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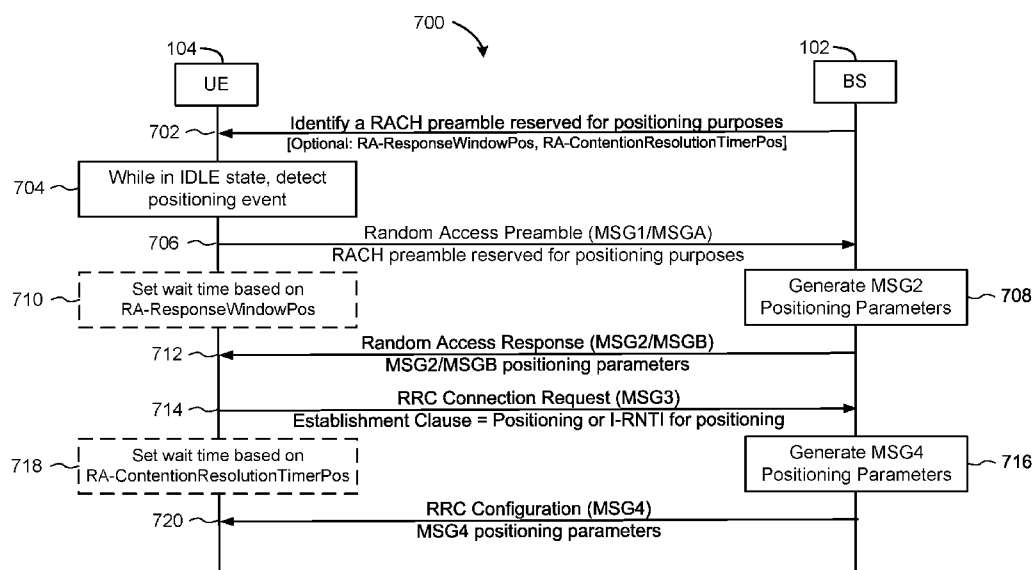


FIG. 7

(57) Abstract: Disclosed are techniques for wireless communication. In an aspect, a user equipment (UE) receives, from a base station (BS), an indication of a random access (RA) channel (RACH) preamble. The RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and the first and second sets of RACH preambles are associated with the BS. The UE detects, while in a radio resource control (RRC) idle or RRC inactive state, a positioning event. The UE transmits, to the BS, the RACH preamble. The UE receives, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes including a random access preamble identifier that is mapped to the RACH preamble.



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RANDOM ACCESS PREAMBLE FOR POSITIONING INDICATION

BACKGROUND OF THE DISCLOSURE

1. Field of the Disclosure

[0001] Aspects of the disclosure relate generally to wireless communications.

2. Description of the Related Art

[0002] 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 and 2.75G networks), a third-generation (3G) high speed data, Internet-capable wireless service and a fourth-generation (4G) service (e.g., Long Term Evolution (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 communications (GSM), etc.

[0003] A fifth generation (5G) wireless standard, referred to as New Radio (NR), calls for 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 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

[0004] 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.

- [0005] In accordance with the various aspects disclosed herein, at least one aspect includes a method of wireless communication performed by a UE. The method of wireless communication includes receiving, from a BS, an indication of a random access (RA) channel (RACH) preamble, where the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and the second set of RACH preambles are associated with the BS. The method also includes detecting, while in a radio resource control (RRC) idle or RRC inactive state, a positioning event. The method also includes transmitting, to the BS, the RACH preamble. The method also includes receiving, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes including a random access preamble identifier that is mapped to the RACH preamble.
- [0006] In accordance with the various aspects disclosed herein, at least one aspect includes a UE. The user equipment includes a memory, at least one transceiver, and at least one processor, communicatively coupled to the memory and the at least one transceiver, configured to: receive, from a BS, an indication of a RACH preamble from a first set of RACH preambles reserved for positioning purposes different from a second set of RACH preambles reserved for communication purposes, the first set of RACH preambles and the second set of RACH preambles being associated with the BS; detect, while in an RRC idle or RRC inactive state, a positioning event; cause the at least one transceiver to transmit, to the BS, the RACH preamble; and receive, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes including a random access preamble identifier that is mapped to the RACH preamble.
- [0007] In accordance with the various aspects disclosed herein, at least one aspect includes a UE. The user equipment includes means for receiving, from a BS, an indication of a RACH

preamble, where the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and the second set of RACH preambles are associated with the BS. The UE also includes means for detecting, while in an RRC idle or RRC inactive state, a positioning event. The UE also includes means for transmitting, to the BS, the RACH preamble. The UE also includes means for receiving, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes including a random access preamble identifier that is mapped to the RACH preamble.

[0008] In accordance with the various aspects disclosed herein, at least one aspect includes a non-transitory computer-readable medium storing a set of instructions. The non-transitory computer-readable medium includes instructions to receive, from a BS, an indication of a RACH preamble from a first set of RACH preambles reserved for positioning purposes different from a second set of RACH preambles reserved for communication purposes, the first set of RACH preambles and the second set of RACH preambles being associated with the BS. The non-transitory computer-readable medium also includes instructions to detect, while in an RRC idle or RRC inactive state, a positioning event. The non-transitory computer-readable medium also includes instructions to transmit, to the BS, the RACH preamble. The non-transitory computer-readable medium also includes instructions to receive, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes including a random access preamble identifier that is mapped to the RACH preamble.

[0009] 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

[0010] 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.

[0011] FIG. 1 illustrates an example wireless communications system, according to aspects of the disclosure.

- [0012] FIGS. 2A and 2B illustrate example wireless network structures, according to aspects of the disclosure.
- [0013] FIGS. 3A to 3C are simplified block diagrams of several sample aspects of components that may be employed in a user equipment (UE), a base station (BS), and a network entity, respectively, and configured to support communications as taught herein.
- [0014] FIG. 4 illustrates a contention-based random access (CBRA) procedure between a UE and a BS according to aspects of the disclosure.
- [0015] FIG. 5 illustrates the different radio resource control (RRC) states available in New Radio (NR), according to aspects of the disclosure.
- [0016] FIG. 6 illustrates a conventional MSG2 preamble.
- [0017] FIG. 7 illustrates a method of wireless communication according to some aspects of the disclosure.
- [0018] FIG. 8 illustrates a random access (RA) channel (RACH) preamble in a MSG2 for positioning according to some aspects of the disclosure.
- [0019] FIGS. 9 and 10 illustrate example methods of wireless communication, according to aspects of the disclosure.

DETAILED DESCRIPTION

- [0020] 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.
- [0021] 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.
- [0022] 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.

[0023] 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 at least one processor, 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.

[0024] 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, commercially-available consumer asset 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 device,” 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 the Institute of Electrical and Electronics Engineers (IEEE) 802.11 specification, etc.) and so on.

[0025] 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 next generation eNB (ng-eNB), a New Radio (NR) Node B (also referred to as a gNB or gNodeB), etc. A base station may be used primarily to support wireless access by UEs, including supporting data, voice, and/or signaling connections for the supported UEs. 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 uplink / reverse or downlink / forward traffic channel.

[0026] 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 (or several cell sectors) 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.

- [0027] In some aspects that support positioning of UEs, a base station may not support wireless access by UEs (e.g., may not support data, voice, and/or signaling connections for UEs), but may instead transmit reference signals to UEs to be measured by the UEs, and/or may receive and measure signals transmitted by the UEs. Such a base station may be referred to as a positioning beacon (e.g., when transmitting signals to UEs) and/or as a location measurement unit (e.g., when receiving and measuring signals from UEs).
- [0028] 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.
- [0029] 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 and/or ng-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.
- [0030] The base stations 102 may collectively form a RAN and interface with a core network 170 (e.g., an evolved packet core (EPC) or a 5G core (5GC)) through backhaul links 122, and through the core network 170 to one or more location servers 172 (which may be part of core network 170 or may be external to core network 170). 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 / 5GC) over backhaul links 134, which may be wired or wireless.

[0031] 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), a cell global identifier (CGI)) 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 of 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.

[0032] 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 (SC) 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).

[0033] The communication links 120 between the base stations 102 and the UEs 104 may include uplink (also referred to as reverse link) transmissions from a UE 104 to a base station 102 and/or downlink (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 downlink and uplink (e.g., more or less carriers may be allocated for downlink than for uplink).

- [0034] 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.
- [0035] The SC 102' may operate in a licensed and/or an unlicensed frequency spectrum. When operating in an unlicensed frequency spectrum, the SC 102' may employ LTE or NR technology and use the same 5 GHz unlicensed frequency spectrum as used by the WLAN AP 150. The SC 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.
- [0036] 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.

- [0037] 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.
- [0038] Transmit beams may be quasi-co-located, 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 co-located. In NR, there are four types of quasi-co-location (QCL) relations. Specifically, a QCL relation of a given type means that certain parameters about a target reference RF signal on a target beam can be derived from information about a source reference RF signal on a source beam. 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 target 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 target 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 target 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 target reference RF signal transmitted on the same channel.
- [0039] 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.

[0040] 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 one or more reference downlink reference signals (e.g., positioning reference signals (PRS), tracking reference signals (TRS), phase tracking reference signal (PTRS), cell-specific reference signals (CRS), channel state information reference signals (CSI-RS), primary synchronization signals (PSS), secondary synchronization signals (SSS), synchronization signal blocks (SSBs), etc.) from a base station. The UE can then form a transmit beam for sending one or more uplink reference signals (e.g., uplink positioning reference signals (UL-PRS), sounding reference signal (SRS), demodulation reference signals (DMRS), PTRS, etc.) to that base station based on the parameters of the receive beam.

[0041] 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.

[0042] 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.

- [0043] 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.
- [0044] 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.

- [0045] 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 (referred to as “sidelinks”). 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.
- [0046] FIG. 2A illustrates an example wireless network structure 200. For example, a 5GC 210 (also referred to as a Next Generation Core (NGC)) 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 5GC 210 and specifically to the control plane functions 214 and user plane functions 212. In an additional configuration, an ng-eNB 224 may also be connected to the 5GC 210 via NG-C 215 to the control plane functions 214 and NG-U 213 to user plane functions 212. Further, ng-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 ng-eNBs 224 and gNBs 222. Either gNB 222 or ng-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 5GC 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, 5GC 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.

[0047] FIG. 2B illustrates another example wireless network structure 250. For example, a 5GC 260 can be viewed functionally as control plane functions, provided by an access and mobility management function (AMF) 264, and user plane functions, provided by a user plane function (UPF) 262, which operate cooperatively to form the core network (i.e., 5GC 260). User plane interface 263 and control plane interface 265 connect the ng-eNB 224 to the 5GC 260 and specifically to UPF 262 and AMF 264, respectively. In an additional configuration, a gNB 222 may also be connected to the 5GC 260 via control plane interface 265 to AMF 264 and user plane interface 263 to UPF 262. Further, ng-eNB 224 may directly communicate with gNB 222 via the backhaul connection 223, with or without gNB direct connectivity to the 5GC 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 ng-eNBs 224 and gNBs 222. Either gNB 222 or ng-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 264 over the N2 interface and with the UPF 262 over the N3 interface.

[0048] The functions of the AMF 264 include registration management, connection management, reachability management, mobility management, lawful interception, transport for session management (SM) messages between the UE 204 and a session management function (SMF) 266, 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 264 also interacts with an 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 264 retrieves the security material from the AUSF. The functions of the AMF 264 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 264 also includes location services management for regulatory services, transport for location services messages between the UE 204 and a location management function (LMF) 270 (which acts as a location server 230), transport for location services messages 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 264 also supports functionalities for non- third generation partnership project (3GPP) access networks.

[0049] Functions of the UPF 262 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 a 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., uplink/ downlink rate enforcement, reflective QoS marking in the downlink), uplink traffic verification (service data flow (SDF) to QoS flow mapping), transport level packet marking in the uplink and downlink, downlink packet buffering and downlink data notification triggering, and sending and forwarding of one or more “end markers” to the source RAN node. The UPF 262 may also support transfer of location services messages over a user plane between the UE 204 and a location server, such as a secure user plane location (SUPL) location platform (SLP) 272.

[0050] The functions of the SMF 266 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 262 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 266 communicates with the AMF 264 is referred to as the N11 interface.

[0051] Another optional aspect may include an LMF 270, which may be in communication with the 5GC 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, 5GC 260, and/or via the Internet (not illustrated). The SLP 272 may support similar functions to the LMF 270, but whereas the LMF 270 may communicate with the AMF 264, New RAN 220, and UEs 204 over a control plane (e.g., using interfaces and protocols intended to convey signaling messages and not voice or data), the SLP 272 may communicate with UEs 204 and external clients

(not shown in FIG. 2B) over a user plane (e.g., using protocols intended to carry voice and/or data like the transmission control protocol (TCP) and/or IP).

[0052] FIGS. 3A, 3B, and 3C illustrate several example 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 aspects (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.

[0053] The UE 302 and the base station 304 each include wireless wide area network (WWAN) transceiver 310 and 350, respectively, providing means for communicating (e.g., means for transmitting, means for receiving, means for measuring, means for tuning, means for refraining from transmitting, etc.) 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 WWAN 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.

[0054] 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, and provide means for communicating (e.g., means for transmitting, means for receiving, means for measuring, means for tuning, means for refraining from transmitting, etc.) 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 WLAN 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.

[0055] Transceiver circuitry including at least one transmitter and at least one receiver may comprise an integrated device (e.g., embodied as a transmitter circuit and a receiver circuit of a single communication device) in some aspects, may comprise a separate transmitter device and a separate receiver device in some aspects, or may be embodied in other ways in other aspects. In an aspect, a transmitter may include or be coupled to a plurality of antennas (e.g., antennas 316, 326, 356, 366), 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, 326, 356, 366), 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, 326, 356, 366), 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 UE 302 and/or the base station 304 may also comprise a network listen module (NLM) or the like for performing various measurements.

