the gNB and the UE is obstructed, the LOS channel tap may be attenuated significantly. This could result in the UE estimating the TOA based on the second or other subsequent channel taps, thereby resulting in an over-estimate of the TOA. This aspect is illustrated in FIG. 10, which depicts a channel response 1000 at a UE receiver in accordance with another embodiment of the disclosure. In FIG. 10, an earliest channel tap 1002 is weaker in terms of peak magnitude while a later channel tap 1004 is stronger in terms of peak magnitude. Hence, the channel tap 1004 may be used to derive the TOA, which results in an overestimate of the TOA (which in turns adds to error in an associated positioning estimate based on the overestimated TOA). While not illustrated expressly, a similar measurement error may occur at the gNB with respect to measurements of an uplink reference signal for positioning, such as an SRS for positioning.

[00231] In some designs, the UE or gNB may also be configured to report the timing of additional paths of the channel relative to a reference timing such as the estimated TOA. In some cases, the reporting of the timing of additional paths may be insufficient since the network cannot determine whether the reported taps correspond to true paths or are spurious taps due to noise. In such situations, if the UE or gNB sends more channel metrics based on the channel estimate, this could enable the network (or UE) to make a more accurate decision regarding the earliest tap, possibly accounting for other available information. In such cases, it is generally desirous for the reporting overhead to be kept small to conserve communication resources.

[00232] One or more embodiments of the present disclosure are thereby directed to detection and/or reporting of peak magnitude data associated with a plurality of peaks (or channel taps) for a set of channel response measurements on a reference signal for positioning, such as a DL PRS or UL SRS for positioning. In some designs, the detection and/or reporting of such peak magnitude data may facilitate more accurate derivation of the TOA for the associated reference signal (e.g., by more accurately identifying the earliest or LOS channel tap for the reference signal), which provides the technical advantage of reducing an error in a positioning estimate for the UE.

[00233] FIG. 11 illustrates an exemplary process 1100 of wireless communication, according to aspects of the disclosure. In an aspect, the process 1100 may be performed by a first node, such as UE 302 of FIG. 3A or BS 304 of FIG. 3B.

[00234] At 1110, the first node (e.g., positioning measurement module 342, receiver 312, receiver 352, positioning measurement module 388, etc.) performs a channel response measurement on a reference signal for positioning. In some designs, the channel response measurement may comprise an SINR measurement. In some designs, the first node may correspond to a UE, and the reference signal for positioning may correspond to a PRS. In other designs, the first node may correspond to a BS (or gNB), and the reference signal for positioning may correspond to a SRS for positioning. However, other types of reference signals for position may be used in other designs.

[00235] At 1120, the first node (e.g., receiver 312, PRS measurement module 342, receiver 352, positioning measurement module 388, etc.) determines, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value. In some designs, the peak magnitude data may include a reference signal

received power (RSRP) associated with a respective peak. In some designs, the channel response measurement may comprise measuring a series of samples in terms of a channel response metric (e.g., SINR) across a period of time. In some designs, the plurality of peaks may comprise the top N peaks in terms of SINR or magnitude, whereby N is configured by the base station (e.g., via L1, L2 or L3 RRC or LPP signaling, etc.). In some designs, the first node may correspond to a UE and the reference signal for positioning may correspond to a PRS, and the value of N may be configured by the base station in conjunction with PRS configuration signaling. In some designs, the first node may correspond to a BS and the reference signal for positioning may correspond to an SRS for positioning, and the value of N may be configured by the base station in conjunction with SRS configuration signaling. In some designs, the reference value may be configured by the base station (e.g., via L1, L2 or L3 RRC or LPP signaling, etc.). In other designs, the reference value may be determined independently at the UE (e.g., as a maximum or median value of the magnitude of the channel estimate samples). In an example, a time associated with each of the plurality of peaks may also be determined relative to a reference timing (e.g., the estimated TOA for the reference signal for positioning, an estimated TOA from a serving BS, or a combination thereof). In a further example, the plurality of peaks (N peaks) may comply with a peak separation parameter. For example, the peak separation parameter may specify a minimum separation (e.g., 1 ms) between peaks. In some designs, the peak separation parameter may be associated with the reference timing for the time window (e.g., the peak separation parameter may specify the timing of the highest peak as the reference timing, and may specify that the N peaks must fall within a threshold period of time away from this reference timing).

[00236] At 1130, the first node (e.g., transmitter 314, transmitter 324, transmitter 354, transmitter 364, etc.) reports the peak-specific information for the plurality of peaks to a second node. In some designs, the second node may correspond to a BS (or gNB). In other designs, the second node may correspond to a UE. In some designs, the report of 1130 may correspond to a PRS measurement report that is transmitted after a PRS measurement period. In other designs, the first node may correspond to a BS (or gNB), and the second node may correspond to an LMF (e.g., integrated with the gNB in which case the report is an internal report, or external to the gNB in which case the report may be sent to the LMF via backhaul signaling). In some designs, the report of 1130 may correspond to a

SRS for positioning measurement report that is transmitted after an SRS for positioning measurement period.

[00237] FIG. 12 illustrates an exemplary process 1200 of wireless communication, according to aspects of the disclosure. In an aspect, the process 1200 may be performed by a second node, such as UE 302 of FIG. 3A BS 304 of FIG. 3B, an LMF in the RAN (e.g., part of BS 304), an external LMF such as LMF 270 or 306, etc..

[00238] At 1210, the second node (e.g., receiver 352, receiver 362, receiver 312, receiver 322, network interface(s) 390, etc.) receives, from a first node (e.g., UE or BS), peak-specific information associated with a plurality of peaks within a channel response measurement on a reference signal for positioning, the peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value. In some designs, the peak magnitude data may include a reference signal received power (RSRP) associated with a respective peak. In In an example, the peak-specific information received at 1210 may be based upon the report transmitted at 1130 of FIG. 11. For example, the peak magnitude data may be based upon a series of samples measured in terms of a channel response metric (e.g., SINR) across a period of time at the UE. In some designs, the plurality of peaks may comprise the top N peaks in terms of SINR, whereby N is configured by the base station (e.g., via L1, L2 or L3 RRC or LPP signaling, etc.). In some designs, the reference signal for positioning may correspond to a PRS, and the value of N may be configured by the base station in conjunction with PRS configuration signaling. In other designs, the reference signal for positioning may correspond to an SRS for positioning, and the value of N may be configured by the base station in conjunction with SRS configuration signaling. In some designs, the reference value may be configured by the base station (e.g., via L1, L2 or L3 RRC or LPP signaling, etc.). In other designs, the reference value may be determined independently at the UE (e.g., as a maximum or median value of the magnitude of the channel estimate samples). In an example, a time associated with each of the plurality of peaks may also be determined relative to a reference timing (e.g., the estimated TOA for the reference signal for positioning, an estimated TOA from a serving BS, or a combination thereof). In a further example, the plurality of peaks (N peaks) may comply with a peak separation parameter. For example, the peak separation parameter may specify a minimum separation (e.g., 1 ms) between peaks. In some designs, the peak separation parameter may be associated with the reference timing for the time window (e.g., the peak separation

parameter may specify the timing of the highest peak as the reference timing, and may specify that the N peaks must fall within a threshold period of time away from this reference timing).

[00239] At 1220, the second node (e.g., PRS measurement module 388, processing system 384, PRS measurement module 342, processing system 332, processing system 394, positioning measurement module 389, etc.) determines a positioning estimate for a UE based on the peak-specific information. In some designs, the determination of 1220 may be implemented via an LMF integrated with the BS (e.g., in scenario where second node is the BS). In other designs, the determination of 1220 may be implemented via at the UE itself (e.g., in scenario where second node is the UE). In some designs, the determination at 1220 may evaluate the peak-specific information to determine whether the estimated TOA at the first node required correction (e.g., whether the estimated TOA at the first node may be incorrect due to UE-side timing error as in FIG. 9 (or an analogous gNB-side timing error) and/or whether the estimated TOA at the first node may be incorrect due to an LOS path being too weak to detect as in FIG. 10). In particular, the evaluation at 1220 may comprise:

- One or more other PRS reports from the same UE,
- One or more other SRS reports from the same BS,
- One or more gNB-side measurements (e.g., angle-of-arrival or time-of-arrival of uplink reference signals from the UE, etc.),
- One or more UE-side measurements (e.g., angle-of-departure or time-of-departure of uplink reference signals from the UE, etc.),
- One or more gNB-centric properties (e.g., location, downtilt, etc.), or
- Any combination thereof.

[00240] Referring to FIGS. 11-12, the various parameters (e.g., number of peaks or N, peak magnitude threshold, peak magnitude reference value, time window, peak separation parameter, etc.) may be configured by the BS (or gNB), the UE, or by a core network component based on a UE capability indication (e.g., a capability signaling wherein the UE informs the network on the values of the parameter that it can support (e.g., maximum number of taps it can signal, the largest magnitude threshold it can operate with, or the largest time window it can accommodate for processing, etc.). The various signaling associated with communication of the above-noted configured parameters may comprise higher-layer protocol signaling (e.g., L3 signaling, such as LPP or L3 RRC), signaling

exchanged from the LMF to the gNB (e.g., NR Positioning Protocol A (NRPPa)), lower-layer signaling (e.g., L1 or L2 RRC, other physical layer or L1 communications between the UE and gNB, etc.), or a combination thereof. In implementations where the various parameters (e.g., number of peaks or N, peak magnitude threshold, peak magnitude reference value, time window, peak separation parameter, etc.) are configured by the UE, the UE may signal the value(s) of these parameter(s) to the network (e.g., in association with a report such as a PRS measurement report).

[00241] Referring to FIGS. 11-12, in an example where the reference signal for positioning corresponds to a DL reference signal such as PRS, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further may comprise an angle of departure (AoD) (e.g., from the BS) associated with the peak. In an alternative example where the reference signal for positioning corresponds to a UL reference signal such as SRS, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further may comprise an angle of arrival (AoA) (e.g., at the BS) associated with the peak.

[00242] FIG. 13 illustrates an example implementation 1300 of FIGS. 11-12 whereby the plurality of peaks comprises N peaks (N=4) across a series of detected channel taps in accordance with an embodiment of the disclosure. In FIG. 13, the plurality of peaks comprises four (4) peaks denoted as P1, P2, P3 and P4, where the first node has identified P2 as the LOS path for determination of the estimated TOA of the PRS or SRS for positioning (e.g., because the peak magnitude of P1 was deemed too low at the first node, as in FIG. 10). However, P1 is captured among the top N peaks, and as such its magnitude data is reported to the second node along with the magnitude data for P2, P3 and P4. The second node evaluates the reported magnitude data for P1-P4 and determines that P1 corresponds to the LOS path rather than P2, and is thereby able to facilitate correction of the TOA of the PRS or SRS for positioning. For example, in a scenario where the first node corresponds to the UE and the second node corresponds to the BS, the BS may compare the PRS measurement report from the UE with one or more other measurements or reports to reach the conclusion that P1 was the true LOS path (i.e., the true TOA). In an alternative example example, in a scenario where the first node corresponds to the BS and the second node corresponds to the UE, the UE may compare the SRS measurement report from the BS with one or more other measurements or reports to reach the conclusion that P1 was the true LOS path (i.e., the true TOA).

[00243] Referring to FIGS. 11-12, in some designs, N may function as a maximum value rather than a required value. In this case, one or more secondary criteria may be evaluated to determine whether or not a particular peak qualifies for inclusion with (or exclusion from) the plurality of peaks for which magnitude data is reported.

[00244] FIG. 14 illustrates a channel response 1400 at a wireless node receiver (e.g., UE or BS) whereby the plurality of peaks from FIGS. 11-12 excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold. In FIG. 14, the peak magnitude threshold is denoted as X, whereby any peak (or channel tap) with a peak magnitude below X is not made part of the plurality of peaks. So, even if N=4, in the example of FIG. 14 only three peaks (P1, P2 and P3) are included among the plurality of peaks, and P4 is excluded for being outside of (or below) X.

[00245] FIG. 15 illustrates a channel response 1500 at a wireless node receiver (e.g., UE or BS) whereby the plurality of peaks from FIGS. 11-12 excludes peaks outside of a defined time window T. In an example, the defined time window can be defined relative to a reference timing, such as an estimated TOA of a BS from which the PRS is transmitted, an estimated TOA from a serving BS, an estimated TOA of a UE from which the SRS for positioning is transmitted, or a combination thereof. In FIG. 15, if N=4, and four (4) peaks (P1, P2, P3 and P5) are included among the plurality of peaks, and P5 is excluded for being outside of (or below) the defined time window T.

[00246] In other designs, a combination of secondary criteria may be applied with respect to the plurality of peaks. For example, a combination of a peak magnitude threshold X and a defined time window T may be implemented.

[00247] Referring to FIGS. 11-12, in some designs, the value of N, the value of any of the various thresholds, and/or the manner in which the reported peak-specific information is factored into the positioning estimate may be enhanced via the use of machine-learning (ML). In this case, rather than being pre-configured or dynamically configured, the various values and/or algorithms may be determined more dynamically in a manner that permits the values and/or algorithms to be optimized based on various criteria, such as environmental factors, specific gNB configurations (e.g., location, downtilt, hardware group delay or antenna-to-baseband delay, etc.), specific UE configurations (e.g., model type, hardware group delay or antenna-to-baseband delay, etc.), and so on.

