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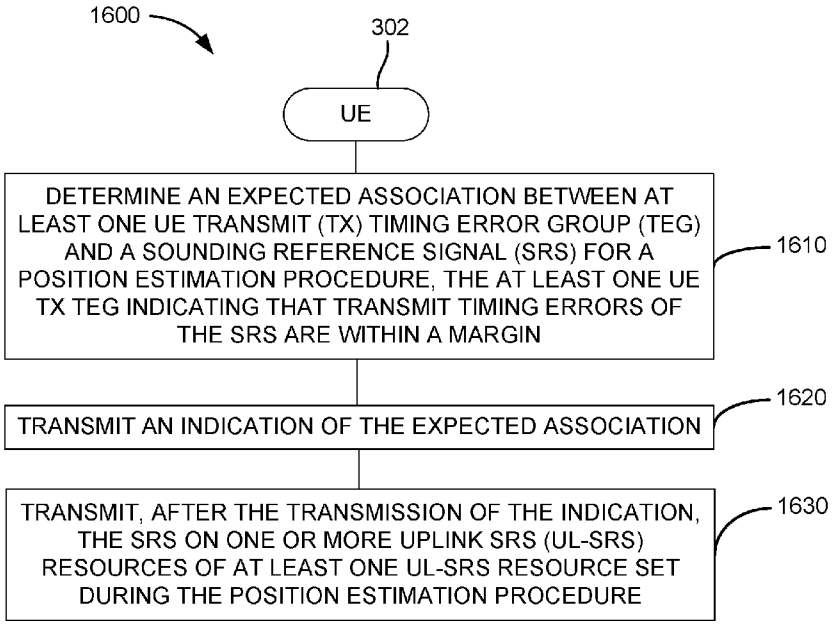


FIG. 16

(57) Abstract: Disclosed are techniques for wireless positioning. In an aspect, UE determines an expected association between at least one UE Tx TEG and SRS for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin. UE transmits an indication of the expected association to a position estimation entity (e.g., another UE, gNB, LMF, etc.). UE transmits the SRS (e.g., either in accordance or discordance with the expected association). The position estimation entity processes measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

[Continued on next page]

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SIGNALING FOR TIMING ERROR GROUP (TEG) REPORTING

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 an aspect, a method of operating a user equipment (UE) includes determining an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; transmitting an indication of the expected association; and transmitting, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

[0006] In some aspects, the method includes transmitting a UE Tx TEG report for the position estimation procedure to a position estimation entity.

[0007] In some aspects, the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association.

[0008] In some aspects, the UE Tx TEG report includes a positive acknowledgment of the expected association.

[0009] In some aspects, the UE Tx TEG report omits a negative acknowledgment of the expected association.

[0010] In some aspects, the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via one or more other UE Tx TEGs that are different than the at least UE Tx TEG in discordance with the expected association.

[0011] In some aspects, the UE Tx TEG report includes a negative acknowledgment of the expected association, or the UE Tx TEG report includes an indication of the one or more other UE Tx TEGs, or a combination thereof.

[0012] In some aspects, the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0013] In some aspects, the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0014] In some aspects, the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0015] In some aspects, the SRS corresponds to an instance of a semi-persistent (SP) SRS.

[0016] In some aspects, the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted via uplink media access control control element (MAC-CE).

[0017] In some aspects, the method includes receiving an activation of a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the transmission of the SRS is transmitted in response to the activation.

[0018] In some aspects, the SRS corresponds to an aperiodic (AP) SRS.

[0019] In some aspects, the method includes receiving a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted in response to the configuration.

[0020] In some aspects, the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0021] In some aspects, the indication of the expected association is further transmitted in conjunction with an associated confidence level.

[0022] In some aspects, the at least one processor is further configured to: transmit, via the at least one transceiver, a UE Tx TEG report for the position estimation procedure to a position estimation entity.

[0023] In some aspects, the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association.

[0024] In some aspects, the UE Tx TEG report includes a positive acknowledgment of the expected association.

[0025] In some aspects, the UE Tx TEG report omits a negative acknowledgment of the expected association.

[0026] In some aspects, the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via one or more other UE Tx TEGs that are different than the at least UE Tx TEG in discordance with the expected association.

[0027] In some aspects, the UE Tx TEG report includes a negative acknowledgment of the expected association, or the UE Tx TEG report includes an indication of the one or more other UE Tx TEGs, or a combination thereof.

[0028] In some aspects, the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0029] In some aspects, the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0030] In some aspects, the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0031] In some aspects, the SRS corresponds to an instance of a semi-persistent (SP) SRS.

[0032] In some aspects, the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted via uplink media access control control element (MAC-CE).

[0033] In some aspects, the at least one processor is further configured to: receive, via the at least one transceiver, an activation of a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the transmission of the SRS is transmitted in response to the activation.

[0034] In some aspects, the SRS corresponds to an aperiodic (AP) SRS.

[0035] In some aspects, the method includes receive, via the at least one transceiver, a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted in response to the configuration.

[0036] In some aspects, the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0037] In some aspects, the indication of the expected association is further transmitted in conjunction with an associated confidence level.

[0038] In some aspects, the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association.

[0039] In some aspects, the UE Tx TEG report includes a positive acknowledgment of the expected association.

[0040] In some aspects, the UE Tx TEG report omits a negative acknowledgment of the expected association.

[0041] In some aspects, the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via one or more other UE Tx TEGs that are different than the at least UE Tx TEG in discordance with the expected association.

[0042] In some aspects, the UE Tx TEG report includes a negative acknowledgment of the expected association, or the UE Tx TEG report includes an indication of the one or more other UE Tx TEGs, or a combination thereof.

[0043] In some aspects, the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted via uplink media access control control element (MAC-CE).

[0044] In some aspects, the method includes means for receiving an activation of a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the transmission of the SRS is transmitted in response to the activation.

[0045] In some aspects, the method includes means for receiving a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted in response to the configuration.

[0046] In some aspects, the UE Tx TEG report includes a positive acknowledgment of the expected association.

[0047] In some aspects, the UE Tx TEG report omits a negative acknowledgment of the expected association.

[0048] In some aspects, the UE Tx TEG report includes a negative acknowledgment of the expected association, or the UE Tx TEG report includes an indication of the one or more other UE Tx TEGs, or a combination thereof.

[0049] In an aspect, a method of operating a position estimation entity includes receiving, from a user equipment (UE), an indication of an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and processing measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

[0050] In some aspects, the method includes receiving, from the UE, a UE Tx TEG report for the position estimation procedure.

[0051] In some aspects, the UE Tx TEG report includes a positive acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0052] In some aspects, the UE Tx TEG report omits a negative acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0053] In some aspects, the UE Tx TEG report includes a negative acknowledgment of the expected association to indicate transmission of the SRS in discordance with the expected

association, or the UE Tx TEG report includes an indication of one or more other UE Tx TEGs associated with the transmission of the SRS, or a combination thereof.

[0054] In some aspects, the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0055] In some aspects, the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0056] In some aspects, the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0057] In some aspects, the SRS corresponds to an instance of a semi-persistent (SP) SRS, or the SRS corresponds to an aperiodic (AP) SRS.

[0058] In some aspects, the indication of the expected association is received from the UE prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0059] In some aspects, the indication of the expected association is further received in conjunction with an associated confidence level.

[0060] In some aspects, the at least one processor is further configured to: receive, via the at least one transceiver, from the UE, a UE Tx TEG report for the position estimation procedure.

[0061] In some aspects, the UE Tx TEG report includes a positive acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0062] In some aspects, the UE Tx TEG report omits a negative acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0063] In some aspects, the UE Tx TEG report includes a negative acknowledgment of the expected association to indicate transmission of the SRS in discordance with the expected association, or the UE Tx TEG report includes an indication of one or more other UE Tx TEGs associated with the transmission of the SRS, or a combination thereof.

[0064] In some aspects, the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0065] In some aspects, the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0066] In some aspects, the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0067] In some aspects, the SRS corresponds to an instance of a semi-persistent (SP) SRS, or the SRS corresponds to an aperiodic (AP) SRS.

[0068] In some aspects, the indication of the expected association is received from the UE prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0069] In some aspects, the indication of the expected association is further received in conjunction with an associated confidence level.

[0070] In some aspects, the UE Tx TEG report includes a positive acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0071] In some aspects, the UE Tx TEG report omits a negative acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0072] In some aspects, the UE Tx TEG report includes a negative acknowledgment of the expected association to indicate transmission of the SRS in discordance with the expected association, or the UE Tx TEG report includes an indication of one or more other UE Tx TEGs associated with the transmission of the SRS, or a combination thereof.

[0073] In an aspect, a user equipment (UE) includes a memory; at least one transceiver; and at least one processor communicatively coupled to the memory and the at least one transceiver, the at least one processor configured to: determine an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; transmit, via the at least one transceiver, an indication of the expected association; and transmit, via the at least one transceiver, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

[0074] In some aspects, the method includes means for transmitting a UE Tx TEG report for the position estimation procedure to a position estimation entity.

[0075] In some aspects, the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0076] In some aspects, the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0077] In some aspects, the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0078] In some aspects, the SRS corresponds to an instance of a semi-persistent (SP) SRS.

[0079] In some aspects, the SRS corresponds to an aperiodic (AP) SRS.

[0080] In some aspects, the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0081] In some aspects, the indication of the expected association is further transmitted in conjunction with an associated confidence level.

[0082] In some aspects, the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association.

[0083] In some aspects, the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via one or more other UE Tx TEGs that are different than the at least UE Tx TEG in discordance with the expected association.

[0084] In some aspects, the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted via uplink media access control control element (MAC-CE).

[0085] In some aspects, the instructions further cause the UE to: receive an activation of a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the transmission of the SRS is transmitted in response to the activation.

[0086] In some aspects, the method includes receive a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted in response to the configuration.

[0087] In an aspect, a position estimation entity includes a memory; at least one transceiver; and at least one processor communicatively coupled to the memory and the at least one transceiver, the at least one processor configured to: receive, via the at least one transceiver, from a user equipment (UE), an indication of an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and process measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

[0088] In some aspects, the method includes means for receiving, from the UE, a UE Tx TEG report for the position estimation procedure.

[0089] In some aspects, the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0090] In some aspects, the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0091] In some aspects, the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0092] In some aspects, the SRS corresponds to an instance of a semi-persistent (SP) SRS, or the SRS corresponds to an aperiodic (AP) SRS.

[0093] In some aspects, the indication of the expected association is received from the UE prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0094] In some aspects, the indication of the expected association is further received in conjunction with an associated confidence level.

[0095] In some aspects, the UE Tx TEG report includes a positive acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0096] In some aspects, the UE Tx TEG report omits a negative acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0097] In some aspects, the UE Tx TEG report includes a negative acknowledgment of the expected association to indicate transmission of the SRS in discordance with the expected association, or the UE Tx TEG report includes an indication of one or more other UE Tx TEGs associated with the transmission of the SRS, or a combination thereof.

[0098] In an aspect, a user equipment (UE) includes means for determining an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; means for transmitting an indication of the expected association; and means for transmitting, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

[0099] In some aspects, the instructions further cause the UE to: transmit a UE Tx TEG report for the position estimation procedure to a position estimation entity.

[0100] In some aspects, the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0101] In some aspects, the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0102] In some aspects, the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0103] In some aspects, the SRS corresponds to an instance of a semi-persistent (SP) SRS.

[0104] In some aspects, the SRS corresponds to an aperiodic (AP) SRS.

[0105] In some aspects, the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0106] In some aspects, the indication of the expected association is further transmitted in conjunction with an associated confidence level.

[0107] In an aspect, a position estimation entity includes means for receiving, from a user equipment (UE), an indication of an expected association between at least one UE

transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and means for processing measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

[0108] In some aspects, the instructions further cause the position estimation entity to: receive, from the UE, a UE Tx TEG report for the position estimation procedure.

[0109] In some aspects, the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0110] In some aspects, the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0111] In some aspects, the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0112] In some aspects, the SRS corresponds to an instance of a semi-persistent (SP) SRS, or the SRS corresponds to an aperiodic (AP) SRS.

[0113] In some aspects, the indication of the expected association is received from the UE prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0114] In some aspects, the indication of the expected association is further received in conjunction with an associated confidence level.

[0115] In an aspect, a non-transitory computer-readable medium storing computer-executable instructions that, when executed by a user equipment (UE), cause the UE to: determine an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least

one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; transmit an indication of the expected association; and transmit, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

[0116] In an aspect, a non-transitory computer-readable medium storing computer-executable instructions that, when executed by a position estimation entity, cause the position estimation entity to: receive, from a user equipment (UE), an indication of an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and process measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

[0117] 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

[0118] 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.

[0119] FIG. 1 illustrates an example wireless communications system, according to aspects of the disclosure.

[0120] FIGS. 2A and 2B illustrate example wireless network structures, according to aspects of the disclosure.

[0121] FIGS. 3A, 3B, and 3C are simplified block diagrams of several sample aspects of components that may be employed in a user equipment (UE), a base station, and a network entity, respectively, and configured to support communications as taught herein.

[0122] FIGS. 4A to 4D are diagrams illustrating example frame structures and channels within the frame structures, according to aspects of the disclosure.

[0123] FIG. 5 illustrates an example Long-Term Evolution (LTE) positioning protocol (LPP) call flow between a UE and a location server for performing positioning operations.

[0124] FIGS. 6A and 6B illustrate an example uplink-only position estimation procedure using LPP for timing error group (TEG) reporting, according to aspects of the disclosure.

[0125] FIG. 7 illustrates an "NR-UL-Tx-TimingErrorGroup" information element (IE) and various IEs included in, or pointed to by, the "NR-UL-Tx-TimingErrorGroup" IE, according to aspects of the disclosure.

[0126] FIGS. 8A and 8B illustrate an example uplink-only position estimation procedure using New Radio positioning protocol type A (NRPPa) for TEG reporting, according to aspects of the disclosure.

[0127] FIG. 9 illustrates an example "SRS-Tx-TEG-ReportConfig" IE, according to aspects of the disclosure.

[0128] FIG. 10 illustrates an example UE Tx TEG Report medium access control control element (MAC-CE), according to aspects of the disclosure.

[0129] FIG. 11 illustrates an example UE Tx TEG MAC-CE, according to aspects of the disclosure.

[0130] FIG. 12 illustrates an example method of an uplink-only wireless position estimation procedure performed at a UE, according to aspects of the disclosure.

[0131] FIG. 13 illustrates another example method of an uplink-only wireless position estimation procedure performed at a UE, according to aspects of the disclosure.

[0132] FIG. 14 illustrates an example method of positioning at a location server that is based on an uplink-only wireless position estimation procedure performed, according to aspects of the disclosure.

[0133] FIG. 15 illustrates an example method of an uplink-only wireless position estimation procedure performed at a base station, according to aspects of the disclosure.

[0134] FIG. 16 illustrates an example method of reporting an expected UE Tx TEG association, according to aspects of the disclosure.

[0135] FIG. 17 illustrates an example method of receiving an expected UE Tx TEG association, according to aspects of the disclosure.

[0136] FIGS. 18A-18B illustrate an example implementation of the processes of FIGS. 16-17 in accordance with aspects of the disclosure.

[0137] FIGS. 19A-19B illustrate an example implementation of the processes of FIGS. 16-17 in accordance with aspects of the disclosure.

DETAILED DESCRIPTION

[0138] 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.

[0139] 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.

[0140] 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.

[0141] Further, many aspects are described in terms of sequences of actions to be performed by, for example, elements of a computing device. It will be recognized that various actions described herein can be performed by specific circuits (e.g., application specific integrated circuits (ASICs)), by program instructions being executed by one or more processors, or by a combination of both. Additionally, the sequence(s) of actions described herein can be considered to be embodied entirely within any form of non-transitory computer-readable storage medium having stored therein a corresponding set of computer instructions that, upon execution, would cause or instruct an associated processor of a device to perform the functionality described herein. Thus, the various aspects of the disclosure may be embodied in a number of different forms, all of which have been contemplated to be within the scope of the claimed subject matter. In addition, for each of the aspects described herein, the corresponding form of any such aspects may be described herein as, for example, "logic configured to" perform the described action.

[0142] 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, consumer asset locating 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.

[0143] 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.

[0144] 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 radio frequency (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.

[0145] In some implementations 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).

[0146] 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. As used herein, an RF signal may also be referred to as a "wireless signal" or simply a "signal" where it is clear from the context that the term "signal" refers to a wireless signal or an RF signal.

[0147] **FIG. 1** illustrates an example wireless communications system 100, according to aspects of the disclosure. The wireless communications system 100 (which may also be referred to as a wireless wide area network (WWAN)) may include various base stations 102 (labeled "BS") 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 stations 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.

[0148] 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 (e.g., a location management function (LMF) or a secure user plane location (SUPL) location platform (SLP)). The location server(s) 172 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.

[0149] 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 geographic 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), an enhanced cell identifier (ECI), a virtual cell identifier (VCI), a cell global identifier (CGI), etc.) 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 addition, because a TRP is typically the physical transmission point of a cell, the terms "cell" and "TRP"

may be used interchangeably. 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.

[0150] While neighboring macro cell base station 102 geographic coverage areas 110 may partially overlap (e.g., in a handover region), some of the geographic coverage areas 110 may be substantially overlapped by a larger geographic coverage area 110. For example, a small cell base station 102' (labeled "SC" for "small cell") may have a geographic coverage area 110' that substantially overlaps with the geographic 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).

[0151] 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 (DL) (also referred to as forward link) transmissions from a base station 102 to a UE 104. The communication links 120 may use MIMO antenna technology, including spatial multiplexing, beamforming, and/or transmit diversity. The communication links 120 may be through one or more carrier frequencies. Allocation of carriers may be asymmetric with respect to downlink and uplink (e.g., more or less carriers may be allocated for downlink than for uplink).

[0152] 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.

[0153] The small cell base station 102' may operate in a licensed and/or an unlicensed frequency spectrum. When operating in an unlicensed frequency spectrum, the small cell base station 102' may employ LTE or NR technology and use the same 5 GHz unlicensed frequency spectrum as used by the WLAN AP 150. The small cell base station 102', employing LTE / 5G in an unlicensed frequency spectrum, may boost coverage to and/or

increase capacity of the access network. NR in unlicensed spectrum may be referred to as NR-U. LTE in an unlicensed spectrum may be referred to as LTE-U, licensed assisted access (LAA), or MulteFire.

[0154] 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.

[0155] 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.

[0156] 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 second reference RF signal on a second beam can be derived from information about a source reference RF signal on a source beam. Thus, if the source reference RF signal is QCL Type A, the receiver can use the source reference RF signal to estimate the Doppler shift, Doppler spread, average delay, and delay spread of a second reference RF signal transmitted on the same channel. If the source reference RF signal is QCL Type B, the receiver can use the source reference RF signal to estimate the Doppler shift and Doppler spread of a second reference RF signal transmitted on the same channel. If the source reference RF signal is QCL Type C, the receiver can use the source reference RF signal to estimate the Doppler shift and average delay of a second reference RF signal transmitted on the same channel. If the source reference RF signal is QCL Type D, the receiver can use the source reference RF signal to estimate the spatial receive parameter of a second reference RF signal transmitted on the same channel.

[0157] 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.

[0158] Transmit and receive beams may be spatially related. A spatial relation means that parameters for a second beam (e.g., a transmit or receive beam) for a second reference signal can be derived from information about a first beam (e.g., a receive beam or a transmit beam) for a first reference signal. For example, a UE may use a particular receive beam to receive a reference downlink reference signal (e.g., synchronization signal block (SSB)) from a base station. The UE can then form a transmit beam for sending an uplink

reference signal (e.g., sounding reference signal (SRS)) to that base station based on the parameters of the receive beam.

[0159] 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.

[0160] 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). mmW frequency bands generally include the FR2, FR3, and FR4 frequency ranges. As such, the terms "mmW" and "FR2" or "FR3" or "FR4" may generally be used interchangeably.

[0161] 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.

[0162] 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.

[0163] 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.

[0164] In the example of FIG. 1, any of the illustrated UEs (shown in FIG. 1 as a single UE 104 for simplicity) may receive signals 124 from one or more Earth orbiting space vehicles (SVs) 112 (e.g., satellites). In an aspect, the SVs 112 may be part of a satellite positioning system that a UE 104 can use as an independent source of location information. A satellite positioning system typically includes a system of transmitters (e.g., SVs 112) positioned to enable receivers (e.g., UEs 104) to determine their location on or above the Earth based, at least in part, on positioning signals (e.g., signals 124) received from the transmitters. Such a transmitter typically transmits a signal marked with a repeating pseudo-random noise (PN) code of a set number of chips. While typically located in SVs 112, transmitters may sometimes be located on ground-based control stations, base stations 102, and/or other UEs 104. A UE 104 may include one or more dedicated receivers specifically designed to receive signals 124 for deriving geo location information from the SVs 112.

[0165] In a satellite positioning system, the use of signals 124 can be augmented by various satellite-based augmentation systems (SBAS) that may be associated with or otherwise enabled for use with one or more global and/or regional navigation satellite systems. For

example an SBAS may include an augmentation system(s) that provides integrity information, differential corrections, etc., such as the Wide Area Augmentation System (WAAS), the European Geostationary Navigation Overlay Service (EGNOS), the Multi-functional Satellite Augmentation System (MSAS), the Global Positioning System (GPS) Aided Geo Augmented Navigation or GPS and Geo Augmented Navigation system (GAGAN), and/or the like. Thus, as used herein, a satellite positioning system may include any combination of one or more global and/or regional navigation satellites associated with such one or more satellite positioning systems.

[0166] In an aspect, SVs 112 may additionally or alternatively be part of one or more non-terrestrial networks (NTNs). In an NTN, an SV 112 is connected to an earth station (also referred to as a ground station, NTN gateway, or gateway), which in turn is connected to an element in a 5G network, such as a modified base station 102 (without a terrestrial antenna) or a network node in a 5GC. This element would in turn provide access to other elements in the 5G network and ultimately to entities external to the 5G network, such as Internet web servers and other user devices. In that way, a UE 104 may receive communication signals (e.g., signals 124) from an SV 112 instead of, or in addition to, communication signals from a terrestrial base station 102.

[0167] 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.

[0168] **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 (C-plane) functions 214 (e.g., UE registration, authentication, network access, gateway selection, etc.) and user plane (U-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 user plane functions 212 and control plane functions 214, respectively. 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, a Next Generation RAN (NG-RAN) 220 may have one or more gNBs 222, while other configurations include one or more of both ng-eNBs 224 and gNBs 222. Either (or both) gNB 222 or ng-eNB 224 may communicate with one or more UEs 204 (e.g., any of the UEs described herein).

[0169] Another optional aspect may include a location server 230, which may be in communication with the 5GC 210 to provide location assistance for UE(s) 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 (e.g., a third party server, such as an original equipment manufacturer (OEM) server or service server).

[0170] **FIG. 2B** illustrates another example wireless network structure 250. A 5GC 260 (which may correspond to 5GC 210 in FIG. 2A) 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). The functions of the AMF 264 include registration management, connection management, reachability management, mobility management, lawful interception, transport for session management (SM) messages between one or more UEs 204 (e.g., any of the UEs described herein) 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 NG-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-3GPP (Third Generation Partnership Project) access networks.