- [0056] The UE 302 and the base station 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, and may provide means for receiving and/or measuring 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 positions of the UE 302 and the base station 304 using measurements obtained by any suitable SPS algorithm.
- [0057] The base station 304 and the network entity 306 each include at least one network interfaces 380 and 390, respectively, providing means for communicating (e.g., means for transmitting, means for receiving, etc.) 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, and/or other types of information.
- [0058] The UE 302, the base station 304, and the network entity 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, wireless positioning, and for providing other processing functionality. The base station 304 includes a processing system 384 for providing functionality relating to, for example, wireless positioning 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, wireless positioning as disclosed herein, and for providing other processing functionality. The processing systems 332, 384, and 394 may therefore provide means for processing, such as means for determining, means for calculating, means for receiving, means for transmitting, means for indicating, etc. In an aspect, the processing systems 332, 384,

and 394 may include, for example, at least one processor, which in various aspects may be general purpose processors, multi-core processors, ASICs, digital signal processors (DSPs), field programmable gate arrays (FPGA), or other programmable logic devices or processing circuitry or various combinations thereof.

[0059] The UE 302, the base station 304, and the network entity 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). The memory components 340, 386, and 396 may therefore provide means for storing, means for retrieving, means for maintaining, etc. In some cases, the UE 302, the base station 304, and the network entity 306 may include positioning components 342, 388, and 398, respectively. The positioning components 342, 388, and 398 may be hardware circuits that are part of or coupled to the processing systems 332, 384, and 394, respectively, that, when executed, cause the UE 302, the base station 304, and the network entity 306 to perform the functionality described herein. In other aspects, the positioning components 342, 388, and 398 may be external to the processing systems 332, 384, and 394 (e.g., part of a modem processing system, integrated with another processing system, etc.). Alternatively, the positioning components 342, 388, and 398 may be memory modules stored in the memory components 340, 386, and 396, respectively, that, when executed by the processing systems 332, 384, and 394 (or a modem processing system, another processing system, etc.), cause the UE 302, the base station 304, and the network entity 306 to perform the functionality described herein. FIG. 3A illustrates possible locations of the positioning component 342, which may be part of the WWAN transceiver 310, the memory component 340, the processing system 332, or any combination thereof, or may be a standalone component. FIG. 3B illustrates possible locations of the positioning component 388, which may be part of the WWAN transceiver 350, the memory component 386, the processing system 384, or any combination thereof, or may be a standalone component. FIG. 3C illustrates possible locations of the positioning component 398, which may be part of the network interface(s) 390, the memory component 396, the processing system 394, or any combination thereof, or may be a standalone component.

[0060] The UE 302 may include one or more sensors 344 coupled to the processing system 332 to provide means for sensing or detecting 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 SPS 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.

[0061] In addition, the UE 302 includes a user interface 346 providing means 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 base station 304 and the network entity 306 may also include user interfaces.

[0062] 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 PDUs, error correction through automatic repeat request (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.

[0063] The transmitter 354 and the receiver 352 may implement Layer-1 (L1) 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 symbol 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.

[0064] 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 (L3) and Layer-2 (L2) functionality.

- [0065] In the uplink, 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.
- [0066] Similar to the functionality described in connection with the downlink 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 hybrid automatic repeat request (HARQ), priority handling, and logical channel prioritization.
- [0067] 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.
- [0068] The uplink 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.
- [0069] In the uplink, 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.

[0070] For convenience, the UE 302, the base station 304, and/or the network entity 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.

[0071] The various components of the UE 302, the base station 304, and the network entity 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 aspects, the components of FIGS. 3A-C may be implemented in one or more circuits such as, for example, at least one processor and/or one or more ASICs (which may include at least one processor). 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 388 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 398 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 components 342, 388, and 398, etc.

[0072] FIG. 4 illustrates a contention-based random access (CBRA) procedure 400 between a UE 104 and a BS 102. At 402, the UE 104 sends a RA preamble, known as “MSG1”, to the BS 102. At 404, the BS 102 sends a RA response, known as “MSG2”, to the UE 104. At 406, the UE 104 sends a PUSCH transmission, known as “MSG3”, to the BS 102.

There are a number of different types of MSG3; one type of MSG3 is an RRC connection request, which may be an RRC setup request or an RRC resume request. At 408, the BS 102 sends a contention resolution message, known as “MSG4”, to the UE 104. In scenarios where the MSG3 comprises an RRC connection request, the MSG4 comprises RRC configuration parameters. In CBRA, the UE randomly selects an RA preamble from a pool of preambles shared with other UEs in the cell. If multiple UEs select/transmit same preamble (MSG1), all those UEs decode same MSG2 content and transmit MSG3 on the same UL time/frequency resources. In the next step (MSG4), the network resolves the contention.

- [0073] After a random access procedure, the UE is in an RRC CONNECTED state. The RRC protocol is used on the air interface between a UE and a base station. The major functions of the RRC protocol include connection establishment and release functions, broadcast of system information, radio bearer establishment, reconfiguration, and release, RRC connection mobility procedures, paging notification and release, and outer loop power control. In LTE, a UE may be in one of two RRC states (CONNECTED or IDLE), but in NR, a UE may be in one of three RRC states (CONNECTED, IDLE, or INACTIVE). The different RRC states have different radio resources associated with them that the UE can use when it is in a given state. Note that the different RRC states are often capitalized, as above; however, this is not necessary, and these states can also be written in lowercase.
- [0074] FIG. 5 is a diagram 500 of the different RRC states (also referred to as RRC modes) available in NR, according to aspects of the disclosure. When a UE is powered up, it is initially in the RRC DISCONNECTED/IDLE state 510, during which the presence of the UE is, in general, not known to the network at the cell level (the location of the UE in the RRC idle state is known to the network at the level of tracking areas, which consist of groups of cells) and base stations do not have any context for the UE. After a random access procedure, it moves to the RRC CONNECTED state 520, during which the network maintains the UE's context and during which there is activity on the physical link. If there is no activity at the UE for a short time, it can suspend its session by moving to the RRC inactive state 530, during which the network maintains the UE's context but during which there is no activity on the physical link.. The UE can resume its session by performing a random access procedure to transition back to the RRC CONNECTED state 520. Thus, the UE needs to perform a random access procedure to transition to the RRC

CONNECTED state 520, regardless of whether the UE is in the RRC idle state 510 or the RRC inactive state 530.

- [0075] The operations performed in the RRC idle state 510 include public land mobile network (PLMN) selection, broadcast of system information, cell re-selection mobility, paging for mobile terminated data (initiated and managed by the 5GC), discontinuous reception (DRX) for core network paging (configured by non-access stratum (NAS)). The operations performed in the RRC CONNECTED state 520 include 5GC (e.g., 5GC 260) and New RAN (e.g., New RAN 220) connection establishment (both control and user planes), UE context storage at the New RAN and the UE, New RAN knowledge of the cell to which the UE belongs, transfer of unicast data to/from the UE, and network controlled mobility. The operations performed in the RRC inactive state 530 include the broadcast of system information, cell re-selection for mobility, paging (initiated by the New RAN), RAN-based notification area (RNA) management (by the New RAN), DRX for RAN paging (configured by the New RAN), 5GC and New RAN connection establishment for the UE (both control and user planes), storage of the UE context in the New RAN and the UE, and New RAN knowledge of the RNA to which the UE belongs.
- [0076] The RA procedure shown in FIG. 4 may be triggered by a number of events, including: initial access from the RRC idle state; RRC connection re-establishment procedure; UL data arrival during the RRC_CONNECTED state when UL synchronization status is out of sync; transition from the RRC inactive state; a request for on-demand system information; and other events. However, in conventional networks, requests for on-demand PRS configuration must be made while the UE is in the RRC_CONNECTED state. There is no mechanism by which a UE in an RRC inactive or RRC idle state to request on-demand PRS configuration. To address this technical deficiency, the following technical solutions are presented.
- [0077] There are 64 random access (RA) channel (RACH) preambles defined in NR for each time-frequency physical random access channel (PRACH) occasion. The preamble includes a cyclic prefix (CP) that occurs once followed by a preamble sequence that may be repeated multiple times.
- [0078] FIG. 6 is a conventional MSG2 preamble 600. The MSG2 preamble 600 includes the following fields:
- A 4-bit backoff indicator 602;

- A 4-bit random access preamble identifier (RAPID) 604, which is mapped to the preamble index contained in MSG1;
- An 11-bit timing advance (TA) 606, to be used by the UE for transmissions to the BS;
- A 27-bit uplink (UL) grant 608; and
- A 16-bit temporary cell radio network temporary identifier (C-RNTI) 610. This is an identity temporarily allocated to the UE and that becomes permanent after a successful RACH procedure.

[0079] In some aspects of the disclosure, one or more of the RACH preambles are reserved for positioning, and, as will be explained in more detail below, modifications are made to the MSG2 preamble, the MSG4 preamble, or both.

[0080] FIG. 7 illustrates a method 700 of wireless communication according to some aspects of the disclosure.

[0081] At 702, the BS 102 may transmit to the UE 104 information identifying a RACH preamble reserved for positioning purposes. In some embodiments, the BS 102 may broadcast this information in a system information block (SIB), such as a positioning-specific SIB (Pos-SIB). In some aspects, the BS 102 may configure the UE 104 with a RACH preamble (e.g. for contention-free random access (CFRA) mode), or a group of RACH preambles (e.g., for CBRA mode). Alternatively, the UE 104 may be already be configured with this information.

[0082] In some aspects, the following new fields may be provided to the UE 104 by the BS 102, e.g., via a SIB or a positioning SIB:

- New field *RA-ResponseWindowPos*, which defines a response window for positioning, to be used instead of the response window defined by existing field *RA-ResponseWindow* for MSG2 transmission.
- New field *RA-ContentionResolutionTimerPos*, which defines a contention resolution timer value for positioning, to be used instead of the contention resolution timer value defined by existing field *RA-ContentionResolutionTimer* for MSG4 transmission.

[0083] The values in these new fields account for different communication latencies in the network for a positioning operation compared to the conventional random access procedure. For example, new field *RA-ContentionResolutionTimerPos* takes into account

the additional, positioning-related interaction between the BS 102 and an LMF 270 or other location server, which the BS 102 needs to complete before it can send a response back to the UE 104. Thus, the value of new field *RA-ContentionResolutionTimerPos* is likely to be larger than the value for existing field *RA-ContentionResolutionTimer*, since a non-positioning-related RACH request does not require such interaction between the BS 102 and the LMF 270.

- [0084] At 704, while in an RRC idle or RRC inactive state, the UE 104 detects a positioning event. In some aspects, the positioning event requires the UE 104 to make an on-demand positioning request.
- [0085] At 706, the UE 104 transmits a MSG1 for positioning to the BS 102. The MSG1 for positioning includes the RACH preamble reserved for positioning purposes. When the UE 104 uses a RACH preamble reserved for positioning, the BS 102 understands that there is a mobile-originated (MO) location request (LR) event (MO-LR).
- [0086] At 708, the BS 102 generates parameters to be included in a MSG2 for positioning, which are referred to herein as MSG2 positioning parameters. The MSG2 positioning parameters may differ from the parameters to be included in a MSG2 that is not for positioning, such as a MSG2 for data. In some aspects the bandwidth of the RACH preamble used in a MSG2 for positioning may be wider than the bandwidth of the RACH preamble used in a MSG2 for data. Other differences will be described in more detail in FIG. 8, below.
- [0087] At 710, if the UE 104 was configured with the new field *RA-ResponseWindowPos*, the UE 104 will use that value to determine how long it will wait to receive a MSG2 from the BS 102. Otherwise, the UE 104 may set its wait time based on the existing field *RA-ResponseWindow*.
- [0088] At 712, the BS 102 transmits, to the UE 104, a MSG2 for positioning that includes the MSG2 positioning parameters.
- [0089] At 714, the UE 104 transmits a MSG3 for positioning to the BS 102. In FIG. 7, the MSG3 comprises an RRC connection request. When the network puts the UE 104 into an RRC inactive state, the network configures an inactive RNTI (I-RNTI) to the UE 104, which the UE 104 signals to the network as part of the RRC connection request within MSG3. In some embodiments, the MSG3 for positioning also includes an establishment clause indicating that establishment is being made for the purpose of positioning. Alternatively, in some embodiments, the network may configure a second I-RNTI for positioning to the

UE 104, which the UE 104 signals to the network within the MSG3 for positioning to indicate a positioning cause.

- [0090] At 716, the BS 102 generates parameters to be included in a MSG4 that is in response to a MSG3 for positioning, which are referred to herein as MSG4 positioning parameters. The MSG4 positioning parameters may differ from the parameters to be included in a MSG4 that is not for positioning. In some aspects, a MSG4 for positioning may include a MAC-CE that triggers SRS transmission, PRS measurement, or both.
- [0091] At 718, if the UE 104 was configured with the new field RA-ContentionResolutionTimerPos, the UE 104 will use that value to determine how long it will wait to receive a MSG4 from the BS 102. Otherwise, the UE 104 may set its wait time based on the existing field RA-ContentionResolutionTimer.
- [0092] At 720, the BS 102 transmits, to the UE 104, a MSG4 for positioning that includes the MSG4 positioning parameters. In FIG. 7, the MSG4 comprises an RRC configuration.
- [0093] Although FIG. 7 illustrates a four-step RACH process, in alternative embodiments a two-step process may be used. In a two-step RACH process, the UE 104 transmits to the BS 102 a MSGA, which is a combination of MSG1 and MSG3, and the BS 102 transmits to the UE 104 a MSGB, which is a combination of MSG2 and MSG4, and may include both the MSG2 parameters and the MSG4 parameters.
- [0094] FIG. 8 illustrates a RACH preamble in a MSG2 for positioning according to some aspects of the disclosure. FIG. 8 illustrates the various ways that a MSG2 RACH preamble for positioning may differ from a MSG2 RACH preamble that is not for positioning, e.g., for data.
- [0095] Backoff value 800. In some aspects, the backoff value used for positioning is different than the backoff value used for data. In some aspects, the backoff value used for positioning is larger than the backoff value used for data communication, e.g., in order to give the network time to reserve positioning resources for the serving cell and the neighboring cells. In some aspects, the backoff value used for positioning is also a function of the loading of neighboring cells, not just the loading of the serving cell. For example, the BS 102 may regularly communicate with neighbor base stations to understand the loading and then derive an overall backoff indicator based on the cumulative network load. In some aspects, such as if the network has already reserved some positioning resources, the backoff value used for positioning may be smaller than the backoff value used for data.