[00248]

[00249] In the detailed description above it can be seen that different features are grouped together in examples. This manner of disclosure should not be understood as an intention that the example clauses have more features than are explicitly mentioned in each clause. Rather, the various aspects of the disclosure may include fewer than all features of an individual example clause disclosed. Therefore, the following clauses should hereby be deemed to be incorporated in the description, wherein each clause by itself can stand as a separate example. Although each dependent clause can refer in the clauses to a specific combination with one of the other clauses, the aspect(s) of that dependent clause are not limited to the specific combination. It will be appreciated that other example clauses can also include a combination of the dependent clause aspect(s) with the subject matter of any other dependent clause or independent clause or a combination of any feature with other dependent and independent clauses. The various aspects disclosed herein expressly include these combinations, unless it is explicitly expressed or can be readily inferred that a specific combination is not intended (e.g., contradictory aspects, such as defining an element as both an insulator and a conductor). Furthermore, it is also intended that aspects of a clause can be included in any other independent clause, even if the clause is not directly dependent on the independent clause.

[00250] Implementation examples are described in the following numbered clauses:

[00251] Those of skill in the art will appreciate that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[00252] Clause 1. A method of operating a first node, comprising: performing a channel response measurement on a reference signal for positioning; determining, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and reporting the peak-specific information for the plurality of peaks to a second node.

[00253] Clause 2. The method of clause 1, wherein the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected

within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[00254] Clause 3. The method of any of clauses 1 to 2, wherein the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[00255] Clause 4. The method of any of clauses 1 to 3, wherein the first node corresponds to a user equipment (UE) and the second node corresponds to a base station (BS) or a location management function (LMF).

[00256] Clause 5. The method of any of clauses 1 to 4, wherein the second node corresponds to a user equipment (UE) or a location management function (LMF) and the first node corresponds to a base station (BS).

[00257] Clause 6. The method of any of clauses 1 to 5, wherein a number of the plurality of peaks is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00258] Clause 7. The method of any of clauses 1 to 6, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[00259] Clause 8. The method of clause 7, wherein the peak magnitude threshold and/or the reference value are configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00260] Clause 9. The method of any of clauses 1 to 8, wherein the plurality of peaks excludes peaks outside of a defined time window.

[00261] Clause 10. The method of clause 9, wherein the defined time window is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00262] Clause 11. The method of clause 10, wherein the defined time window is defined relative to a reference timing.

[00263] Clause 12. The method of clause 11, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00264] Clause 13. The method of any of clauses 1 to 12, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises peak timing data that is based on a peak timing relative to a reference timing.

[00265] Clause 14. The method of clause 13, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00266] Clause 15. The method of any of clauses 1 to 14, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[00267] Clause 16. A method of operating a second node, comprising: receiving, from a first node, peak-specific information associated with a plurality of peaks within a channel response measurement on a reference signal for positioning, the peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and determining a positioning estimate for a user equipment (UE) based on the peak-specific information.

[00268] Clause 17. The method of clause 16, wherein the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[00269] Clause 18. The method of any of clauses 16 to 17, wherein the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[00270] Clause 19. The method of any of clauses 16 to 18, wherein the first node corresponds to the UE and the second node corresponds to a base station (BS) or a location management function (LMF).

[00271] Clause 20. The method of any of clauses 16 to 19, wherein the second node corresponds to the UE or an location management function (LMF) and the first node corresponds to a base station (BS).

[00272] Clause 21. The method of any of clauses 16 to 20, wherein a number of the plurality of peaks is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00273] Clause 22. The method of any of clauses 16 to 21, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[00274] Clause 23. The method of clause 22, wherein the peak magnitude threshold and/or the reference value are configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00275] Clause 24. The method of any of clauses 16 to 23, wherein the plurality of peaks excludes peaks outside of a defined time window.

[00276] Clause 25. The method of clause 24, wherein the defined time window is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00277] Clause 26. The method of any of clauses 24 to 25, wherein the defined time window is defined relative to a reference timing.

[00278] Clause 27. The method of any of clauses 24 to 26, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00279] Clause 28. The method of any of clauses 16 to 27, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises peak timing data that is based on a peak timing relative to a reference timing.

[00280] Clause 29. The method of clause 28, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00281] Clause 30. The method of any of clauses 16 to 29, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[00282] Clause 31. A first node, comprising: a memory; at least one transceiver; and at least one processor communicatively coupled to the memory and the at least one transceiver, the at least one processor configured to: perform a channel response measurement on a reference signal for positioning; determine, for each of a plurality of peaks detected within the channel response measurement, peak-specific information

comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and report the peak-specific information for the plurality of peaks to a second node.

[00283] Clause 32. The first node of clause 31, wherein the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[00284] Clause 33. The first node of any of clauses 31 to 32, wherein the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[00285] Clause 34. The first node of any of clauses 31 to 33, wherein the first node corresponds to a user equipment (UE) and the second node corresponds to a base station (BS) or a location management function (LMF).

[00286] Clause 35. The first node of any of clauses 31 to 34, wherein the second node corresponds to a user equipment (UE) or a location management function (LMF) and the first node corresponds to a base station (BS).

[00287] Clause 36. The first node of any of clauses 31 to 35, wherein a number of the plurality of peaks is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00288] Clause 37. The first node of any of clauses 31 to 36, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[00289] Clause 38. The first node of clause 37, wherein the peak magnitude threshold and/or the reference value are configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00290] Clause 39. The first node of any of clauses 31 to 38, wherein the plurality of peaks excludes peaks outside of a defined time window.

[00291] Clause 40. The first node of clause 39, wherein the defined time window is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00292] Clause 41. The first node of clause 40, wherein the defined time window is defined relative to a reference timing.

[00293] Clause 42. The first node of clause 41, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00294] Clause 43. The first node of any of clauses 31 to 42, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information wherein the at least one processor is further configured to peak timing data that is based on a peak timing relative to a reference timing.

[00295] Clause 44. The first node of clause 43, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00296] Clause 45. The first node of any of clauses 31 to 44, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[00297] Clause 46. A second node, comprising: a memory; at least one transceiver; and at least one processor communicatively coupled to the memory and the at least one transceiver, the at least one processor configured to: receive, via the at least one transceiver, from a first node, peak-specific information associated with a plurality of peaks within a channel response measurement on a reference signal for positioning, the peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and determine a positioning estimate for a user equipment (UE) based on the peak-specific information.

[00298] Clause 47. The second node of clause 46, wherein the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[00299] Clause 48. The second node of any of clauses 46 to 47, wherein the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[00300] Clause 49. The second node of any of clauses 46 to 48, wherein the first node corresponds to the UE and the second node corresponds to a base station (BS) or a location management function (LMF).

[00301] Clause 50. The second node of any of clauses 46 to 49, wherein the second node corresponds to the UE or an location management function (LMF) and the first node corresponds to a base station (BS).

[00302] Clause 51. The second node of any of clauses 46 to 50, wherein a number of the plurality of peaks is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00303] Clause 52. The second node of any of clauses 46 to 51, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[00304] Clause 53. The second node of clause 52, wherein the peak magnitude threshold and/or the reference value are configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00305] Clause 54. The second node of any of clauses 46 to 53, wherein the plurality of peaks excludes peaks outside of a defined time window.

[00306] Clause 55. The second node of clause 54, wherein the defined time window is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00307] Clause 56. The second node of any of clauses 54 to 55, wherein the defined time window is defined relative to a reference timing.

[00308] Clause 57. The second node of any of clauses 54 to 56, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00309] Clause 58. The second node of any of clauses 46 to 57, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information wherein the at least one processor is further configured to peak timing data that is based on a peak timing relative to a reference timing.

[00310] Clause 59. The second node of clause 58, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the

reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00311] Clause 60. The second node of any of clauses 46 to 59, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[00312] Clause 61. A first node, comprising: means for performing a channel response measurement on a reference signal for positioning; means for determining, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and means for reporting the peak-specific information for the plurality of peaks to a second node.

[00313] Clause 62. The first node of clause 61, wherein the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[00314] Clause 63. The first node of any of clauses 61 to 62, wherein the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[00315] Clause 64. The first node of any of clauses 61 to 63, wherein the first node corresponds to a user equipment (UE) and the second node corresponds to a base station (BS) or a location management function (LMF).

[00316] Clause 65. The first node of any of clauses 61 to 64, wherein the second node corresponds to a user equipment (UE) or a location management function (LMF) and the first node corresponds to a base station (BS).

[00317] Clause 66. The first node of any of clauses 61 to 65, wherein a number of the plurality of peaks is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00318] Clause 67. The first node of any of clauses 61 to 66, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[00319] Clause 68. The first node of clause 67, wherein the peak magnitude threshold and/or the reference value are configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00320] Clause 69. The first node of any of clauses 61 to 68, wherein the plurality of peaks excludes peaks outside of a defined time window.

[00321] Clause 70. The first node of clause 69, wherein the defined time window is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00322] Clause 71. The first node of clause 70, wherein the defined time window is defined relative to a reference timing.

[00323] Clause 72. The first node of clause 71, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00324] Clause 73. The first node of any of clauses 61 to 72, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises means for peaking timing data that is based on a peak timing relative to a reference timing.

[00325] Clause 74. The first node of clause 73, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00326] Clause 75. The first node of any of clauses 61 to 74, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[00327] Clause 76. A second node, comprising: means for receiving, from a first node, peak-specific information associated with a plurality of peaks within a channel response measurement on a reference signal for positioning, the peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and means for determining a positioning estimate for a user equipment (UE) based on the peak-specific information.

[00328] Clause 77. The second node of clause 76, wherein the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks

detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[00329] Clause 78. The second node of any of clauses 76 to 77, wherein the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[00330] Clause 79. The second node of any of clauses 76 to 78, wherein the first node corresponds to the UE and the second node corresponds to a base station (BS) or a location management function (LMF).

[00331] Clause 80. The second node of any of clauses 76 to 79, wherein the second node corresponds to the UE or an location management function (LMF) and the first node corresponds to a base station (BS).

[00332] Clause 81. The second node of any of clauses 76 to 80, wherein a number of the plurality of peaks is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00333] Clause 82. The second node of any of clauses 76 to 81, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[00334] Clause 83. The second node of clause 82, wherein the peak magnitude threshold and/or the reference value are configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00335] Clause 84. The second node of any of clauses 76 to 83, wherein the plurality of peaks excludes peaks outside of a defined time window.

[00336] Clause 85. The second node of clause 84, wherein the defined time window is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00337] Clause 86. The second node of any of clauses 84 to 85, wherein the defined time window is defined relative to a reference timing.

[00338] Clause 87. The second node of any of clauses 84 to 86, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00339] Clause 88. The second node of any of clauses 76 to 87, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises means for peaking timing data that is based on a peak timing relative to a reference timing.

[00340] Clause 89. The second node of clause 88, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00341] Clause 90. The second node of any of clauses 76 to 89, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[00342] Clause 91. A non-transitory computer-readable medium storing computer-executable instructions that, when executed by a first node, cause the first node to: perform a channel response measurement on a reference signal for positioning; determine, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and report the peak-specific information for the plurality of peaks to a second node.

[00343] Clause 92. The non-transitory computer-readable medium of clause 91, wherein the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[00344] Clause 93. The non-transitory computer-readable medium of any of clauses 91 to 92, wherein the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[00345] Clause 94. The non-transitory computer-readable medium of any of clauses 91 to 93, wherein the first node corresponds to a user equipment (UE) and the second node corresponds to a base station (BS) or a location management function (LMF).

[00346] Clause 95. The non-transitory computer-readable medium of any of clauses 91 to 94, wherein the second node corresponds to a user equipment (UE) or a location management function (LMF) and the first node corresponds to a base station (BS).

[00347] Clause 96. The non-transitory computer-readable medium of any of clauses 91 to 95, wherein a number of the plurality of peaks is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00348] Clause 97. The non-transitory computer-readable medium of any of clauses 91 to 96, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[00349] Clause 98. The non-transitory computer-readable medium of clause 97, wherein the peak magnitude threshold and/or the reference value are configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00350] Clause 99. The non-transitory computer-readable medium of any of clauses 91 to 98, wherein the plurality of peaks excludes peaks outside of a defined time window.

[00351] Clause 100. The non-transitory computer-readable medium of clause 99, wherein the defined time window is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

[00352] Clause 101. The non-transitory computer-readable medium of clause 100, wherein the defined time window is defined relative to a reference timing.

[00353] Clause 102. The non-transitory computer-readable medium of clause 101, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00354] Clause 103. The non-transitory computer-readable medium of any of clauses 91 to 102, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information wherein the one or more instructions further cause the first node to peak timing data that is based on a peak timing relative to a reference timing.

[00355] Clause 104. The non-transitory computer-readable medium of clause 103, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00356] Clause 105. The non-transitory computer-readable medium of any of clauses 91 to 104, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[00357] Clause 106. A non-transitory computer-readable medium storing computer-executable instructions that, when executed by a second node, cause the second node to: receive, from a first node, peak-specific information associated with a plurality of peaks within a channel response measurement on a reference signal for positioning, the peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and determine a positioning estimate for a user equipment (UE) based on the peak-specific information.

[00358] Clause 107. The non-transitory computer-readable medium of clause 106, wherein the reference signal for positioning is a downlink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

[00359] Clause 108. The non-transitory computer-readable medium of any of clauses 106 to 107, wherein the reference signal for positioning is an uplink reference signal, and wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

[00360] Clause 109. The non-transitory computer-readable medium of any of clauses 106 to 108, wherein the first node corresponds to the UE and the second node corresponds to a base station (BS) or a location management function (LMF).

[00361] Clause 110. The non-transitory computer-readable medium of any of clauses 106 to 109, wherein the second node corresponds to the UE or an location management function (LMF) and the first node corresponds to a base station (BS).

[00362] Clause 111. The non-transitory computer-readable medium of any of clauses 106 to 110, wherein a number of the plurality of peaks is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00363] Clause 112. The non-transitory computer-readable medium of any of clauses 106 to 111, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

[00364] Clause 113. The non-transitory computer-readable medium of clause 112, wherein the peak magnitude threshold and/or the reference value are configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00365] Clause 114. The non-transitory computer-readable medium of any of clauses 106 to 113, wherein the plurality of peaks excludes peaks outside of a defined time window.