[0171] 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 an SLP 272.

[0172] 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.

[0173] 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, NG-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).

[0174] User plane interface 263 and control plane interface 265 connect the 5GC 260, and specifically the UPF 262 and AMF 264, respectively, to one or more gNBs 222 and/or ng-eNBs 224 in the NG-RAN 220. The interface between gNB(s) 222 and/or ng-eNB(s) 224 and the AMF 264 is referred to as the "N2" interface, and the interface between gNB(s) 222 and/or ng-eNB(s) 224 and the UPF 262 is referred to as the "N3" interface. The gNB(s) 222 and/or ng-eNB(s) 224 of the NG-RAN 220 may communicate directly with each other via backhaul connections 223, referred to as the "Xn-C" interface. One or more of gNBs 222 and/or ng-eNBs 224 may communicate with one or more UEs 204 over a wireless interface, referred to as the "Uu" interface.

[0175] The functionality of a gNB 222 is divided between a gNB central unit (gNB-CU) 226 and one or more gNB distributed units (gNB-DUs) 228. The interface 232 between the gNB-CU 226 and the one or more gNB-DUs 228 is referred to as the "F1" interface. A gNB-CU 226 is a logical node that includes the base station functions of transferring user data, mobility control, radio access network sharing, positioning, session management, and the like, except for those functions allocated exclusively to the gNB-DU(s) 228. More specifically, the gNB-CU 226 hosts the radio resource control (RRC), service data adaptation protocol (SDAP), and packet data convergence protocol (PDCP) protocols of the gNB 222. A gNB-DU 228 is a logical node that hosts the radio link control (RLC), medium access control (MAC), and physical (PHY) layers of the gNB 222. Its operation is controlled by the gNB-CU 226. One gNB-DU 228 can support one or more cells, and one cell is supported by only one gNB-DU 228. Thus, a UE 204 communicates with the

gNB-CU 226 via the RRC, SDAP, and PDCP layers and with a gNB-DU 228 via the RLC, MAC, and PHY layers.

[0176] **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, or alternatively may be independent from the NG-RAN 220 and/or 5GC 210/260 infrastructure depicted in FIGS. 2A and 2B, such as a private network) to support the file transmission operations as taught herein. It will be appreciated that these components may be implemented in different types of apparatuses in different implementations (e.g., in an ASIC, in a system-on-chip (SoC), etc.). The illustrated components may also be incorporated into other apparatuses in a communication system. For example, other apparatuses in a system may include components similar to those described to provide similar functionality. Also, a given apparatus may contain one or more of the components. For example, an apparatus may include multiple transceiver components that enable the apparatus to operate on multiple carriers and/or communicate via different technologies.

[0177] The UE 302 and the base station 304 each include one or more wireless wide area network (WWAN) transceivers 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 each 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.

[0178] The UE 302 and the base station 304 each also include, at least in some cases, one or more short-range wireless transceivers 320 and 360, respectively. The short-range wireless 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®, Zigbee®, Z-Wave®, PC5, dedicated short-range communications (DSRC), wireless access for vehicular environments (WAVE), near-field communication (NFC), etc.) over a wireless communication medium of interest. The short-range wireless 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 short-range wireless 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. As specific examples, the short-range wireless transceivers 320 and 360 may be WiFi transceivers, Bluetooth® transceivers, Zigbee® and/or Z-Wave® transceivers, NFC transceivers, or vehicle-to-vehicle (V2V) and/or vehicle-to-everything (V2X) transceivers.

[0179] The UE 302 and the base station 304 also include, at least in some cases, satellite signal receivers 330 and 370. The satellite signal 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 satellite positioning/communication signals 338 and 378, respectively. Where the satellite signal receivers 330 and 370 are satellite positioning system receivers, the satellite positioning/communication signals 338 and 378 may be 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. Where the satellite signal receivers 330 and 370 are

non-terrestrial network (NTN) receivers, the satellite positioning/communication signals 338 and 378 may be communication signals (e.g., carrying control and/or user data) originating from a 5G network. The satellite signal receivers 330 and 370 may comprise any suitable hardware and/or software for receiving and processing satellite positioning/communication signals 338 and 378, respectively. The satellite signal receivers 330 and 370 may request information and operations as appropriate from the other systems, and, at least in some cases, perform calculations to determine locations of the UE 302 and the base station 304, respectively, using measurements obtained by any suitable satellite positioning system algorithm.

[0180] The base station 304 and the network entity 306 each include one or more network transceivers 380 and 390, respectively, providing means for communicating (e.g., means for transmitting, means for receiving, etc.) with other network entities (e.g., other base stations 304, other network entities 306). For example, the base station 304 may employ the one or more network transceivers 380 to communicate with other base stations 304 or network entities 306 over one or more wired or wireless backhaul links. As another example, the network entity 306 may employ the one or more network transceivers 390 to communicate with one or more base station 304 over one or more wired or wireless backhaul links, or with other network entities 306 over one or more wired or wireless core network interfaces.

[0181] A transceiver may be configured to communicate over a wired or wireless link. A transceiver (whether a wired transceiver or a wireless transceiver) includes transmitter circuitry (e.g., transmitters 314, 324, 354, 364) and receiver circuitry (e.g., receivers 312, 322, 352, 362). A transceiver may be an integrated device (e.g., embodying transmitter circuitry and receiver circuitry in a single device) in some implementations, may comprise separate transmitter circuitry and separate receiver circuitry in some implementations, or may be embodied in other ways in other implementations. The transmitter circuitry and receiver circuitry of a wired transceiver (e.g., network transceivers 380 and 390 in some implementations) may be coupled to one or more wired network interface ports. Wireless transmitter circuitry (e.g., transmitters 314, 324, 354, 364) 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 (e.g., UE 302, base station 304) to perform transmit "beamforming," as described herein. Similarly, wireless receiver circuitry (e.g., receivers 312, 322, 352, 362) 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 (e.g., UE 302, base station 304) to perform receive beamforming, as described herein. In an aspect, the transmitter circuitry and receiver circuitry 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 transceiver (e.g., WWAN transceivers 310 and 350, short-range wireless transceivers 320 and 360) may also include a network listen module (NLM) or the like for performing various measurements.

[0182] As used herein, the various wireless transceivers (e.g., transceivers 310, 320, 350, and 360, and network transceivers 380 and 390 in some implementations) and wired transceivers (e.g., network transceivers 380 and 390 in some implementations) may generally be characterized as "a transceiver," "at least one transceiver," or "one or more transceivers." As such, whether a particular transceiver is a wired or wireless transceiver may be inferred from the type of communication performed. For example, backhaul communication between network devices or servers will generally relate to signaling via a wired transceiver, whereas wireless communication between a UE (e.g., UE 302) and a base station (e.g., base station 304) will generally relate to signaling via a wireless transceiver.

[0183] 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, the base station 304, and the network entity 306 include one or more processors 332, 384, and 394, respectively, for providing functionality relating to, for example, wireless communication, and for providing other processing functionality. The processors 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 processors 332, 384, and 394 may include, for example, one or more general purpose processors, multi-core processors, central processing units (CPUs), ASICs, digital signal processors (DSPs), field programmable gate arrays (FPGAs), other programmable logic devices or processing circuitry, or various combinations thereof.

[0184] The UE 302, the base station 304, and the network entity 306 include memory circuitry implementing memories 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 memories 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 component 342, 388, and 398, respectively. The positioning component 342, 388, and 398 may be hardware circuits that are part of or coupled to the processors 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 component 342, 388, and 398 may be external to the processors 332, 384, and 394 (e.g., part of a modem processing system, integrated with another processing system, etc.). Alternatively, the positioning component 342, 388, and 398 may be memory modules stored in the memories 340, 386, and 396, respectively, that, when executed by the processors 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, for example, part of the one or more WWAN transceivers 310, the memory 340, the one or more processors 332, or any combination thereof, or may be a standalone component. FIG. 3B illustrates possible locations of the positioning component 388, which may be, for example, part of the one or more WWAN transceivers 350, the memory 386, the one or more processors 384, or any combination thereof, or may be a standalone component. FIG. 3C illustrates possible locations of the positioning component 398, which may be, for example, part of the one or more network transceivers 390, the memory 396, the one or more processors 394, or any combination thereof, or may be a standalone component.

[0185] The UE 302 may include one or more sensors 344 coupled to the one or more processors 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 one or more WWAN transceivers 310, the one or more short-range wireless transceivers 320, and/or the satellite 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 two-dimensional (2D) and/or three-dimensional (3D) coordinate systems.

[0186] 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.

[0187] Referring to the one or more processors 384 in more detail, in the downlink, IP packets from the network entity 306 may be provided to the processor 384. The one or more processors 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 one or more processors 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.

[0188] 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.

[0189] 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 one or more processors 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 one or more processors 332, which implements Layer-3 (L3) and Layer-2 (L2) functionality.

[0190] In the uplink, the one or more processors 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 one or more processors 332 are also responsible for error detection.

[0191] Similar to the functionality described in connection with the downlink transmission by the base station 304, the one or more processors 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.

[0192] 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.

[0193] 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 one or more processors 384.

[0194] In the uplink, the one or more processors 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 one or more processors 384 may be provided to the core network. The one or more processors 384 are also responsible for error detection.

[0195] For convenience, the UE 302, the base station 304, and/or the network entity 306 are shown in FIGS. 3A, 3B, and 3C as including various components that may be configured according to the various examples described herein. It will be appreciated, however, that

the illustrated components may have different functionality in different designs. In particular, various components in FIGS. 3A to 3C are optional in alternative configurations and the various aspects include configurations that may vary due to design choice, costs, use of the device, or other considerations. For example, in case of FIG. 3A, a particular implementation of UE 302 may omit the WWAN transceiver(s) 310 (e.g., a wearable device or tablet computer or PC or laptop may have Wi-Fi and/or Bluetooth capability without cellular capability), or may omit the short-range wireless transceiver(s) 320 (e.g., cellular-only, etc.), or may omit the satellite receiver 330, or may omit the sensor(s) 344, and so on. In another example, in case of FIG. 3B, a particular implementation of the base station 304 may omit the WWAN transceiver(s) 350 (e.g., a Wi-Fi "hotspot" access point without cellular capability), or may omit the short-range wireless transceiver(s) 360 (e.g., cellular-only, etc.), or may omit the satellite receiver 370, and so on. For brevity, illustration of the various alternative configurations is not provided herein, but would be readily understandable to one skilled in the art.

[0196] The various components of the UE 302, the base station 304, and the network entity 306 may be communicatively coupled to each other over data buses 334, 382, and 392, respectively. In an aspect, the data buses 334, 382, and 392 may form, or be part of, a communication interface of the UE 302, the base station 304, and the network entity 306, respectively. For example, where different logical entities are embodied in the same device (e.g., gNB and location server functionality incorporated into the same base station 304), the data buses 334, 382, and 392 may provide communication between them.

[0197] The components of FIGS. 3A, 3B, and 3C may be implemented in various ways. In some implementations, the components of FIGS. 3A, 3B, and 3C may be implemented in one or more circuits such as, for example, one or more processors and/or one or more ASICs (which may include one or more processors). Here, each circuit may use and/or incorporate at least one memory component for storing information or executable code used by the circuit to provide this functionality. For example, some or all of the functionality represented by blocks 310 to 346 may be implemented by processor and memory component(s) of the UE 302 (e.g., by execution of appropriate code and/or by appropriate configuration of processor components). Similarly, some or all of the functionality represented by blocks 350 to 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 network 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 302, base station 304, network entity 306, etc., such as the processors 332, 384, 394, the transceivers 310, 320, 350, and 360, the memories 340, 386, and 396, the positioning component 342, 388, and 398, etc.

[0198] In some designs, the network entity 306 may be implemented as a core network component. In other designs, the network entity 306 may be distinct from a network operator or operation of the cellular network infrastructure (e.g., NG RAN 220 and/or 5GC 210/260). For example, the network entity 306 may be a component of a private network that may be configured to communicate with the UE 302 via the base station 304 or independently from the base station 304 (e.g., over a non-cellular communication link, such as WiFi).

[0199] NR supports a number of cellular network-based positioning technologies, including downlink-based, uplink-based, and downlink-and-uplink-based positioning methods. Downlink-based positioning methods include observed time difference of arrival (OTDOA) in LTE, downlink time difference of arrival (DL-TDOA) in NR, and downlink angle-of-departure (DL-AoD) in NR. In an OTDOA or DL-TDOA position estimation procedure, a UE measures the differences between the times of arrival (ToAs) of reference signals (e.g., positioning reference signals (PRS)) received from pairs of base stations, referred to as reference signal time difference (RSTD) or time difference of arrival (TDOA) measurements, and reports them to a positioning entity. More specifically, the UE receives the identifiers (IDs) of a reference base station (e.g., a serving base station) and multiple non-reference base stations in assistance data. The UE then measures the RSTD between the reference base station and each of the non-reference base stations. Based on the known locations of the involved base stations and the RSTD measurements, the positioning entity can estimate the UE's location.

[0200] For DL-AoD positioning, the positioning entity uses a beam report from the UE of received signal strength measurements of multiple downlink transmit beams to determine the angle(s) between the UE and the transmitting base station(s). The positioning entity

can then estimate the location of the UE based on the determined angle(s) and the known location(s) of the transmitting base station(s).

[0201] Uplink-based positioning methods include uplink time difference of arrival (UL-TDOA) and uplink angle-of-arrival (UL-AoA). UL-TDOA is similar to DL-TDOA, but is based on uplink reference signals (e.g., sounding reference signals (SRS)) transmitted by the UE. For UL-AoA positioning, one or more base stations measure the received signal strength of one or more uplink reference signals (e.g., SRS) received from a UE on one or more uplink receive beams. The positioning entity uses the signal strength measurements and the angle(s) of the receive beam(s) to determine the angle(s) between the UE and the base station(s). Based on the determined angle(s) and the known location(s) of the base station(s), the positioning entity can then estimate the location of the UE.

[0202] Downlink-and-uplink-based positioning methods include enhanced cell-ID (E-CID) positioning and multi-round-trip-time (RTT) positioning (also referred to as "multi-cell RTT"). In an RTT procedure, an initiator (a base station or a UE) transmits an RTT measurement signal (e.g., a PRS or SRS) to a responder (a UE or base station), which transmits an RTT response signal (e.g., an SRS or PRS) back to the initiator. The RTT response signal includes the difference between the ToA of the RTT measurement signal and the transmission time of the RTT response signal, referred to as the reception-to-transmission (Rx-Tx) time difference. The initiator calculates the difference between the transmission time of the RTT measurement signal and the ToA of the RTT response signal, referred to as the transmission-to-reception (Tx-Rx) time difference. The propagation time (also referred to as the "time of flight") between the initiator and the responder can be calculated from the Tx-Rx and Rx-Tx time differences. Based on the propagation time and the known speed of light, the distance between the initiator and the responder can be determined. For multi-RTT positioning, a UE performs an RTT procedure with multiple base stations to enable its location to be determined (e.g., using multilateration) based on the known locations of the base stations. RTT and multi-RTT methods can be combined with other positioning techniques, such as UL-AoA and DL-AoD, to improve location accuracy.

[0203] The E-CID positioning method is based on radio resource management (RRM) measurements. In E-CID, the UE reports the serving cell ID, the timing advance (TA), and the identifiers, estimated timing, and signal strength of detected neighbor base

stations. The location of the UE is then estimated based on this information and the known locations of the base station(s).

[0204] To assist positioning operations, a location server (e.g., location server 230, LMF 270, SLP 272) may provide assistance data to the UE. For example, the assistance data may include identifiers of the base stations (or the cells/TRPs of the base stations) from which to measure reference signals, the reference signal configuration parameters (e.g., the number of consecutive positioning subframes, periodicity of positioning subframes, muting sequence, frequency hopping sequence, reference signal identifier, reference signal bandwidth, etc.), and/or other parameters applicable to the particular positioning method. Alternatively, the assistance data may originate directly from the base stations themselves (e.g., in periodically broadcasted overhead messages, etc.). in some cases, the UE may be able to detect neighbor network nodes itself without the use of assistance data.

[0205] In the case of an OTDOA or DL-TDOA position estimation procedure, the assistance data may further include an expected RSTD value and an associated uncertainty, or search window, around the expected RSTD. In some cases, the value range of the expected RSTD may be +/- 500 microseconds (μs). In some cases, when any of the resources used for the positioning measurement are in FR1, the value range for the uncertainty of the expected RSTD may be +/- 32 μs. In other cases, when all of the resources used for the positioning measurement(s) are in FR2, the value range for the uncertainty of the expected RSTD may be +/- 8 μs.

[0206] A location estimate may be referred to by other names, such as a position estimate, location, position, position fix, fix, or the like. A location estimate may be geodetic and comprise coordinates (e.g., latitude, longitude, and possibly altitude) or may be civic and comprise a street address, postal address, or some other verbal description of a location. A location estimate may further be defined relative to some other known location or defined in absolute terms (e.g., using latitude, longitude, and possibly altitude). A location estimate may include an expected error or uncertainty (e.g., by including an area or volume within which the location is expected to be included with some specified or default level of confidence).

[0207] Various frame structures may be used to support downlink and uplink transmissions between network nodes (e.g., base stations and UEs). **FIG. 4A** is a diagram 400 illustrating an example of a downlink frame structure, according to aspects of the disclosure. **FIG. 4B** is a diagram 430 illustrating an example of channels within the

downlink frame structure, according to aspects of the disclosure. **FIG. 4C** is a diagram 450 illustrating an example of an uplink frame structure, according to aspects of the disclosure. **FIG. 4D** is a diagram 480 illustrating an example of channels within an uplink frame structure, according to aspects of the disclosure. Other wireless communications technologies may have different frame structures and/or different channels.

[0208] LTE, and in some cases NR, utilizes OFDM on the downlink and single-carrier frequency division multiplexing (SC-FDM) on the uplink. Unlike LTE, however, NR has an option to use OFDM on the uplink as well. OFDM and SC-FDM partition the system bandwidth into multiple (K) orthogonal subcarriers, which are also commonly referred to as tones, bins, etc. Each subcarrier may be modulated with data. In general, modulation symbols are sent in the frequency domain with OFDM and in the time domain with SC-FDM. The spacing between adjacent subcarriers may be fixed, and the total number of subcarriers (K) may be dependent on the system bandwidth. For example, the spacing of the subcarriers may be 15 kilohertz (kHz) and the minimum resource allocation (resource block) may be 12 subcarriers (or 180 kHz). Consequently, the nominal FFT size may be equal to 128, 256, 512, 1024, or 2048 for system bandwidth of 1.25, 2.5, 5, 10, or 20 megahertz (MHz), respectively. The system bandwidth may also be partitioned into subbands. For example, a subband may cover 1.08 MHz (i.e., 6 resource blocks), and there may be 1, 2, 4, 8, or 16 subbands for system bandwidth of 1.25, 2.5, 5, 10, or 20 MHz, respectively.

[0209] LTE supports a single numerology (subcarrier spacing (SCS), symbol length, etc.). In contrast, NR may support multiple numerologies (μ), for example, subcarrier spacings of 15 kHz (μ=0), 30 kHz (μ=1), 60 kHz (μ=2), 120 kHz (μ=3), and 240 kHz (μ=4) or greater may be available. In each subcarrier spacing, there are 14 symbols per slot. For 15 kHz SCS (μ=0), there is one slot per subframe, 10 slots per frame, the slot duration is 1 millisecond (ms), the symbol duration is 66.7 microseconds (μs), and the maximum nominal system bandwidth (in MHz) with a 4K FFT size is 50. For 30 kHz SCS (μ=1), there are two slots per subframe, 20 slots per frame, the slot duration is 0.5 ms, the symbol duration is 33.3 μs, and the maximum nominal system bandwidth (in MHz) with a 4K FFT size is 100. For 60 kHz SCS (μ=2), there are four slots per subframe, 40 slots per frame, the slot duration is 0.25 ms, the symbol duration is 16.7 μs, and the maximum nominal system bandwidth (in MHz) with a 4K FFT size is 200. For 120 kHz SCS (μ=3), there are eight slots per subframe, 80 slots per frame, the slot duration is 0.125 ms, the

symbol duration is 8.33 μs, and the maximum nominal system bandwidth (in MHz) with a 4K FFT size is 400. For 240 kHz SCS (μ=4), there are 16 slots per subframe, 160 slots per frame, the slot duration is 0.0625 ms, the symbol duration is 4.17 μs, and the maximum nominal system bandwidth (in MHz) with a 4K FFT size is 800.

[0210] In the example of FIGS. 4A to 4D, a numerology of 15 kHz is used. Thus, in the time domain, a 10 ms frame is divided into 10 equally sized subframes of 1 ms each, and each subframe includes one time slot. In FIGS. 4A to 4D, time is represented horizontally (on the X axis) with time increasing from left to right, while frequency is represented vertically (on the Y axis) with frequency increasing (or decreasing) from bottom to top.

[0211] A resource grid may be used to represent time slots, each time slot including one or more time-concurrent resource blocks (RBs) (also referred to as physical RBs (PRBs)) in the frequency domain. The resource grid is further divided into multiple resource elements (REs). An RE may correspond to one symbol length in the time domain and one subcarrier in the frequency domain. In the numerology of FIGS. 4A to 4D, for a normal cyclic prefix, an RB may contain 12 consecutive subcarriers in the frequency domain and seven consecutive symbols in the time domain, for a total of 84 REs. For an extended cyclic prefix, an RB may contain 12 consecutive subcarriers in the frequency domain and six consecutive symbols in the time domain, for a total of 72 REs. The number of bits carried by each RE depends on the modulation scheme.

[0212] Some of the REs carry downlink reference (pilot) signals (DL-RS). The DL-RS may include positioning reference signals (PRS), tracking reference signals (TRS), phase tracking reference signals (PTRS), cell-specific reference signals (CRS), channel state information reference signals (CSI-RS), demodulation reference signals (DMRS), primary synchronization signals (PSS), secondary synchronization signals (SSS), synchronization signal blocks (SSBs), etc. FIG. 4A illustrates example locations of REs carrying PRS (labeled "R").

[0213] A collection of resource elements (REs) that are used for transmission of PRS is referred to as a "PRS resource." The collection of resource elements can span multiple PRBs in the frequency domain and 'N' (such as 1 or more) consecutive symbol(s) within a slot in the time domain. In a given OFDM symbol in the time domain, a PRS resource occupies consecutive PRBs in the frequency domain.

[0214] The transmission of a PRS resource within a given PRB has a particular comb size (also referred to as the "comb density"). A comb size 'N' represents the subcarrier spacing (or

frequency/tone spacing) within each symbol of a PRS resource configuration. Specifically, for a comb size 'N,' PRS are transmitted in every Nth subcarrier of a symbol of a PRB. For example, for comb-4, for each symbol of the PRS resource configuration, REs corresponding to every fourth subcarrier (such as subcarriers 0, 4, 8) are used to transmit PRS of the PRS resource. Currently, comb sizes of comb-2, comb-4, comb-6, and comb-12 are supported for DL-PRS. FIG. 4A illustrates an example PRS resource configuration for comb-6 (which spans six symbols). That is, the locations of the shaded REs (labeled "R") indicate a comb-6 PRS resource configuration.