- [0096] RAPID field 802. In some aspects, the RAPID field is mapped to the preamble index indicated for positioning.
- [0097] Timing advance (TA) field 804. In some aspects, the width of the TA field used for positioning may be increased compared to the width of the TA field used for data communication, to allow a finer granularity of the timing advance in order to improve positioning accuracy.
- [0098] UL grant field 806. In some aspects, the UL grant field used for positioning can include a delta transmission power control (TPC) command, e.g., a regular TPC is used for data communication and the delta TPC is used for SRS positioning.
- [0099] Preamble bandwidth 808. In some aspect, the RACH preamble used for positioning may use a wider bandwidth than a RACH preamble used for data communication, which facilitates finer TA reporting.
- [0100] In some aspects, a different DCI is scrambled with a new RNTI (e.g., *Pos-RA-RNTI*) for positioning is used to transmit the MSG2 corresponding to RACH preambles reserved for positioning. In some aspects, the MSG2 can be transmitted in CORESET 0.
- [0101] In some aspects, such as for an on-demand, low-latency scenario, if the UE in RRC inactive state already has the PRS or SRS configuration stored, and the RACH preamble is dedicated to the UE, then MSG2 or MSG4 may also contain a MAC-CE that triggers SRS transmission or PRS measurement. Conventional call flows, by contrast, do not trigger SRS transmission or PRS measurement until after MSG4.
- [0102] The modifications and parameters described above may be used individually or in combinations thereof.
- [0103] FIG. 9 is a flowchart of an example process 900 associated with random access preambles for positioning indication. In some aspects, one or more process blocks of FIG. 9 may be performed by a BS (e.g., BS 102). In some aspects, one or more process blocks of FIG. 9 may be performed by another device or a group of devices separate from or including the BS. Additionally, or alternatively, one or more process blocks of FIG. 9 may be performed by one or more components of device 304, such as processing system 384, memory 386, transceiver 350, transceiver 360, and/or network interface 380.
- [0104] As shown in FIG. 9, process 900 may include transmitting, to a UE, an indication of a random access channel (RACH) preamble from a first set of RACH preambles reserved for positioning purposes different from a second set of RACH preambles reserved for communication purposes, the first set of RACH preambles and the second set of RACH

preambles being associated with the BS (block 902). For example, the BS may transmit, to a UE, an indication of a random access channel (RACH) preamble from a first set of RACH preambles reserved for positioning purposes different from a second set of RACH preambles reserved for communication purposes, the first set of RACH preambles and the second set of RACH preambles being associated with the BS, as described above.

[0105] As further shown in FIG. 9, process 900 may include receiving, from the UE, the RACH preamble reserved for positioning (block 904). For example, the BS may receive, from the UE, the RACH preamble reserved for positioning, as described above.

[0106] As further shown in FIG. 9, process 900 may include generating a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble reserved for positioning (block 906). For example, the BS may generate a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble reserved for positioning, as described above.

[0107] As further shown in FIG. 9, process 900 may include transmitting, to the UE, the RA response for positioning purposes (block 908). For example, the BS may transmit, to the UE, the RA response for positioning purposes, as described above.

[0108] Process 900 may include additional aspects, such as any single aspect or any combination of aspect described below and/or in connection with one or more other processes described elsewhere herein.

[0109] In some aspects, generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a backoff value that is different from a backoff value for communication purposes.

[0110] In some aspects, generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a timing advance field having a width that is wider than a timing advance field for communication purposes.

[0111] In some aspects, generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response

comprising an uplink (UL) grant indicating a transmit power that is different from a transmit power for communication purposes.

- [0112] In some aspects, generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a RACH preamble having a bandwidth that is wider than a RACH preamble for communication purposes.
- [0113] In some aspects, generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a downlink control information (DCI) that is scrambled with a radio network temporary identifier (RNTI) used for positioning purposes that is different from an RNTI used for communication purposes.
- [0114] In some aspects, generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a medium access control (MAC) control element (CE) that triggers a positioning reference signal (PRS) measurement, a sounding reference signal (SRS) transmission, or both.
- [0115] In some aspects, transmitting the RA response for positioning purposes comprises using a response window for positioning purposes that is different from a response window for communication purposes.
- [0116] In some aspects, receiving the RACH preamble reserved for positioning comprises receiving a MSG1.
- [0117] In some aspects, receiving the RACH preamble reserved for positioning comprises receiving the RACH preamble from a UE in the RRC idle state or the RRC inactive state.
- [0118] In some aspects, transmitting the RA response comprises transmitting a MSG2.
- [0119] In some aspects, process 900 includes receiving, from the UE, a RRC connection request indicating a positioning cause, and transmitting, to the UE, a RRC configuration.
- [0120] In some aspects, the RRC connection request indicating a positioning cause comprises an establishment clause that indicates positioning.
- [0121] In some aspects, process 900 includes transmitting, to the UE, an indication of an inactive radio network temporary identifier (I-RNTI) for positioning, wherein the RRC connection request indicating a positioning cause comprises the I-RNTI for positioning.
- [0122] In some aspects, the RRC connection request indicating a positioning cause comprises an RRC resume request.

- [0123] In some aspects, the RRC connection request comprises a MSG3.
- [0124] In some aspects, the RRC configuration comprises a MSG4.
- [0125] In some aspects, receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a backoff value that is different from a backoff value for communication purposes.
- [0126] Although FIG. 9 shows example blocks of process 900, in some aspects, process 900 may include additional blocks, fewer blocks, different blocks, or differently arranged blocks than those depicted in FIG. 9. Additionally, or alternatively, two or more of the blocks of process 900 may be performed in parallel.
- [0127] FIG. 10 is a flowchart of an example process 1000 associated with random access preambles for positioning indication. In some aspects, one or more process blocks of FIG. 10 may be performed by a UE (e.g., UE 104). In some aspects, one or more process blocks of FIG. 10 may be performed by another device or a group of devices separate from or including the UE. Additionally, or alternatively, one or more process blocks of FIG. 10 may be performed by one or more components of device 302, such as processing system 332, memory 340, transceiver 310, transceiver 320, and/or user interface 346.
- [0128] As shown in FIG. 10, process 1000 may include receiving, from a BS, an indication of a random access channel (RACH) preamble from a first set of RACH preambles reserved for positioning purposes different from a second set of RACH preambles reserved for communication purposes, the first set of RACH preambles and the second set of RACH preambles being associated with the BS (block 1010). For example, the UE may receive, from a BS, an indication of a random access channel (RACH) preamble from a first set of RACH preambles reserved for positioning purposes different from a second set of RACH preambles reserved for communication purposes, the first set of RACH preambles and the second set of RACH preambles being associated with the BS, as described above.
- [0129] As further shown in FIG. 10, process 1000 may include detecting, while in an RRC idle or RRC inactive state, a positioning event (block 1020). For example, the UE may detect, while in an RRC idle or RRC inactive state, a positioning event, as described above.
- [0130] As further shown in FIG. 10, process 1000 may include transmitting, to the BS, the RACH preamble reserved for positioning (block 1030). For example, the UE may transmit, to the BS, the RACH preamble reserved for positioning, as described above.

- [0131] As further shown in FIG. 10, process 1000 may include receiving, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble reserved for positioning (block 1040). For example, the UE may receive, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble reserved for positioning, as described above.
- [0132] Process 1000 may include additional aspects, such as any single aspect or any combination of aspects described below and/or in connection with one or more other processes described elsewhere herein.
- [0133] In some aspects, receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a timing advance field having a width that is wider than a timing advance field for communication purposes.
- [0134] In some aspects, receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising an uplink (UL) grant indicating a transmit power that is different from a transmit power for communication purposes.
- [0135] In some aspects, receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a RACH preamble having a bandwidth that is wider than a RACH preamble for communication purposes.
- [0136] In some aspects, receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a downlink control information (DCI) that is scrambled with a radio network temporary identifier (RNTI) used for positioning purposes that is different from an RNTI used for communication purposes.
- [0137] In some aspects, receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a medium access control (MAC) control element (CE) that triggers a positioning reference signal (PRS) measurement, a sounding reference signal (SRS) transmission, or both.

- [0138] In some aspects, receiving the RA response for positioning purposes comprises receiving the RA response for positioning purposes during a response window for positioning purposes that is different from a response window for communication purposes.
- [0139] In some aspects, transmitting the RACH preamble reserved for positioning comprises transmitting a MSG1.
- [0140] In some aspects, receiving the RA response comprises receiving a MSG2.
- [0141] In some aspects, process 1000 includes transmitting, to the BS, a physical uplink shared channel (PUSCH) transmission indicating a positioning cause, and receiving, from the BS, a RRC configuration.
- [0142] In some aspects, the RRC connection request indicating a positioning cause comprises an establishment clause that indicates positioning.
- [0143] In some aspects, process 1000 includes receiving, from the BS, an indication of an inactive radio network temporary identifier (I-RNTI) for positioning, wherein the RRC connection request indicating a positioning cause comprises the I-RNTI for positioning.
- [0144] In some aspects, the RRC connection request comprises a MSG3.
- [0145] In some aspects, the RRC configuration comprises a MSG4.
- [0146] Although FIG. 10 shows example blocks of process 1000, in some aspects, process 1000 may include additional blocks, fewer blocks, different blocks, or differently arranged blocks than those depicted in FIG. 10. Additionally, or alternatively, two or more of the blocks of process 1000 may be performed in parallel.
- [0147] In accordance with the various aspects disclosed herein, at least one aspect includes a method of wireless communication performed by a base station (BS). The method of wireless communication includes transmitting, to a user equipment (UE), an indication of a random access channel (RACH) preamble, where the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and the second set of RACH preambles are associated with the BS. The method also includes receiving, from the UE, the RACH preamble reserved for positioning. The method also includes generating a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes including a random access preamble identifier that is mapped to the RACH preamble. The method also includes transmitting, to the UE, the RA response for positioning purposes.

- [0148] In some aspects, generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a backoff value that is different from a backoff value for communication purposes.
- [0149] In some aspects, generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a timing advance field having a width that is wider than a timing advance field for communication purposes.
- [0150] In some aspects, generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising an uplink (UL) grant indicating a transmit power that is different from a transmit power for communication purposes.
- [0151] In some aspects, generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a RACH preamble having a bandwidth that is wider than a RACH preamble for communication purposes.
- [0152] In some aspects, generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a downlink control information (DCI) that is scrambled with a radio network temporary identifier (RNTI) used for positioning purposes that is different from an RNTI used for communication purposes.
- [0153] In some aspects, generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a medium access control (MAC) control element (CE) that triggers a positioning reference signal (PRS) measurement, a sounding reference signal (SRS) transmission, or both.
- [0154] In some aspects, transmitting the RA response for positioning purposes comprises using a response window for positioning purposes that is different from a response window for communication purposes.
- [0155] In some aspects, receiving the RACH preamble comprises receiving a MSG1.
- [0156] In some aspects, receiving the RACH preamble comprises receiving a MSGA comprising the RACH preamble reserved for positioning and a radio resource control (RRC) connection request.

- [0157] In some aspects, receiving the RACH preamble comprises receiving the RACH preamble from a UE in a radio resource control (RRC) idle or RRC inactive state.
- [0158] In some aspects, transmitting the RA response comprises transmitting a MSG2.
- [0159] In some aspects, transmitting the RA response comprises transmitting a MSGB comprising the RA response and a radio resource control (RRC) configuration.
- [0160] In some aspects, the method further comprises receiving, from the UE, a radio resource control (RRC) connection request indicating a positioning cause; and transmitting, to the UE, a RRC configuration.
- [0161] In some aspects, the RRC connection request indicating a positioning cause comprises an establishment clause that indicates positioning.
- [0162] In some aspects, the method further comprises transmitting, to the UE, an indication of an inactive radio network temporary identifier (I-RNTI) for positioning, wherein the RRC connection request indicating a positioning cause comprises the I-RNTI for positioning.
- [0163] In some aspects, the RRC connection request indicating a positioning cause comprises an RRC resume request.
- [0164] In some aspects, the RRC connection request comprises a MSG3.
- [0165] In some aspects, the RRC configuration comprises a MSG4.
- [0166] In accordance with the various aspects disclosed herein, at least one aspect includes a BS. The BS includes a memory, at least one transceiver, and at least one processor, communicatively coupled to the memory and the at least one transceiver, configured to: cause the at least one transceiver to transmit, to a UE, an indication of a RACH preamble, where the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and the second set of RACH preambles are associated with the BS; receive, from the UE, the RACH preamble; generate a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes including a random access preamble identifier that is mapped to the RACH preamble; and cause the at least one transceiver to transmit, to the UE, the RA response for positioning purposes.
- [0167] In some aspects, the at least one processor, when generating a RA response for positioning purposes that is different from a RA response for communication purposes, is configured

to generate a RA response comprising a backoff value that is different from a backoff value for communication purposes.