[00366] Clause 115. The non-transitory computer-readable medium of clause 114, wherein the defined time window is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

[00367] Clause 116. The non-transitory computer-readable medium of any of clauses 114 to 115, wherein the defined time window is defined relative to a reference timing.

[00368] Clause 117. The non-transitory computer-readable medium of any of clauses 114 to 116, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00369] Clause 118. The non-transitory computer-readable medium of any of clauses 106 to 117, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information wherein the one or more instructions further cause the second node to peak timing data that is based on a peak timing relative to a reference timing.

[00370] Clause 119. The non-transitory computer-readable medium of clause 118, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

[00371] Clause 120. The non-transitory computer-readable medium of any of clauses 106 to 119, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

[00372] Further, those of skill in the art will appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the aspects disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design

constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present disclosure.

[00373] The various illustrative logical blocks, modules, and circuits described in connection with the aspects disclosed herein may be implemented or performed with a general purpose processor, a DSP, an ASIC, an FPGA, or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[00374] The methods, sequences and/or algorithms described in connection with the aspects disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in random access memory (RAM), flash memory, read-only memory (ROM), erasable programmable ROM (EPROM), electrically erasable programmable ROM (EEPROM), registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal (e.g., UE). In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

[00375] In one or more exemplary aspects, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Computer-readable media includes both computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such

computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above should also be included within the scope of computer-readable media.

[00376] While the foregoing disclosure shows illustrative aspects of the disclosure, it should be noted that various changes and modifications could be made herein without departing from the scope of the disclosure as defined by the appended claims. The functions, steps and/or actions of the method claims in accordance with the aspects of the disclosure described herein need not be performed in any particular order. Furthermore, although elements of the disclosure may be described or claimed in the singular, the plural is contemplated unless limitation to the singular is explicitly stated.

CLAIMS

What is claimed is:

1. A method of operating a first node, comprising:

performing a channel response measurement on a reference signal for positioning;

determining, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and

reporting the peak-specific information for the plurality of peaks to a second node.

2. The method of claim 1,

wherein the reference signal for positioning is a downlink reference signal, and

wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

3. The method of claim 1,

wherein the reference signal for positioning is an uplink reference signal, and

wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

4. The method of claim 1, wherein the first node corresponds to a user equipment (UE) and the second node corresponds to a base station (BS) or a location management function (LMF).

5. The method of claim 1, wherein the second node corresponds to a user equipment (UE) or a location management function (LMF) and the first node corresponds to a base station (BS).

6. The method of claim 1, wherein a number of the plurality of peaks is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

7. The method of claim 1, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

8. The method of claim 7, wherein the peak magnitude threshold and/or the reference value are configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

9. The method of claim 1, wherein the plurality of peaks excludes peaks outside of a defined time window.

10. The method of claim 9, wherein the defined time window is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

11. The method of claim 10, wherein the defined time window is defined relative to a reference timing.

12. The method of claim 11, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

13. The method of claim 1, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises peak timing data that is based on a peak timing relative to a reference timing.

14. The method of claim 13, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

15. The method of claim 1, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

16. A method of operating a second node, comprising:

receiving, from a first node, peak-specific information associated with a plurality of peaks within a channel response measurement on a reference signal for positioning, the peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and

determining a positioning estimate for a user equipment (UE) based on the peak-specific information.

17. The method of claim 16,

wherein the reference signal for positioning is a downlink reference signal, and

wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

18. The method of claim 16,

wherein the reference signal for positioning is an uplink reference signal, and

wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

19. The method of claim 16, wherein the first node corresponds to the UE and the second node corresponds to a base station (BS) or a location management function (LMF).

20. The method of claim 16, wherein the second node corresponds to the UE or an location management function (LMF) and the first node corresponds to a base station (BS).

21. The method of claim 16, wherein a number of the plurality of peaks is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

22. The method of claim 16, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

23. The method of claim 22, wherein the peak magnitude threshold and/or the reference value are configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

24. The method of claim 16, wherein the plurality of peaks excludes peaks outside of a defined time window.

25. The method of claim 24, wherein the defined time window is configured by the UE, a base station (BS), or a core network component based on a UE capability indication.

26. The method of claim 24, wherein the defined time window is defined relative to a reference timing.

27. The method of claim 24, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

28. The method of claim 16, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises peak timing data that is based on a peak timing relative to a reference timing.

29. The method of claim 28, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for

positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

30. The method of claim 16, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

31. A first node, comprising:

a memory;

at least one transceiver; and

at least one processor communicatively coupled to the memory and the at least one transceiver, the at least one processor configured to:

perform a channel response measurement on a reference signal for positioning;

determine, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and

report the peak-specific information for the plurality of peaks to a second node.

32. The first node of claim 31,

wherein the reference signal for positioning is a downlink reference signal, and

wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

33. The first node of claim 31,

wherein the reference signal for positioning is an uplink reference signal, and

wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

34. The first node of claim 31, wherein the first node corresponds to a user equipment (UE) and the second node corresponds to a base station (BS) or a location management function (LMF).

35. The first node of claim 31, wherein the second node corresponds to a user equipment (UE) or a location management function (LMF) and the first node corresponds to a base station (BS).

36. The first node of claim 31, wherein a number of the plurality of peaks is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

37. The first node of claim 31, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

38. The first node of claim 37, wherein the peak magnitude threshold and/or the reference value are configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

39. The first node of claim 31, wherein the plurality of peaks excludes peaks outside of a defined time window.

40. The first node of claim 39, wherein the defined time window is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

41. The first node of claim 40, wherein the defined time window is defined relative to a reference timing.

42. The first node of claim 41, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

43. The first node of claim 31, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information

wherein the at least one processor is further configured to peak timing data that is based on a peak timing relative to a reference timing.

44. The first node of claim 43, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

45. The first node of claim 31, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

46. A first node, comprising:

means for performing a channel response measurement on a reference signal for positioning;

means for determining, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and

means for reporting the peak-specific information for the plurality of peaks to a second node.

47. The first node of claim 46,

wherein the reference signal for positioning is a downlink reference signal, and

wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

48. The first node of claim 46,

wherein the reference signal for positioning is an uplink reference signal, and

wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

49. The first node of claim 46, wherein the first node corresponds to a user equipment (UE) and the second node corresponds to a base station (BS) or a location management function (LMF).

50. The first node of claim 46, wherein the second node corresponds to a user equipment (UE) or a location management function (LMF) and the first node corresponds to a base station (BS).

51. The first node of claim 46, wherein a number of the plurality of peaks is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

52. The first node of claim 46, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

53. The first node of claim 52, wherein the peak magnitude threshold and/or the reference value are configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

54. The first node of claim 46, wherein the plurality of peaks excludes peaks outside of a defined time window.

55. The first node of claim 54, wherein the defined time window is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

56. The first node of claim 55, wherein the defined time window is defined relative to a reference timing.

57. The first node of claim 56, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for

positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

58. The first node of claim 46, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises means for peaking timing data that is based on a peak timing relative to a reference timing.

59. The first node of claim 58, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

60. The first node of claim 46, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

61. A non-transitory computer-readable medium storing computer-executable instructions that, when executed by a first node, cause the first node to:

perform a channel response measurement on a reference signal for positioning;

determine, for each of a plurality of peaks detected within the channel response measurement, peak-specific information comprising at least peak magnitude data that is based on a peak magnitude relative to a reference value; and

report the peak-specific information for the plurality of peaks to a second node.

62. The non-transitory computer-readable medium of claim 61,

wherein the reference signal for positioning is a downlink reference signal, and

wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of departure associated with the peak relative from a base station (BS).

63. The non-transitory computer-readable medium of claim 61,

wherein the reference signal for positioning is an uplink reference signal, and

wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information further comprises an angle of arrival associated with the peak at a base station (BS).

64. The non-transitory computer-readable medium of claim 61, wherein the first node corresponds to a user equipment (UE) and the second node corresponds to a base station (BS) or a location management function (LMF).

65. The non-transitory computer-readable medium of claim 61, wherein the second node corresponds to a user equipment (UE) or a location management function (LMF) and the first node corresponds to a base station (BS).

66. The non-transitory computer-readable medium of claim 61, wherein a number of the plurality of peaks is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

67. The non-transitory computer-readable medium of claim 61, wherein the plurality of peaks excludes peaks associated with a respective peak magnitude relative to the reference value that is below a peak magnitude threshold.

68. The non-transitory computer-readable medium of claim 67, wherein the peak magnitude threshold and/or the reference value are configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

69. The non-transitory computer-readable medium of claim 61, wherein the plurality of peaks excludes peaks outside of a defined time window.

70. The non-transitory computer-readable medium of claim 69, wherein the defined time window is configured by a user equipment (UE), a base station (BS), or a core network component based on a UE capability indication.

71. The non-transitory computer-readable medium of claim 70, wherein the defined time window is defined relative to a reference timing.

72. The non-transitory computer-readable medium of claim 71, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

73. The non-transitory computer-readable medium of claim 61, wherein, for each of the plurality of peaks detected within the channel response measurement, the peak-specific information wherein the one or more instructions further cause the first node to peak timing data that is based on a peak timing relative to a reference timing.

74. The non-transitory computer-readable medium of claim 73, wherein the reference timing corresponds to an estimated time of arrival (TOA) of a wireless node from which the reference signal for positioning is transmitted, an estimated TOA from a serving base station (BS), or a combination thereof.

75. The non-transitory computer-readable medium of claim 61, wherein the peak magnitude data comprises a reference signal received power (RSRP) associated with a respective peak.

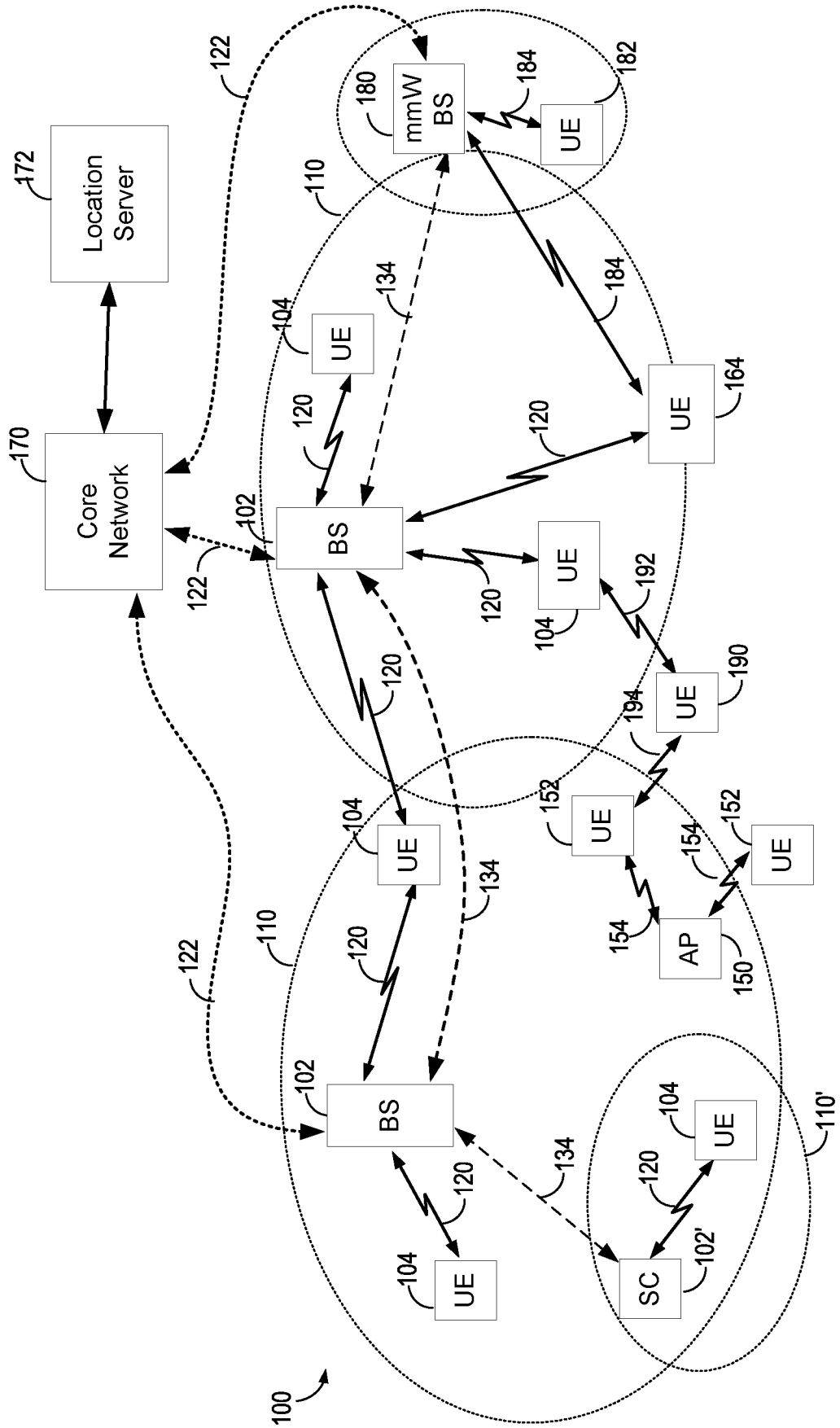

Location Server
172
Core Network
170
122
mmW BS
180
184
UE
182
110
134
104
120
BS
102
164
192
190
194
152
154
AP
150
110'
SC
102'
100