[0215] Currently, a DL-PRS resource may span 2, 4, 6, or 12 consecutive symbols within a slot with a fully frequency-domain staggered pattern. A DL-PRS resource can be configured in any higher layer configured downlink or flexible (FL) symbol of a slot. There may be a constant energy per resource element (EPRE) for all REs of a given DL-PRS resource. The following are the frequency offsets from symbol to symbol for comb sizes 2, 4, 6, and 12 over 2, 4, 6, and 12 symbols. 2-symbol comb-2: {0, 1}; 4-symbol comb-2: {0, 1, 0, 1}; 6-symbol comb-2: {0, 1, 0, 1, 0, 1}; 12-symbol comb-2: {0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1}; 4-symbol comb-4: {0, 2, 1, 3}; 12-symbol comb-4: {0, 2, 1, 3, 0, 2, 1, 3, 0, 2, 1, 3}; 6-symbol comb-6: {0, 3, 1, 4, 2, 5}; 12-symbol comb-6: {0, 3, 1, 4, 2, 5, 0, 3, 1, 4, 2, 5}; and 12-symbol comb-12: {0, 6, 3, 9, 1, 7, 4, 10, 2, 8, 5, 11}.

[0216] A "PRS resource set" is a set of PRS resources used for the transmission of PRS signals, where each PRS resource has a PRS resource ID. In addition, the PRS resources in a PRS resource set are associated with the same TRP. A PRS resource set is identified by a PRS resource set ID and is associated with a particular TRP (identified by a TRP ID). In addition, the PRS resources in a PRS resource set have the same periodicity, a common muting pattern configuration, and the same repetition factor (such as "PRS-ResourceRepetitionFactor") across slots. The periodicity is the time from the first repetition of the first PRS resource of a first PRS instance to the same first repetition of the same first PRS resource of the next PRS instance. The periodicity may have a length selected from $2^{\mu}*\{4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 160, 320, 640, 1280, 2560, 5120, 10240\}$ slots, with $\mu = 0, 1, 2, 3$. The repetition factor may have a length selected from {1, 2, 4, 6, 8, 16, 32} slots.

[0217] A PRS resource ID in a PRS resource set is associated with a single beam (or beam ID) transmitted from a single TRP (where a TRP may transmit one or more beams). That is, each PRS resource of a PRS resource set may be transmitted on a different beam, and as

such, a "PRS resource," or simply "resource," also can be referred to as a "beam." Note that this does not have any implications on whether the TRPs and the beams on which PRS are transmitted are known to the UE.

[0218] A "PRS instance" or "PRS occasion" is one instance of a periodically repeated time window (such as a group of one or more consecutive slots) where PRS are expected to be transmitted. A PRS occasion also may be referred to as a "PRS positioning occasion," a "PRS positioning instance, a "positioning occasion," "a positioning instance," a "positioning repetition," or simply an "occasion," an "instance," or a "repetition."

[0219] A "positioning frequency layer" (also referred to simply as a "frequency layer") is a collection of one or more PRS resource sets across one or more TRPs that have the same values for certain parameters. Specifically, the collection of PRS resource sets has the same subcarrier spacing and cyclic prefix (CP) type (meaning all numerologies supported for the PDSCH are also supported for PRS), the same Point A, the same value of the downlink PRS bandwidth, the same start PRB (and center frequency), and the same comb-size. The Point A parameter takes the value of the parameter "ARFCN-ValueNR" (where "ARFCN" stands for "absolute radio-frequency channel number") and is an identifier/code that specifies a pair of physical radio channel used for transmission and reception. The downlink PRS bandwidth may have a granularity of four PRBs, with a minimum of 24 PRBs and a maximum of 272 PRBs. Currently, up to four frequency layers have been defined, and up to two PRS resource sets may be configured per TRP per frequency layer.

[0220] The concept of a frequency layer is somewhat like the concept of component carriers and bandwidth parts (BWPs), but different in that component carriers and BWPs are used by one base station (or a macro cell base station and a small cell base station) to transmit data channels, while frequency layers are used by several (usually three or more) base stations to transmit PRS. A UE may indicate the number of frequency layers it can support when it sends the network its positioning capabilities, such as during an LTE positioning protocol (LPP) session. For example, a UE may indicate whether it can support one or four positioning frequency layers.

[0221] FIG. 4B illustrates an example of various channels within a downlink slot of a radio frame. In NR, the channel bandwidth, or system bandwidth, is divided into multiple BWPs. A BWP is a contiguous set of PRBs selected from a contiguous subset of the common RBs for a given numerology on a given carrier. Generally, a maximum of four

BWPs can be specified in the downlink and uplink. That is, a UE can be configured with up to four BWPs on the downlink, and up to four BWPs on the uplink. Only one BWP (uplink or downlink) may be active at a given time, meaning the UE may only receive or transmit over one BWP at a time. On the downlink, the bandwidth of each BWP should be equal to or greater than the bandwidth of the SSB, but it may or may not contain the SSB.

[0222] Referring to FIG. 4B, a primary synchronization signal (PSS) is used by a UE to determine subframe/symbol timing and a physical layer identity. A secondary synchronization signal (SSS) is used by a UE to determine a physical layer cell identity group number and radio frame timing. Based on the physical layer identity and the physical layer cell identity group number, the UE can determine a PCI. Based on the PCI, the UE can determine the locations of the aforementioned DL-RS. The physical broadcast channel (PBCH), which carries an MIB, may be logically grouped with the PSS and SSS to form an SSB (also referred to as an SS/PBCH). The MIB provides a number of RBs in the downlink system bandwidth and a system frame number (SFN). The physical downlink shared channel (PDSCH) carries user data, broadcast system information not transmitted through the PBCH, such as system information blocks (SIBs), and paging messages.

[0223] The physical downlink control channel (PDCCH) carries downlink control information (DCI) within one or more control channel elements (CCEs), each CCE including one or more RE group (REG) bundles (which may span multiple symbols in the time domain), each REG bundle including one or more REGs, each REG corresponding to 12 resource elements (one resource block) in the frequency domain and one OFDM symbol in the time domain. The set of physical resources used to carry the PDCCH/DCI is referred to in NR as the control resource set (CORESET). In NR, a PDCCH is confined to a single CORESET and is transmitted with its own DMRS. This enables UE-specific beamforming for the PDCCH.

[0224] In the example of FIG. 4B, there is one CORESET per BWP, and the CORESET spans three symbols (although it may be only one or two symbols) in the time domain. Unlike LTE control channels, which occupy the entire system bandwidth, in NR, PDCCH channels are localized to a specific region in the frequency domain (i.e., a CORESET). Thus, the frequency component of the PDCCH shown in FIG. 4B is illustrated as less than a single BWP in the frequency domain. Note that although the illustrated CORESET

is contiguous in the frequency domain, it need not be. In addition, the CORESET may span less than three symbols in the time domain.

[0225] The DCI within the PDCCH carries information about uplink resource allocation (persistent and non-persistent) and descriptions about downlink data transmitted to the UE, referred to as uplink and downlink grants, respectively. More specifically, the DCI indicates the resources scheduled for the downlink data channel (e.g., PDSCH) and the uplink data channel (e.g., PUSCH). Multiple (e.g., up to eight) DCIs can be configured in the PDCCH, and these DCIs can have one of multiple formats. For example, there are different DCI formats for uplink scheduling, for downlink scheduling, for uplink transmit power control (TPC), etc. A PDCCH may be transported by 1, 2, 4, 8, or 16 CCEs in order to accommodate different DCI payload sizes or coding rates.

[0226] As illustrated in FIG. 4C, some of the REs (labeled "R") carry DMRS for channel estimation at the receiver (e.g., a base station, another UE, etc.). A UE may additionally transmit SRS in, for example, the last symbol of a slot. The SRS may have a comb structure, and a UE may transmit SRS on one of the combs. In the example of FIG. 4C, the illustrated SRS is comb-2 over one symbol. The SRS may be used by a base station to obtain the channel state information (CSI) for each UE. CSI describes how an RF signal propagates from the UE to the base station and represents the combined effect of scattering, fading, and power decay with distance. The system uses the SRS for resource scheduling, link adaptation, massive MIMO, beam management, etc.

[0227] Currently, an SRS resource may span 1, 2, 4, 8, or 12 consecutive symbols within a slot with a comb size of comb-2, comb-4, or comb-8. The following are the frequency offsets from symbol to symbol for the SRS comb patterns that are currently supported. 1-symbol comb-2: {0}; 2-symbol comb-2: {0, 1}; 4-symbol comb-2: {0, 1, 0, 1}; 4-symbol comb-4: {0, 2, 1, 3}; 8-symbol comb-4: {0, 2, 1, 3, 0, 2, 1, 3}; 12-symbol comb-4: {0, 2, 1, 3, 0, 2, 1, 3, 0, 2, 1, 3}; 4-symbol comb-8: {0, 4, 2, 6}; 8-symbol comb-8: {0, 4, 2, 6, 1, 5, 3, 7}; and 12-symbol comb-8: {0, 4, 2, 6, 1, 5, 3, 7, 0, 4, 2, 6}.

[0228] A collection of resource elements that are used for transmission of SRS is referred to as an "SRS resource," and may be identified by the parameter "SRS-ResourceId."" The collection of resource elements can span multiple PRBs in the frequency domain and N (e.g., one or more) consecutive symbol(s) within a slot in the time domain. In a given OFDM symbol, an SRS resource occupies consecutive PRBs. An "SRS resource set" is

a set of SRS resources used for the transmission of SRS signals, and is identified by an SRS resource set ID ("SRS-ResourceSetId").

[0229] Generally, a UE transmits SRS to enable the receiving base station (either the serving base station or a neighboring base station) to measure the channel quality between the UE and the base station. However, SRS can also be specifically configured as uplink positioning reference signals for uplink-based position estimation procedures, such as uplink time difference of arrival (UL-TDOA), round-trip-time (RTT), uplink angle-of-arrival (UL-AoA), etc. As used herein, the term "SRS" may refer to SRS configured for channel quality measurements or SRS configured for positioning purposes. The former may be referred to herein as "SRS-for-communication" and/or the latter may be referred to as "SRS-for-positioning" when needed to distinguish the two types of SRS.

[0230] Several enhancements over the previous definition of SRS have been proposed for SRS-for-positioning (also referred to as "UL-PRS"), such as a new staggered pattern within an SRS resource (except for single-symbol/comb-2), a new comb type for SRS, new sequences for SRS, a higher number of SRS resource sets per component carrier, and a higher number of SRS resources per component carrier. In addition, the parameters "SpatialRelationInfo" and "PathLossReference" are to be configured based on a downlink reference signal or SSB from a neighboring TRP. Further still, one SRS resource may be transmitted outside the active BWP, and one SRS resource may span across multiple component carriers. Also, SRS may be configured in RRC connected state and only transmitted within an active BWP. Further, there may be no frequency hopping, no repetition factor, a single antenna port, and new lengths for SRS (e.g., 8 and 12 symbols). There also may be open-loop power control and not closed-loop power control, and comb-8 (i.e., an SRS transmitted every eighth subcarrier in the same symbol) may be used. Lastly, the UE may transmit through the same transmit beam from multiple SRS resources for UL-AoA. All of these are features that are additional to the current SRS framework, which is configured through RRC higher layer signaling (and potentially triggered or activated through MAC control element (CE) or DCI).

[0231] FIG. 4D illustrates an example of various channels within an uplink slot of a frame, according to aspects of the disclosure. A random-access channel (RACH), also referred to as a physical random-access channel (PRACH), may be within one or more slots within a frame based on the PRACH configuration. The PRACH may include six consecutive RB pairs within a slot. The PRACH allows the UE to perform initial system access and

achieve uplink synchronization. A physical uplink control channel (PUCCH) may be located on edges of the uplink system bandwidth. The PUCCH carries uplink control information (UCI), such as scheduling requests, CSI reports, a channel quality indicator (CQI), a precoding matrix indicator (PMI), a rank indicator (RI), and HARQ ACK/NACK feedback. The physical uplink shared channel (PUSCH) carries data, and may additionally be used to carry a buffer status report (BSR), a power headroom report (PHR), and/or UCI.

[0232] Note that the terms "positioning reference signal" and "PRS" generally refer to specific reference signals that are used for positioning in NR and LTE systems. However, as used herein, the terms "positioning reference signal" and "PRS" may also refer to any type of reference signal that can be used for positioning, such as but not limited to, PRS as defined in LTE and NR, TRS, PTRS, CRS, CSI-RS, DMRS, PSS, SSS, SSB, SRS, UL-PRS, etc. In addition, the terms "positioning reference signal" and "PRS" may refer to downlink or uplink positioning reference signals, unless otherwise indicated by the context. If needed to further distinguish the type of PRS, a downlink positioning reference signal may be referred to as a "DL-PRS," and an uplink positioning reference signal (e.g., an SRS-for-positioning, PTRS) may be referred to as an "UL-PRS." In addition, for signals that may be transmitted in both the uplink and downlink (e.g., DMRS, PTRS), the signals may be prepended with "UL" or "DL" to distinguish the direction. For example, "UL-DMRS" may be differentiated from "DL-DMRS."

[0233] **FIG. 5** illustrates an example Long-Term Evolution (LTE) positioning protocol (LPP) procedure 500 between a UE 504 and a location server (illustrated as a location management function (LMF) 570) for performing positioning operations. As illustrated in FIG. 5, positioning of the UE 504 is supported via an exchange of LPP messages between the UE 504 and the LMF 570. The LPP messages may be exchanged between UE 504 and the LMF 570 via the UE's 504 serving base station (illustrated as a serving gNB 502) and a core network (not shown). The LPP procedure 500 may be used to position the UE 504 in order to support various location-related services, such as navigation for UE 504 (or for the user of UE 504), or for routing, or for provision of an accurate location to a public safety answering point (PSAP) in association with an emergency call from UE 504 to a PSAP, or for some other reason. The LPP procedure 500 may also be referred to as a positioning session, and there may be multiple positioning

sessions for different types of positioning methods (e.g., downlink time difference of arrival (DL-TDOA), round-trip-time (RTT), enhanced cell identity (E-CID), etc.).

[0234] Initially, the UE 504 may receive a request for its positioning capabilities from the LMF 570 at stage 510 (e.g., an LPP Request Capabilities message). At stage 520, the UE 504 provides its positioning capabilities to the LMF 570 relative to the LPP protocol by sending an LPP Provide Capabilities message to LMF 570 indicating the position methods and features of these position methods that are supported by the UE 504 using LPP. The capabilities indicated in the LPP Provide Capabilities message may, in some aspects, indicate the type of positioning the UE 504 supports (e.g., DL-TDOA, RTT, E-CID, etc.) and may indicate the capabilities of the UE 504 to support those types of positioning.

[0235] Upon reception of the LPP Provide Capabilities message, at stage 520, the LMF 570 determines to use a particular type of positioning method (e.g., DL-TDOA, RTT, E-CID, etc.) based on the indicated type(s) of positioning the UE 504 supports and determines a set of one or more transmission-reception points (TRPs) from which the UE 504 is to measure downlink positioning reference signals or towards which the UE 504 is to transmit uplink positioning reference signals. At stage 530, the LMF 570 sends an LPP Provide Assistance Data message to the UE 504 identifying the set of TRPs.

[0236] In some implementations, the LPP Provide Assistance Data message at stage 530 may be sent by the LMF 570 to the UE 504 in response to an LPP Request Assistance Data message sent by the UE 504 to the LMF 570 (not shown in FIG. 5). An LPP Request Assistance Data message may include an identifier of the UE's 504 serving TRP and a request for the positioning reference signal (PRS) configuration of neighboring TRPs.

[0237] At stage 540, the LMF 570 sends a request for location information to the UE 504. The request may be an LPP Request Location Information message. This message usually includes information elements defining the location information type, desired accuracy of the location estimate, and response time (i.e., desired latency). Note that a low latency requirement allows for a longer response time while a high latency requirement requires a shorter response time. However, a long response time is referred to as high latency and a short response time is referred to as low latency.

[0238] Note that in some implementations, the LPP Provide Assistance Data message sent at stage 530 may be sent after the LPP Request Location Information message at 540 if, for example, the UE 504 sends a request for assistance data to LMF 570 (e.g., in an LPP

Request Assistance Data message, not shown in FIG. 5) after receiving the request for location information at stage 540.

[0239] At stage 550, the UE 504 utilizes the assistance information received at stage 530 and any additional data (e.g., a desired location accuracy or a maximum response time) received at stage 540 to perform positioning operations (e.g., measurements of DL-PRS, transmission of UL-PRS, etc.) for the selected positioning method.

[0240] At stage 560, the UE 504 may send an LPP Provide Location Information message to the LMF 570 conveying the results of any measurements that were obtained at stage 550 (e.g., time of arrival (ToA), reference signal time difference (RSTD), reception-to-transmission (Rx-Tx), etc.) and before or when any maximum response time has expired (e.g., a maximum response time provided by the LMF 570 at stage 540). The LPP Provide Location Information message at stage 560 may also include the time (or times) at which the positioning measurements were obtained and the identity of the TRP(s) from which the positioning measurements were obtained. Note that the time between the request for location information at 540 and the response at 560 is the "response time" and indicates the latency of the positioning session.

[0241] The LMF 570 computes an estimated location of the UE 504 using the appropriate positioning techniques (e.g., DL-TDOA, RTT, E-CID, etc.) based, at least in part, on measurements received in the LPP Provide Location Information message at stage 560.

[0242] A UE is expected to report one or more measurement instances (of RSTD, downlink RSRP, and/or UE Rx-Tx time difference measurements) in a single measurement report (e.g., in the LPP Provide Location Information message at stage 560) to the location server for UE-assisted positioning (there is no such reporting for UE-based positioning). Each UE measurement instance can be configured with 'N' (including N=1) instances of a DL-PRS resource set. Similarly, a TRP is expected to report one or more measurement instances (of relative ToA (RTOA), uplink RSRP, and/or base station Tx-Rx time difference measurements) in a single measurement report to the location server (e.g., via NR positioning protocol type A (NRPPa)). Each measurement instance is reported with its own timestamp, and the measurement instances may be within a (configured) measurement window. Each TRP measurement instance can be configured with 'M' (including M=1) SRS measurement time occasions. Note that a measurement instance refers to one or more measurements, which can either be the same or different types, and which are obtained from the same DL-PRS resource(s) or the same SRS resource(s).

[0243] The following definitions are used for the purpose of describing internal timing errors:

[0244] Transmit (Tx) timing error: From a signal transmission perspective, there is a time delay from the time when the digital signal is generated at the baseband to the time when the RF signal is transmitted from the transmit antenna. For supporting positioning, the UE/TRP may implement an internal calibration/compensation of the transmit time delay for the transmission of the DL-PRS/UL-SRS, which may also include the calibration/compensation of the relative time delay between different RF chains in the same UE/TRP. The compensation may also consider the offset of the transmit antenna phase center to the physical antenna center. However, the calibration may not be perfect. The remaining transmit time delay after the calibration, or the uncalibrated transmit time delay is defined as the "transmit timing error" or "Tx timing error."

[0245] Receive (Rx) timing error: From a signal reception perspective, there is a time delay from the time when the RF signal arrives at the Rx antenna to the time when the signal is digitized and time-stamped at the baseband. For supporting positioning, the UE/TRP may implement an internal calibration/compensation of the Rx time delay before it reports the measurements that are obtained from the DL-PRS/SRS, which may also include the calibration/compensation of the relative time delay between different RF chains in the same UE/TRP. The compensation may also consider the offset of the Rx antenna phase center to the physical antenna center. However, the calibration may not be perfect. The remaining Rx time delay after the calibration, or the uncalibrated Rx time delay, is defined as the "Rx timing error."

[0246] UE Tx timing error group (TEG): A UE Tx TEG (or TxTEG) is associated with the transmissions of one or more SRS resources for the positioning purpose, which have the Tx timing errors within a certain margin (e.g., within a threshold of each other).

[0247] TRP Tx TEG: A TRP Tx TEG (or TxTEG) is associated with the transmissions of one or more DL-PRS resources, which have the Tx timing errors within a certain margin.

[0248] UE Rx TEG: A UE Rx TEG (or RxTEG) is associated with one or more downlink measurements, which have the Rx timing errors within a certain margin.

[0249] TRP Rx TEG: A TRP Rx TEG (or RxTEG) is associated with one or more uplink measurements, which have the Rx timing errors within a margin.

[0250] UE Rx-Tx TEG: A UE Rx-Tx TEG (or RxTxTEG) is associated with one or more UE Rx-Tx time difference measurements, and one or more SRS resources for the positioning purpose, which have the Rx timing errors plus Tx timing errors within a certain margin.

[0251] TRP Rx-Tx TEG: A TRP Rx-Tx TEG (or RxTxTEG) is associated with one or more TRP Rx-Tx time difference measurements and one or more DL-PRS resources, which have the Rx timing errors plus Tx timing errors within a certain margin.

[0252] **FIGS. 6A and 6B** illustrate an example uplink-only position estimation procedure 600 using LPP for TEG reporting, according to aspects of the disclosure. At stage 605a, the LMF 270 sends an LPP Request Capabilities message to a target UE 204, as at stage 510 of FIG. 5. At stage 605b, the UE 204 sends an LPP Provide Capabilities message to the LMF 270, as at stage 520 of FIG. 5.

[0253] At stage 610a, the LMF 270 sends an NRPPa Positioning Information Request to the target UE's 204 serving gNB 222 (or TRP) to request UL-SRS configuration information for the UE 204. The LMF 270 may provide any assistance data needed by the serving gNB 222 (e.g., pathloss reference, spatial relation, SSB configuration, etc.). At stage 610b, the serving gNB 222 determines the resources available for UL-SRS and configures the target UE 204 with the UL-SRS resource sets. At stage 610c, the serving gNB 222 provides the UL-SRS configuration information to the UE 204. At stage 610d, the serving gNB 222 sends an NRPPa Positioning Information Response message to the LMF 270. The NRPPa Positioning Information Response message includes the UL-SRS configuration information sent to the UE 204.

[0254] At stage 615a, the LMF 270 sends an NRPPa Positioning Activation Request message to the serving gNB 222 instructing it to configure the UE 204 to activate UL-SRS transmission on the configured / allocated resources. The UL-SRS may be aperiodic (e.g., on-demand) UL-SRS, and therefore, at stage 615b, the serving gNB 222 configures / instructs the UE 204 to activate (i.e., begin) UL-SRS transmission. At stage 615c, the serving gNB 222 sends an NRPPa Positioning Activation Response message to the LMF 270 to indicate that UL-SRS transmission has been activated.

[0255] At stage 620, the LMF 270 sends an LPP Request Location Information message to the target UE 204, as at stage 540 of FIG. 5. The response time for the LPP Request Location Information message applies as usual. However, the LPP Request Location Information message includes a UE Tx TEG request, as described further below.

[0256] At stage 625, the LMF 270 sends an NRPPa Measurement Request message to the serving gNB 222 and candidate neighbor gNBs 222 (or TRPs). The NRPPa Measurement Request message includes all information needed to enable the gNBs 222 to perform uplink measurements of the UL-SRS transmissions from the target UE 204.