- [0168] In some aspects, the at least one processor, when generating a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to generate a RA response comprising a timing advance field having a width that is wider than a timing advance field for communication purposes.
- [0169] In some aspects, the at least one processor, when generating a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to generate a RA response comprising an uplink (UL) grant indicating a transmit power that is different from a transmit power for communication purposes.
- [0170] In some aspects, the at least one processor, when generating a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to generate a RA response comprising a RACH preamble having a bandwidth that is wider than a RACH preamble for communication purposes.
- [0171] In some aspects, the at least one processor, when generating a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to generate a RA response comprising a downlink control information (DCI) that is scrambled with a radio network temporary identifier (RNTI) used for positioning purposes that is different from an RNTI used for communication purposes.
- [0172] In some aspects, the at least one processor, when generating a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to generate a RA response comprising a medium access control (MAC) control element (CE) that triggers a positioning reference signal (PRS) measurement, a sounding reference signal (SRS) transmission, or both.
- [0173] In some aspects, the at least one processor, when causing the at least one transceiver to transmit the RA response for positioning purposes, is configured to use a response window for positioning purposes that is different from a response window for communication purposes.
- [0174] In some aspects, the at least one processor, when receiving the RACH preamble, is configured to receive a MSG1.
- [0175] In some aspects, the at least one processor, when receiving the RACH preamble, is configured to receive a MSGA comprising the RACH preamble and a radio resource control (RRC) connection request.

- [0176] In some aspects, the at least one processor, when receiving the RACH preamble, is configured to receive the RACH preamble from a UE in an RRC idle state or an RRC inactive state.
- [0177] In some aspects, the at least one processor, when causing the at least one transceiver to transmit the RA response, is configured to cause the at least one transceiver to transmit a MSG2.
- [0178] In some aspects, the at least one processor, when causing the at least one transceiver to transmit the RA response, is configured to cause the at least one transceiver to transmit a MSGB comprising the RA response and a radio resource control (RRC) configuration.
- [0179] In some aspects, the at least one processor is further configured to receive, from the UE, a radio resource control (RRC) connection request indicating a positioning cause, and transmit, to the UE, a RRC configuration.
- [0180] In some aspects, the RRC connection request indicating a positioning cause comprises an establishment clause that indicates positioning.
- [0181] In some aspects, the at least one processor is further configured to cause the at least one transceiver to transmit, to the UE, an indication of an inactive radio network temporary identifier (I-RNTI) for positioning, wherein the RRC connection request indicating a positioning cause comprises the I-RNTI for positioning.
- [0182] In some aspects, the RRC connection request indicating a positioning cause comprises an RRC resume request.
- [0183] In some aspects, wherein the RRC connection request comprises a MSG3.
- [0184] In some aspects, the RRC configuration comprises a MSG4.
- [0185] In accordance with the various aspects disclosed herein, at least one aspect includes a BS. The BS includes means for transmitting, to a UE, an indication of a RACH preamble from a first set of RACH preambles reserved for positioning purposes different from a second set of RACH preambles reserved for communication purposes, the first set of RACH preambles and the second set of RACH preambles being associated with the BS, means for receiving, from the UE, the RACH preamble, means for generating a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes including a random access preamble identifier that is mapped to the RACH preamble, and means for transmitting, to the UE, the RA response for positioning purposes.

- [0186] In accordance with the various aspects disclosed herein, at least one aspect includes a non-transitory computer-readable medium storing a set of instructions. The non-transitory computer-readable medium includes instructions to transmit, to a UE, an indication of a RACH preamble, where the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and the second set of RACH preambles are associated with the BS. The non-transitory computer-readable medium includes instructions to receive, from the UE, the RACH preamble, to generate a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes including a random access preamble identifier that is mapped to the RACH preamble, and to transmit, to the UE, the RA response for positioning purposes.
- [0187] 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.
- [0188] 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 aspect decisions should not be interpreted as causing a departure from the scope of the present disclosure.
- [0189] 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.

[0190] 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 example 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.

[0191] In one or more example 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.

- [0192] 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.
- [0193] Implementation examples are described in the following numbered clauses:
- [0194] Clause 1. A method of wireless communication performed by a base station (BS), the method comprising: transmitting, to a user equipment (UE), an indication of a random access channel (RACH) preamble, where the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and the second set of RACH preambles are associated with the BS; receiving, from the UE, the RACH preamble; generating a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes including a random access preamble identifier that is mapped to the RACH preamble; and transmitting, to the UE, the RA response for positioning purposes..
- [0195] Clause 2. The method of clause 1, wherein generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a backoff value that is different from a backoff value for communication purposes.
- [0196] Clause 3. The method of any of clauses 1-2, wherein generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a timing advance field having a width that is wider than a timing advance field for communication purposes.

- [0197] Clause 4. The method of any of clauses 1-3, wherein generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising an uplink (UL) grant indicating a transmit power that is different from a transmit power for communication purposes.
- [0198] Clause 5. The method of any of clauses 1-4, wherein generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a RACH preamble having a bandwidth that is wider than a RACH preamble for communication purposes.
- [0199] Clause 6. The method of any of clauses 1-5, wherein generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a downlink control information (DCI) that is scrambled with a radio network temporary identifier (RNTI) used for positioning purposes that is different from an RNTI used for communication purposes.
- [0200] Clause 7. The method of any of clauses 1-6, wherein generating a RA response for positioning purposes that is different from a RA response for communication purposes comprises generating a RA response comprising a medium access control (MAC) control element (CE) that triggers a positioning reference signal (PRS) measurement, a sounding reference signal (SRS) transmission, or both.
- [0201] Clause 8. The method of any of clauses 1-7, wherein transmitting the RA response for positioning purposes comprises using a response window for positioning purposes that is different from a response window for communication purposes.
- [0202] Clause 9. The method of any of clauses 1-8, wherein receiving the RACH preamble comprises receiving a MSG1.
- [0203] Clause 10. The method of any of clauses 1-9, wherein receiving the RACH preamble comprises receiving a MSGA comprising the RACH preamble and a radio resource control (RRC) connection request.
- [0204] Clause 11. The method of any of clauses 1-10, wherein receiving the RACH preamble comprises receiving the RACH preamble from a UE in a radio resource control (RRC) idle or RRC inactive state.
- [0205] Clause 12. The method of any of clauses 1-11, wherein transmitting the RA response comprises transmitting a MSG2.

- [0206] Clause 13. The method of any of clauses 1-12, wherein transmitting the RA response comprises transmitting a MSGB comprising the RA response and a radio resource control (RRC) configuration.
- [0207] Clause 14. The method of any of clauses 1-13, further comprising: receiving, from the UE, a radio resource control (RRC) connection request indicating a positioning cause; and transmitting, to the UE, a RRC configuration.
- [0208] Clause 15. The method of clause 14, wherein the RRC connection request indicating a positioning cause comprises an establishment clause that indicates positioning.
- [0209] Clause 16. The method of any of clauses 14-15, further comprising transmitting, to the UE, an indication of an inactive radio network temporary identifier (I-RNTI) for positioning, wherein the RRC connection request indicating a positioning cause comprises the I-RNTI for positioning.
- [0210] Clause 17. The method of any of clauses 14-16, wherein the RRC connection request indicating a positioning cause comprises an RRC resume request.
- [0211] Clause 18. The method of any of clauses 14-17, wherein the RRC connection request comprises a MSG3.
- [0212] Clause 19. The method of any of clauses 14-18, wherein the RRC configuration comprises a MSG4.
- [0213] Clause 20. A method of wireless communication performed by a user equipment (UE), the method comprising: receiving, from a base station (BS), an indication of a random access channel (RACH) preamble, where the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and the second set of RACH preambles are associated with the BS; detecting, while in a radio resource control (RRC) idle or RRC inactive state, a positioning event; transmitting, to the BS, the RACH preamble; and receiving, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble.
- [0214] Clause 21. The method of clause 20, where receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises

receiving a RA response comprising a backoff value that is different from a backoff value for communication purposes.

- [0215] Clause 22. The method of any of clauses 20-21, where receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a timing advance field having a width that is wider than a timing advance field for communication purposes.
- [0216] Clause 23. The method of any of clauses 20-22, where receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising an uplink (UL) grant indicating a transmit power that is different from a transmit power for communication purposes.
- [0217] Clause 24. The method of any of clauses 20-23, where receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a RACH preamble having a bandwidth that is wider than a RACH preamble for communication purposes.
- [0218] Clause 25. The method of any of clauses 20-24, where receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a downlink control information (DCI) that is scrambled with a radio network temporary identifier (RNTI) used for positioning purposes that is different from an RNTI used for communication purposes.
- [0219] Clause 26. The method of any of clauses 20-25, where receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a medium access control (MAC) control element (CE) that triggers a positioning reference signal (PRS) measurement, a sounding reference signal (SRS) transmission, or both.
- [0220] Clause 27. The method of any of clauses 20-26, where receiving the RA response for positioning purposes comprises receiving the RA response for positioning purposes during a response window for positioning purposes that is different from a response window for communication purposes.
- [0221] Clause 28. The method of any of clauses 20-27, where transmitting the RACH preamble comprises transmitting a MSG1.
- [0222] Clause 29. The method of any of clauses 20-28, where transmitting the RACH preamble comprises transmitting a MSGA comprising the RACH preamble and a radio resource control (RRC) connection request.

- [0223] Clause 30. The method of any of clauses 20-29, where receiving the RA response comprises receiving a MSG2.
- [0224] Clause 31. The method of any of clauses 20-30, where receiving the RA response comprises receiving a MSGB comprising the RA response and a radio resource control (RRC) configuration.
- [0225] Clause 32. The method of any of clauses 20-31, further comprising: transmitting, to the BS, a radio resource control (RRC) connection request indicating a positioning cause; and receiving, from the BS, a RRC configuration.
- [0226] Clause 33. The method of clause 32, where the RRC connection request indicating a positioning cause comprises an establishment clause that indicates positioning.
- [0227] Clause 34. The method of any of clauses 32-33, further comprising receiving, from the BS, an indication of an inactive radio network temporary identifier (I-RNTI) for positioning, where the RRC connection request indicating a positioning cause comprises the I-RNTI for positioning.
- [0228] Clause 35. The method of any of clauses 32-34, where the RRC connection request comprises a MSG3.
- [0229] Clause 36. The method of any of clauses 32-35, where the RRC configuration comprises a MSG4.
- [0230] Clause 37. A base station (BS), comprising: a memory, at least one transceiver, and at least one processor, communicatively coupled to the memory and the at least one transceiver, configured to: cause the at least one transceiver to transmit, to a user equipment (UE), an indication of a random access channel (RACH) preamble, where the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and the second set of RACH preambles are associated with the BS; receive, from the UE, the RACH preamble; generate a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble; and cause the at least one transceiver to transmit, to the UE, the RA response for positioning purposes.
- [0231] Clause 38. The BS of clause 37, where the at least one processor, when generating a RA response for positioning purposes that is different from a RA response for communication

purposes, is configured to generate a RA response comprising a backoff value that is different from a backoff value for communication purposes.

- [0232] Clause 39. The BS of any of clauses 37-38, where the at least one processor, when generating a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to generate a RA response comprising a timing advance field having a width that is wider than a timing advance field for communication purposes.
- [0233] Clause 40. The BS of any of clauses 37-39, where the at least one processor, when generating a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to generate a RA response comprising an uplink (UL) grant indicating a transmit power that is different from a transmit power for communication purposes.
- [0234] Clause 41. The BS of any of clauses 37-40, where the at least one processor, when generating a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to generate a RA response comprising a RACH preamble having a bandwidth that is wider than a RACH preamble for communication purposes.
- [0235] Clause 42. The BS of any of clauses 37-41, where the at least one processor, when generating a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to generate a RA response comprising a downlink control information (DCI) that is scrambled with a radio network temporary identifier (RNTI) used for positioning purposes that is different from an RNTI used for communication purposes.
- [0236] Clause 43. The BS of any of clauses 37-42, where the at least one processor, when generating a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to generate a RA response comprising a medium access control (MAC) control element (CE) that triggers a positioning reference signal (PRS) measurement, a sounding reference signal (SRS) transmission, or both.
- [0237] Clause 44. The BS of any of clauses 37-43, where the at least one processor, when transmitting the RA response for positioning purposes, is configured to use a response window for positioning purposes that is different from a response window for communication purposes.

- [0238] Clause 45. The BS of any of clauses 37-44, where the at least one processor, when receiving the RACH preamble, is configured to receive a MSG1.
- [0239] Clause 46. The BS of any of clauses 37-45, where the at least one processor, when receiving the RACH preamble, is configured to receive a MSGA comprising the RACH preamble and a radio resource control (RRC) connection request.
- [0240] Clause 47. The BS of any of clauses 37-46, where the at least one processor, when receiving the RACH preamble, is configured to receive the RACH preamble from a UE in an RRC idle state or an RRC inactive state.
- [0241] Clause 48. The BS of any of clauses 37-47, where the at least one processor, when transmitting the RA response, is configured to transmit a MSG2.
- [0242] Clause 49. The BS of any of clauses 37-48, where the at least one processor, when transmitting the RA response, is configured to transmit a MSGB comprising the RA response and a radio resource control (RRC) configuration.
- [0243] Clause 50. The BS of any of clauses 37-49, where the at least one processor is further configured to: receive, from the UE, a radio resource control (RRC) connection request indicating a positioning cause; and transmit, to the UE, a RRC configuration.
- [0244] Clause 51. The BS of clause 50, where the RRC connection request indicating a positioning cause comprises an establishment clause that indicates positioning.
- [0245] Clause 52. The BS of any of clauses 50-51, where the at least one processor is further configured to transmit, to the UE, an indication of an inactive radio network temporary identifier (I-RNTI) for positioning, where the RRC connection request indicating a positioning cause comprises the I-RNTI for positioning.
- [0246] Clause 53. The BS of any of clauses 50-52, where the RRC connection request indicating a positioning cause comprises an RRC resume request.
- [0247] Clause 54. The BS of any of clauses 50-53, where the RRC connection request comprises a MSG3.
- [0248] Clause 55. The BS of any of clauses 50-54, where the RRC configuration comprises a MSG4.
- [0249] Clause 56. A user equipment (UE), comprising: a memory, at least one transceiver, and at least one processor, communicatively coupled to the memory and the at least one transceiver, configured to: receive, from a base station (BS), an indication of a random access channel (RACH) preamble, where the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH

preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and the second set of RACH preambles are associated with the BS; detect, while in a radio resource control (RRC) idle or RRC inactive state, a positioning event; cause the at least one transceiver to transmit, to the BS, the RACH preamble; and receive, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble.