FIG. 1

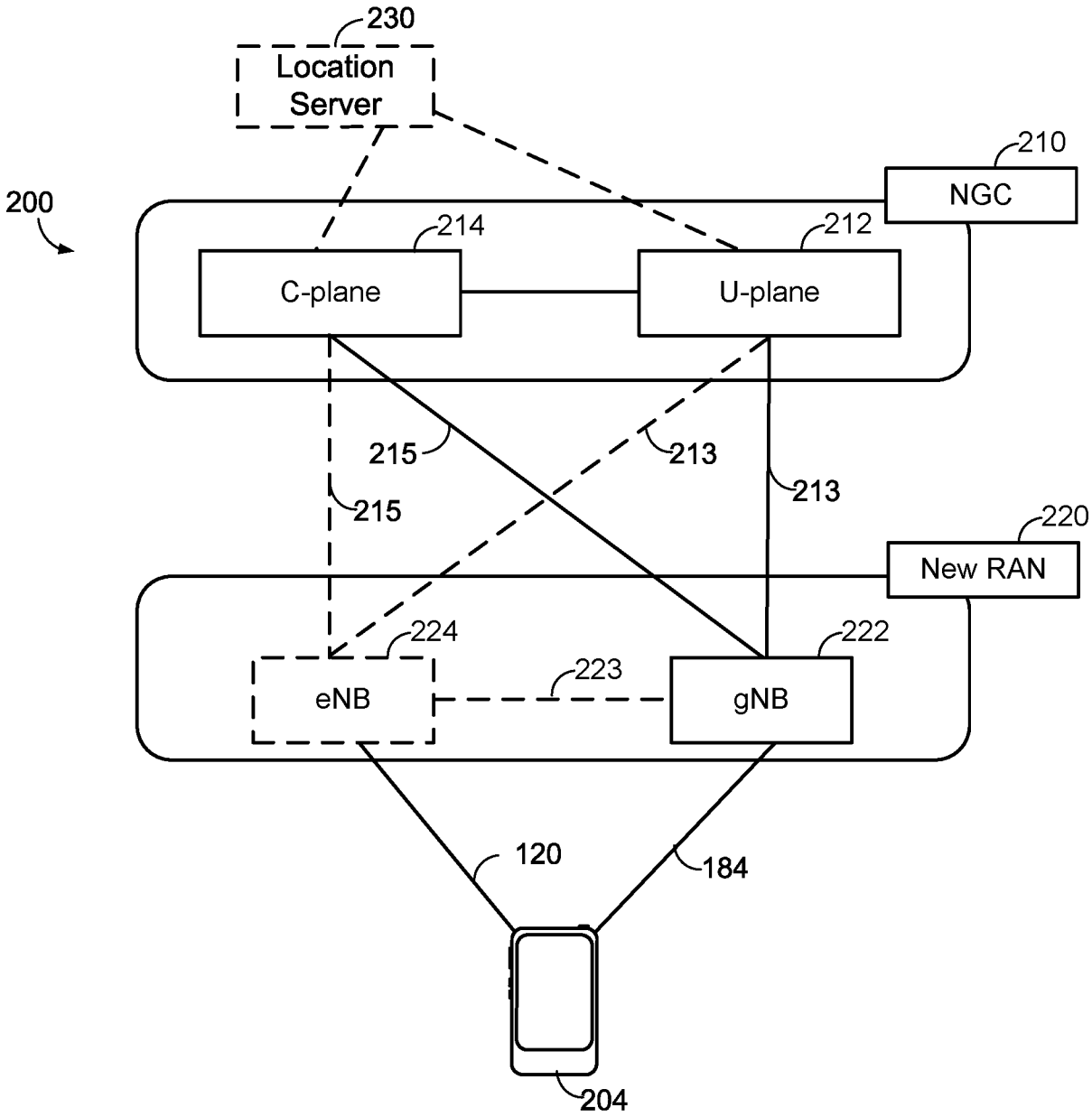

230
Location Server
210
NGC
200
214
212
C-plane
U-plane
215
213
213
215
220
New RAN
224
222
223
eNB
gNB
120
184
204

FIG. 2A

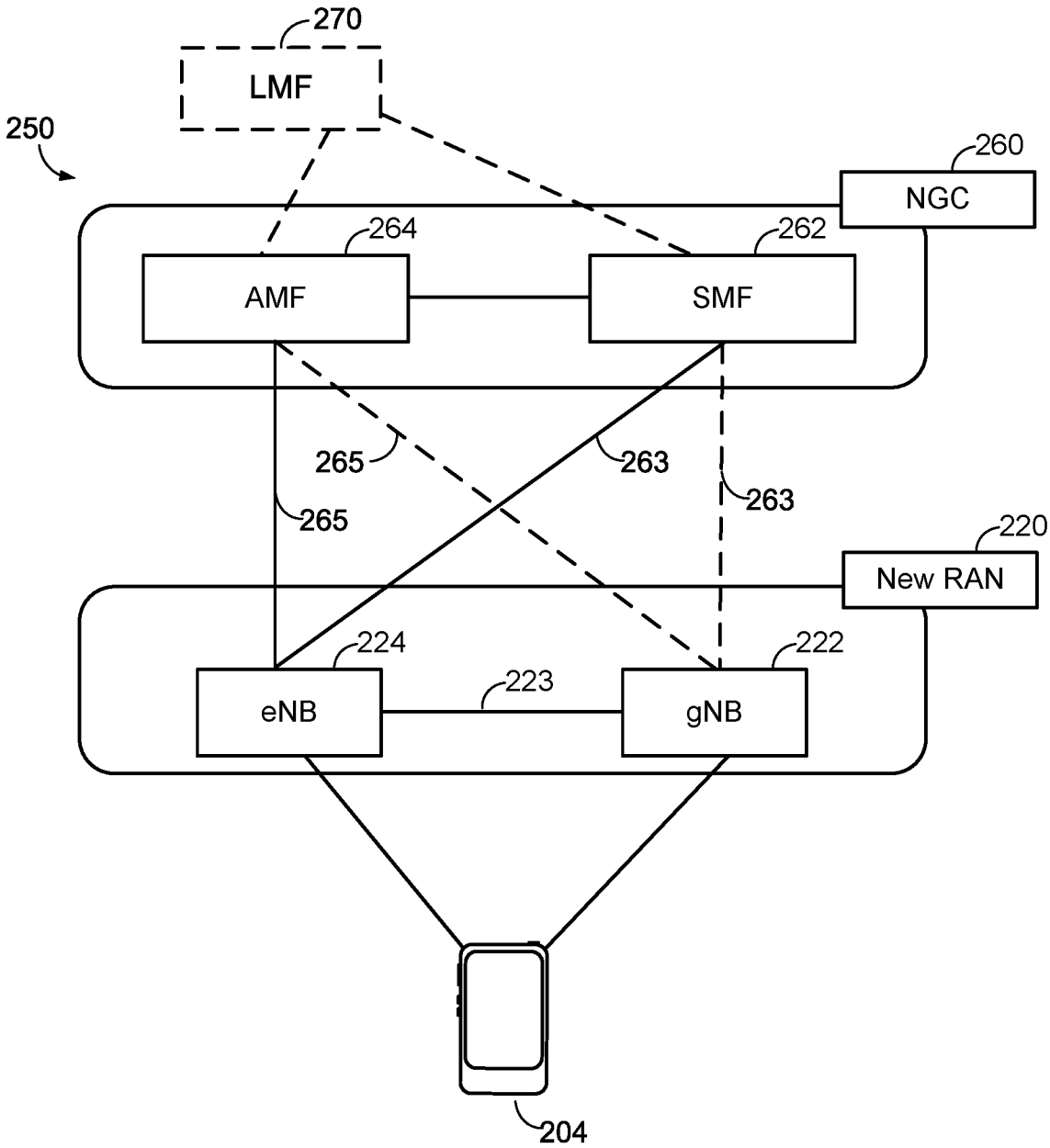

270
LMF
250
260
NGC
264
262
AMF
SMF
265
263
263
265
220
New RAN
224
222
223
eNB
gNB
204

FIG. 2B

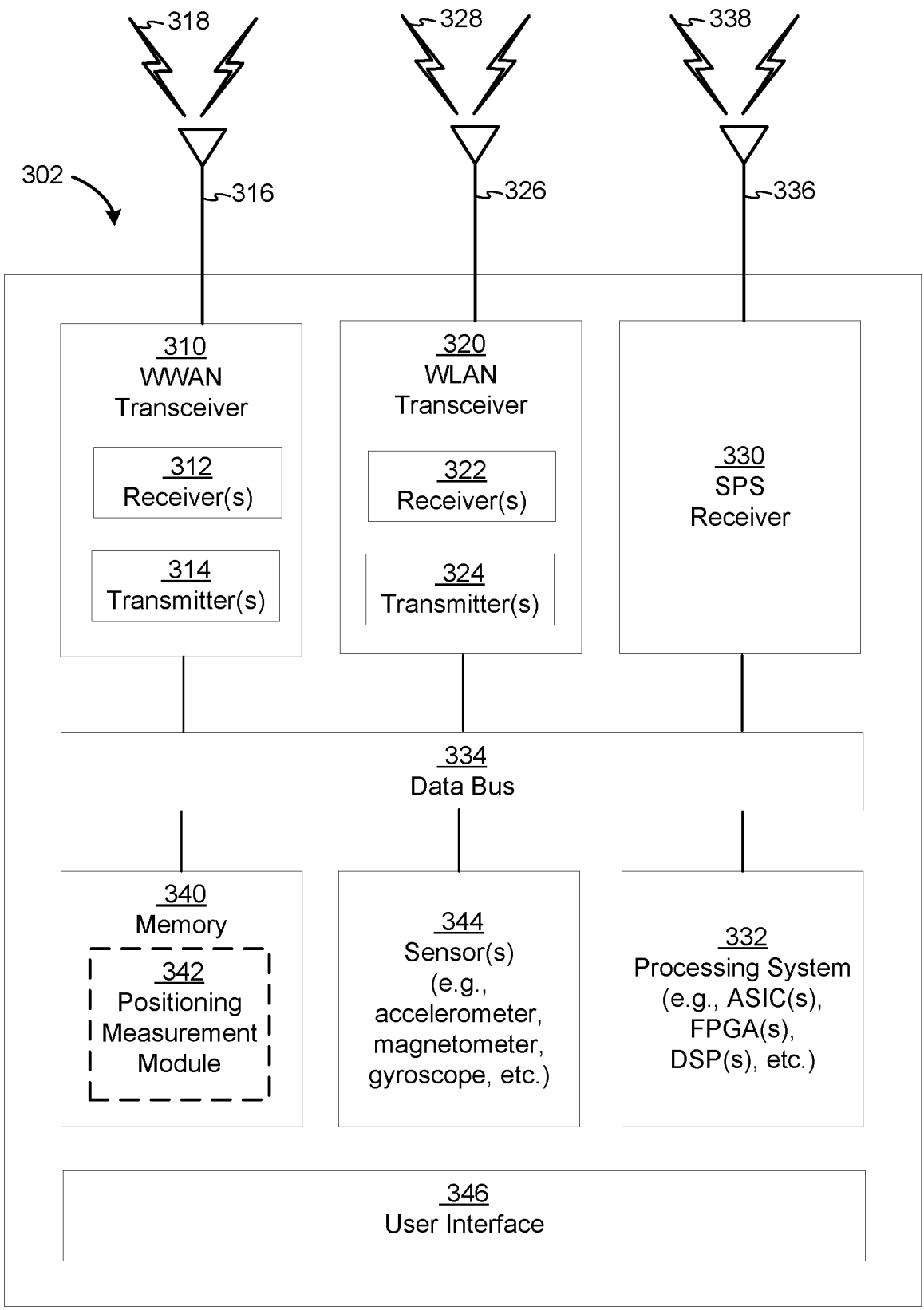

318
328
338
302
316
326
336
310
WWAN
Transceiver
312
Receiver(s)
314
Transmitter(s)
320
WLAN
Transceiver
322
Receiver(s)
324
Transmitter(s)
330
SPS
Receiver
334
Data Bus
340
Memory
342
Positioning
Measurement
Module
344
Sensor(s)
(e.g.,
accelerometer,
magnetometer,
gyroscope, etc.)
332
Processing System
(e.g., ASIC(s),
FPGA(s),
DSP(s), etc.)
346
User Interface