[0257] At stage 630, the involved gNBs 222 (here, the serving gNB 222 and the neighbor gNBs 222) perform positioning measurements of the UL-SRS transmissions from the target UE 204. For example, the gNBs 222 may measure the ToA, UL-RSTD, AoA, etc. of the UL-SRS transmitted by the UE 204.

[0258] At stage 635, the involved gNBs 222 send NRPPa Measurement Response messages to the LMF 270. The NRPPa Measurement Response messages include the measurements of the UL-SRS transmissions measured at stage 630.

[0259] At stage 640, the target UE 204 sends an LPP Provide Location Information message, as at stage 560 of FIG. 5. Unlike the LPP Provide Location Information message at stage 560, however, the LPP Provide Location Information message at stage 640 includes the UE Tx TEG report requested at stage 620.

[0260] At stage 645a, the LMF 270 sends an NRPPa Positioning Deactivation message to the serving gNB 222. At stage 645b, the serving gNB 222 configures / instructs the UE 204 to deactivate (i.e., cease) transmission of the UL-SRS.

[0261] Referring back to stage 620, an LPP Request Location Information message includes a "LocationInformationType" field in the "CommonIEsRequestLocationInformation" information element (IE). Currently, the location information type may indicate a downlink-based or downlink-and-uplink-based positioning type. As such, the "LocationInformationType" field is not applicable to UL-only positioning. For UL-only positioning (i.e., where the "RequestLocationInformation" IE includes only the "NR-UL-RequestLocationInformation" IE), the "LocationInformationType" can be ignored by the receiver (e.g., target UE 204). Alternatively, a new codepoint can be added for TEG-only reporting for UL-only positioning. For example, a "ue-tx-TEG-Required" field can be added to the "LocationInformationType" field.

[0262] UL-only Request and Provide Location Information messages (as at stages 620 and 640) can then be defined for TEG reporting. For example, an optional "nr-UL-RequestLocationInformation" field can be added in the "RequestLocationInformation" IE of the LPP Request Location Information message. This field would point to an "NR-UL-RequestLocationInformation" IE. The "NR-UL-RequestLocationInformation" IE would be used by the location server (e.g., LMF 270) to request uplink location information from a target device (e.g., UE 204). The "NR-UL-RequestLocationInformation" IE would include a "ue-tx-timing-error-group-request"

field. This field would be set to "true" to indicate a UE Tx TEG request (i.e., that the target UE is requested to provide a UE Tx TEG report to the LMF 270, as at stage 640).

[0263] Referring back to stage 640, the LPP Provide Location Information message is used by the target device (e.g., UE 204) to provide positioning measurements or position estimates to the location server (e.g., LMF 270). Similar to an LPP Request Location Information message, an optional "nr-UL-ProvideLocationInformation" field can be added to the "ProvideLocationInformation" IE of the LPP Provide Location Information message. This field would point to an "NR-UL-ProvideLocationInformation" IE. The "NR-UL-ProvideLocationInformation" IE would be used by the target device (e.g., UE 204) to provide uplink location information to the location server (e.g., LMF 270). It may also be used to provide an uplink positioning-specific error reason.

[0264] In an aspect, the "NR-UL-ProvideLocationInformation" IE may include an "nr-ul-Tx-TimingErrorGroup" field and an "nr-UL-Error" field. The "nr-ul-Tx-TimingErrorGroup" field points to an "NR-UL-Tx-TimingErrorGroup" IE, which may be used by the target device to provide the UE Tx TEG information to the location server. A UE Tx TEG is associated with the transmissions of one or more UL-SRS resources, which have the same transmit timing errors within a certain margin (e.g., within a threshold of each other). **FIG. 7** illustrates an "NR-UL-Tx-TimingErrorGroup" IE and various IEs included in, or pointed to by, the "NR-UL-Tx-TimingErrorGroup" IE, according to aspects of the disclosure. Note that while FIG. 7 illustrates various fields of the "NR-UL-Tx-TimingErrorGroup," "UE-TX-TEG," "TEG-SRS-PosResourceSet," and "TX-TEG-CalibrationInfo" IEs, there may be additional fields in these IEs, as needed.

[0265] The following table describes some of the fields of an "NR-UL-Tx-TimingErrorGroup" IE.

srsPos-tx-TimingError
This field specifies the Tx Timing Error in time units $T_c = 1/(\Delta f_{max} \cdot N_f)$, where $\Delta f_{\max} = 480 \cdot 10^3$ Hz and $N_f = 4096$. Scale factor 1 T_c. Range 0… 129.70 nanoseconds.
srsPos-tx-TimingErrorUncertainty
This field specifies the (single-sided) uncertainty of the "srsPos-tx-TimingError." Scale factor 0.5 T_c. Range 0..64.85 nanoseconds.

txTEG-CalibrationInfo   This field provides information on the UE Tx Time Delay calibration, and comprises the following subfields: - "lastCalibrationTime": This field indicates the last time when the TEG was calibrated.   If this field is absent, the "UE-TX-TEG" is not calibrated.
srs-PosResourceIdList   This field specifies the SRS-for-positioning resource IDs of this SRS-for-positioning resource set ID which belong to this "UE-TX-TEG." If this field is absent, all SRS for positioning resource IDs belonging to this "srs-PosResourceSetId" are included in this "UE-TX-TEG."

Table 1

[0266] Note that for the Tx Timing Error in Table 1, from a signal transmission perspective, there will be a time delay from the time when the digital signal is generated at baseband to the time when the RF signal is transmitted from the transmit antenna. For supporting positioning, the UE (e.g., UE 204) may implement an internal calibration/compensation of the UE Tx Time Delay for the transmission of the UL-SRS. The compensation may also consider the offset of the transmit antenna phase center to the physical antenna center. However, the calibration may not be perfect. The remaining Tx Time Delay after the calibration, or the uncalibrated Tx Time Delay, is defined as the Tx Timing Error.

[0267] **FIGS. 8A and 8B** illustrate an example uplink-only position estimation procedure 800 using NRPPa for TEG reporting, according to aspects of the disclosure. At stage 805a, the LMF 270 sends an LPP Request Capabilities message to a target UE 204, as at stage 510 of FIG. 5. At stage 805b, the UE 204 sends an LPP Provide Capabilities message to the LMF 270, as at stage 520 of FIG. 5.

[0268] At stage 810a, the LMF 270 sends an NRPPa Positioning Information Request message to the target UE's 204 serving gNB 222 (or TRP) to request UL-SRS configuration information for the UE 204. The LMF 270 may provide any assistance data needed by the serving gNB 222 (e.g., pathloss reference, spatial relation, SSB configuration, etc.). The NRPPa Positioning Information Request message may include a UE Tx TEG report request, as described further below. At stage 810b, the serving gNB 222 determines the resources available for UL-SRS and configures the target UE 204 with the UL-SRS resource sets. At stage 810c, the serving gNB 222 provides the UL-SRS configuration information to the UE 204. The UL-SRS configuration information may include a UE

Tx TEG report configuration, as described further below. At stage 810d, the serving gNB 222 sends an NRPPa Positioning Information Response message to the LMF 270. The NRPPa Positioning Information Response message includes the UL-SRS configuration information sent to the UE 204. It may also include the UE Tx TEG report configuration indicated to the target UE 204, as described further below.

[0269] At stage 815a, the LMF 270 sends an NRPPa Positioning Activation Request message to the serving gNB 222 instructing it to configure the UE 204 to activate UL-SRS transmission on the configured / allocated resources. The UL-SRS may be aperiodic (e.g., on-demand) UL-SRS, and therefore, at stage 815b, the serving gNB 222 configures / instructs the UE 204 to activate (i.e., begin) UL-SRS transmission. At stage 815c, the serving gNB 222 sends an NRPPa Positioning Activation Response message to the LMF 270 to indicate that UL-SRS transmission has been activated.

[0270] At stage 820, the LMF 270 sends an NRPPa Measurement Request message to the serving gNB 222 and candidate neighbor gNBs 222 (or TRPs). The NRPPa Measurement Request message includes all information needed to enable the gNBs 222 to perform uplink measurements of the UL-SRS transmissions from the target UE 204.

[0271] At stage 825, the involved gNBs 222 (here, the serving gNB 222 and the neighbor gNBs 222) perform positioning measurements of the UL-SRS transmissions from the target UE 204. For example, the gNBs 222 may measure the ToA, UL-RSTD, AoA, etc. of the UL-SRS transmitted by the UE 204.

[0272] At stage 830, the target UE 204 sends one or more MAC control elements (MAC-CEs) or RRC messages to the serving gNB 222 containing the UE Tx TEG report, as described further below. At stage 835, the serving gNB 222 sends an NRPPa Positioning Information Update message to the LMF 270. The NRPPa Positioning Information Update message includes the UE's 204 UE Tx TEG report received at stage 830, as described further below.

[0273] At stage 840, the involved gNBs 222 send NRPPa Measurement Response messages to the LMF 270. The NRPPa Measurement Response messages include the measurements of the UL-SRS transmissions measured at stage 825.

[0274] At stage 845a, the LMF 270 sends an NRPPa Positioning Deactivation message to the serving gNB 222. At stage 845b, the serving gNB 222 configures / instructs the UE 204 to deactivate (i.e., cease) transmission of the UL-SRS.

[0275] Referring back to stage 810a, the LMF 270 sends an NRPPa Positioning Information Request message to request positioning information from a gNB 222. In an aspect, an optional "Requested UE Tx TEG Report Configuration" parameter can be added to this message to indicate the UE Tx TEG report configuration to be provided to the UE 204 at stage 820c. A "UE Tx TEG Report Configuration" IE may include the following fields and example values:

IE/Group Name	Presence	IE Type and Reference	Semantics Description
TEG Timer	Optional	ENUMERATED (1, 5, 10, 16, 20, 32, 40, 64, 80, 128, 160, 320, 640, 1280, 2560)	According to 3GPP Technical Specification (TS) 38.331
Periodic TEG Timer	Optional	ENUMERATED (1, 5, 10, 16, 20, 32, 40, 64, 80, 128, 160, 320, sf640, 1280, 2560)	According to 3GPP TS 38.331
Number of periodic TEG reports	Optional	INTEGER (2.. 129)	According to 3GPP TS 38.331

Table 2

[0276] Note that a value of 129 for the number of periodic TEG reports corresponds to an "infinite" number of reports. That is, the LMF 270 requests that the serving gNB 222 configure the target UE 204 to report until the occurrence of some reconfiguration.

[0277] Referring back to stage 810c, the "SRS-Config" IE is used to configure UL-SRS transmissions. The configuration defines a list of SRS resources and a list of SRS resource sets. Each SRS resource set defines a set of SRS resources. The network (e.g., serving gNB 222) triggers the transmission of the set of SRS resources (at stage 815b) using a configured "aperiodicSRS-ResourceTrigger" (a Layer 1 DCI signal).

[0278] An "srs-Tx-TEG-ReportConfig" field can be added to the "SRS-Config" IE to indicate the requested UE Tx TEG report configuration to the UE 204. The "srs-Tx-TEG-ReportConfig" field points to an "SRS-Tx-TEG-ReportConfig" IE. **FIG. 9** illustrates an example "SRS-Tx-TEG-ReportConfig" IE 900, according to aspects of the disclosure. The following table describes some of the fields of an "NR-UL-Tx-TimingErrorGroup" IE.

tegTimer This field indicates when the UE should provide the UE Tx TEG Report MAC-CE. The "tegTimer" starts at the subframe of the first/latest/last SRS transmission. Value in number of subframes/slots. Value "sf1" corresponds to 1 subframe, "sf2" corresponds to 2 subframes, and so on.
periodicTegTimer This field indicates when the UE should provide periodic UE Tx TEG Report MAC-CEs. The "periodicTegTimer" starts at the subframe of the first SRS transmission. Value in number of subframes. Value "sf1" corresponds to 1 subframe, "sf2" corresponds to 2 subframes, and so on.
numberOfPeridicTegReports This field indicates the number of periodic UE Tx TEG Report MAC-CEs. Value 129 corresponds to "infinite."

Table 3

[0279] Referring back to stage 810d, the serving gNB 222 sends a Positioning Information Response message to the LMF 270 to provide positioning information. A "UE Tx TEG Report Configuration" IE can be added to this message to report the UE Tx TEG report configuration provided to the UE 204 at stage 810c.

[0280] Referring back to stage 830, a UE Tx TEG Report MAC-CE is identified by a MAC subheader with enhanced logical channel identifier (eLCID). **FIG. 10** illustrates an example UE Tx TEG Report MAC-CE 1000, according to aspects of the disclosure. A UE Tx TEG Report MAC-CE 1000 has a variable size and, as shown in FIG. 10, has the following fields. A "Positioning SRS Resource Set's Cell ID" field indicates the identity of the serving cell (e.g., serving gNB 222) that contains the positioning SRS resource sets. This field may alternatively, or additionally, include a BWP identifier for the BWP that contains the positioning SRS resource sets. A "Number of TEGs" field indicates the number 'M' of UE Tx timing error groups included in this UE Tx TEG Report MAC-CE 1000. A "TEG" field indicates a UE Tx TEG MAC-CE as described below with reference to FIG. 11.

[0281] **FIG. 11** illustrates an example UE Tx TEG MAC-CE 1100, according to aspects of the disclosure. A UE Tx TEG MAC-CE 1100 includes the following fields. A "TX Timing Error" field indicates the TX Timing Error as specified in 3GPP TS 37.355. A "TX

Timing Error Uncertainty" field indicates the (single-sided) uncertainty of the TX Timing Error as specified in 3GPP TS 37.355. A "Positioning SRS Resource Set ID" field indicates the SRS resource set ID. A "Cal" field indicates whether the UE Tx TEG is calibrated (e.g., set to '1') or not (e.g., set to '0'). A "Number of Resources N" field indicates the number of positioning SRS resource IDs included. If this field is zero, all positioning SRS resource IDs of the positioning SRS resource set ID belong to the TEG. A "Positioning SRS Resource ID" field indicates the SRS resource ID. The "R" fields represent a reserved bit, set to '0.'

[0282] Referring back to stage 835, the serving gNB 222 sends an NRPPa Positioning Information Update message to the LMF 270 to indicate that a change in the SRS configuration has occurred. A UE Tx TEG report IE can be added to this message to provide the UE Tx TEG information. A "UE Tx TEG Report" IE may include the following fields and example values:

IE/Group Name	**Presence**	**Range**	**IE Type and Reference**
UE TX TEG		1… <maxNoTEGs>	
>TX Timing Error	Optional		INTEGER (0..255)
>TX Timing Error Uncertainty	Optional		INTEGER (0..255)
>TEG Calibration Info	Optional		Table 5
>SRS Resources in TEG List		1… <maxNoResources>	
>>SRS Resource Set ID	Mandatory		INTEGER (0..15)
>>SRS Resource List		1… <maxNoResources perSet>	
>>>SRS Resource ID	Mandatory		INTEGER (0..63)

Table 4

[0283] Note that the semantics description of the "TX Timing Error" and "TX Timing Error Uncertainty" parameters may be specified according to 3GPP TS 37.355. The parameter "maxNoTEGs" is the maximum number of TEGs provided (e.g., 16). The parameter "maxNoResources" is the maximum number of SRS reosurce sets in the TEG (e.g., 16). The parameter "maxNoResourcesperSet" is the maximum number of SRS resources per SRS resource set (e.g., 16).

[0284] Referring to Table 4, the "TEG Calibration Info" parameter provides information about the UE Tx Time Delay calibration. A "TEG Calibration Info" IE may include the following fields and example values:

IE/Group Name	IE type and reference
CHOICE CalibrationTime	
>UTC Time	UTCTime
>SFN Time	
>>SFN	INTEGER (0... 1023)
>>CHOICE Slot	
>>SCS15	INTEGER (0... 9)
>>SCS30	INTEGER (0... 19)
>>SCS60	INTEGER (0... 39)
>>SCS120	INTEGER (0... 79)

Table 5

[0285] Note that in the above table, the slot choice is based on the subcarrier spacing (SCS) of 15, 30, 60, or 120 kHz.

[0286] **FIG. 12** illustrates an example method 1200 of wireless positioning, according to aspects of the disclosure. In an aspect, method 1200 may be performed by a UE (e.g., any of the UEs described herein).

[0287] At 1210, the UE receives, from a location server (e.g., LMF 270), a request to provide a UE Tx TEG report for an uplink-only position estimation procedure, as at stage 620. The request to provide the UE Tx TEG report may be included in an LPP request location information message for the uplink-only position estimation procedure. In an aspect, operation 1210 may be performed by the one or more WWAN transceivers 310, the one or more processors 332, memory 340, and/or positioning component 342, any or all of which may be considered means for performing this operation.

[0288] At 1220, the UE transmits one or more UL-SRS resources of at least one UL-SRS resource set during the uplink-only position estimation procedure. In an aspect, operation 1220 may be performed by the one or more WWAN transceivers 310, the one or more processors 332, memory 340, and/or positioning component 342, any or all of which may be considered means for performing this operation.

[0289] At 1230, the UE transmits the UE Tx TEG report to the location server, the UE Tx TEG report including at least one UE Tx TEG associated with transmission of the one or more UL-SRS resources of the at least one UL-SRS resource set, the at least one UE Tx TEG indicating that transmit timing errors of the transmission of the one or more UL-SRS resources of the at least one UL-SRS resource set are within a margin, as at stage 640. The UE Tx TEG report may be included in an LPP provide location information message for the uplink-only position estimation procedure. In an aspect, operation 1230 may be performed by the one or more WWAN transceivers 310, the one or more processors 332, memory 340, and/or positioning component 342, any or all of which may be considered means for performing this operation.

[0290] **FIG. 13** illustrates an example method 1300 of wireless positioning, according to aspects of the disclosure. In an aspect, method 1300 may be performed by a UE (e.g., any of the UEs described herein).

[0291] At 1310, the UE receives, from a serving base station (e.g., a gNB 222), a request to provide a UE Tx TEG report for an uplink-only position estimation procedure, as at stage 810c. The request to provide the UE Tx TEG report may be included in an SRS configuration for the one or more UL-SRS resources. In an aspect, operation 1310 may be performed by the one or more WWAN transceivers 310, the one or more processors 332, memory 340, and/or positioning component 342, any or all of which may be considered means for performing this operation.

[0292] At 1320, the UE transmits one or more UL-SRS resources of at least one UL-SRS resource set during the uplink-only position estimation procedure. In an aspect, operation 1320 may be performed by the one or more WWAN transceivers 310, the one or more processors 332, memory 340, and/or positioning component 342, any or all of which may be considered means for performing this operation.

[0293] At 1330, the UE transmits the UE Tx TEG report to the serving base station, the UE Tx TEG report including at least one UE Tx TEG associated with transmission of the one or more UL-SRS resources of the at least one UL-SRS resource set, the at least one UE Tx

TEG indicating that transmit timing errors of the transmission of the one or more UL-SRS resources of the at least one UL-SRS resource set are within a margin, as at stage 830. The UE Tx TEG report may be included in an RRC message or a MAC-CE. In an aspect, operation 1330 may be performed by the one or more WWAN transceivers 310, the one or more processors 332, memory 340, and/or positioning component 342, any or all of which may be considered means for performing this operation.

[0294] **FIG. 14** illustrates an example method 1400 of positioning, according to aspects of the disclosure. In an aspect, method 1400 may be performed by a location server (e.g., LMF 270).

[0295] At 1410, the location server transmits, to a UE (e.g., any of the UEs described herein), a request for the UE to provide a UE Tx TEG report for an uplink-only position estimation procedure, as at stage 620. The request to provide the UE Tx TEG report may be included in an LPP request location information message for the uplink-only position estimation procedure. In an aspect, operation 1410 may be performed by the one or more network transceivers 390, the one or more processors 394, memory 396, and/or positioning component 398, any or all of which may be considered means for performing this operation.

[0296] At 1420, the location server receives the UE Tx TEG report from the UE, the UE Tx TEG report including at least one UE Tx TEG associated with transmission, by the UE, of one or more UL-SRS resources of at least one UL-SRS resource set, the at least one UE Tx TEG indicating that transmit timing errors of the transmission of the one or more UL-SRS resources of the at least one UL-SRS resource set are within a margin, as at stage 640. The UE Tx TEG report may be included in an LPP provide location information message for the uplink-only position estimation procedure. In an aspect, operation 1420 may be performed by the one or more network transceivers 390, the one or more processors 394, memory 396, and/or positioning component 398, any or all of which may be considered means for performing this operation.

[0297] **FIG. 15** illustrates an example method 1500 of positioning, according to aspects of the disclosure. In an aspect, method 1500 may be performed by a serving base station (e.g., a gNB 222).

[0298] At 1510, the serving base station transmits, to a UE (e.g., any of the UEs described herein), a request for the UE to provide a UE Tx TEG report for an uplink-only position estimation procedure, as at stage 810c. The request to provide the UE Tx TEG report

may be included in an UL-SRS configuration for one or more UL-SRS resources of at least one UL-SRS resource set. In an aspect, operation 1510 may be performed by the one or more WWAN transceivers 350, the one or more network transceivers 380, the one or more processors 384, memory 386, and/or positioning component 388, any or all of which may be considered means for performing this operation.

[0299] At 1520, the serving base station receives the UE Tx TEG report from the UE, the UE Tx TEG report including at least one UE Tx TEG associated with transmission, by the UE, of the one or more UL-SRS resources of the at least one UL-SRS resource set, the at least one UE Tx TEG indicating that transmit timing errors of the transmission of the one or more UL-SRS resources of the at least one UL-SRS resource set are within a margin, as at stage 830. The UE Tx TEG report may be included in an RRC message or a MAC-CE. In an aspect, operation 1320 may be performed by the one or more WWAN transceivers 350, the one or more network transceivers 380, the one or more processors 384, memory 386, and/or positioning component 388, any or all of which may be considered means for performing this operation.

[0300] As will be appreciated, a technical advantage of the methods 1200 and 1300 is the reporting of UE Tx TEGs for uplink-only position estimation procedures.

[0301] As discussed above with respect to 640 of FIG. 6B and 830 of FIG. 8B, a UE may provide a UE Tx TEG report after transmission of UL-SRS. In particular, the UE Tx TEG report may arrive at the LMF after the LMF has received some or all of the UL-SRS measurements from the gNBs involved is the position estimation procedure. Accordingly, the UE Tx TEG report may delay processing of the UL-SRS at the LMF, which in turn delays the position estimation procedure.

[0302] Aspects of the disclosure are thereby directed to an early indication of an expected (e.g., or predicted or committed) association between at least one UE Tx TEG and a SRS for a position estimation procedure (e.g., UL-only for UL-TDOA or angle measurement, or DL+UL for RTT, etc.). While there is some risk because the expected association may be incorrect(e.g., due to active BWP switch, RRC reconfiguration, UL-SRS resource reconfiguration, DRX OFF transition, etc.), in some aspects, the early indication of the expected association may facilitate a position estimation entity (e.g., LMF, or UE for UE-based position estimation, etc.) to begin processing of UL-SRS earlier. Such aspects may provide various technical advantages, such as faster position estimation of a target UE.

[0303] **FIG. 16** illustrates an example method 1600 of positioning, according to aspects of the disclosure. In an aspect, method 1600 may be performed by a UE (e.g., UE 302).