- [0250] Clause 57. The UE of clause 56, where the at least one processor, when receiving a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to receive a RA response comprising a timing advance field having a width that is wider than a timing advance field for communication purposes.
- [0251] Clause 58. The UE of any of clauses 56-57, where the at least one processor, when receiving a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to receive a RA response comprising an uplink (UL) grant indicating a transmit power that is different from a transmit power for communication purposes.
- [0252] Clause 59. The UE of any of clauses 56-58, where the at least one processor, when receiving a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to receive a RA response comprising a RACH preamble having a bandwidth that is wider than a RACH preamble for communication purposes.
- [0253] Clause 60. The UE of any of clauses 56-59, where the at least one processor, when receiving a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to receive a RA response comprising a downlink control information (DCI) that is scrambled with a radio network temporary identifier (RNTI) used for positioning purposes that is different from an RNTI used for communication purposes.
- [0254] Clause 61. The UE of any of clauses 56-60, where the at least one processor, when receiving a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to receive a RA response comprising a medium access control (MAC) control element (CE) that triggers a positioning reference signal (PRS) measurement, a sounding reference signal (SRS) transmission, or both.

- [0255] Clause 62. The UE of any of clauses 56-61, where the at least one processor, when receiving the RA response for positioning purposes, is configured to receive the RA response for positioning purposes during a response window for positioning purposes that is different from a response window for communication purposes.
- [0256] Clause 63. The UE of any of clauses 56-62, where the at least one processor, when transmitting the RACH preamble, is configured to transmit a MSG1.
- [0257] Clause 64. The UE of any of clauses 56-63, where the at least one processor, when transmitting the RACH preamble, is configured to transmit a MSGA comprising the RACH preamble and a radio resource control (RRC) connection request.
- [0258] Clause 65. The UE of any of clauses 56-64, where the at least one processor, when receiving the RA response, is configured to receive a MSG2.
- [0259] Clause 66. The UE of any of clauses 56-65, where the at least one processor, when receiving the RA response, is configured to receive a MSGB comprising the RA response and a radio resource control (RRC) configuration.
- [0260] Clause 67. The UE of any of clauses 56-66, where the at least one processor is further configured to: transmit, to the BS, a physical uplink shared channel (PUSCH) transmission indicating a positioning cause; and receive, from the BS, a RRC configuration.
- [0261] Clause 68. The UE of clause 67, where the RRC connection request indicating a positioning cause comprises an establishment clause that indicates positioning.
- [0262] Clause 69. The UE of any of clauses 67-68, where the at least one processor is further configured to receive, from the BS, an indication of an inactive radio network temporary identifier (I-RNTI) for positioning, where the RRC connection request indicating a positioning cause comprises the I-RNTI for positioning.
- [0263] Clause 70. The UE of any of clauses 67-69, where the RRC connection request comprises a MSG3.
- [0264] Clause 71. The UE of any of clauses 67-70, where the RRC configuration comprises a MSG4.
- [0265] Clause 72. A base station (BS), comprising: means for transmitting, to a user equipment (UE), an indication of a random access channel (RACH) preamble, where the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and

the second set of RACH preambles are associated with the BS; means for receiving, from the UE, the RACH preamble; means for generating a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble; and means for transmitting, to the UE, the RA response for positioning purposes.

[0266] Clause 73. A user equipment (UE), comprising: means for receiving, from a base station (BS), an indication of a random access channel (RACH) preamble, where the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and the second set of RACH preambles are associated with the BS; means for detecting, while in a radio resource control (RRC) idle or RRC inactive state, a positioning event; means for transmitting, to the BS, the RACH preamble; and means for receiving, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble.

[0267] Clause 74. A non-transitory computer-readable medium storing a set of instructions, the set of instructions comprising one or more instructions that, when executed by at least one processor of a base station (BS), cause the BS to: transmit, to a user equipment (UE), an indication of a random access channel (RACH) preamble, where the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and the second set of RACH preambles are associated with the BS; receive, from the UE, the RACH preamble; generate a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble; and transmit, to the UE, the RA response for positioning purposes.

[0268] Clause 75. A non-transitory computer-readable medium storing a set of instructions, the set of instructions comprising one or more instructions that, when executed by at least one processor of a user equipment (UE), cause the UE to: receive, from a base station (BS), an indication of a random access channel (RACH) preamble, where the RACH

preamble is a member of a first set of RACH preambles reserved for positioning purposes, where the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and where the first set of RACH preambles and the second set of RACH preambles are associated with the BS; detect, while in a radio resource control (RRC) idle or RRC inactive state, a positioning event; transmit, to the BS, the RACH preamble; and receive, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble.

CLAIMS

What is claimed is:

1. A method of wireless communication performed by a user equipment (UE), the method comprising:

receiving, from a base station (BS), an indication of a random access (RA) channel (RACH) preamble, wherein the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, wherein the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and wherein the first set of RACH preambles and the second set of RACH preambles are associated with the BS;

detecting, while in a radio resource control (RRC) idle or RRC inactive state, a positioning event;

transmitting, to the BS, the RACH preamble; and

receiving, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble.

2. The method of claim 1, wherein receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a backoff value that is different from a backoff value for communication purposes.

3. The method of claim 1, wherein receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a timing advance field having a width that is wider than a timing advance field for communication purposes.

4. The method of claim 1, wherein receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising an uplink (UL) grant indicating a transmit power that is different from a transmit power for communication purposes.

5. The method of claim 1, wherein receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a RACH preamble having a bandwidth that is wider than a RACH preamble for communication purposes.

6. The method of claim 1, wherein receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a downlink control information (DCI) that is scrambled with a radio network temporary identifier (RNTI) used for positioning purposes that is different from an RNTI used for communication purposes.

7. The method of claim 1, wherein receiving a RA response for positioning purposes that is different from a RA response for communication purposes comprises receiving a RA response comprising a medium access control (MAC) control element (CE) that triggers a positioning reference signal (PRS) measurement, a sounding reference signal (SRS) transmission, or both.

8. The method of claim 1, wherein receiving the RA response for positioning purposes comprises receiving the RA response for positioning purposes during a response window for positioning purposes that is different from a response window for communication purposes.

9. The method of claim 1, wherein transmitting the RACH preamble comprises transmitting a message comprising the RACH preamble and a radio resource control (RRC) connection request.

10. The method of claim 1, wherein receiving the RA response comprises receiving a message comprising the RA response and a radio resource control (RRC) configuration.

11. The method of claim 1, further comprising:
transmitting, to the BS, a radio resource control (RRC) connection request indicating a positioning cause; and

receiving, from the BS, a RRC configuration.

12. The method of claim 11, wherein the RRC connection request indicating a positioning cause comprises an establishment clause that indicates positioning.

13. The method of claim 11, further comprising receiving, from the BS, an indication of an inactive radio network temporary identifier (I-RNTI) for positioning, wherein the RRC connection request indicating a positioning cause comprises the I-RNTI for positioning.

14. A user equipment (UE), comprising:
a memory;
at least one transceiver; and
at least one processor, communicatively coupled to the memory and the at least one transceiver, configured to:

receive, from a base station (BS), an indication of a random access (RA) channel (RACH) preamble, wherein the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, wherein the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and wherein the first set of RACH preambles and the second set of RACH preambles are associated with the BS;

detect, while in a radio resource control (RRC) idle or RRC inactive state, a positioning event;

cause the at least one transceiver to transmit, to the BS, the RACH preamble; and

receive, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble.

15. The UE of claim 14, wherein the at least one processor, when receiving a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to receive a RA response comprising a timing

advance field having a width that is wider than a timing advance field for communication purposes.

16. The UE of claim 14, wherein the at least one processor, when receiving a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to receive a RA response comprising an uplink (UL) grant indicating a transmit power that is different from a transmit power for communication purposes.

17. The UE of claim 14, wherein the at least one processor, when receiving a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to receive a RA response comprising a RACH preamble having a bandwidth that is wider than a RACH preamble for communication purposes.

18. The UE of claim 14, wherein the at least one processor, when receiving a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to receive a RA response comprising a downlink control information (DCI) that is scrambled with a radio network temporary identifier (RNTI) used for positioning purposes that is different from an RNTI used for communication purposes.

19. The UE of claim 14, wherein the at least one processor, when receiving a RA response for positioning purposes that is different from a RA response for communication purposes, is configured to receive a RA response comprising a medium access control (MAC) control element (CE) that triggers a positioning reference signal (PRS) measurement, a sounding reference signal (SRS) transmission, or both.

20. The UE of claim 14, wherein the at least one processor, when receiving the RA response for positioning purposes, is configured to receive the RA response for positioning purposes during a response window for positioning purposes that is different from a response window for communication purposes.

21. The UE of claim 14, wherein the at least one processor, when causing the at least one transceiver to transmit the RACH preamble, is configured to cause the at least one transceiver to transmit a message comprising the RACH preamble and a radio resource control (RRC) connection request.

22. The UE of claim 14, wherein the at least one processor, when receiving the RA response, is configured to receive a message comprising the RA response and a radio resource control (RRC) configuration.

23. The UE of claim 14, wherein the at least one processor is further configured to: cause the at least one transceiver to transmit, to the BS, a radio resource control (RRC) connection request indicating a positioning cause; and receive, from the BS, a RRC configuration.

24. The UE of claim 23, wherein the RRC connection request indicating a positioning cause comprises an establishment clause that indicates positioning.

25. The UE of claim 23, wherein the at least one processor is further configured to receive, from the BS, an indication of an inactive radio network temporary identifier (I-RNTI) for positioning, wherein the RRC connection request indicating a positioning cause comprises the I-RNTI for positioning.

26. A user equipment (UE), comprising:
means for receiving, from a base station (BS), an indication of a random access (RA) channel (RACH) preamble, wherein the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, wherein the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and wherein the first set of RACH preambles and the second set of RACH preambles are associated with the BS;
means for detecting, while in a radio resource control (RRC) idle or RRC inactive state, a positioning event;
means for transmitting, to the BS, the RACH preamble; and

means for receiving, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble.

27. A non-transitory computer-readable medium storing a set of instructions, the set of instructions comprising one or more instructions that, when executed by at least one processor of a user equipment (UE), cause the UE to:

receive, from a base station (BS), an indication of a random access (RA) channel (RACH) preamble, wherein the RACH preamble is a member of a first set of RACH preambles reserved for positioning purposes, wherein the first set of RACH preambles is different from a second set of RACH preambles reserved for communication purposes, and wherein the first set of RACH preambles and the second set of RACH preambles are associated with the BS;

detect, while in a radio resource control (RRC) idle or RRC inactive state, a positioning event;

transmit, to the BS, the RACH preamble; and

receive, from the BS, a RA response for positioning purposes that is different from a RA response for communication purposes, the RA response for positioning purposes comprising a random access preamble identifier that is mapped to the RACH preamble.

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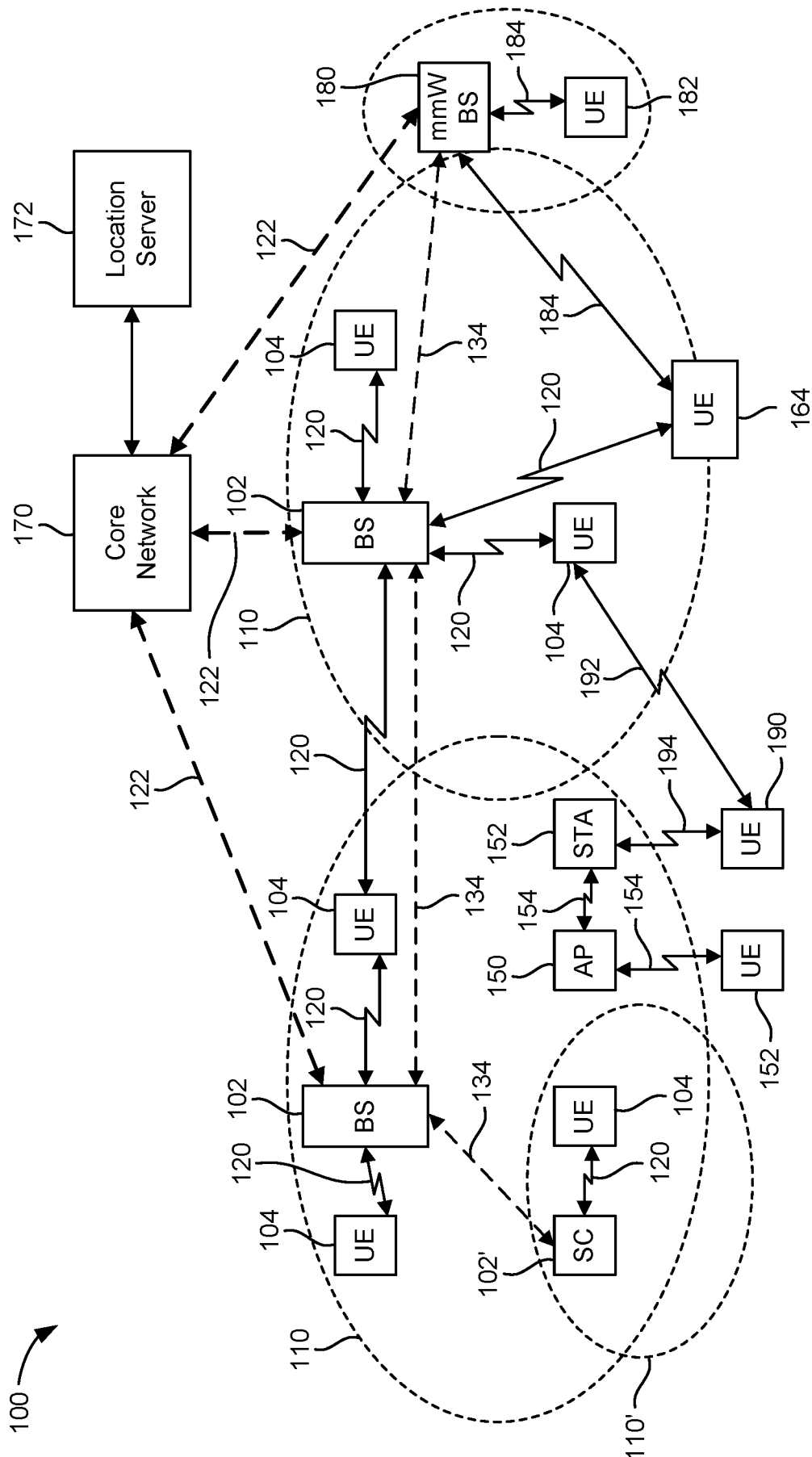