FIG. 3A

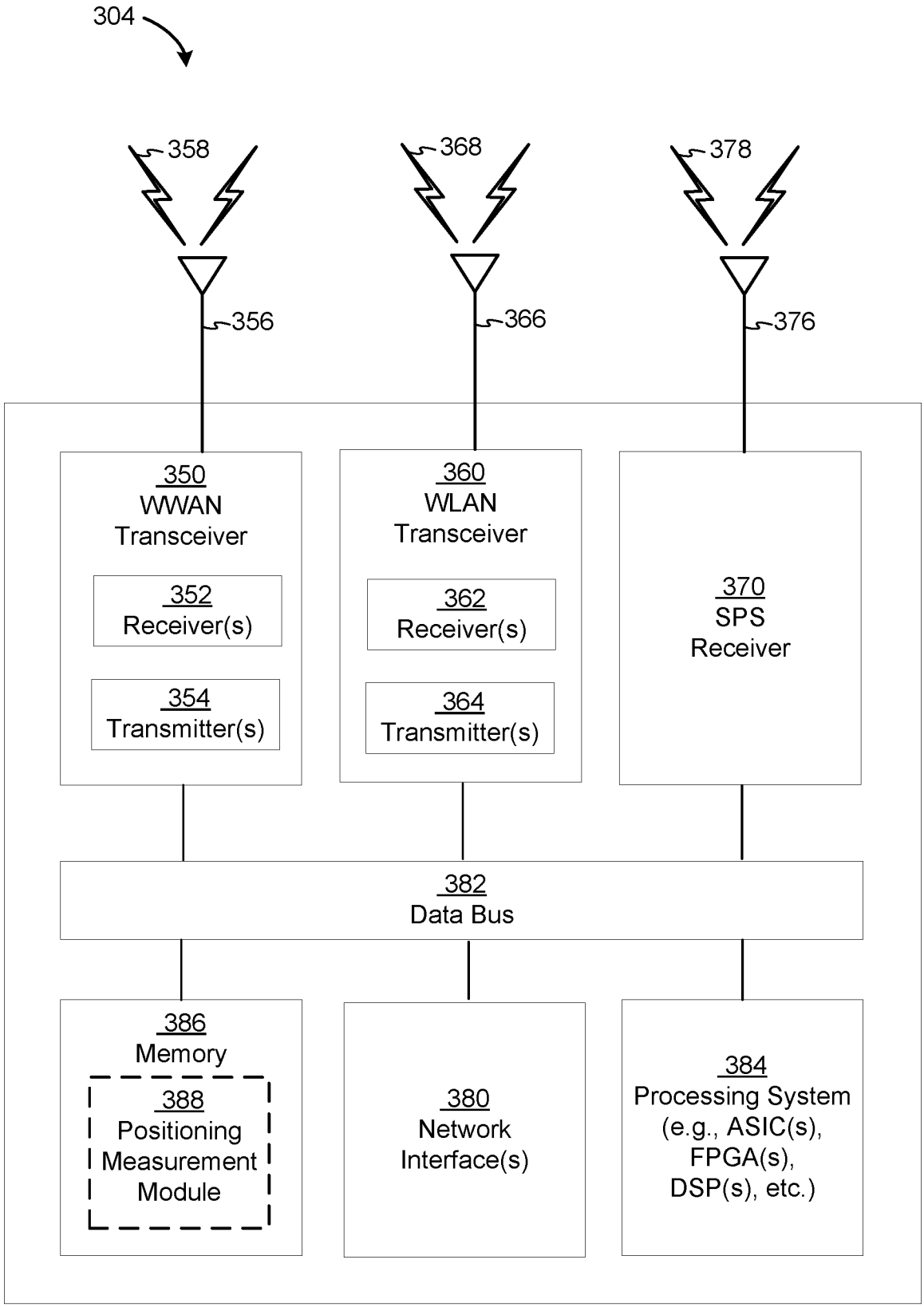

304
358
368
378
356
366
376
350
WWAN
Transceiver
352
Receiver(s)
354
Transmitter(s)
360
WLAN
Transceiver
362
Receiver(s)
364
Transmitter(s)
370
SPS
Receiver
382
Data Bus
386
Memory
388
Positioning
Measurement
Module
380
Network
Interface(s)
384
Processing System
(e.g., ASIC(s),
FPGA(s),
DSP(s), etc.)

FIG. 3B

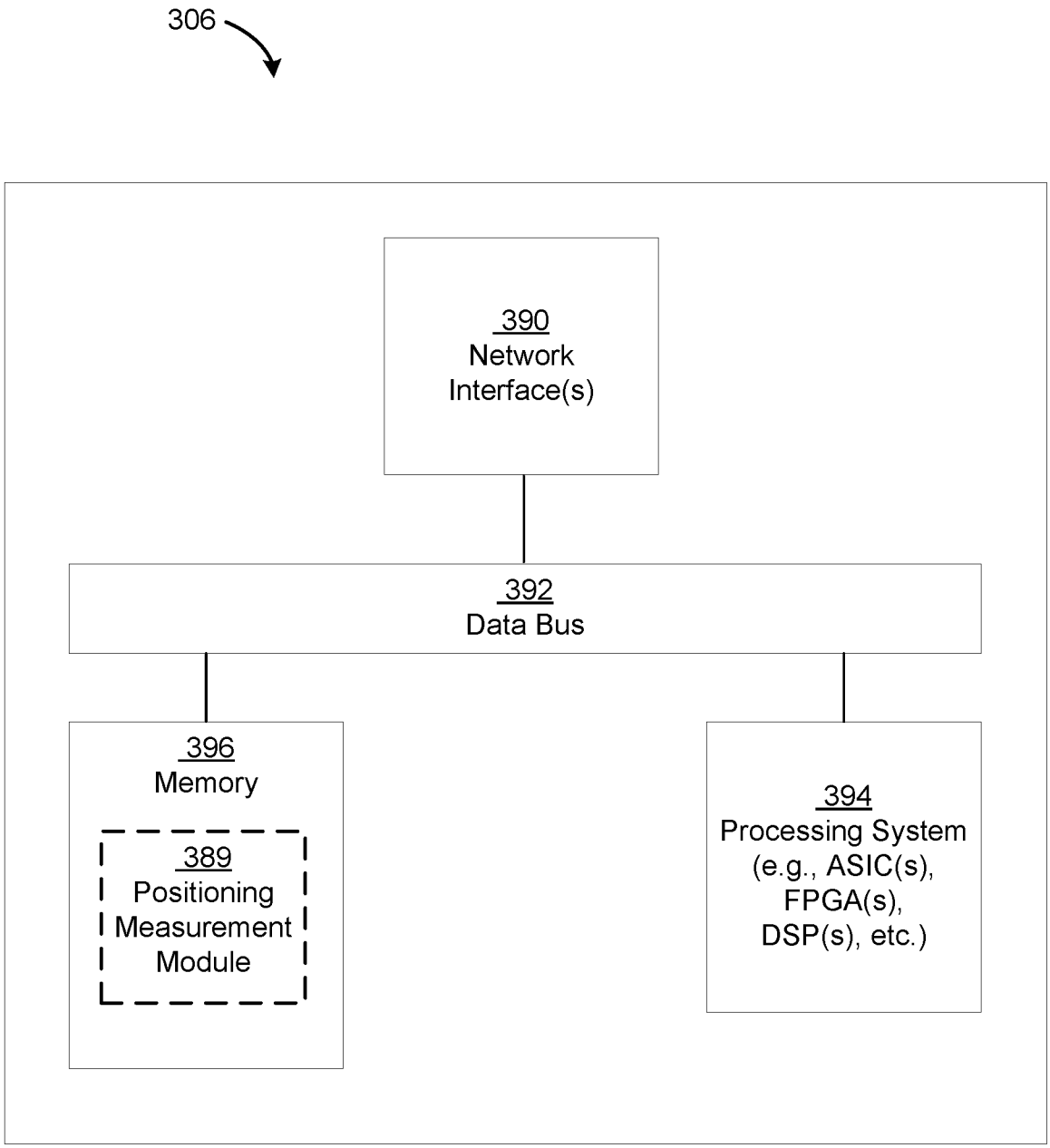

306
390
Network
Interface(s)
392
Data Bus
396
Memory
389
Positioning
Measurement
Module
394
Processing System
(e.g., ASIC(s),
FPGA(s),
DSP(s), etc.)

FIG. 3C

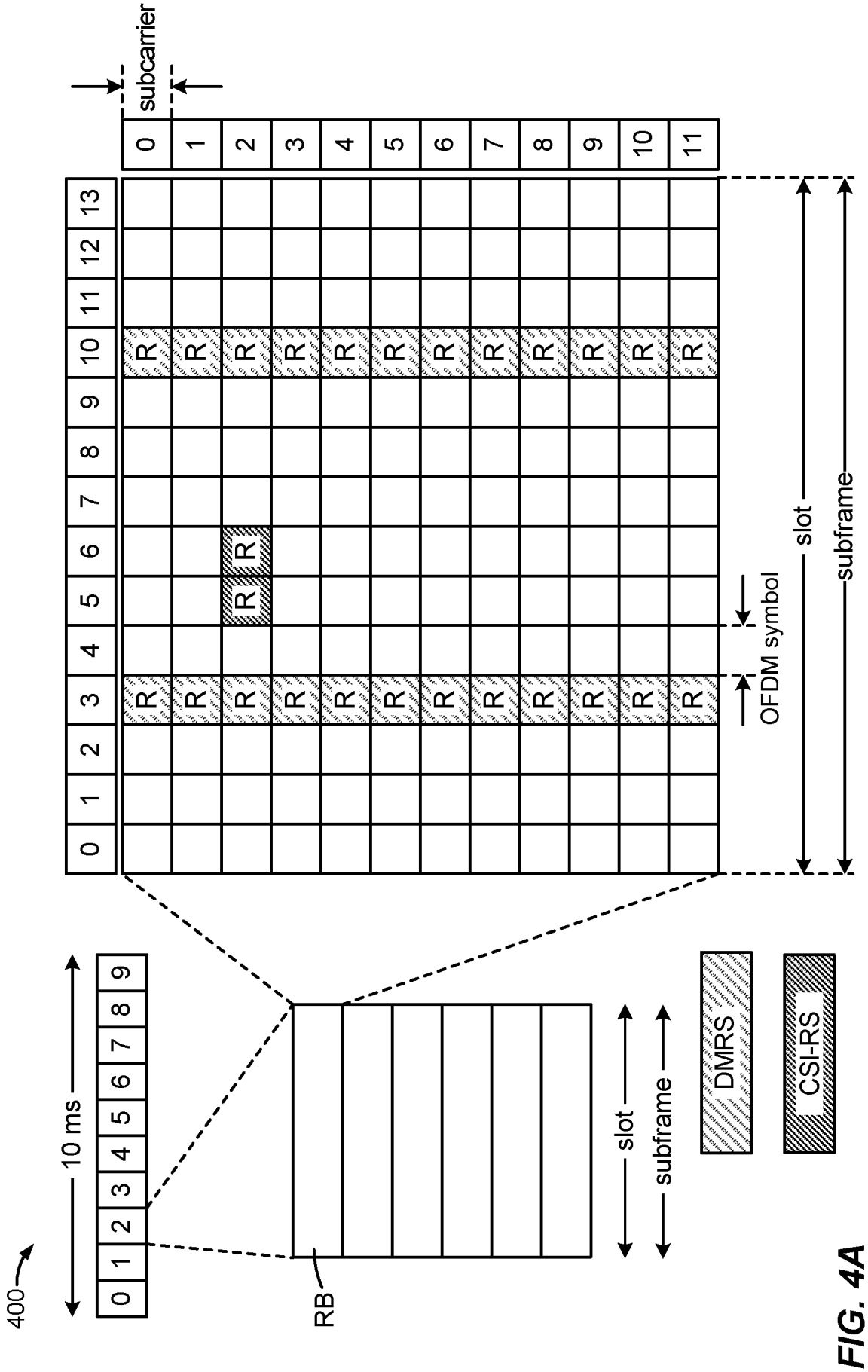

400
0 1 2 3 4 5 6 7 8 9
10 ms
RB
slot
subframe
DMRS
CSI-RS
subcarrier
0 1 2 3 4 5 6 7 8 9 10 11
0 1 2 3 4 5 6 7 8 9 10 11 12 13
R
OFDM symbol
slot
subframe

FIG. 4A

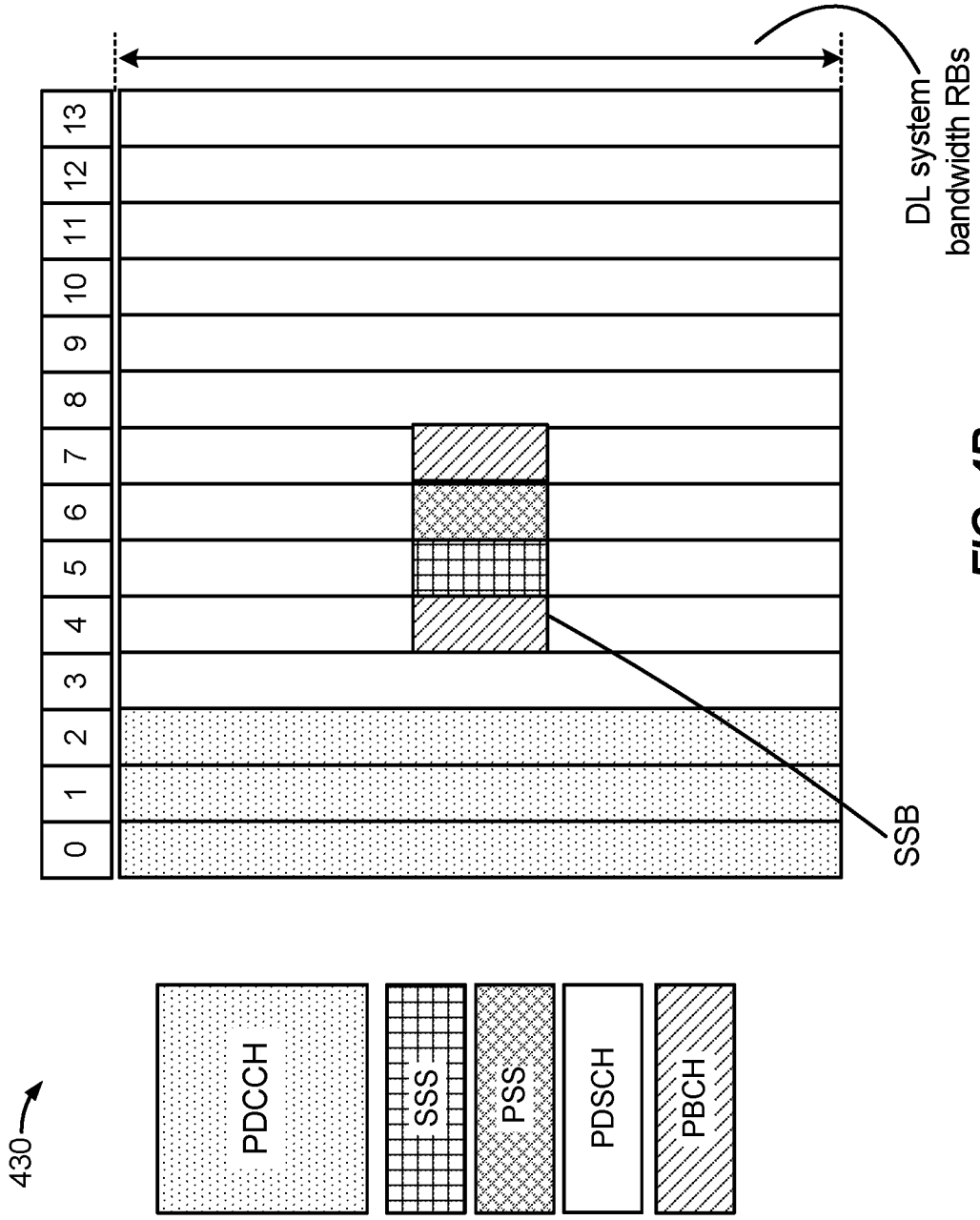

0
1
2
3
4
5
6
7
8
9
10
11
12
13
DL system bandwidth RBs
SSB
430
PDCCH
SSS
PSS
PDSCH
PBCH