[0304] At 1610, UE 302 (e.g., processor(s) 332, positioning component 342, etc.) determines an expected association between at least one UE Tx TEG and a SRS a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin. In some designs, the position estimation procedure may be UL-only for UL-TDOA or angle measurement, or DL+UL for RTT, etc. In some designs, the expected association may be determined as a current association between the at least one UE Tx TEG and the SRS when the determination of 1610 is performed (e.g., responsive to some triggering event, such as activation of SRS configuration in case of SP-SRS, or receipt of SRS configuration for AP-SRS, etc.). In other designs, the UE may be aware of a possible or likely upcoming change in UE Tx. For example, UE has switched on both panels in the current scenario for the purpose of servicing a high-priority/ultra-reliable/low-latency demanding communication scenario for a limited time, but the UE knows that it will switch off one of the panels when this high priority transmission ends. In another example, UE has received an activation command of a signal in the future which is now turned off, so UE knows that UE will do a change into how the antennas map into the resources. In another example, UE is configured with semi-persistent traffic for which UE decides a different antenna-to-resource mapping or for which antennas are powered on. The UE determines that the SRS for positioning will be transmitted while the UE is transmitting the semi-persistent traffic, and therefore the expected association may be different than the current association

[0305] At 1620, UE 302 (e.g., transmitter 314 or 324, etc.) transmits an indication of the expected association.

[0306] At 1630, UE 302 (e.g., transmitter 314 or 324, etc.) transmits, after the transmission of the indication, the SRS on one or more UL-SRS resources of at least one UL-SRS resource set during the position estimation procedure.

[0307] **FIG. 17** illustrates an example method 1700 of positioning, according to aspects of the disclosure. In an aspect, method 1700 may be performed by a position estimation entity (e.g., LMF integrated at gNB such as BS 304 or core network such as network entity 306, other location server, UE for UE-based position estimation, etc.).

[0308] At 1710, the position estimation entity (e.g., receiver 312 or 322 or 352 or 362, network transceiver(s) 380 or 390, etc.) receives, from a UE, an indication of an expected

association between at least one UE Tx TEG and a SRS for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin. In some designs, the position estimation procedure may be UL-only for UL-TDOA or angle measurement, or DL+UL for RTT, etc.

[0309] At 1720, the position estimation entity (e.g., processor(s) 332 or 384 or 394, positioning component 342 or 388 or 398, etc.) processes measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

[0310] Referring to FIGS. 16-17, in some designs, UE 302 may further transmit a UE Tx TEG report for the position estimation procedure to a position estimation entity. In some designs, assume that the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association. In this case, in some designs, the UE Tx TEG report includes a positive acknowledgment of the expected association (e.g., the expected association is ACKed). the UE Tx TEG report omits a negative acknowledgment of the expected association (e.g., the expected association is not NACKed). In other designs, if the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association, a supplemental UE Tx TEG report can be omitted altogether (e.g., the lack of a 'corrective' UE Tx TEG report within a threshold period of time is interpreted at the position estimation entity as confirmatory of the earlier indication of the expected indication). In other designs, assume that the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via one or more other UE Tx TEGs that are different than the at least UE Tx TEG in discordance with the expected association. In other words, the expected association turns out to be incorrect (e.g., bad prediction). In this case, the UE Tx TEG report includes a negative acknowledgment of the expected association, or the UE Tx TEG report includes an indication of the one or more other UE Tx TEGs, or a combination thereof. In some designs, the UE Tx TEG report may be optional if the expected association is correct, and the UE Tx TEG report may be mandatory if the expected association is incorrect.

[0311] Referring to FIGS. 16-17, in some designs as noted above, a supplemental or post-SRS UE Tx TEG report may be optional or conditional (e.g., sent only if the expected association turns out to be incorrect). In some designs, the supplemental or post-SRS UE Tx TEG report may have the format of an "error message". Alternatively, the

supplemental or post-SRS UE Tx TEG report may have the same format as the TxTEG report that is sent before the SRS (e.g., with different values to indicate the "true" Tx TEG information). In some designs, the indication of the expected association (or "early" UL Tx TEG report) and the supplemental or post-SRS UE Tx TEG report may be configured differently. For example, if there is a timestamp in the UE Tx TEG report, and that timestamp corresponds to an SRS in the past, then this UE Tx TEG report indicates "an actual TxTEG" used (or indication of actual association). Alternatively, if there is a timestamp in the report, and that timestamp corresponds to an SRS in the future, then this UE Tx TEG report is "an intended TxTEG" (or indication of expected association).

[0312] Referring to FIGS. 16-17, in some designs, the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof. For example, the timestamp, time-domain window, and/or number of SRS instances may designate when the expected association is valid (e.g., while valid, the expected association may be used for processing of positioning measurements for position estimation).

[0313] Referring to FIGS. 16-17, in some designs, the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association (e.g., TxTEG <> SRS resource). In other designs, the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS (e.g., TxTEG <> Spatial-Relation-Info <> SRS resource). In other designs, the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS (e.g., TxTEG <> PathLossReference <> SRS resource).

[0314] Referring to FIGS. 16-17, in some designs, the expected association remain may valid (e.g., subject to other constraint(s), such as the above noted timestamp, time-domain window, and/or number of SRS instances, etc.) until a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF (or Inactive time) (e.g., between the indication of the expected association and the SRS transmission), or any combination thereof.

[0315] Referring to FIGS. 16-17, in some designs, the SRS corresponds to an instance of a semi-persistent (SP) SRS. In some designs, the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted via uplink media access control control element (MAC-CE). receiving an activation of a configuration of the SRS for the position estimation procedure, the indication of the expected association between the at least one UE Tx TEG and the transmission of the SRS is transmitted in response to the activation.

[0316] Referring to FIGS. 16-17, in some designs, the SRS corresponds to an aperiodic (AP) SRS. In some designs, UE 302 may receive a configuration of the SRS for the position estimation procedure, and the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted in response to the configuration (e.g., rather than in response to activation of a previously received configuration as in SP SRS, as noted above). In other designs, the indication of the expected association can be skipped for AP SRS.

[0317] Referring to FIGS. 16-17, in some designs, the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure (e.g., although, still before transmission of SRS).

[0318] Referring to FIGS. 16-17, in some designs, the indication of the expected association is further transmitted in conjunction with an associated confidence level. For example, the confidence level may be factored into the measurement information processing at 1720 of FIG. 17 at the position estimation entity (e.g., if below threshold, ignore measurement information or de-weight measurement information, etc.).

[0319] FIGS. 18A-18B illustrate an example implementation 1800 of the processes 1600-1700 of FIGS. 16-17 in accordance with aspects of the disclosure. In FIGS. 18A-18B, the UE performing the process of FIG. 16 corresponds to UE 204, and the position estimation entity performing the process 1700 of FIG. 17 corresponds to LMF 270. Moreover, FIGS. 18A-18B correspond to a modified implementation of the process 600 of FIGS. 6A-6B, with like-numbered operations in FIGS. 18A-18B corresponding to those described above with respect to FIGS. 6A-6B. In FIG. 18A, the indication of the expected association is transmitted form UE 204 to LMF 270 at 1805 as an LPP Provide Location Information message responsive to the LPP Request Location Information message from 620. In FIG. 18B, the supplemental or post-SRS Tx TEG report is transmitted from UE 204 to LMF

270 at 1840 as an LPP Provide Location Information message. In some designs, the LPP Provide Location Information message at 1840 may be configured similarly to the LPP Provide Location Information message at 640, although the LPP Provide Location Information message at 1840 may alternatively be configured differently (e.g., configured as an error message, or only indicating the information that was incorrect, or providing an ACK to the LPP Provide Location Information message from 1805 which provided the early indication of the expected association, etc.). Also, as noted above, the LPP Provide Location Information message at 1840 may be optional and can be omitted in some implementations (e.g., if the LPP Provide Location Information message at 1805 is correct, then in some designs the LPP Provide Location Information message at 1805 may be ACKed implicitly by not sending the LPP Provide Location Information message at 1840).

[0320] FIGS. 19A-19B illustrate an example implementation 1900 of the processes 1600-1700 of FIGS. 16-17 in accordance with aspects of the disclosure. In FIGS. 19A-19B, the UE performing the process of FIG. 16 corresponds to UE 204, and the position estimation entity performing the process 1700 of FIG. 17 corresponds to LMF 270. Moreover, FIGS. 19A-19B correspond to a modified implementation of the process 600 of FIGS. 6A-6B, with like-numbered operations in FIGS. 19A-19B corresponding to those described above with respect to FIGS. 8A-8B. In FIG. 19A, the indication of the expected association is transmitted form UE 204 to LMF 270 at 1905 as MAC-CE or RRC message signaling in response to the Active UE SRS transmission signaling from 815b. In FIG. 19B, the supplemental or post-SRS Tx TEG report is transmitted from UE 204 to LMF 270 at 1930 as MAC-CE or RRC message signaling. In some designs, the MAC-CE or RRC message signaling at 1930 may be configured similarly to the MAC-CE or RRC message signaling at 830, although the MAC-CE or RRC message signaling at 1930 may alternatively be configured differently (e.g., configured as an error message, or only indicating the information that was incorrect, or providing an ACK to the MAC-CE or RRC message signaling at 1905 which provided the early indication of the expected association, etc.). Also, as noted above, the MAC-CE or RRC message signaling at 1930 may be optional and can be omitted in some implementations (e.g., if the MAC-CE or RRC message signaling at 1905 is correct, then in some designs the MAC-CE or RRC message signaling at 1905 may be ACKed implicitly by not sending the MAC-CE or RRC message signaling at 1930).

[0321] In the detailed description above it can be seen that different features are grouped together in examples. This manner of disclosure should not be understood as an intention that the example clauses have more features than are explicitly mentioned in each clause. Rather, the various aspects of the disclosure may include fewer than all features of an individual example clause disclosed. Therefore, the following clauses should hereby be deemed to be incorporated in the description, wherein each clause by itself can stand as a separate example. Although each dependent clause can refer in the clauses to a specific combination with one of the other clauses, the aspect(s) of that dependent clause are not limited to the specific combination. It will be appreciated that other example clauses can also include a combination of the dependent clause aspect(s) with the subject matter of any other dependent clause or independent clause or a combination of any feature with other dependent and independent clauses. The various aspects disclosed herein expressly include these combinations, unless it is explicitly expressed or can be readily inferred that a specific combination is not intended (e.g., contradictory aspects, such as defining an element as both an insulator and a conductor). Furthermore, it is also intended that aspects of a clause can be included in any other independent clause, even if the clause is not directly dependent on the independent clause.

[0322] Implementation examples are described in the following numbered clauses:

[0323] Clause 1. A method of operating a user equipment (UE), comprising: determining an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; transmitting an indication of the expected association; and transmitting, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

[0324] Clause 2. The method of clause 1, further comprising: transmitting a UE Tx TEG report for the position estimation procedure to a position estimation entity.

[0325] Clause 3. The method of clause 2, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association.

[0326] Clause 4. The method of clause 3, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association.

[0327] Clause 5. The method of any of clauses 3 to 4, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association.

[0328] Clause 6. The method of any of clauses 2 to 5, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via one or more other UE Tx TEGs that are different than the at least UE Tx TEG in discordance with the expected association.

[0329] Clause 7. The method of clause 6, wherein the UE Tx TEG report includes a negative acknowledgment of the expected association, or wherein the UE Tx TEG report includes an indication of the one or more other UE Tx TEGs, or a combination thereof.

[0330] Clause 8. The method of any of clauses 1 to 7, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0331] Clause 9. The method of any of clauses 1 to 8, wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0332] Clause 10. The method of any of clauses 1 to 9, wherein the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0333] Clause 11. The method of any of clauses 1 to 10, wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS.

[0334] Clause 12. The method of clause 11, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted via uplink media access control control element (MAC-CE).

[0335] Clause 13. The method of any of clauses 11 to 12, further comprising: receiving an activation of a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the transmission of the SRS is transmitted in response to the activation.

[0336] Clause 14. The method of any of clauses 1 to 13, wherein the SRS corresponds to an aperiodic (AP) SRS.

[0337] Clause 15. The method of clause 14, receiving a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted in response to the configuration.

[0338] Clause 16. The method of any of clauses 1 to 15, wherein the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0339] Clause 17. The method of any of clauses 1 to 16, wherein the indication of the expected association is further transmitted in conjunction with an associated confidence level.

[0340] Clause 18. A method of operating a position estimation entity, comprising: receiving, from a user equipment (UE), an indication of an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and processing measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

[0341] Clause 19. The method of clause 18, further comprising: receiving, from the UE, a UE Tx TEG report for the position estimation procedure.

[0342] Clause 20. The method of clause 19, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0343] Clause 21. The method of any of clauses 19 to 20, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0344] Clause 22. The method of any of clauses 19 to 21, wherein the UE Tx TEG report includes a negative acknowledgment of the expected association to indicate transmission of the SRS in discordance with the expected association, or wherein the UE Tx TEG report includes an indication of one or more other UE Tx TEGs associated with the transmission of the SRS, or a combination thereof.

[0345] Clause 23. The method of any of clauses 18 to 22, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0346] Clause 24. The method of any of clauses 18 to 23, wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0347] Clause 25. The method of any of clauses 18 to 24, wherein the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0348] Clause 26. The method of any of clauses 18 to 25, wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS, or wherein the SRS corresponds to an aperiodic (AP) SRS.

[0349] Clause 27. The method of any of clauses 18 to 26, wherein the indication of the expected association is received from the UE prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0350] Clause 28. The method of any of clauses 18 to 27, wherein the indication of the expected association is further received in conjunction with an associated confidence level.

[0351] Clause 29. 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, the at least one processor configured to: determine an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; transmit, via the at least one transceiver, an indication of the expected association; and transmit, via the at least one transceiver, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

[0352] Clause 30. The UE of any of clauses 1 to 29, wherein the at least one processor is further configured to: transmit, via the at least one transceiver, a UE Tx TEG report for the position estimation procedure to a position estimation entity.

[0353] Clause 31. The UE of any of clauses 2 to 30, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association.

[0354] Clause 32. The UE of any of clauses 3 to 31, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association.

[0355] Clause 33. The UE of any of clauses 3 to 32, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association.

[0356] Clause 34. The UE of any of clauses 2 to 33, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via one or more other UE Tx TEGs that are different than the at least UE Tx TEG in discordance with the expected association.

[0357] Clause 35. The UE of any of clauses 6 to 34, wherein the UE Tx TEG report includes a negative acknowledgment of the expected association, or wherein the UE Tx TEG report includes an indication of the one or more other UE Tx TEGs, or a combination thereof.

[0358] Clause 36. The UE of any of clauses 1 to 35, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0359] Clause 37. The UE of any of clauses 1 to 36, wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0360] Clause 38. The UE of any of clauses 1 to 37, wherein the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0361] Clause 39. The UE of any of clauses 1 to 38, wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS.

[0362] Clause 40. The UE of any of clauses 11 to 39, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted via uplink media access control control element (MAC-CE).

[0363] Clause 41. The UE of any of clauses 11 to 40, wherein the at least one processor is further configured to: receive, via the at least one transceiver, an activation of a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the transmission of the SRS is transmitted in response to the activation.

[0364] Clause 42. The UE of any of clauses 1 to 41, wherein the SRS corresponds to an aperiodic (AP) SRS.

[0365] Clause 43. The UE of any of clauses 14 to 42, receive, via the at least one transceiver, a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted in response to the configuration.

[0366] Clause 44. The UE of any of clauses 1 to 43, wherein the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0367] Clause 45. The UE of any of clauses 1 to 44, wherein the indication of the expected association is further transmitted in conjunction with an associated confidence level.

[0368] Clause 46. A position estimation entity, comprising: a memory; at least one transceiver; and at least one processor communicatively coupled to the memory and the at least one transceiver, the at least one processor configured to: receive, via the at least one transceiver, from a user equipment (UE), an indication of an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and process measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

[0369] Clause 47. The position estimation entity of any of clauses 18 to 46, wherein the at least one processor is further configured to: receive, via the at least one transceiver, from the UE, a UE Tx TEG report for the position estimation procedure.

[0370] Clause 48. The position estimation entity of any of clauses 19 to 47, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0371] Clause 49. The position estimation entity of any of clauses 19 to 48, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0372] Clause 50. The position estimation entity of any of clauses 19 to 49, wherein the UE Tx TEG report includes a negative acknowledgment of the expected association to indicate transmission of the SRS in discordance with the expected association, or wherein the UE Tx TEG report includes an indication of one or more other UE Tx TEGs associated with the transmission of the SRS, or a combination thereof.

[0373] Clause 51. The position estimation entity of any of clauses 18 to 50, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0374] Clause 52. The position estimation entity of any of clauses 18 to 51, wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0375] Clause 53. The position estimation entity of any of clauses 18 to 52, wherein the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0376] Clause 54. The position estimation entity of any of clauses 18 to 53, wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS, or wherein the SRS corresponds to an aperiodic (AP) SRS.

[0377] Clause 55. The position estimation entity of any of clauses 18 to 54, wherein the indication of the expected association is received from the UE prior to a maximum

permitted time subsequent to a triggering event associated with the position estimation procedure.

[0378] Clause 56. The position estimation entity of any of clauses 18 to 55, wherein the indication of the expected association is further received in conjunction with an associated confidence level.

[0379] Clause 57. A user equipment (UE), comprising: means for determining an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; means for transmitting an indication of the expected association; and means for transmitting, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

[0380] Clause 58. The UE of any of clauses 29 to 57, further comprising: means for transmitting a UE Tx TEG report for the position estimation procedure to a position estimation entity.

[0381] Clause 59. The UE of any of clauses 30 to 58, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association.

[0382] Clause 60. The UE of any of clauses 31 to 59, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association.

[0383] Clause 61. The UE of any of clauses 31 to 60, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association.

[0384] Clause 62. The UE of any of clauses 30 to 61, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via one or more other UE Tx TEGs that are different than the at least UE Tx TEG in discordance with the expected association.

[0385] Clause 63. The UE of any of clauses 34 to 62, wherein the UE Tx TEG report includes a negative acknowledgment of the expected association, or wherein the UE Tx TEG report includes an indication of the one or more other UE Tx TEGs, or a combination thereof.

[0386] Clause 64. The UE of any of clauses 29 to 63, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0387] Clause 65. The UE of any of clauses 29 to 64, wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or wherein

the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0388] Clause 66. The UE of any of clauses 29 to 65, wherein the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0389] Clause 67. The UE of any of clauses 29 to 66, wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS.

[0390] Clause 68. The UE of any of clauses 39 to 67, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted via uplink media access control control element (MAC-CE).

[0391] Clause 69. The UE of any of clauses 39 to 68, further comprising: means for receiving an activation of a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the transmission of the SRS is transmitted in response to the activation.

[0392] Clause 70. The UE of any of clauses 29 to 69, wherein the SRS corresponds to an aperiodic (AP) SRS.

[0393] Clause 71. The UE of any of clauses 42 to 70, means for receiving a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted in response to the configuration.

[0394] Clause 72. The UE of any of clauses 29 to 71, wherein the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0395] Clause 73. The UE of any of clauses 29 to 72, wherein the indication of the expected association is further transmitted in conjunction with an associated confidence level.

[0396] Clause 74. A position estimation entity, comprising: means for receiving, from a user equipment (UE), an indication of an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a

position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and means for processing measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

[0397] Clause 75. The position estimation entity of any of clauses 46 to 74, further comprising: means for receiving, from the UE, a UE Tx TEG report for the position estimation procedure.

[0398] Clause 76. The position estimation entity of any of clauses 47 to 75, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0399] Clause 77. The position estimation entity of any of clauses 47 to 76, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0400] Clause 78. The position estimation entity of any of clauses 47 to 77, wherein the UE Tx TEG report includes a negative acknowledgment of the expected association to indicate transmission of the SRS in discordance with the expected association, or wherein the UE Tx TEG report includes an indication of one or more other UE Tx TEGs associated with the transmission of the SRS, or a combination thereof.

[0401] Clause 79. The position estimation entity of any of clauses 46 to 78, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0402] Clause 80. The position estimation entity of any of clauses 46 to 79, wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0403] Clause 81. The position estimation entity of any of clauses 46 to 80, wherein the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources,

or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0404] Clause 82. The position estimation entity of any of clauses 46 to 81, wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS, or wherein the SRS corresponds to an aperiodic (AP) SRS.

[0405] Clause 83. The position estimation entity of any of clauses 46 to 82, wherein the indication of the expected association is received from the UE prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0406] Clause 84. The position estimation entity of any of clauses 46 to 83, wherein the indication of the expected association is further received in conjunction with an associated confidence level.

[0407] Clause 85. A non-transitory computer-readable medium storing computer-executable instructions that, when executed by a user equipment (UE), cause the UE to: determine an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; transmit an indication of the expected association; and transmit, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

[0408] Clause 86. The non-transitory computer-readable medium of any of clauses 57 to 85, wherein the instructions further cause the UE to: transmit a UE Tx TEG report for the position estimation procedure to a position estimation entity.

[0409] Clause 87. The non-transitory computer-readable medium of any of clauses 58 to 86, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association.

[0410] Clause 88. The non-transitory computer-readable medium of any of clauses 59 to 87, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association.

[0411] Clause 89. The non-transitory computer-readable medium of any of clauses 59 to 88, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association.

[0412] Clause 90. The non-transitory computer-readable medium of any of clauses 58 to 89, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via one or more other UE Tx TEGs that are different than the at least UE Tx TEG in discordance with the expected association.

[0413] Clause 91. The non-transitory computer-readable medium of any of clauses 62 to 90, wherein the UE Tx TEG report includes a negative acknowledgment of the expected association, or wherein the UE Tx TEG report includes an indication of the one or more other UE Tx TEGs, or a combination thereof.

[0414] Clause 92. The non-transitory computer-readable medium of any of clauses 57 to 91, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0415] Clause 93. The non-transitory computer-readable medium of any of clauses 57 to 92, wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0416] Clause 94. The non-transitory computer-readable medium of any of clauses 57 to 93, wherein the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0417] Clause 95. The non-transitory computer-readable medium of any of clauses 57 to 94, wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS.

[0418] Clause 96. The non-transitory computer-readable medium of any of clauses 67 to 95, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted via uplink media access control control element (MAC-CE).

[0419] Clause 97. The non-transitory computer-readable medium of any of clauses 67 to 96, wherein the instructions further cause the UE to: receive an activation of a configuration

of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the transmission of the SRS is transmitted in response to the activation.

[0420] Clause 98. The non-transitory computer-readable medium of any of clauses 57 to 97, wherein the SRS corresponds to an aperiodic (AP) SRS.

[0421] Clause 99. The non-transitory computer-readable medium of any of clauses 70 to 98, receive a configuration of the SRS for the position estimation procedure, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted in response to the configuration.

[0422] Clause 100. The non-transitory computer-readable medium of any of clauses 57 to 99, wherein the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0423] Clause 101. The non-transitory computer-readable medium of any of clauses 57 to 100, wherein the indication of the expected association is further transmitted in conjunction with an associated confidence level.

[0424] Clause 102. A non-transitory computer-readable medium storing computer-executable instructions that, when executed by a position estimation entity, cause the position estimation entity to: receive, from a user equipment (UE), an indication of an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and process measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

[0425] Clause 103. The non-transitory computer-readable medium of any of clauses 74 to 102, wherein the instructions further cause the position estimation entity to: receive, from the UE, a UE Tx TEG report for the position estimation procedure.