FIG. 1

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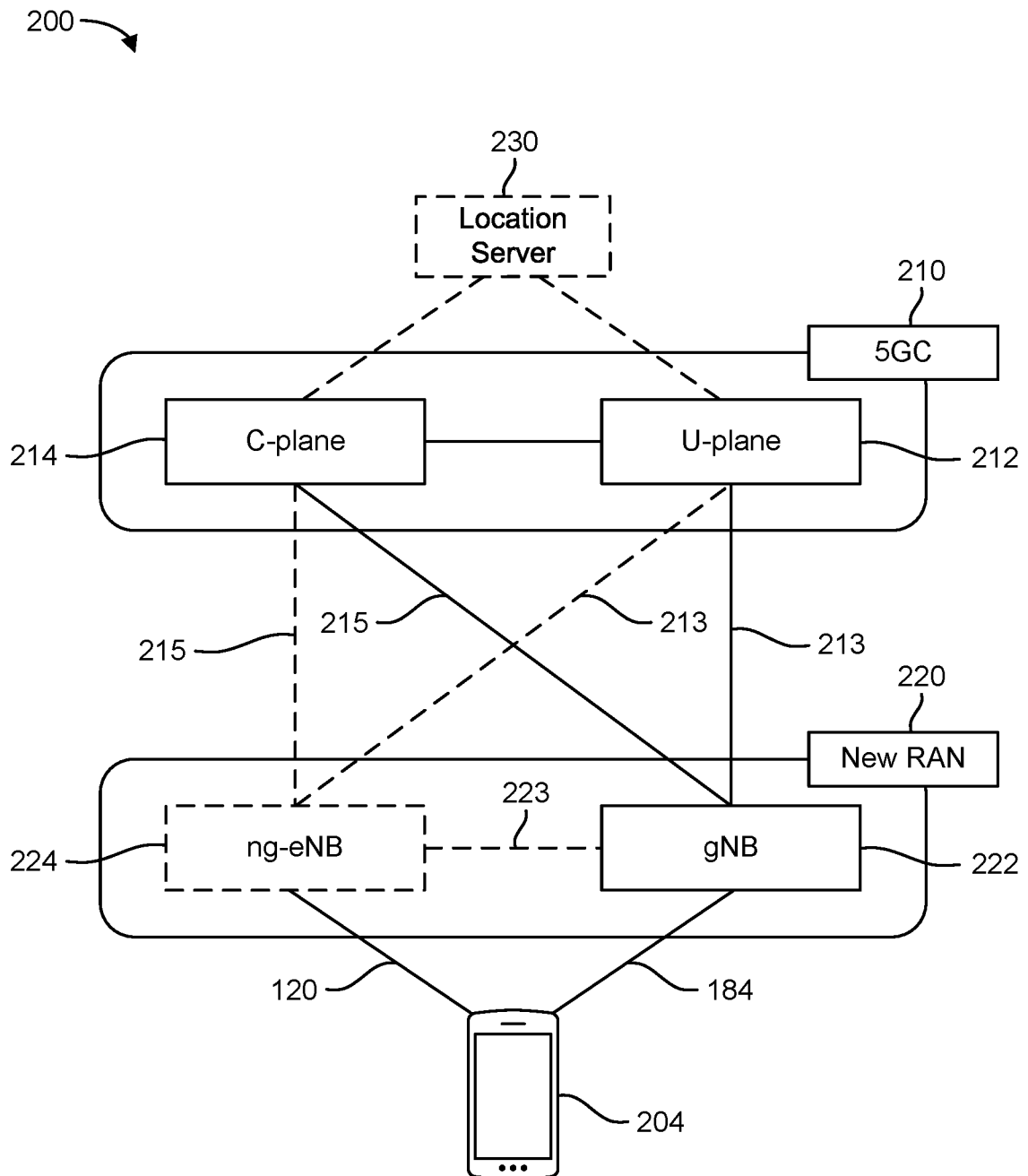


FIG. 2A

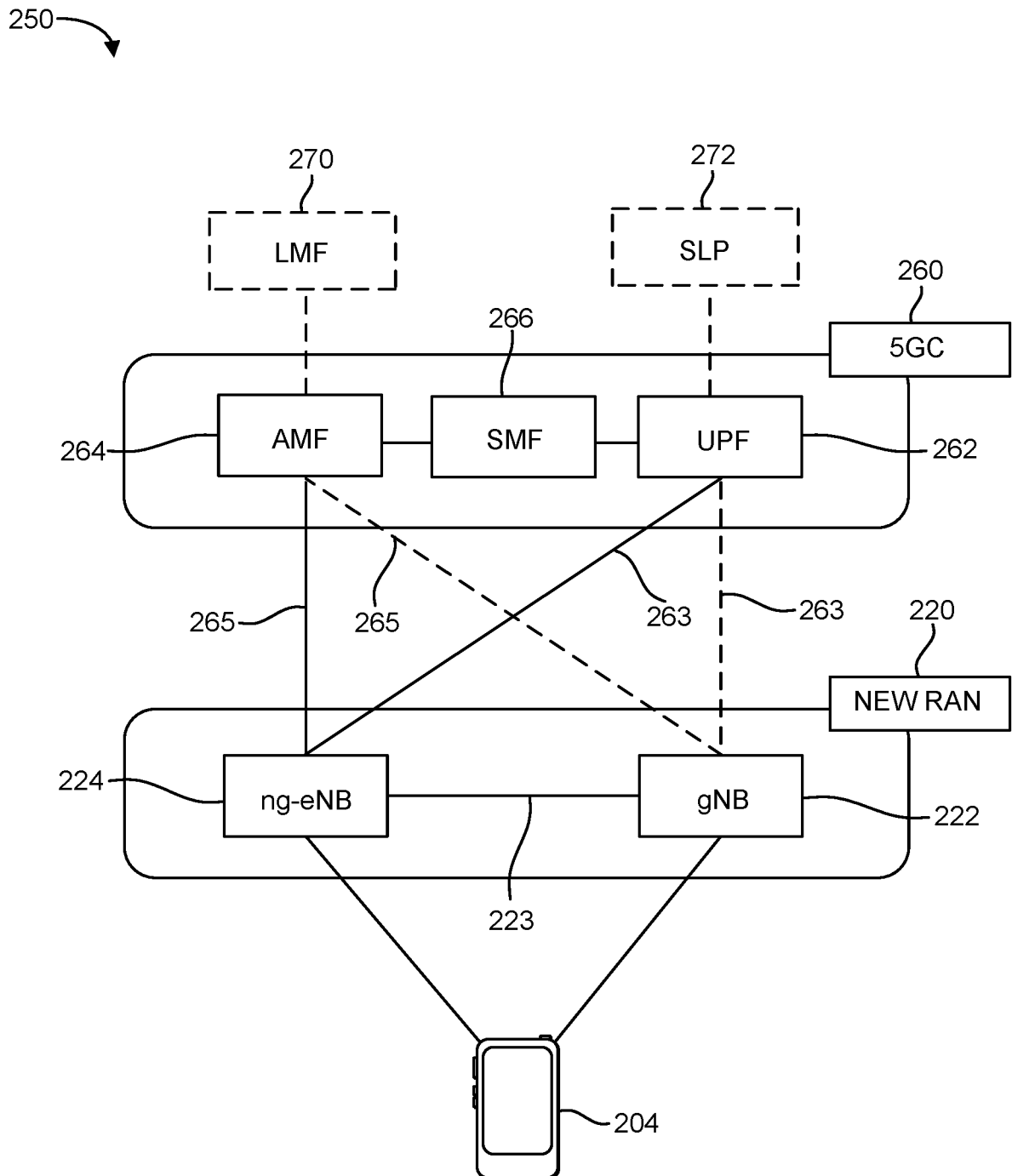


FIG. 2B

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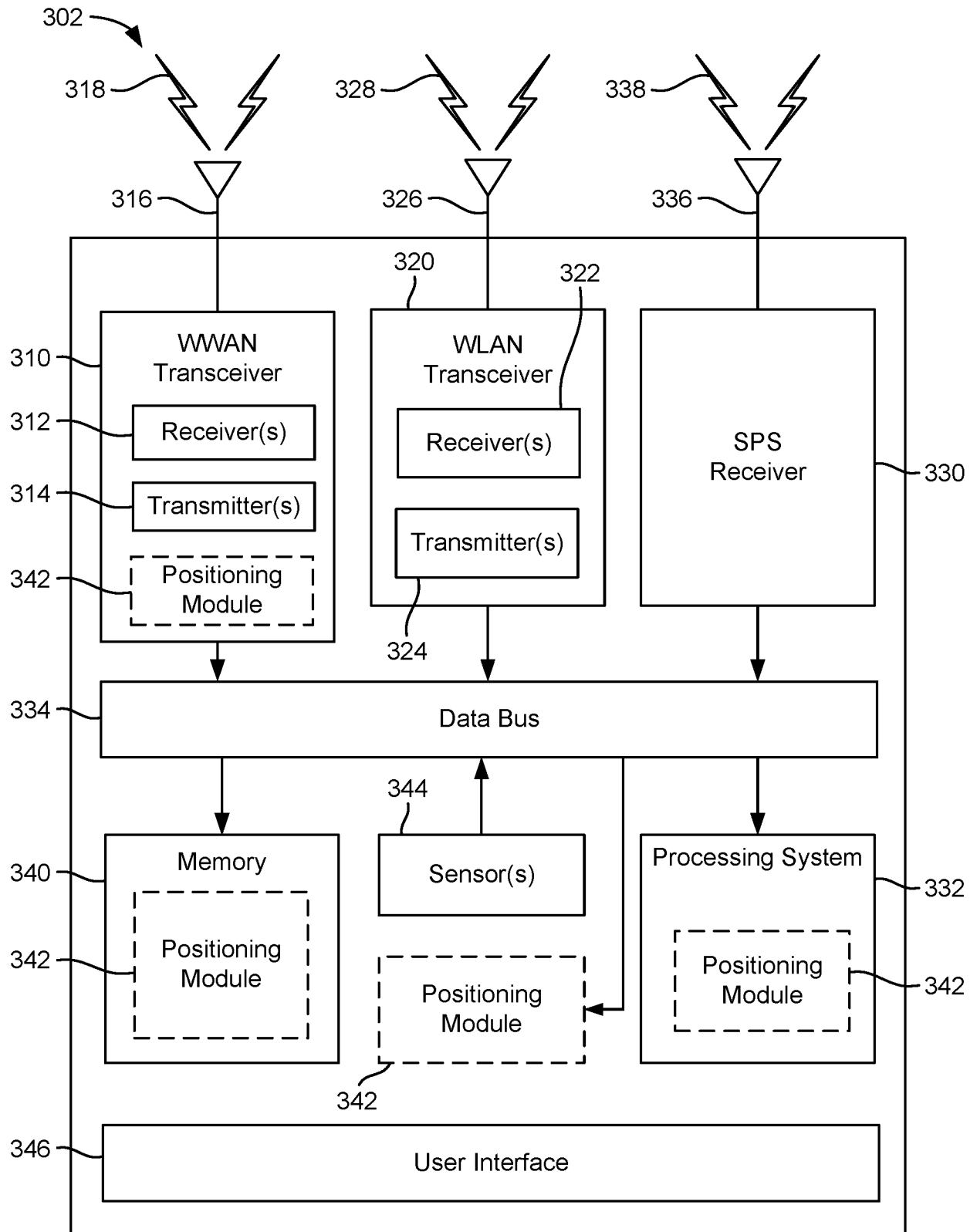