FIG. 4B

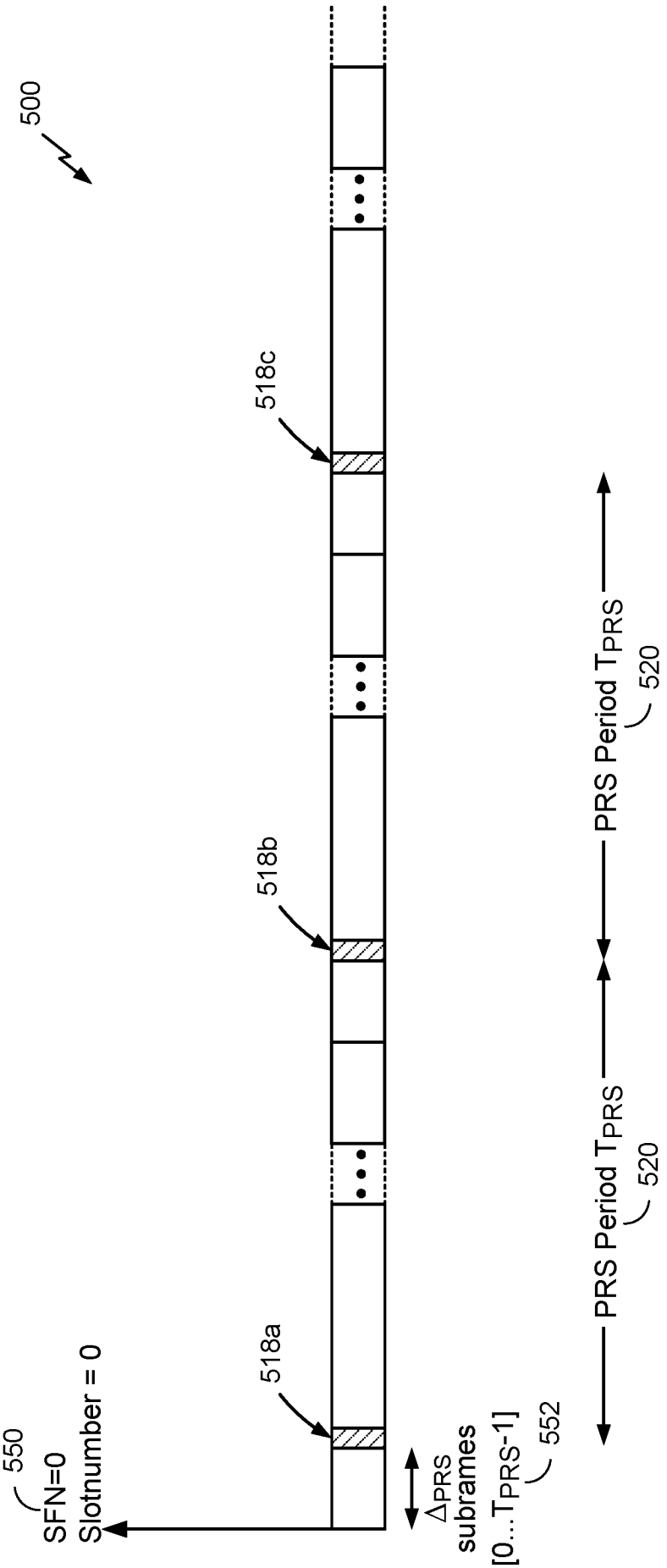

500
518c
518b
518a
550
SFN=0
Slotnumber = 0
ΔPRS
subrames
[0...TPRS-1]
552
PRS Period TPRS
520
PRS Period TPRS
520

FIG. 5

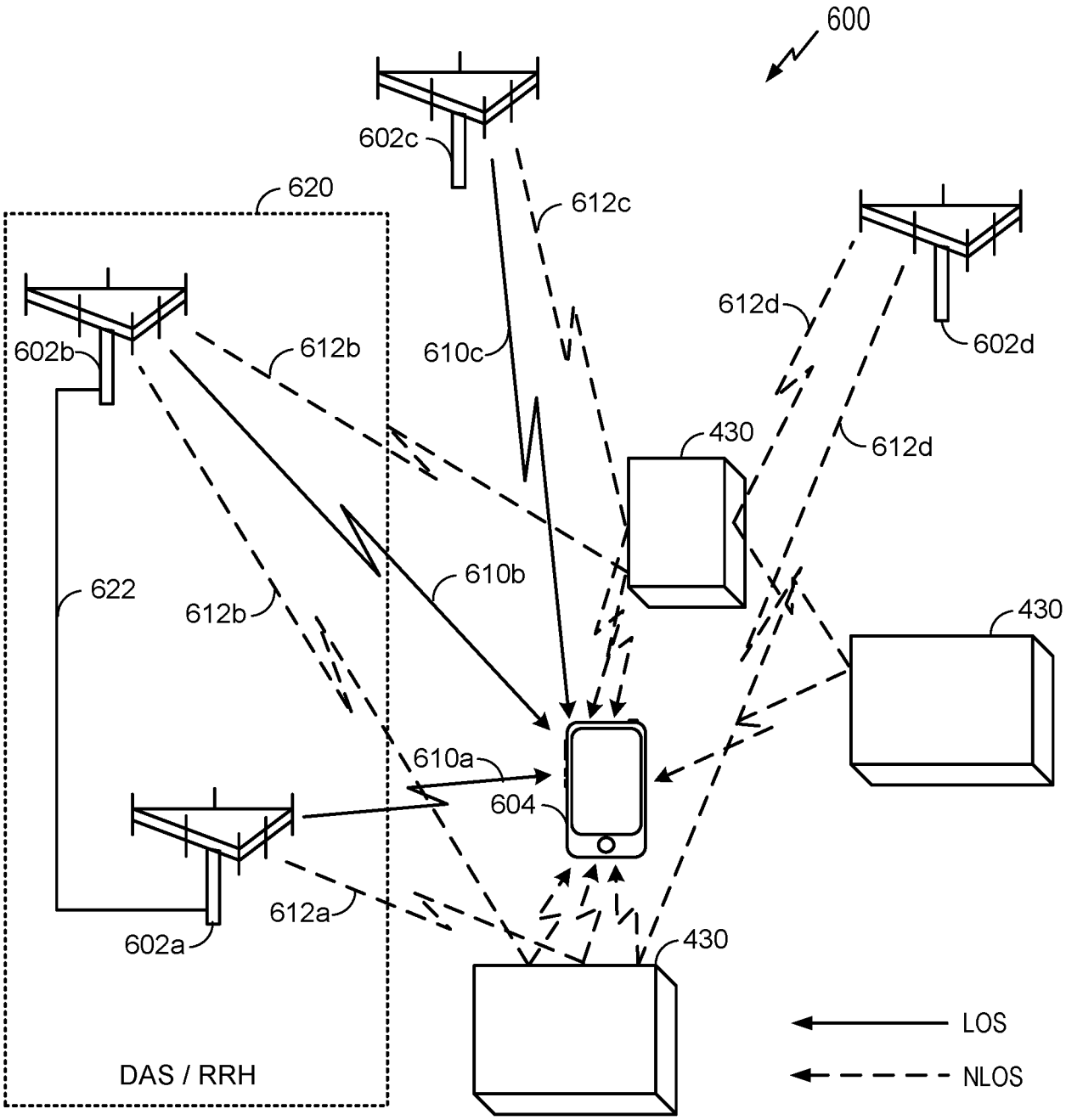

600
602c
620
612c
602b
612b
610c
612d
602d
430
612d
622
610b
612b
430
610a
604
602a
612a
430
LOS
NLOS
DAS / RRH

FIG. 6

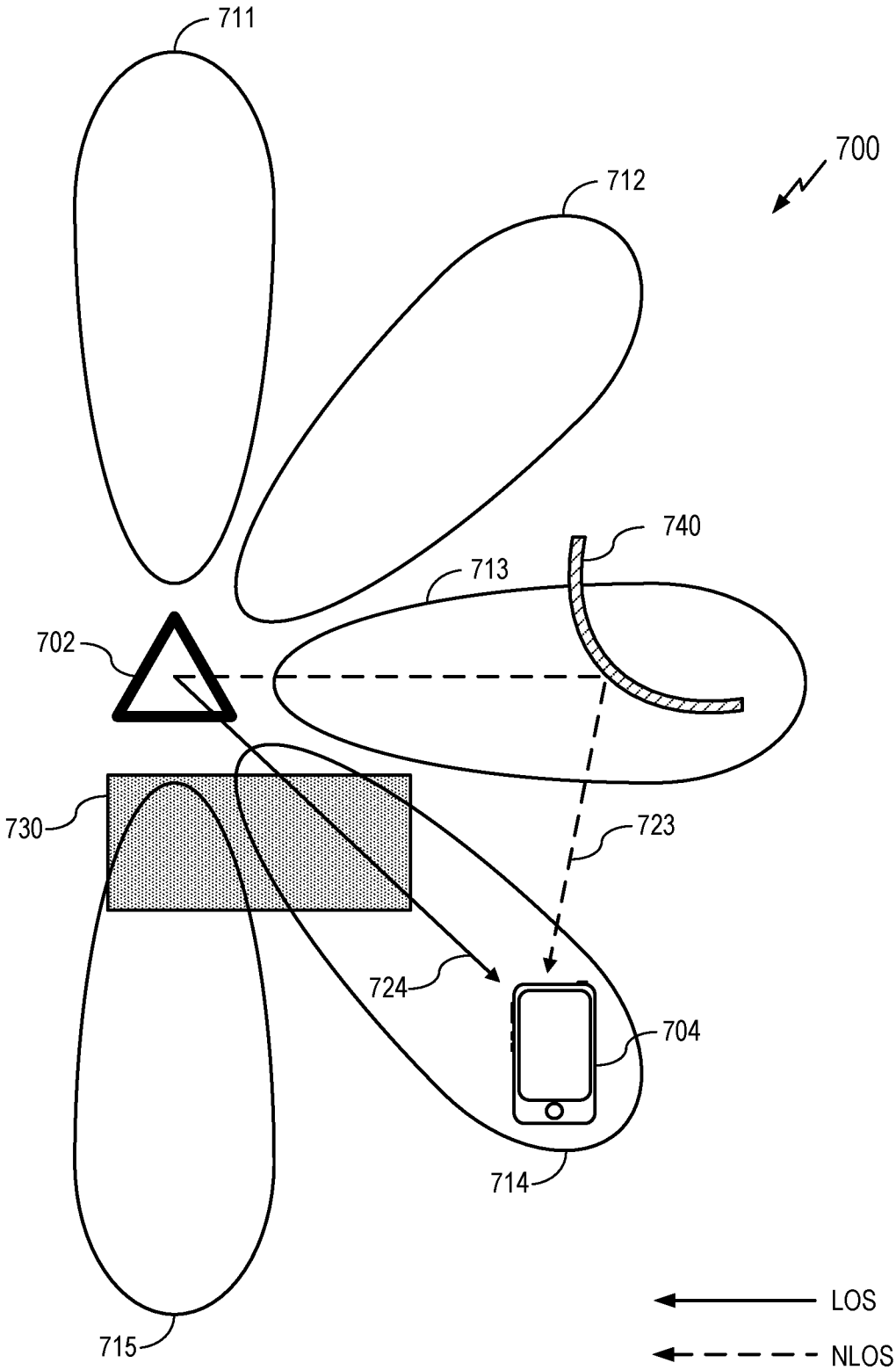


FIG. 7

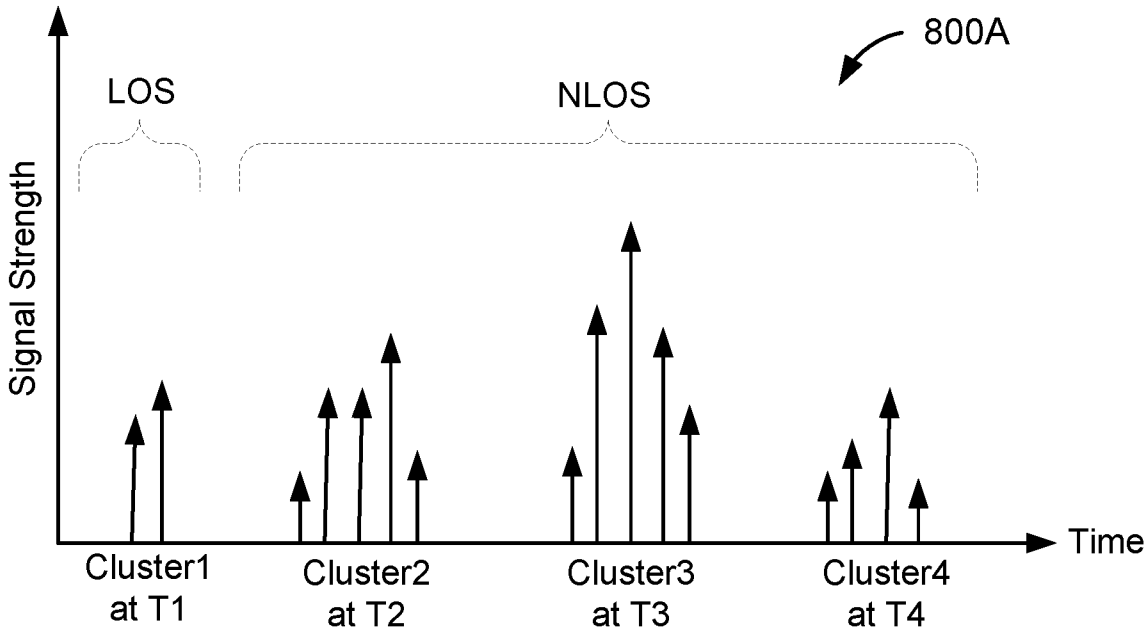

800A
LOS
NLOS
Signal Strength
Time
Cluster1
at T1
Cluster2
at T2
Cluster3
at T3
Cluster4
at T4