[0426] Clause 104. The non-transitory computer-readable medium of any of clauses 75 to 103, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

[0427] Clause 105. The non-transitory computer-readable medium of any of clauses 75 to 104, wherein the UE Tx TEG report omits a negative acknowledgment of the expected

association to confirm transmission of the SRS in accordance with the expected association.

[0428] Clause 106. The non-transitory computer-readable medium of any of clauses 75 to 105, wherein the UE Tx TEG report includes a negative acknowledgment of the expected association to indicate transmission of the SRS in discordance with the expected association, or wherein the UE Tx TEG report includes an indication of one or more other UE Tx TEGs associated with the transmission of the SRS, or a combination thereof.

[0429] Clause 107. The non-transitory computer-readable medium of any of clauses 74 to 106, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

[0430] Clause 108. The non-transitory computer-readable medium of any of clauses 74 to 107, wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

[0431] Clause 109. The non-transitory computer-readable medium of any of clauses 74 to 108, wherein the expected association remains valid until: a reconfiguration of the one or more UL-SRS resources, or a radio resource control (RRC) reconfiguration, or a bandwidth part (BWP) switch, or a transition to discontinuous reception (DRX) OFF, or any combination thereof.

[0432] Clause 110. The non-transitory computer-readable medium of any of clauses 74 to 109, wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS, or wherein the SRS corresponds to an aperiodic (AP) SRS.

[0433] Clause 111. The non-transitory computer-readable medium of any of clauses 74 to 110, wherein the indication of the expected association is received from the UE prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

[0434] Clause 112. The non-transitory computer-readable medium of any of clauses 74 to 111, wherein the indication of the expected association is further received in conjunction with an associated confidence level.

[0435] 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.

[0436] Further, those of skill in the art will appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the aspects disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present disclosure.

[0437] 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 digital signal processor (DSP), an ASIC, a field-programable gate array (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, for example, 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.

[0438] 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.

[0439] 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 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.

[0440] While the foregoing disclosure shows illustrative aspects of the disclosure, it should be noted that various changes and modifications could be made herein without departing

from the scope of the disclosure as defined by the appended claims. The functions, steps and/or actions of the method claims in accordance with the aspects of the disclosure described herein need not be performed in any particular order. Furthermore, although elements of the disclosure may be described or claimed in the singular, the plural is contemplated unless limitation to the singular is explicitly stated.

CLAIMS

What is claimed is:

1. A method of operating a user equipment (UE), comprising:

determining an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin;

transmitting an indication of the expected association; and

transmitting, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

2. The method of claim 1, further comprising:

transmitting a UE Tx TEG report for the position estimation procedure to a position estimation entity.

3. The method of claim 2, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association.

4. The method of claim 3, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association.

5. The method of claim 3, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association.

6. The method of claim 2, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via one or more other UE Tx TEGs that are different than the at least UE Tx TEG in discordance with the expected association.

7. The method of claim 6,

wherein the UE Tx TEG report includes a negative acknowledgment of the expected association, or

wherein the UE Tx TEG report includes an indication of the one or more other UE Tx TEGs, or

a combination thereof.

8. The method of claim 1, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

9. The method of claim 1,

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

10. The method of claim 1, wherein the expected association remains valid until:

a reconfiguration of the one or more UL-SRS resources, or

a radio resource control (RRC) reconfiguration, or

a bandwidth part (BWP) switch, or

a transition to discontinuous reception (DRX) OFF, or

any combination thereof.

11. The method of claim 1, wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS.

12. The method of claim 11, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted via uplink media access control control element (MAC-CE).

13. The method of claim 11, further comprising:

receiving an activation of a configuration of the SRS for the position estimation procedure,

wherein the indication of the expected association between the at least one UE Tx TEG and the transmission of the SRS is transmitted in response to the activation.

14. The method of claim 1, wherein the SRS corresponds to an aperiodic (AP) SRS.

15. The method of claim 14,

receiving a configuration of the SRS for the position estimation procedure,

wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted in response to the configuration.

16. The method of claim 1, wherein the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

17. The method of claim 1, wherein the indication of the expected association is further transmitted in conjunction with an associated confidence level.

18. A method of operating a position estimation entity, comprising:

receiving, from a user equipment (UE), an indication of an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and

processing measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

19. The method of claim 18, further comprising:

receiving, from the UE, a UE Tx TEG report for the position estimation procedure.

20. The method of claim 19, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

21. The method of claim 19, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

22. The method of claim 19,

wherein the UE Tx TEG report includes a negative acknowledgment of the expected association to indicate transmission of the SRS in discordance with the expected association, or

wherein the UE Tx TEG report includes an indication of one or more other UE Tx TEGs associated with the transmission of the SRS, or

a combination thereof.

23. The method of claim 18, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

24. The method of claim 18,

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

25. The method of claim 18, wherein the expected association remains valid until:

a reconfiguration of one or more uplink SRS (UL-SRS) resources, or
a radio resource control (RRC) reconfiguration, or
a bandwidth part (BWP) switch, or
a transition to discontinuous reception (DRX) OFF, or
any combination thereof.

26. The method of claim 18,
wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS, or
wherein the SRS corresponds to an aperiodic (AP) SRS.

27. The method of claim 18, wherein the indication of the expected association is received from the UE prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

28. The method of claim 18, wherein the indication of the expected association is further received in conjunction with an associated confidence level.

29. 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, the at least one processor configured to:
determine an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin;
transmit, via the at least one transceiver, an indication of the expected association; and

transmit, via the at least one transceiver, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

30. The UE of claim 29, wherein the at least one processor is further configured to:

transmit, via the at least one transceiver, a UE Tx TEG report for the position estimation procedure to a position estimation entity.

31. The UE of claim 30, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association.

32. The UE of claim 31, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association.

33. The UE of claim 31, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association.

34. The UE of claim 30, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via one or more other UE Tx TEGs that are different than the at least UE Tx TEG in discordance with the expected association.

35. The UE of claim 34,

wherein the UE Tx TEG report includes a negative acknowledgment of the expected association, or

wherein the UE Tx TEG report includes an indication of the one or more other UE Tx TEGs, or

a combination thereof.

36. The UE of claim 29, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

37. The UE of claim 29,

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

38. The UE of claim 29, wherein the expected association remains valid until:

a reconfiguration of the one or more UL-SRS resources, or

a radio resource control (RRC) reconfiguration, or

a bandwidth part (BWP) switch, or

a transition to discontinuous reception (DRX) OFF, or

any combination thereof.

39. The UE of claim 29, wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS.

40. The UE of claim 39, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted via uplink media access control control element (MAC-CE).

41. The UE of claim 39, wherein the at least one processor is further configured to:

receive, via the at least one transceiver, an activation of a configuration of the SRS for the position estimation procedure,

wherein the indication of the expected association between the at least one UE Tx TEG and the transmission of the SRS is transmitted in response to the activation.

42. The UE of claim 29, wherein the SRS corresponds to an aperiodic (AP) SRS.

43. The UE of claim 42,

receive, via the at least one transceiver, a configuration of the SRS for the position estimation procedure,

wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted in response to the configuration.

44. The UE of claim 29, wherein the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

45. The UE of claim 29, wherein the indication of the expected association is further transmitted in conjunction with an associated confidence level.

46. A position estimation entity, comprising:

a memory;

at least one transceiver; and

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

receive, via the at least one transceiver, from a user equipment (UE), an indication of an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and

process measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

47. The position estimation entity of claim 46, wherein the at least one processor is further configured to:

receive, via the at least one transceiver, from the UE, a UE Tx TEG report for the position estimation procedure.

48. The position estimation entity of claim 47, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

49. The position estimation entity of claim 47, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

50. The position estimation entity of claim 47,

wherein the UE Tx TEG report includes a negative acknowledgment of the expected association to indicate transmission of the SRS in discordance with the expected association, or

wherein the UE Tx TEG report includes an indication of one or more other UE Tx TEGs associated with the transmission of the SRS, or

a combination thereof.

51. The position estimation entity of claim 46, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

52. The position estimation entity of claim 46,

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

53. The position estimation entity of claim 46, wherein the expected association remains valid until:

a reconfiguration of one or more uplink SRS (UL-SRS) resources, or

a radio resource control (RRC) reconfiguration, or

a bandwidth part (BWP) switch, or

a transition to discontinuous reception (DRX) OFF, or

any combination thereof.

54. The position estimation entity of claim 46,

wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS, or

wherein the SRS corresponds to an aperiodic (AP) SRS.

55. The position estimation entity of claim 46, wherein the indication of the expected association is received from the UE prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

56. The position estimation entity of claim 46, wherein the indication of the expected association is further received in conjunction with an associated confidence level.

57. A user equipment (UE), comprising:

means for determining an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin;

means for transmitting an indication of the expected association; and

means for transmitting, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

58. The UE of claim 57, further comprising:

means for transmitting a UE Tx TEG report for the position estimation procedure to a position estimation entity.

59. The UE of claim 57, wherein the indication of the expected association is further transmitted in conjunction with an associated confidence level.

60. A position estimation entity, comprising:

means for receiving, from a user equipment (UE), an indication of an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and

means for processing measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

61. The position estimation entity of claim 60, further comprising:

means for receiving, from the UE, a UE Tx TEG report for the position estimation procedure.

62. The position estimation entity of claim 60, wherein the indication of the expected association is further received in conjunction with an associated confidence level.

AMENDED CLAIMS
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What is claimed is:

1. A method of operating a user equipment (UE), comprising:

determining an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin;

transmitting an indication of the expected association; and

transmitting, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

2. The method of claim 1, further comprising:

transmitting a UE Tx TEG report for the position estimation procedure to a position estimation entity.

3. The method of claim 2, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via the at least UE Tx TEG in accordance with the expected association.

4. The method of claim 3, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association.

5. The method of claim 3, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association.

6. The method of claim 2, wherein the SRS is transmitted on the one or more UL-SRS resources of the at least one UL-SRS resource via one or more other UE Tx TEGs that are different than the at least UE Tx TEG in discordance with the expected association.

7. The method of claim 6,

wherein the UE Tx TEG report includes a negative acknowledgment of the expected association, or

wherein the UE Tx TEG report includes an indication of the one or more other UE Tx TEGs, or

a combination thereof.

8. The method of claim 1, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

9. The method of claim 1,

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

10. The method of claim 1, wherein the expected association remains valid until:

a reconfiguration of the one or more UL-SRS resources, or

a radio resource control (RRC) reconfiguration, or

a bandwidth part (BWP) switch, or

a transition to discontinuous reception (DRX) OFF, or

any combination thereof.

11. The method of claim 1, wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS.

12. The method of claim 11, wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted via uplink media access control control element (MAC-CE).

13. The method of claim 11, further comprising:

receiving an activation of a configuration of the SRS for the position estimation procedure,

wherein the indication of the expected association between the at least one UE Tx TEG and the transmission of the SRS is transmitted in response to the activation.

14. The method of claim 1, wherein the SRS corresponds to an aperiodic (AP) SRS.

15. The method of claim 14,

receiving a configuration of the SRS for the position estimation procedure,

wherein the indication of the expected association between the at least one UE Tx TEG and the SRS is transmitted in response to the configuration.

16. The method of claim 1, wherein the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

17. The method of claim 1, wherein the indication of the expected association is further transmitted in conjunction with an associated confidence level.

18. A method of operating a position estimation entity, comprising:

receiving, from a user equipment (UE), an indication of an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and

processing measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

19. The method of claim 18, further comprising:

receiving, from the UE, a UE Tx TEG report for the position estimation procedure.

20. The method of claim 19, wherein the UE Tx TEG report includes a positive acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

21. The method of claim 19, wherein the UE Tx TEG report omits a negative acknowledgment of the expected association to confirm transmission of the SRS in accordance with the expected association.

22. The method of claim 19,

wherein the UE Tx TEG report includes a negative acknowledgment of the expected association to indicate transmission of the SRS in discordance with the expected association, or

wherein the UE Tx TEG report includes an indication of one or more other UE Tx TEGs associated with the transmission of the SRS, or

a combination thereof.

23. The method of claim 18, wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof.

24. The method of claim 18,

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to a direct association, or

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and spatial relationship information, with the spatial relationship information being further associated with the SRS, or

wherein the expected association between the at least one UE Tx TEG and the SRS corresponds to an association between the at least one UE Tx TEG and a pathloss reference, with the pathloss reference being further associated with the SRS.

25. The method of claim 18, wherein the expected association remains valid until:
a reconfiguration of one or more uplink SRS (UL-SRS) resources, or
a radio resource control (RRC) reconfiguration, or
a bandwidth part (BWP) switch, or
a transition to discontinuous reception (DRX) OFF, or
any combination thereof.

26. The method of claim 18,
wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS, or
wherein the SRS corresponds to an aperiodic (AP) SRS.

27. The method of claim 18, wherein the indication of the expected association is received from the UE prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure.

28. The method of claim 18, wherein the indication of the expected association is further received in conjunction with an associated confidence level.

29. 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, the at least one processor configured to:
determine an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin;
transmit, via the at least one transceiver, an indication of the expected association; and
transmit, via the at least one transceiver, after the transmission of the indication, the SRS on one or more uplink SRS (UL-SRS) resources of at least one UL-SRS resource set during the position estimation procedure.

30. The UE of claim 29, wherein the at least one processor is further configured to:

transmit, via the at least one transceiver, a UE Tx TEG report for the position estimation procedure to a position estimation entity.

31. The UE of claim 29,

wherein the SRS corresponds to an instance of a semi-persistent (SP) SRS, or

wherein the SRS corresponds to an aperiodic (AP) SRS.

32. The UE of claim 29,

wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof, or

wherein the indication of the expected association is transmitted prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure, or

wherein the indication of the expected association is further transmitted in conjunction with an associated confidence level.

33. A position estimation entity, comprising:

a memory;

at least one transceiver; and

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

receive, via the at least one transceiver, from a user equipment (UE), an indication of an expected association between at least one UE transmit (Tx) timing error group (TEG) and a sounding reference signal (SRS) for a position estimation procedure, the at least one UE Tx TEG indicating that transmit timing errors of the SRS are within a margin; and

process measurement information associated with the position estimation procedure based in part upon the indication of the expected association.

34. The position estimation entity of claim 33, wherein the at least one processor is further configured to:

receive, via the at least one transceiver, from the UE, a UE Tx TEG report for the position estimation procedure.

35. The position estimation entity of claim 33,

wherein the indication of the expected association of the at least one UE Tx TEG is associated with a timestamp, a time-domain window, a number of SRS instances, or a combination thereof, or

wherein the indication of the expected association is received from the UE prior to a maximum permitted time subsequent to a triggering event associated with the position estimation procedure, or

wherein the indication of the expected association is further received in conjunction with an associated confidence level.

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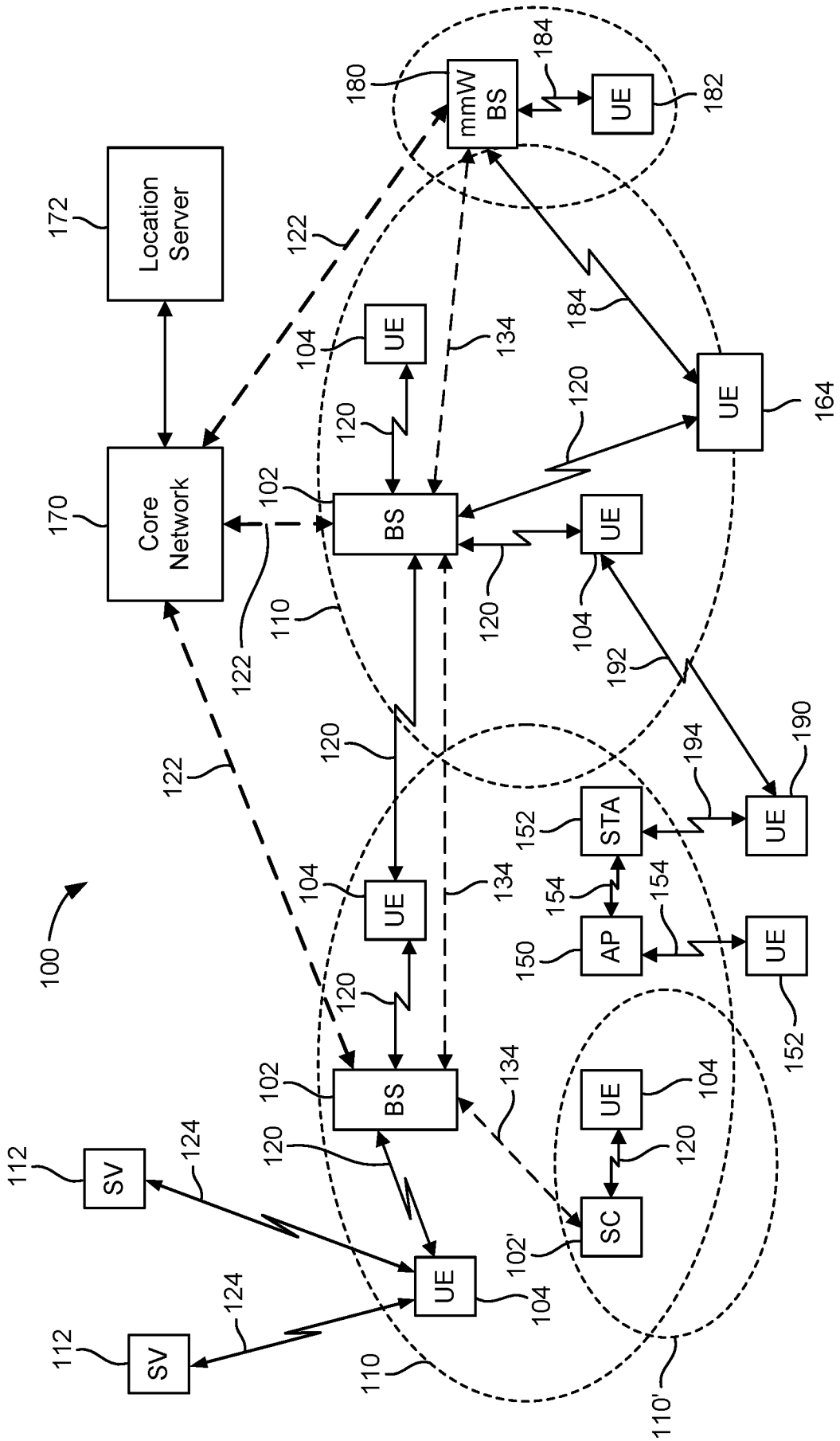

100
Location Server
172
Core Network
170
mmW BS
180
184
UE
182
122
104
134
120
102
BS
UE
164
110
192
190
194
STA
152
154
AP
150
SV
112
124
102'
SC
110'

FIG. 1

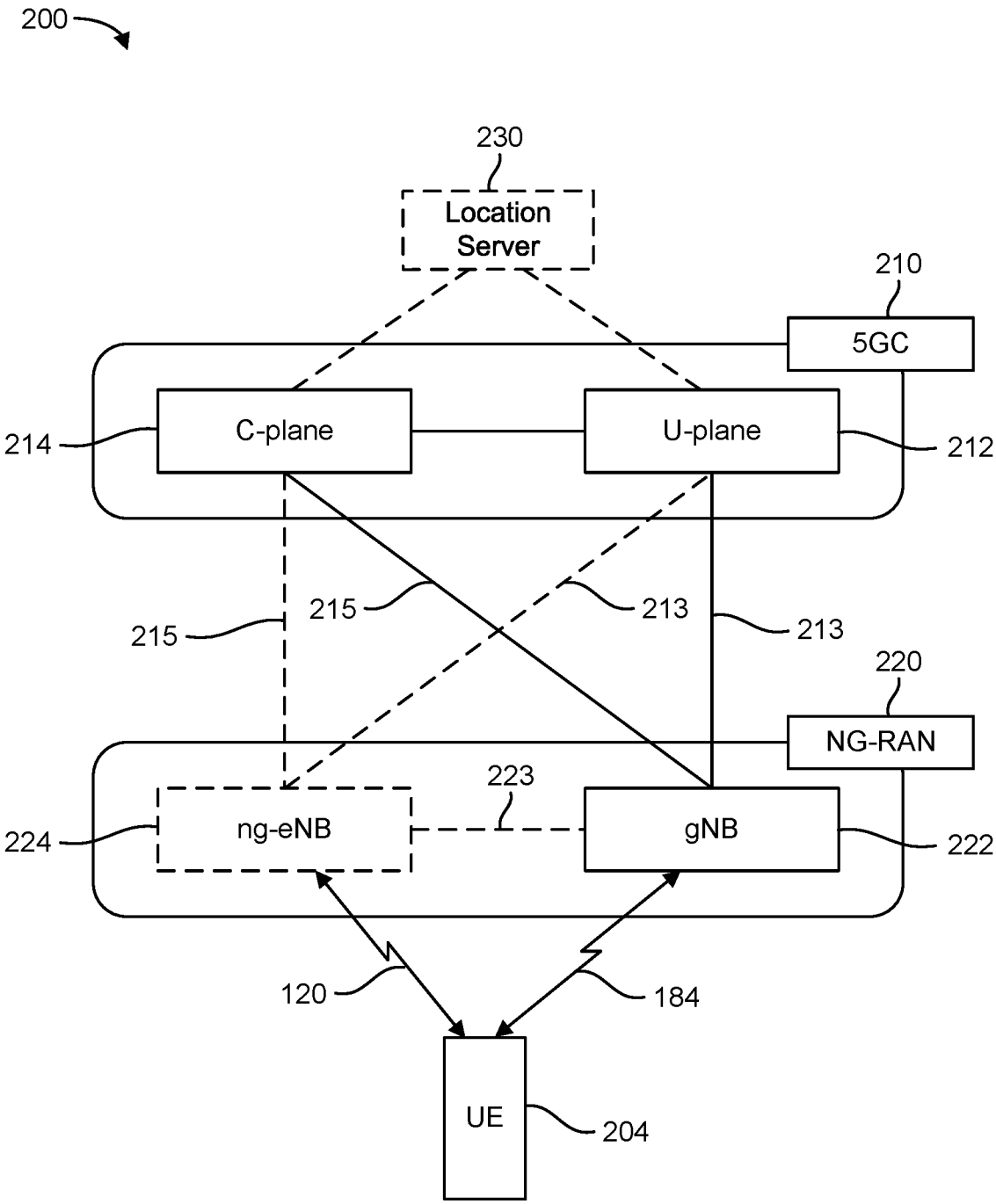

200
230
Location Server
210
5GC
214
C-plane
U-plane
212
215
215
213
213
220
NG-RAN
223
224
ng-eNB
gNB
222
120
184
UE
204