FIG. 3A

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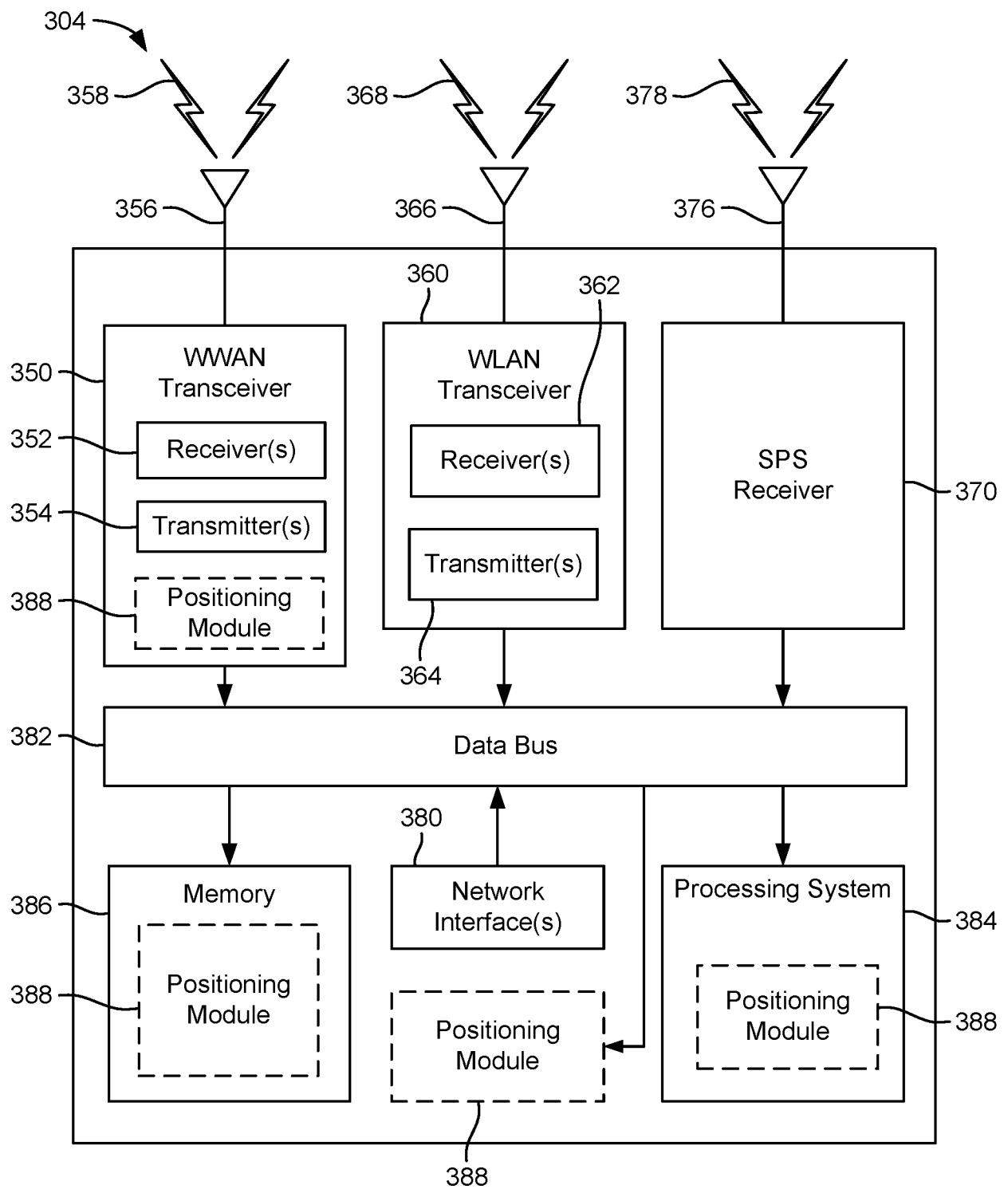


FIG. 3B

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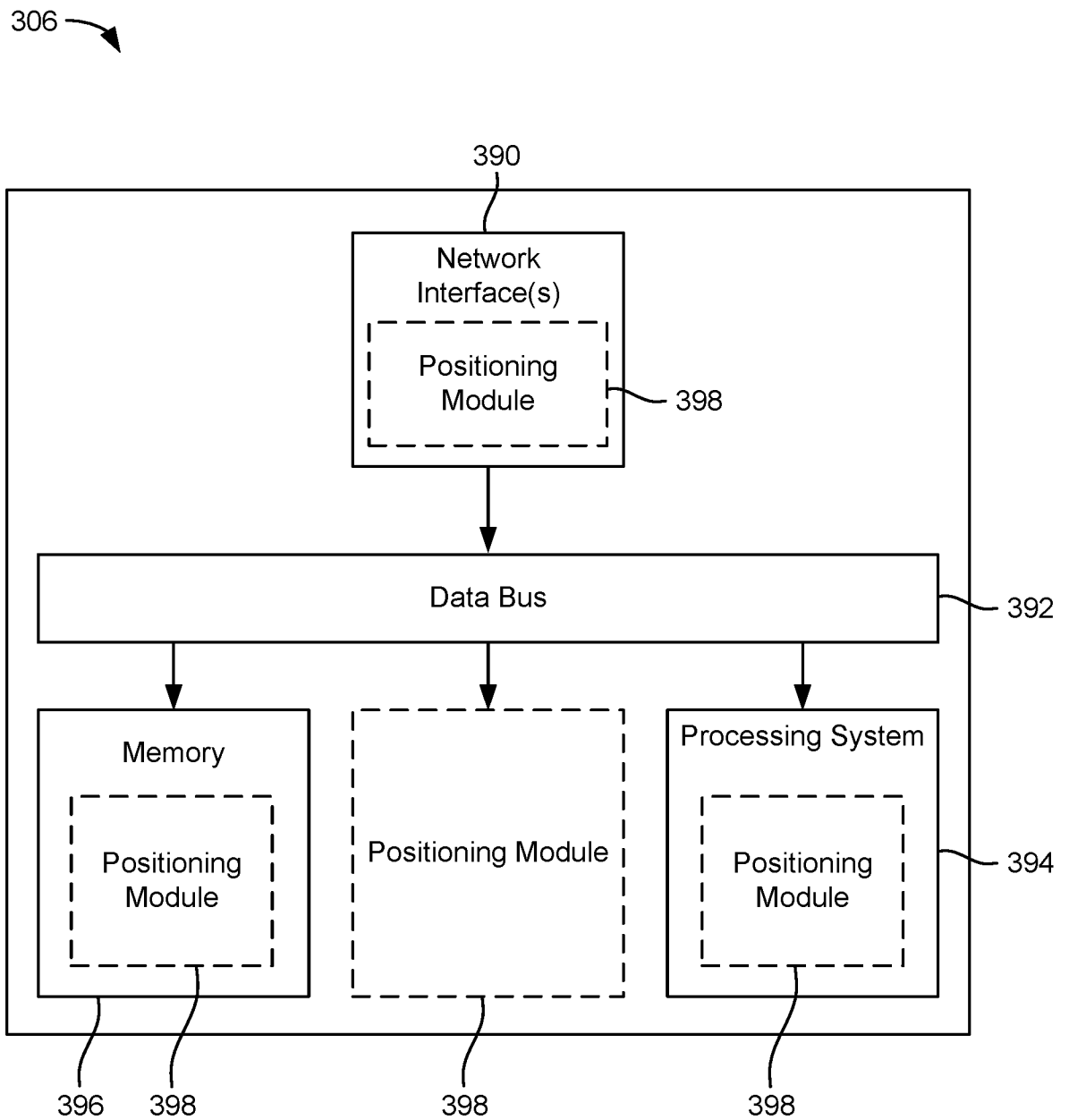


FIG. 3C

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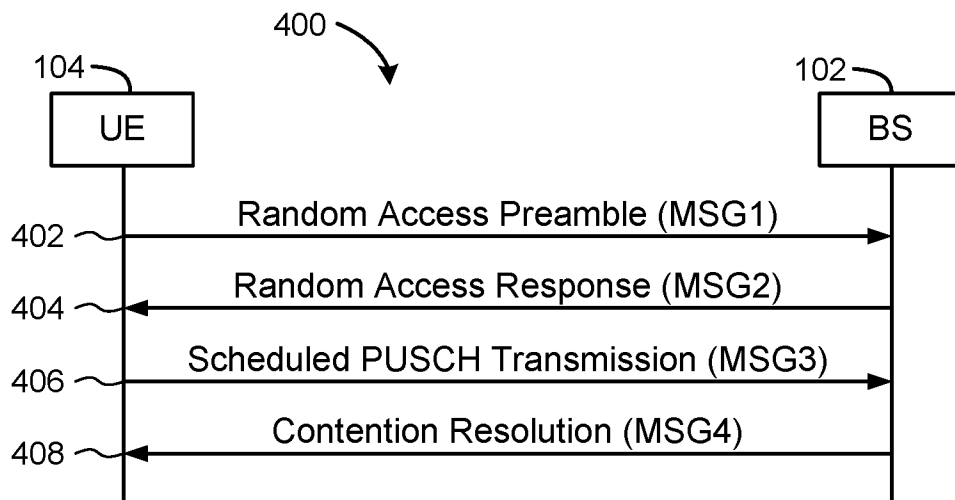