FIG. 8A

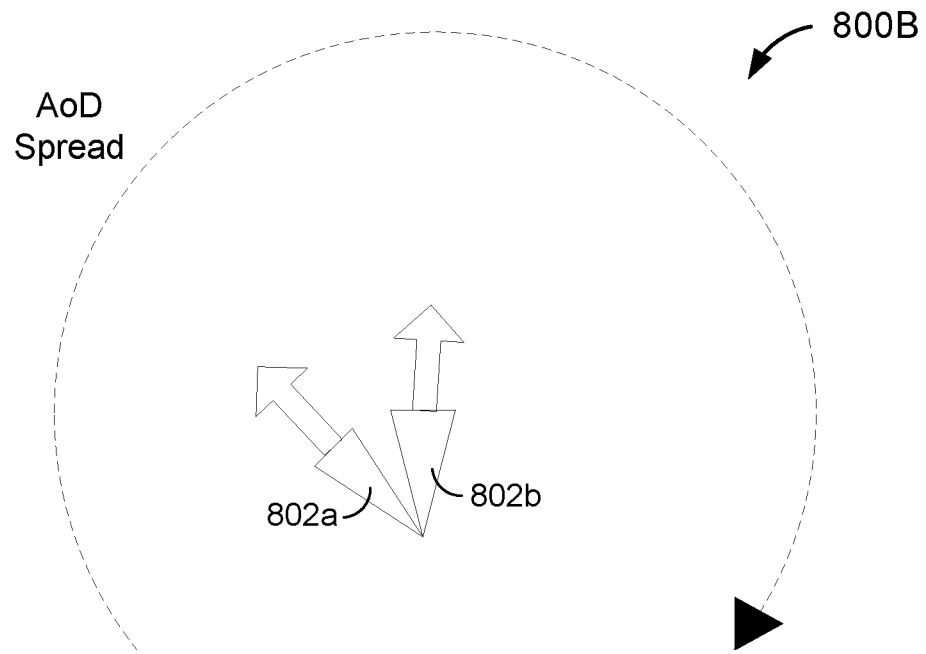

800B
AoD
Spread
802a
802b

FIG. 8B

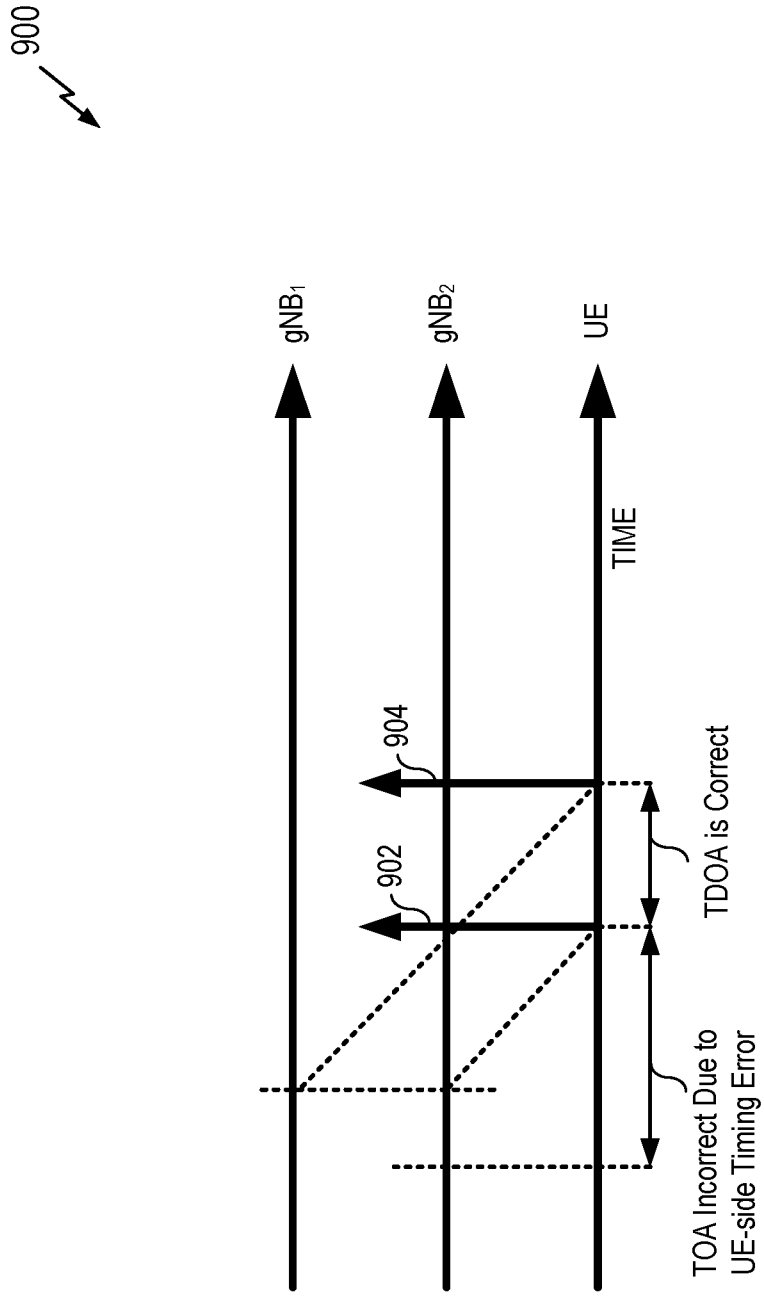

900
gNB1
gNB2
UE
TIME
904
902
TDOA is Correct
TOA Incorrect Due to
UE-side Timing Error

FIG. 9

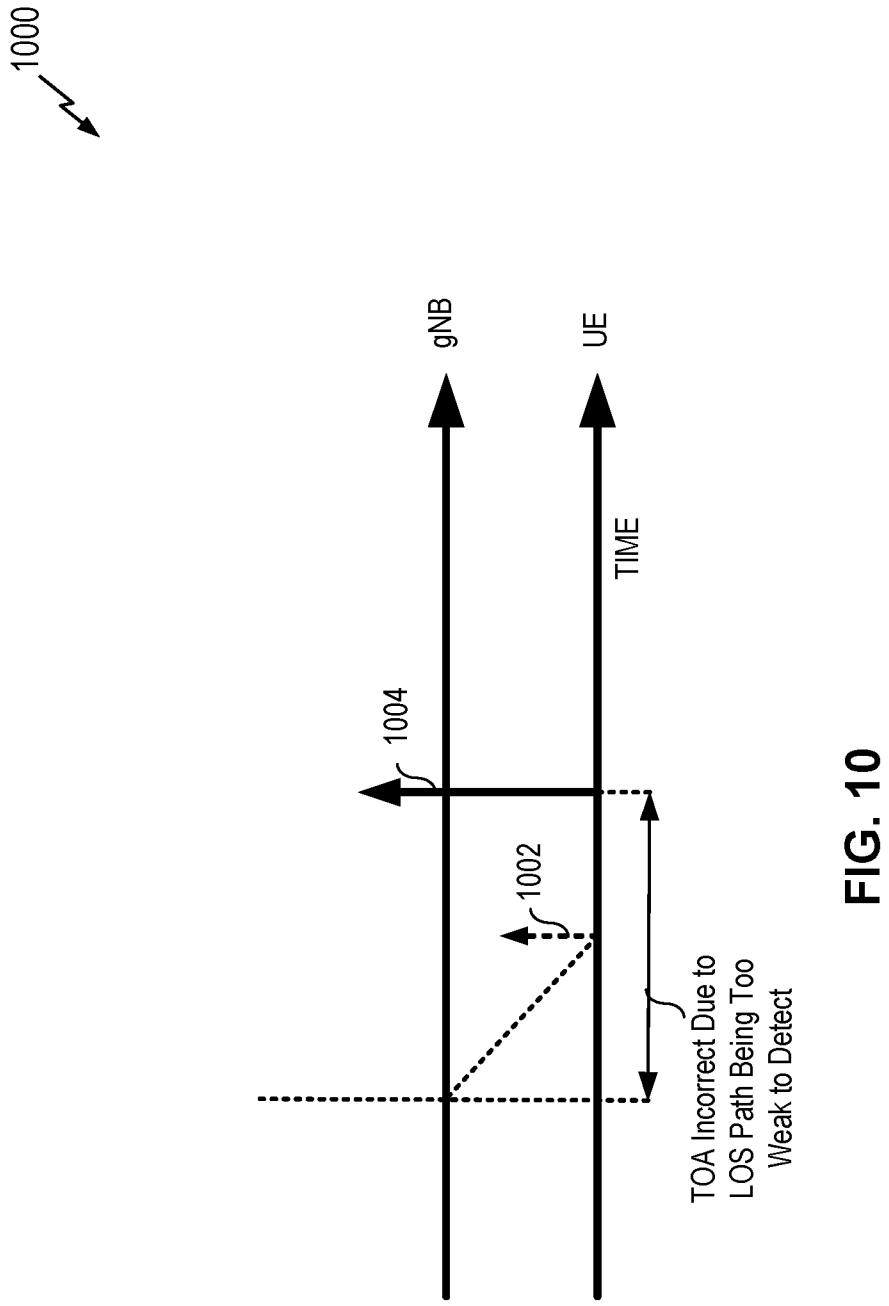

1000
gNB
UE
TIME
1004
1002
TOA Incorrect Due to
LOS Path Being Too
Weak to Detect

FIG. 10

1100

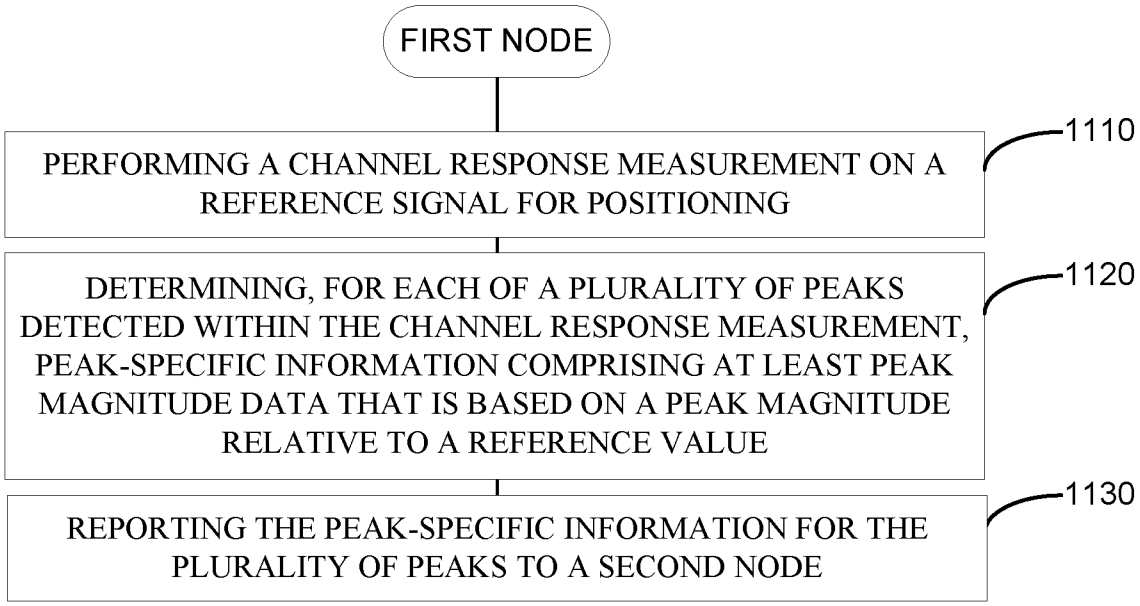

FIRST NODE
PERFORMING A CHANNEL RESPONSE MEASUREMENT ON A REFERENCE SIGNAL FOR POSITIONING
1110
DETERMINING, FOR EACH OF A PLURALITY OF PEAKS DETECTED WITHIN THE CHANNEL RESPONSE MEASUREMENT, PEAK-SPECIFIC INFORMATION COMPRISING AT LEAST PEAK MAGNITUDE DATA THAT IS BASED ON A PEAK MAGNITUDE RELATIVE TO A REFERENCE VALUE
1120
REPORTING THE PEAK-SPECIFIC INFORMATION FOR THE PLURALITY OF PEAKS TO A SECOND NODE
1130