FIG. 2A

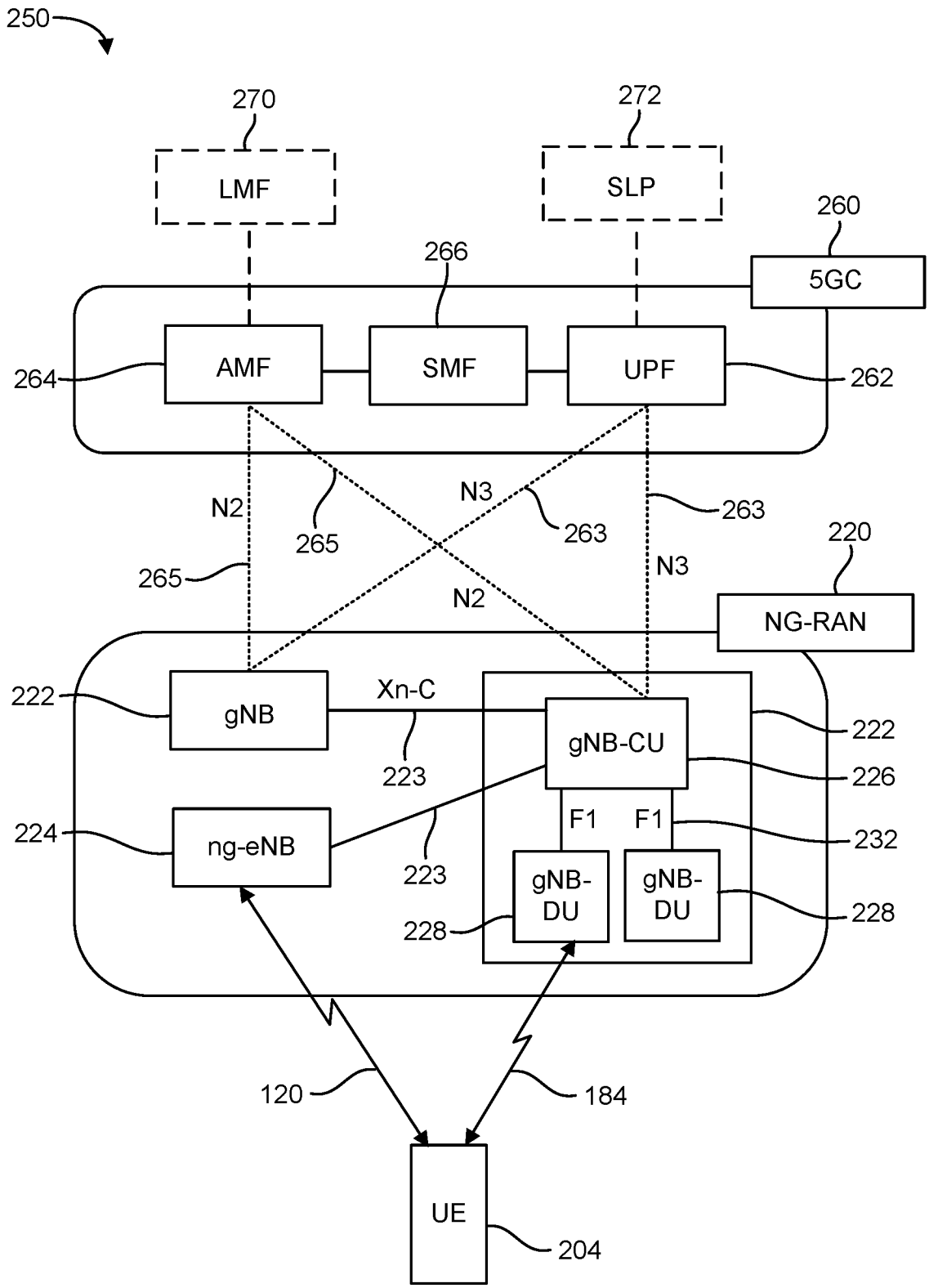

250
270
LMF
272
SLP
260
5GC
266
AMF
SMF
UPF
264
262
N2
265
N3
263
263
265
N3
N2
220
NG-RAN
222
gNB
Xn-C
gNB-CU
222
223
226
224
ng-eNB
F1
F1
232
223
gNB-DU
gNB-DU
228
228
120
184
UE
204

FIG. 2B

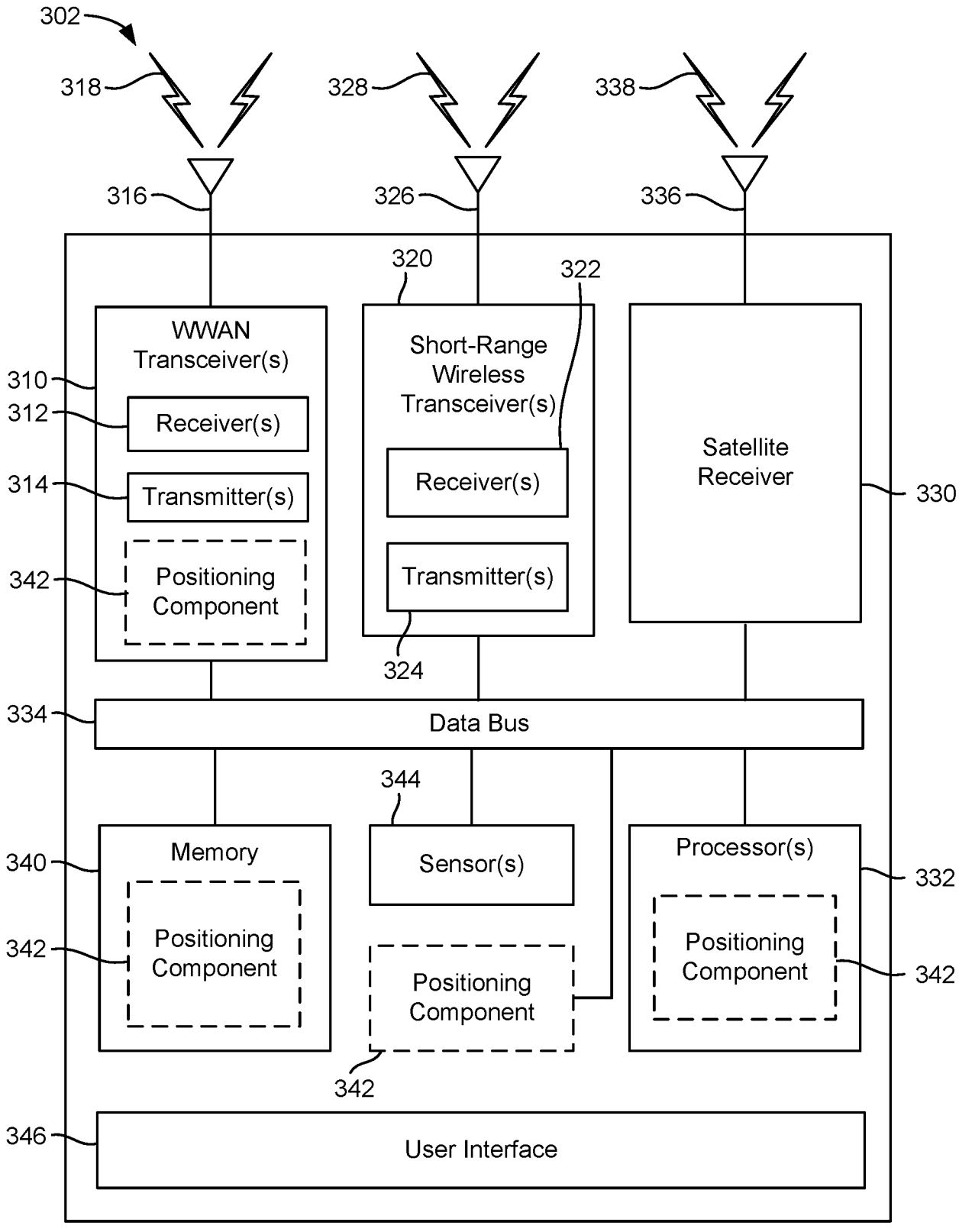

302
318
328
338
316
326
336
320
322
WWAN Transceiver(s)
Short-Range Wireless Transceiver(s)
Satellite Receiver
310
312
Receiver(s)
314
Transmitter(s)
342
Positioning Component
Receiver(s)
Transmitter(s)
330
324
334
Data Bus
344
340
Memory
Sensor(s)
Processor(s)
332
342
Positioning Component
Positioning Component
342
Positioning Component
342
342
346
User Interface

FIG. 3A

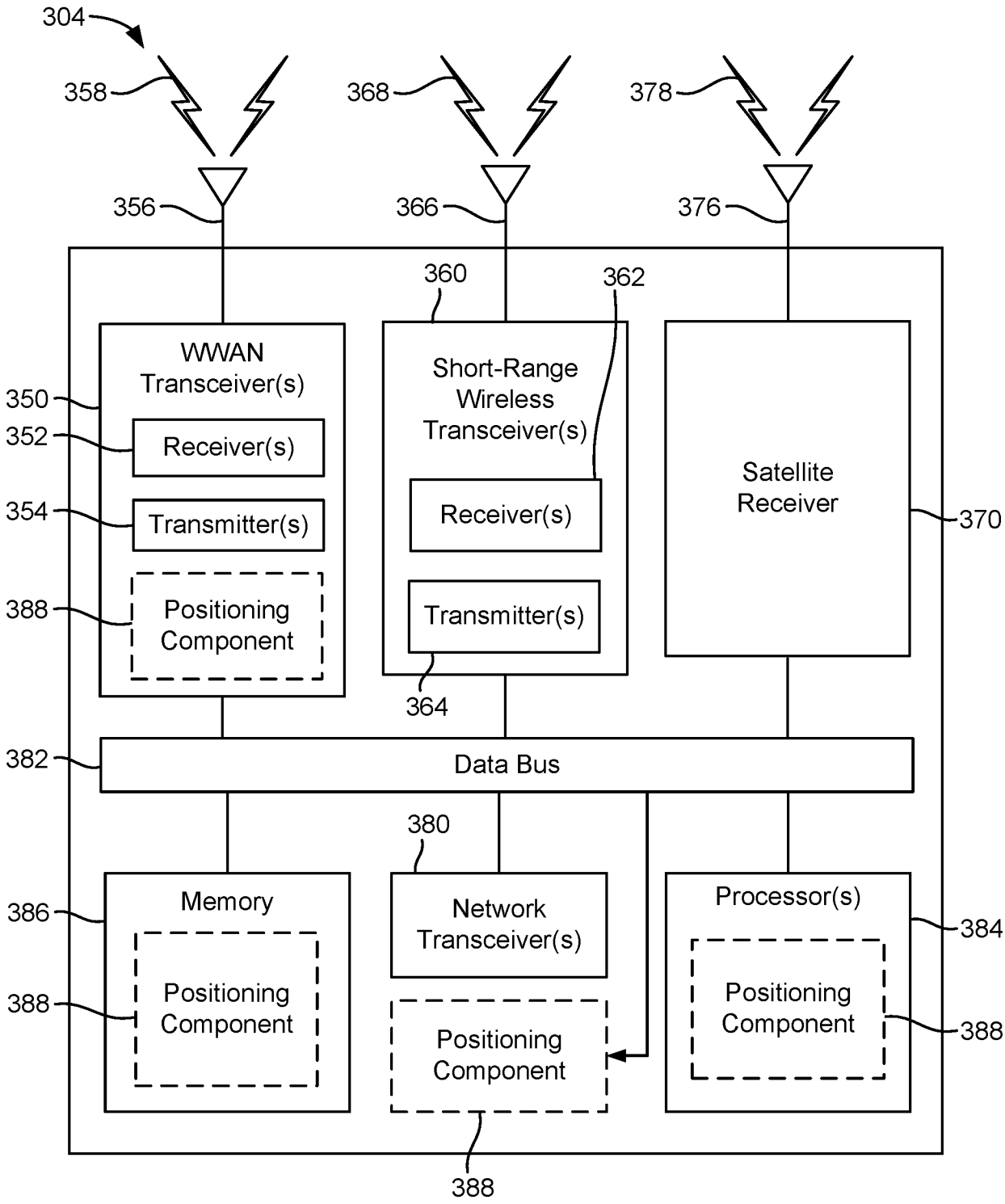

304
358
368
378
356
366
376
360
362
WWAN Transceiver(s)
Short-Range Wireless Transceiver(s)
Satellite Receiver
350
352
Receiver(s)
354
Transmitter(s)
388
Positioning Component
Receiver(s)
Transmitter(s)
370
364
382
Data Bus
380
Memory
Network Transceiver(s)
Processor(s)
386
384
388
Positioning Component
Positioning Component
Positioning Component
388
388

FIG. 3B

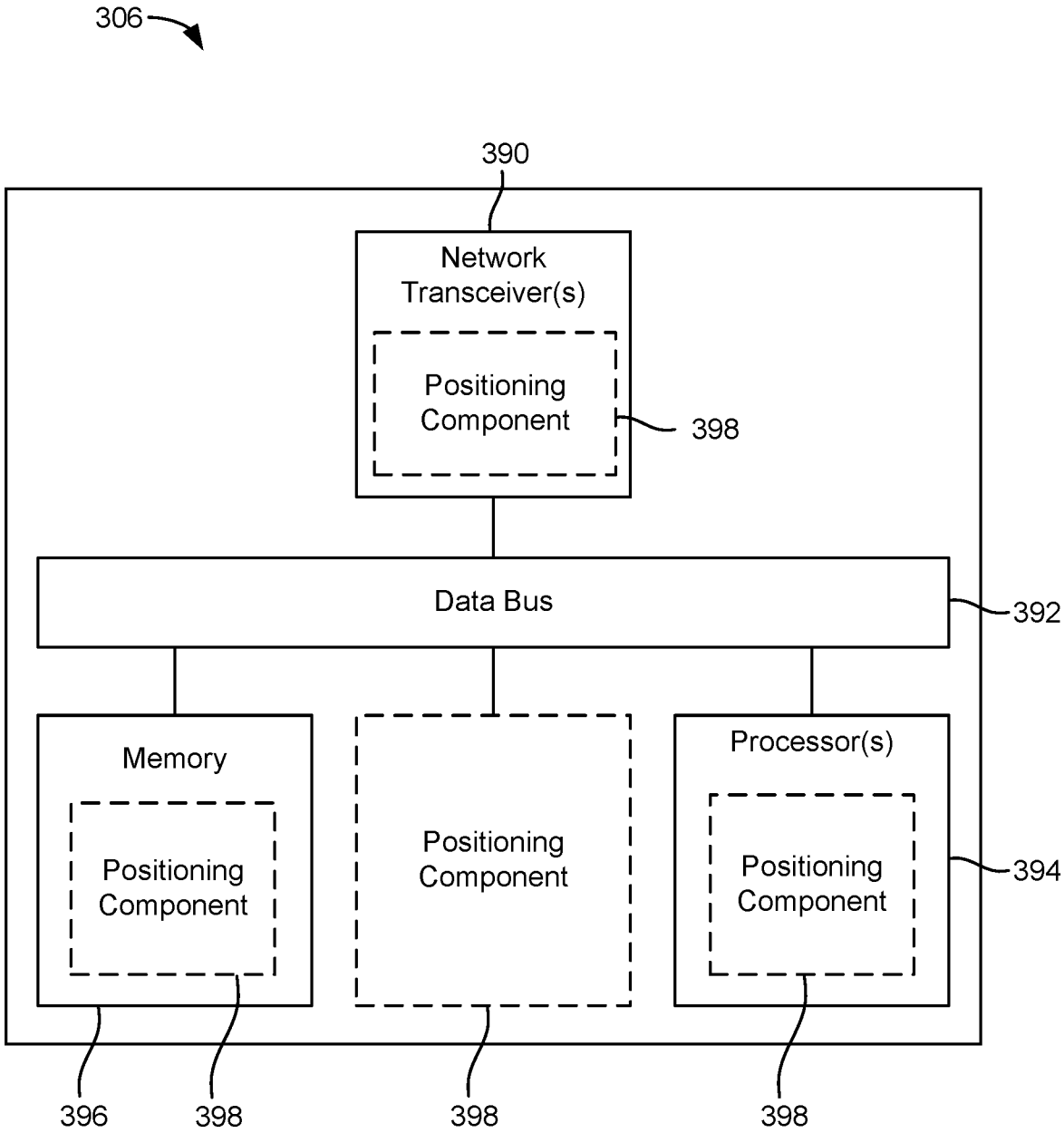

306
390
Network Transceiver(s)
Positioning Component
398
Data Bus
392
Memory
Positioning Component
Positioning Component
Processor(s)
Positioning Component
394
396
398
398
398

FIG. 3C

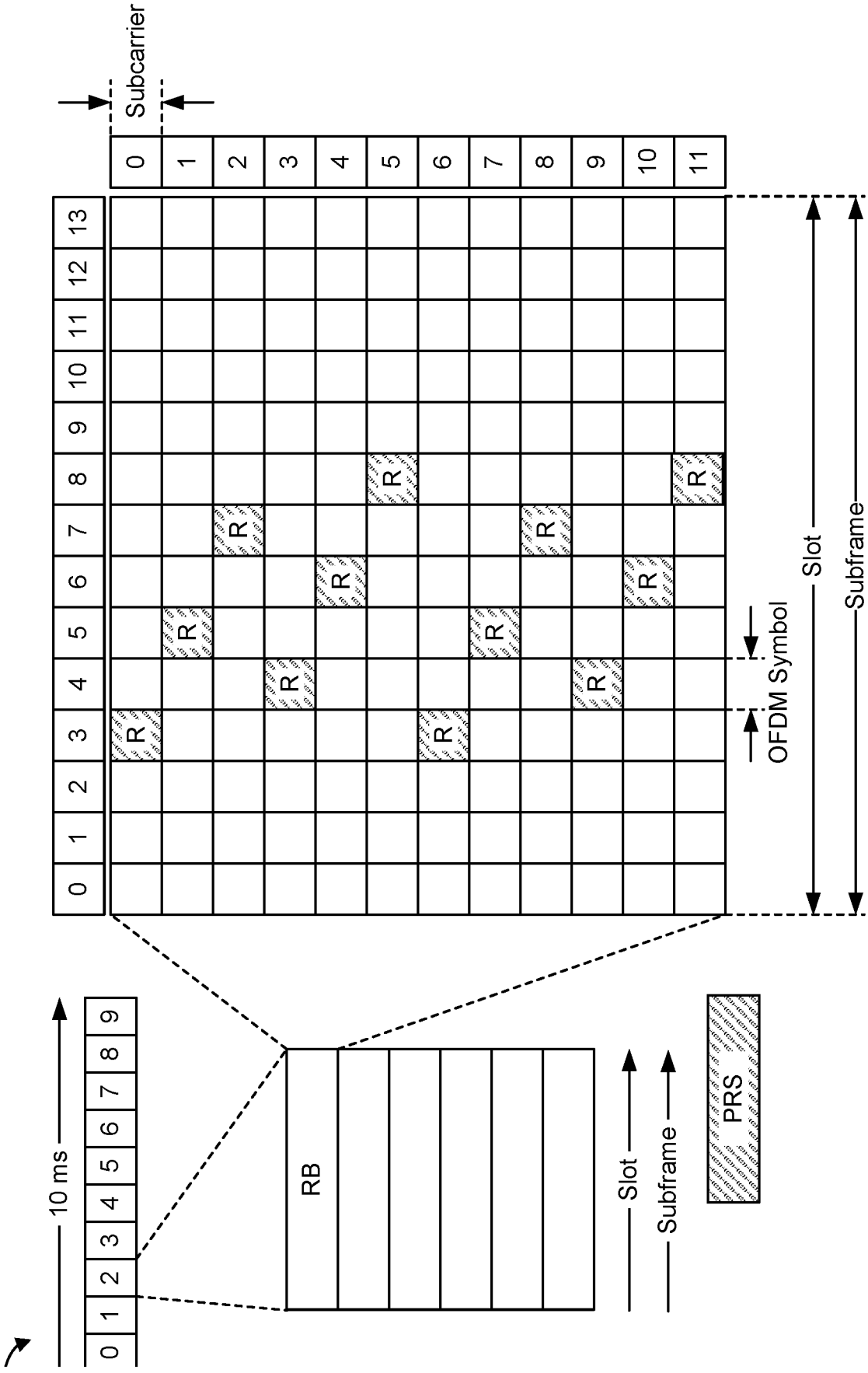

Subcarrier
0 1 2 3 4 5 6 7 8 9 10 11
0 1 2 3 4 5 6 7 8 9 10 11 12 13
R
OFDM Symbol
Slot
Subframe
10 ms
0 1 2 3 4 5 6 7 8 9
RB
Slot
Subframe
PRS

FIG. 4A

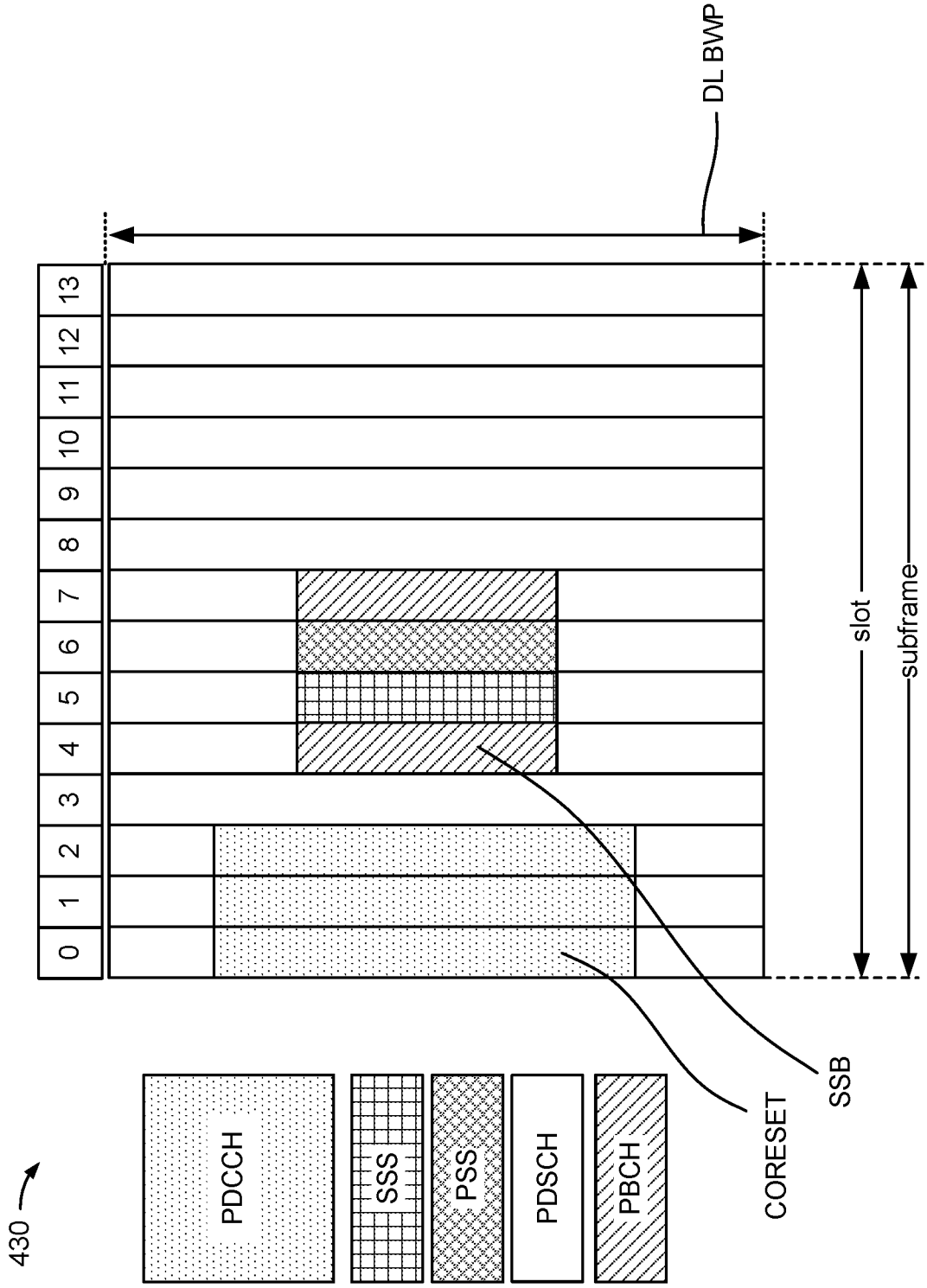

DL BWP
0
1
2
3
4
5
6
7
8
9
10
11
12
13
slot
subframe
SSB
CORESET
PDCCH
SSS
PSS
PDSCH
PBCH
430