FIG. 4

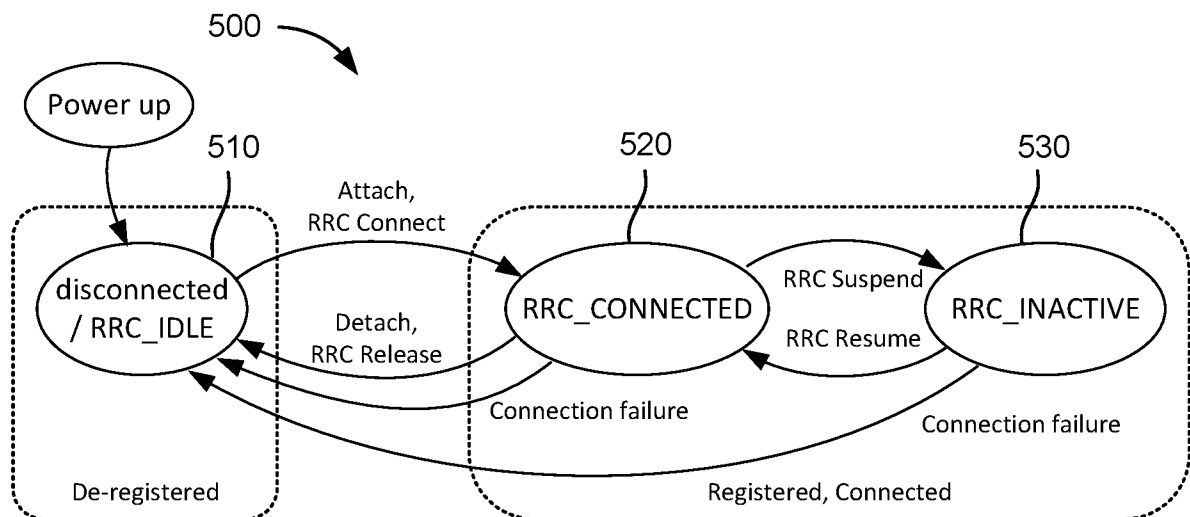


FIG. 5

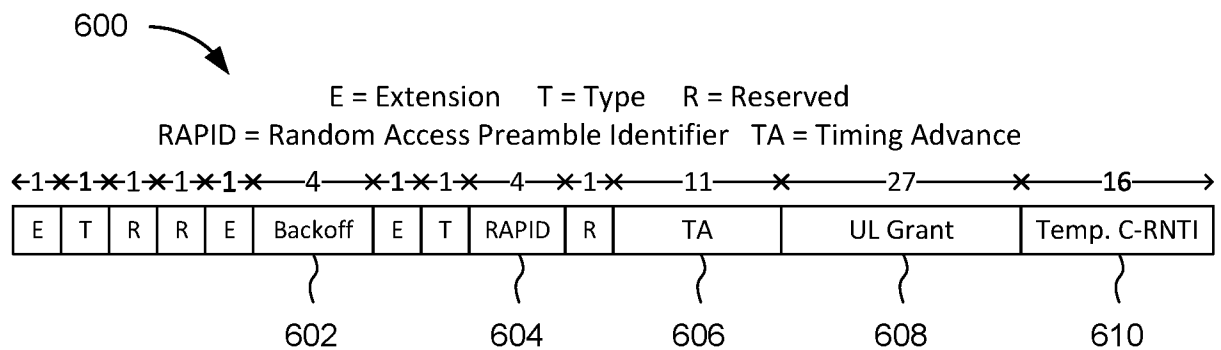


FIG. 6

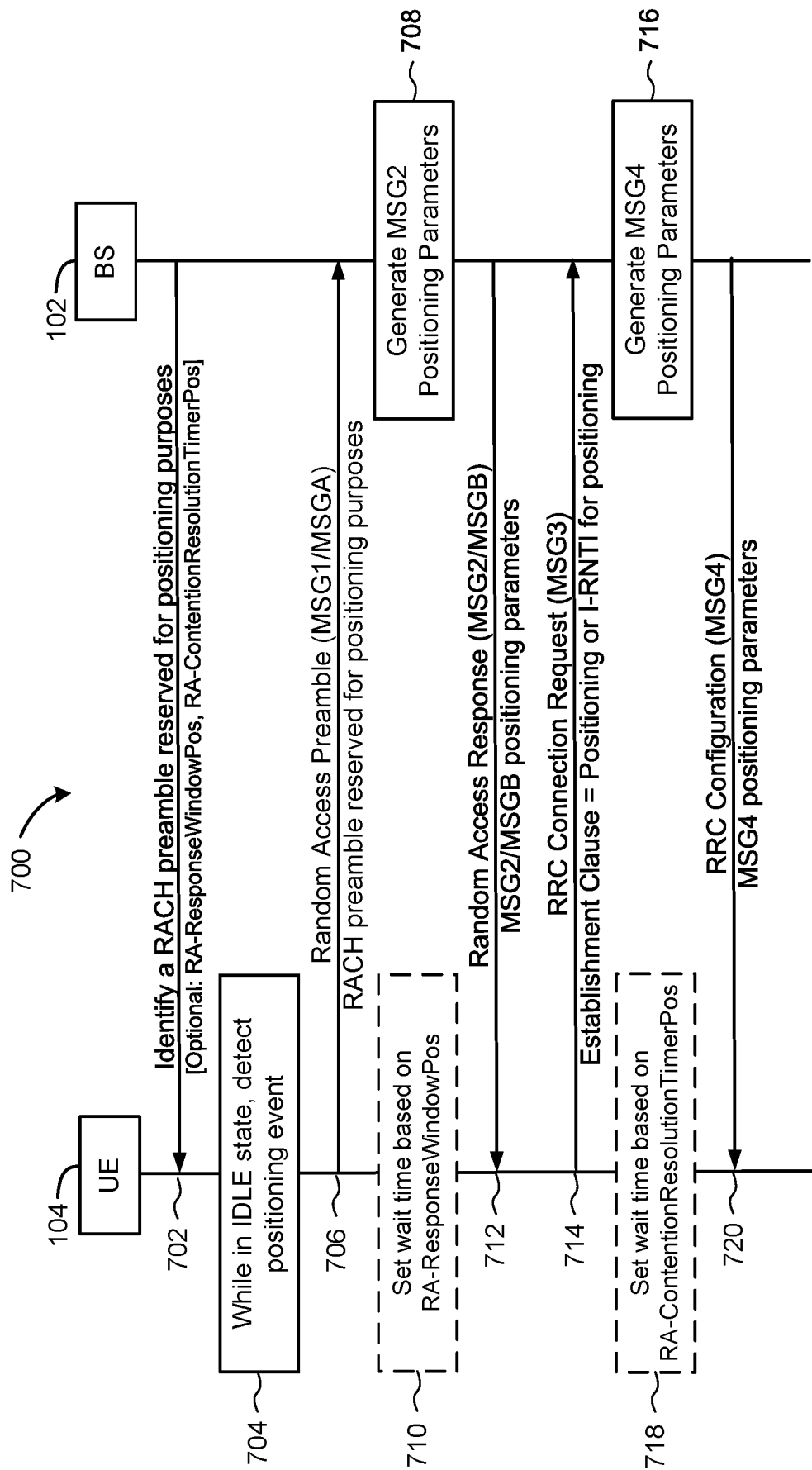
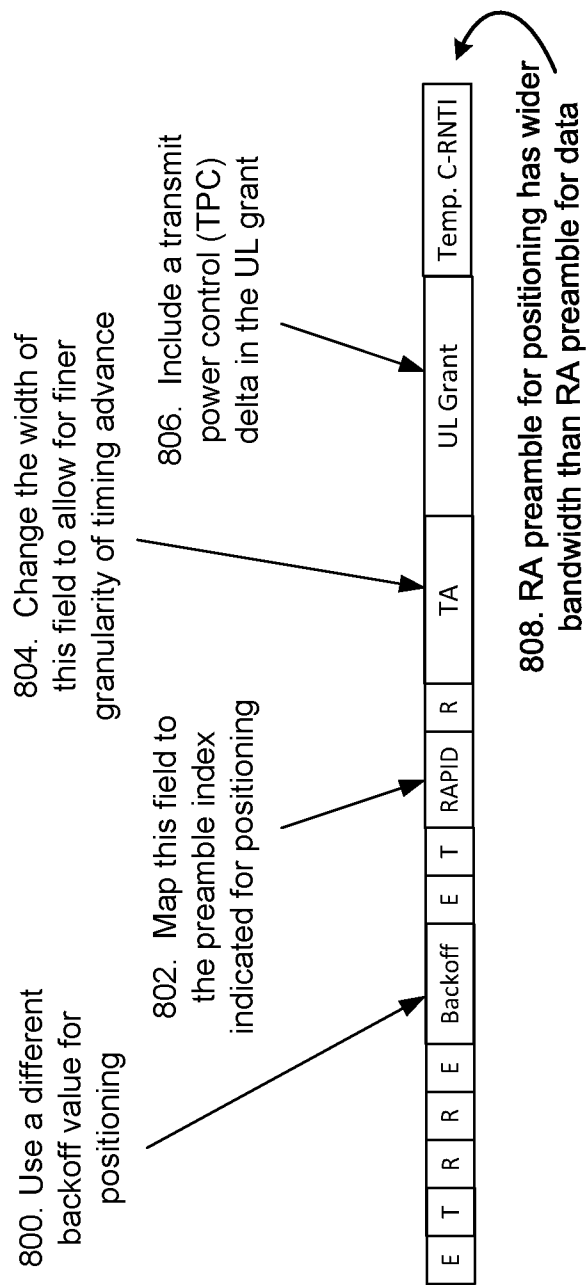


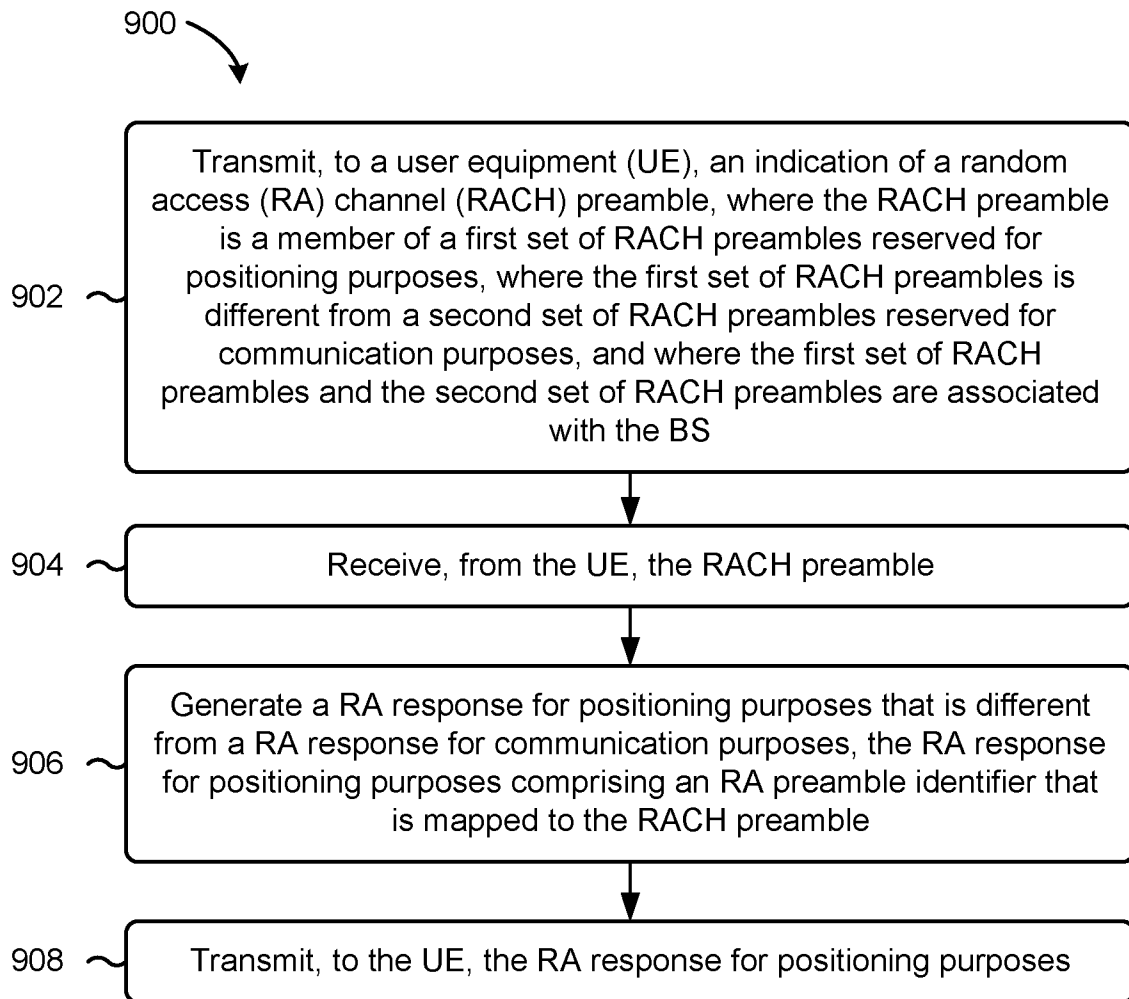
FIG. 7



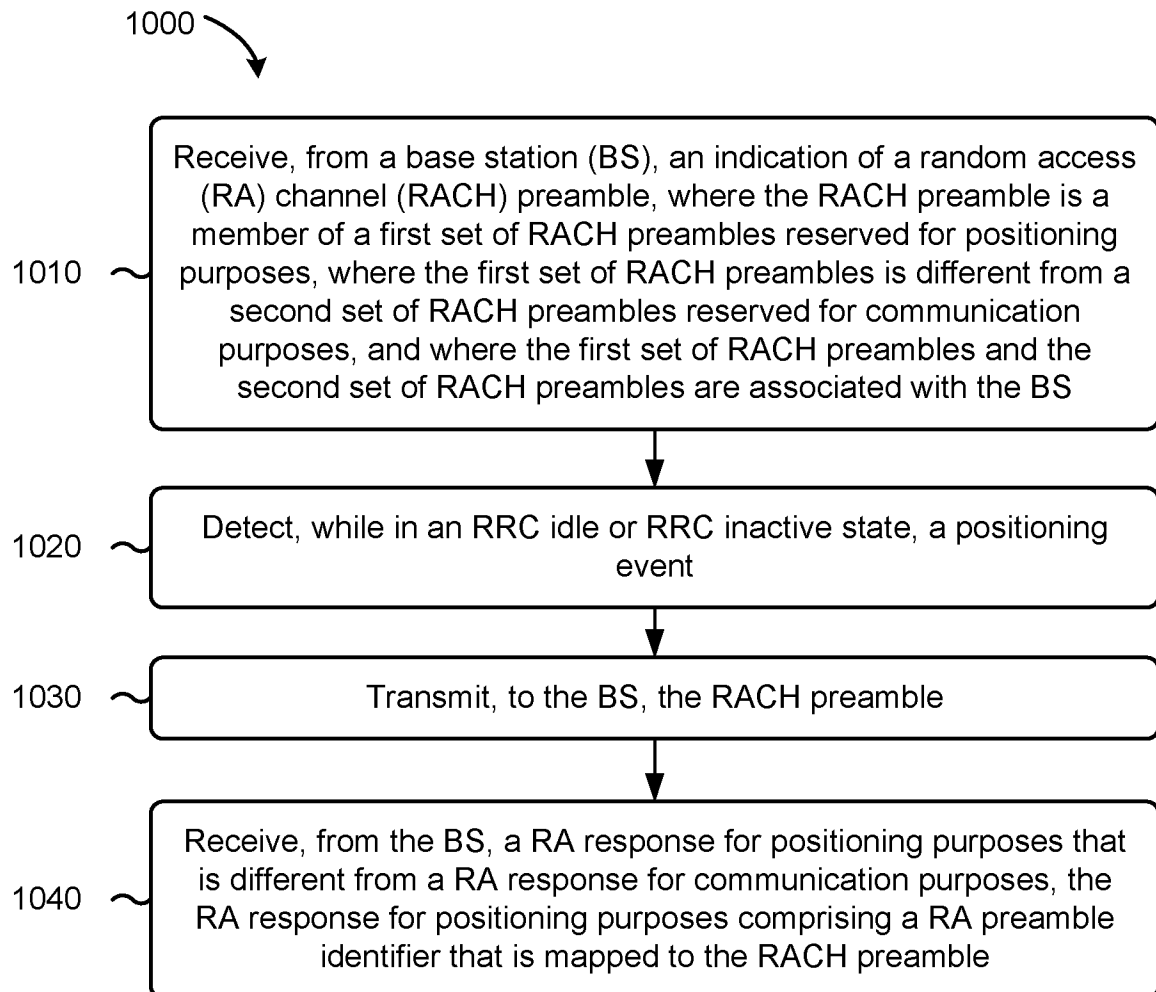
MSG2 RACH Preamble for positioning

FIG. 8

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**FIG. 9**

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**FIG. 10**

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2021/072077

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W64/00 H04W74/08 H04W74/00
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	WO 2020/197829 A1 (IDAC HOLDINGS INC [US]) 1 October 2020 (2020-10-01) paragraph [0101] paragraph [0106] paragraphs [0115] - [0136] paragraph [0163] -----	1-27
X	WO 2020/146739 A1 (APPLE INC [US]) 16 July 2020 (2020-07-16) paragraphs [0045] - [0059] ----- ----- -/--	1-5, 7-17, 19-27



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

10 February 2022

Date of mailing of the international search report

23/02/2022

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Fax: (+31-70) 340-3016

Authorized officer

Hegeman, Hans

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2021/072077

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	XIAOMI: "Potential positioning enhancements", 3GPP DRAFT; R1-2008083, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. e-Meeting; 20201026 - 20201113 17 October 2020 (2020-10-17), XP051940020, Retrieved from the Internet: URL:https://ftp.3gpp.org/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2008083.zip R1-2008083 Positioning.docx [retrieved on 2020-10-17] Section 3	1-5, 8-17, 20-27
A	Anonymous: "LTE Quick Reference - backoff indicator", www.sharetechnote.com, 24 July 2020 (2020-07-24), pages 1-2, XP055889986, Retrieved from the Internet: URL:https://web.archive.org/web/20200724173709/https://www.sharetechnote.com/html/Ha ndbook_LTE_BackOffIndicator.html [retrieved on 2022-02-10] the whole document	2
A	US 2020/099565 A1 (PALALLY HEMANTH [IN] ET AL) 26 March 2020 (2020-03-26) paragraph [0006] paragraph [0043]	3,15
A	Anonymous: "RACH", ShareTechnote, 25 April 2020 (2020-04-25), pages 1-37, XP055850016, Retrieved from the Internet: URL:https://web.archive.org/web/20200425082631/http://www.sharetechnote.com/html/RAC H_LTE.html#How_can_we_get_RA_RNTI [retrieved on 2021-10-11] the whole document	1-27

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2021/072077

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