FIG. 11

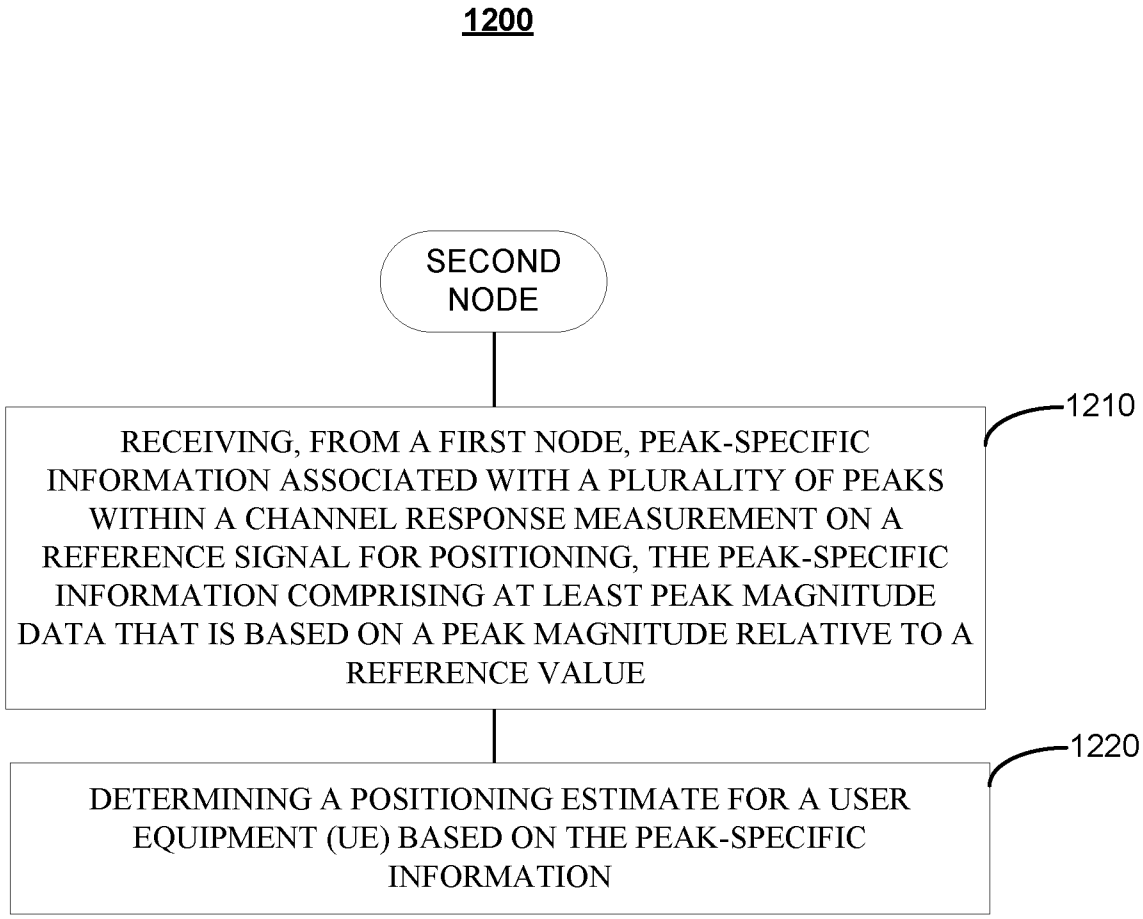

1200
SECOND NODE
RECEIVING, FROM A FIRST NODE, PEAK-SPECIFIC INFORMATION ASSOCIATED WITH A PLURALITY OF PEAKS WITHIN A CHANNEL RESPONSE MEASUREMENT ON A REFERENCE SIGNAL FOR POSITIONING, THE PEAK-SPECIFIC INFORMATION COMPRISING AT LEAST PEAK MAGNITUDE DATA THAT IS BASED ON A PEAK MAGNITUDE RELATIVE TO A REFERENCE VALUE
1210
DETERMINING A POSITIONING ESTIMATE FOR A USER EQUIPMENT (UE) BASED ON THE PEAK-SPECIFIC INFORMATION
1220

FIG. 12

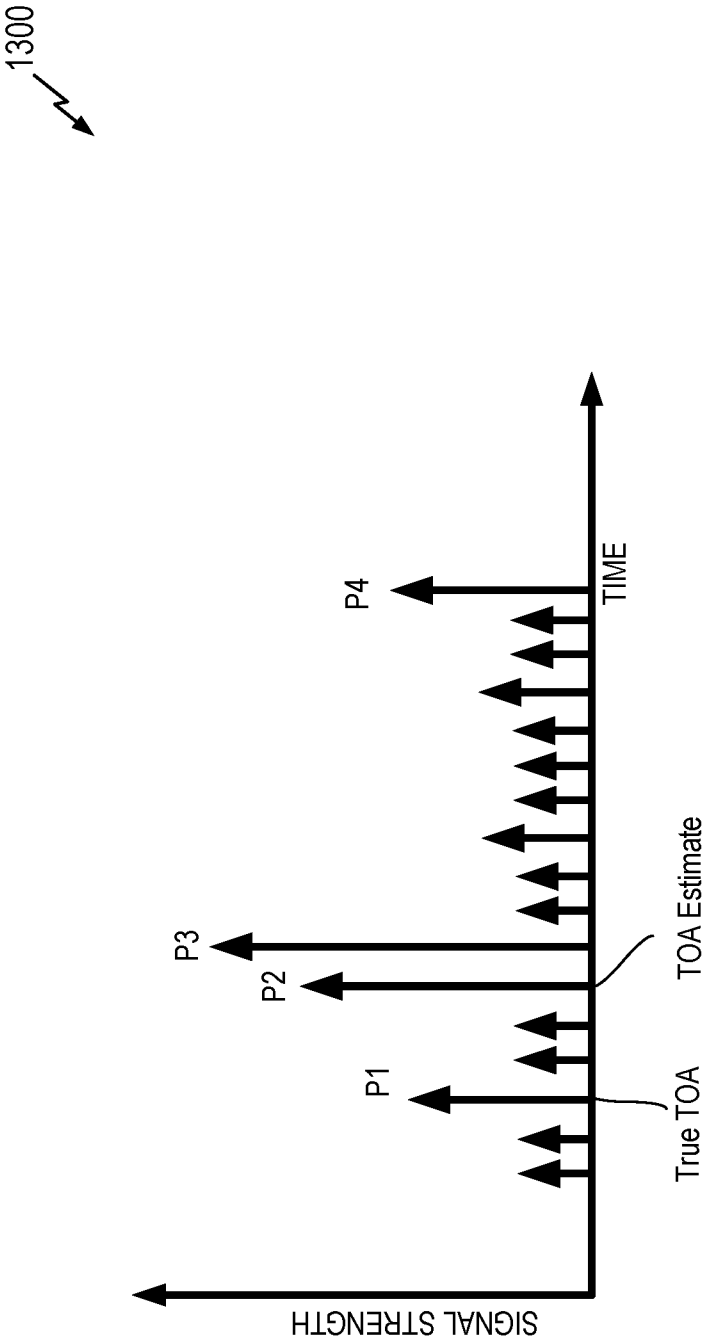


FIG. 13

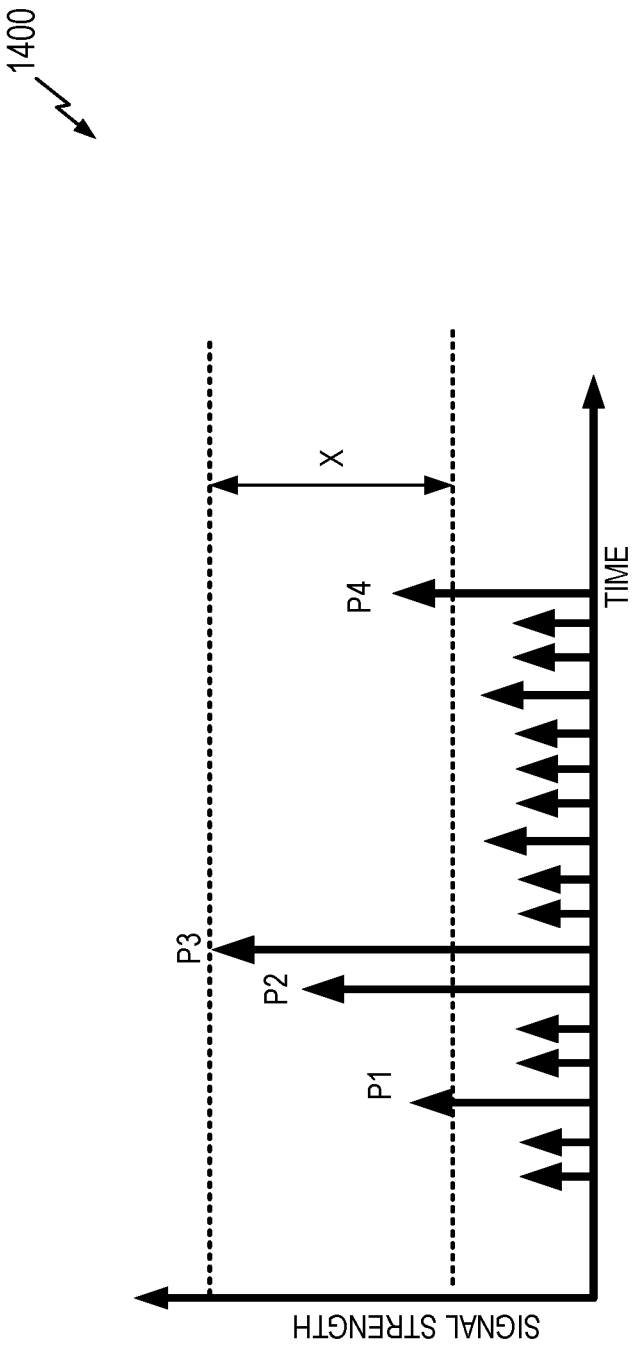


FIG. 14

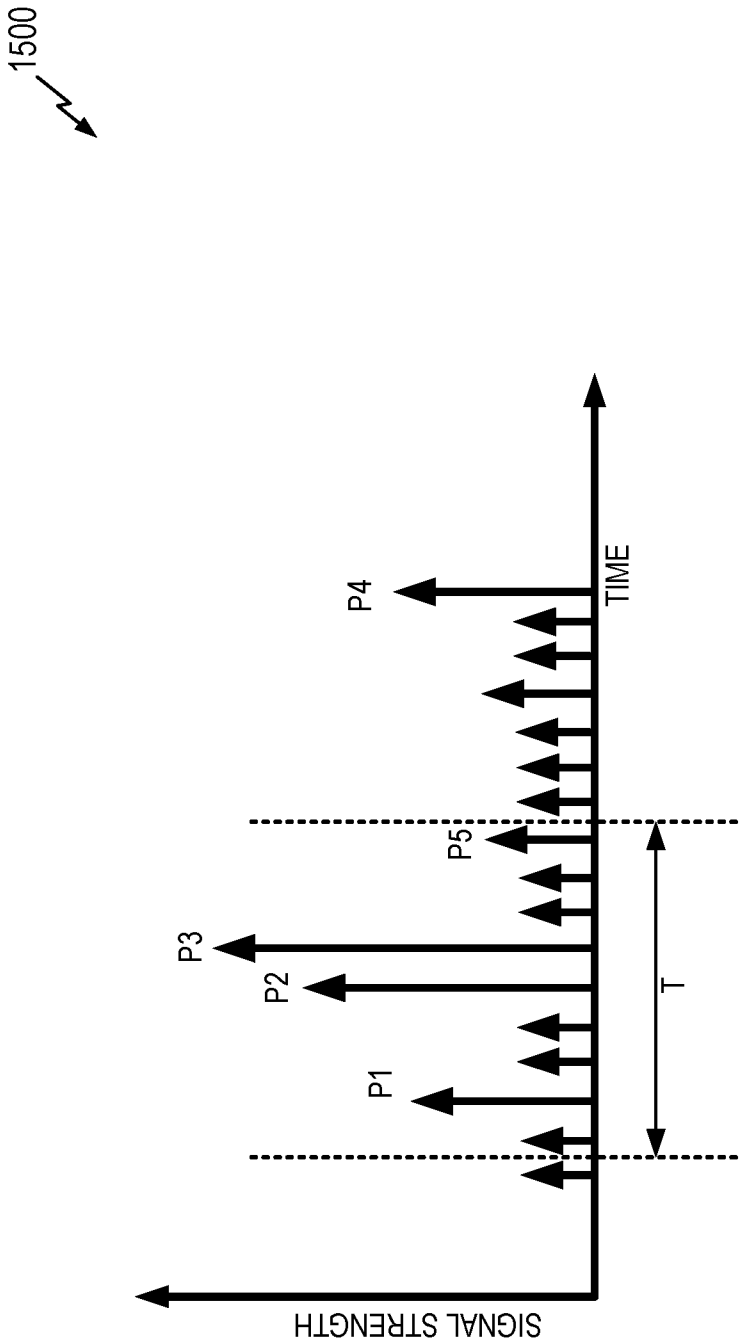


FIG. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2021/032465

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W64/00 G01S5/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2019/285721 A1 (XIONG ZHILAN [GB] ET AL) 19 September 2019 (2019-09-19) paragraphs [0002], [0005] - [0017], [0024] - [0038], [0053] - [0056], [0063], [0068] - [0072], [0103], [0104]; claim 10	1-75

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 September 2021	24/09/2021

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Nogueroles Petersen

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ERICSSON: "UE and gNB measurements for NR positioning", 3GPP DRAFT; R1-1909426 UE GNB MEASUREMENTS, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Prague, CZ; 20190826 - 20190830 16 August 2019 (2019-08-16), XP051766031, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_98/Docs/R1-1909426.zip [retrieved on 2019-08-16] Section 2, 2.2, 3, Fig. 3 -----	1-75
X	ERICSSON: "UE and gNB measurements for NR positioning", 3GPP DRAFT; R1-1905462 UE GNB MEASUREMENTS, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Xi'an, P.R. China; 20190408 - 20190412 2 April 2019 (2019-04-02), XP051707531, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg%5Fran/WG1%5FRL1/TSGR1%5F96b/Docs/R1%2D1905462%2Ezip [retrieved on 2019-04-02] Section 2.2, 3.3 -----	1-75
X	US 2019/380054 A1 (MANOLAKOS ALEXANDROS [US] ET AL) 12 December 2019 (2019-12-12) paragraphs [0068], [0092] - [0096]; figure 8 -----	1,16,31, 46,61
A	WO 2018/083610 A1 (ERICSSON TELEFON AB L M [SE]) 11 May 2018 (2018-05-11) the whole document -----	1-75

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2021/032465

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2019285721 A1	19-09-2019	CN 109564272 A	02-04-2019
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