FIG. 4B

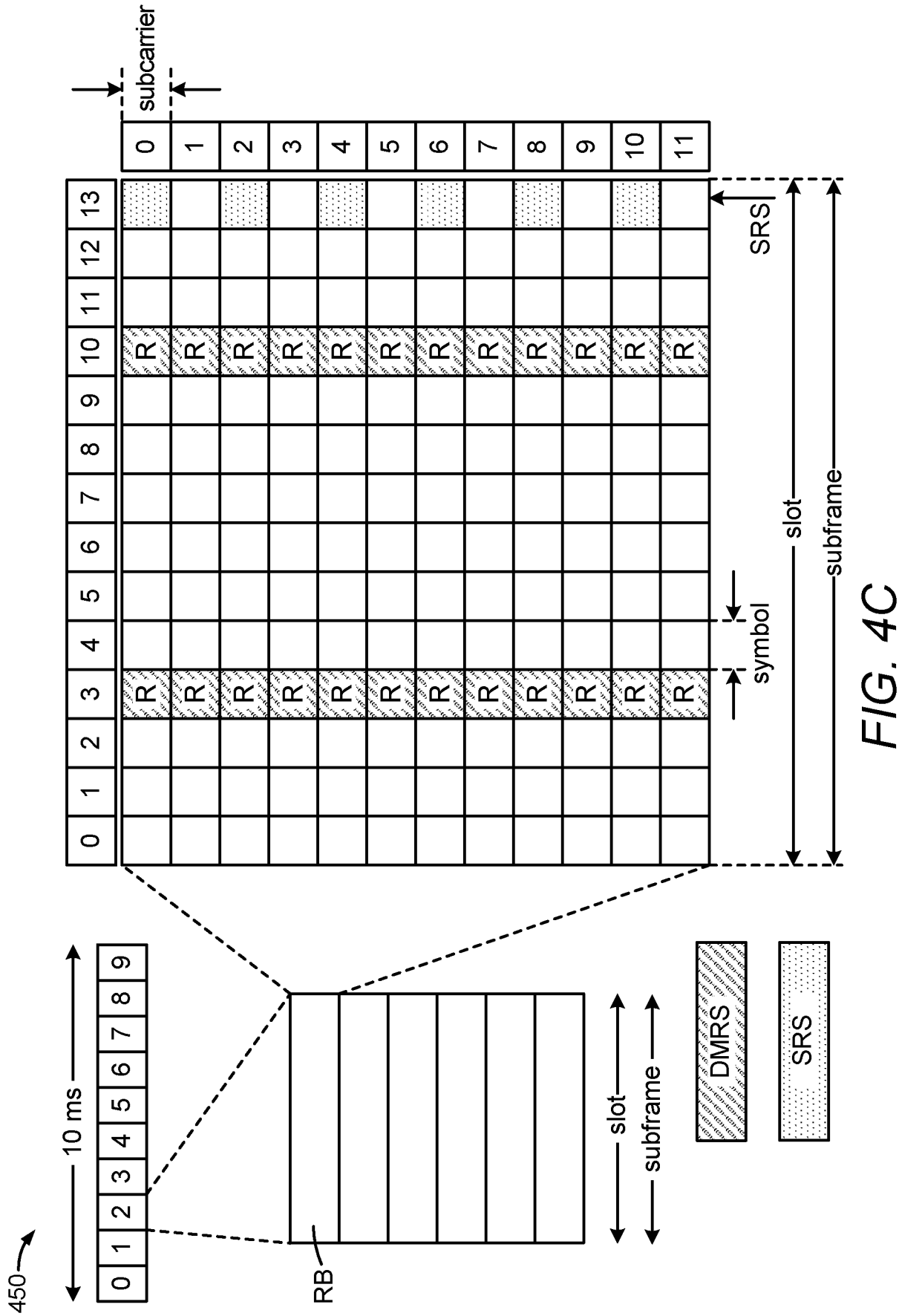

450
0 1 2 3 4 5 6 7 8 9
10 ms
RB
slot
subframe
DMRS
SRS
subcarrier
0 1 2 3 4 5 6 7 8 9 10 11
0 1 2 3 4 5 6 7 8 9 10 11 12 13
R
SRS
symbol
slot
subframe

FIG. 4C

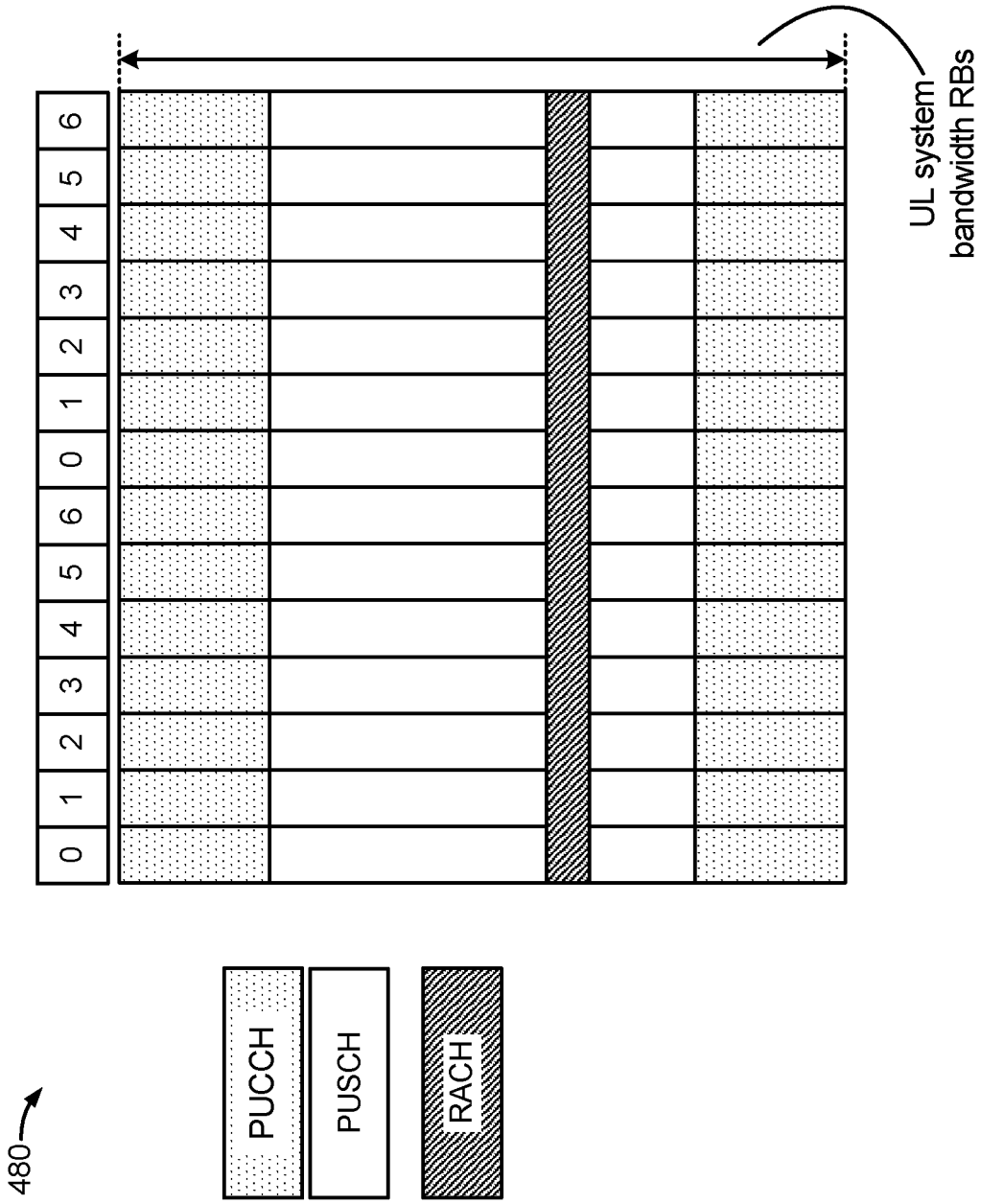

UL system bandwidth RBs
0 1 2 3 4 5 6 0 1 2 3 4 5 6
PUCCH
PUSCH
RACH
480

FIG. 4D

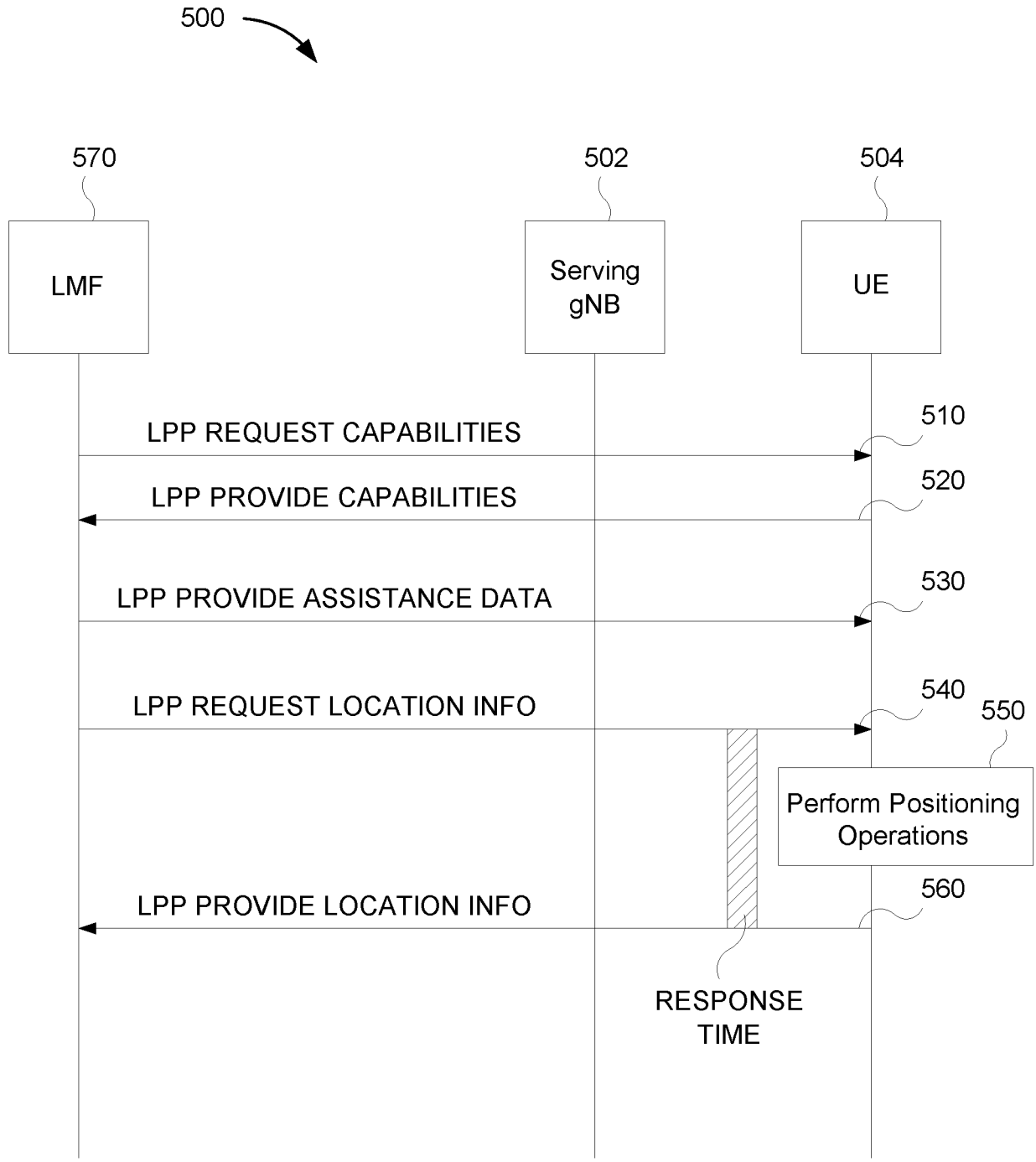

500
570
LMF
502
Serving gNB
504
UE
LPP REQUEST CAPABILITIES
510
LPP PROVIDE CAPABILITIES
520
LPP PROVIDE ASSISTANCE DATA
530
LPP REQUEST LOCATION INFO
540
550
Perform Positioning Operations
LPP PROVIDE LOCATION INFO
560
RESPONSE TIME

FIG. 5

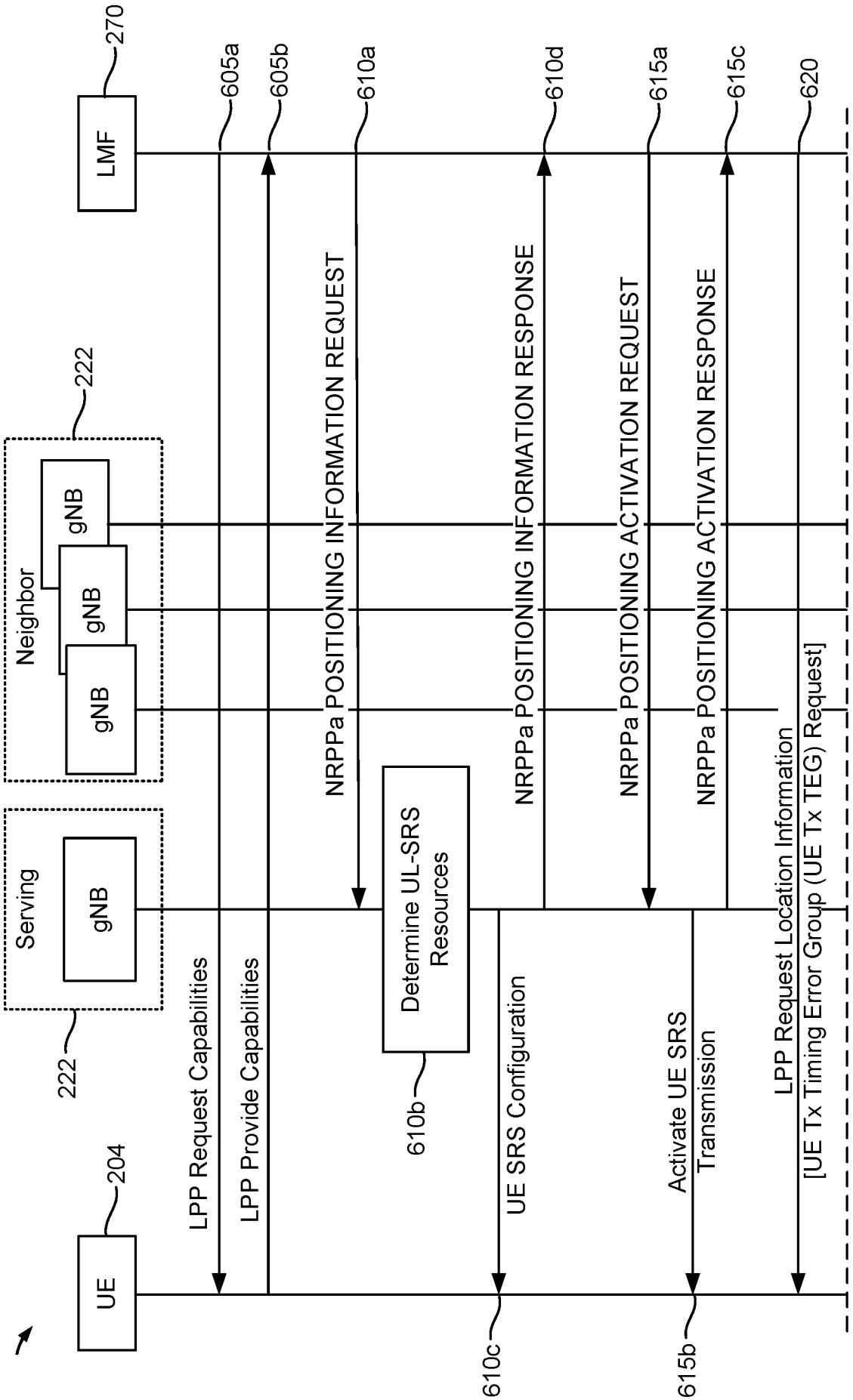

UE
204
LMF
270
Serving
gNB
222
Neighbor
gNB
gNB
gNB
222
605a
605b
610a
610d
615a
615c
620
LPP Request Capabilities
LPP Provide Capabilities
NRPPa POSITIONING INFORMATION REQUEST
Determine UL-SRS Resources
610b
NRPPa POSITIONING INFORMATION RESPONSE
NRPPa POSITIONING ACTIVATION REQUEST
NRPPa POSITIONING ACTIVATION RESPONSE
UE SRS Configuration
Activate UE SRS Transmission
LPP Request Location Information [UE Tx Timing Error Group (UE Tx TEG) Request]
610c
615b

FIG. 6A

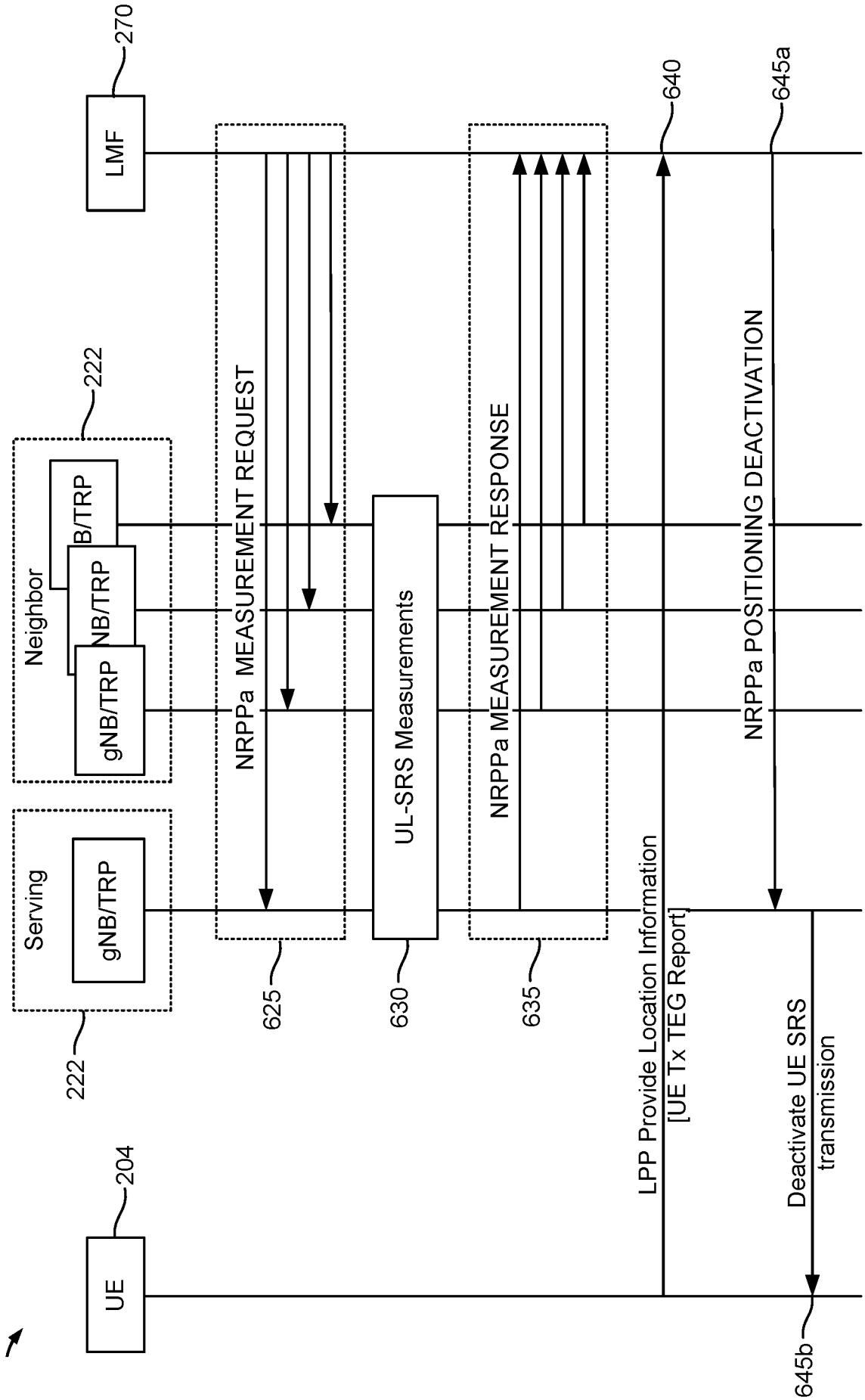

LMF
270
640
645a
222
Neighbor
B/TRP
NB/TRP
gNB/TRP
Serving
gNB/TRP
222
NRPPa MEASUREMENT REQUEST
625
UL-SRS Measurements
630
NRPPa MEASUREMENT RESPONSE
635
NRPPa POSITIONING DEACTIVATION
LPP Provide Location Information
[UE Tx TEG Report]
Deactivate UE SRS
transmission
645b
UE
204

FIG. 6B

```
    L-Tx-TimingErrorGroup-r17 ::= SEQUENCE {
    e-txTimimingErrorGroups-r17  SEQUENCE (SIZE(1..maxNrOfTE-Groups-r17)) OF
                                 UE-TX-TEG-r17                  OPTIONAL,


    X-TEG-r17 ::= SEQUENCE {
    rsPos-tx-TimingError-r17              INTEGER (0..255)          OPTIONAL,
    rsPos-tx-TimingErrorUncertainty-r17   INTEGER (0..255)          OPTIONAL,
    cTEG-CalibrationInfo-r17              TX-TEG-CalibrationInfo-r17    OPTIONAL,
  srsPos-Resources-in-TEG-r17             SEQUENCE (SIZE(1...maxNrofSRS-PosResourceSets-r16)) OF
                                 TEG-SRS-PosResourceSet-r17,
}

TEG-SRS-PosResourceSet-r17 ::= SEQUNCE {
  srs-PosResourceSetId-r17               SRS-PosResourceSetId-r16,
  srs-PosResourceIdList-r17              SEQUENCE (SIZE(1..maxNrofSRS-ResourcesPerSet)) OF
                                 SRS-PosResourceId-r16      OPTIONAL,
}

TX-TEG-CalibrationInfo-r17 ::= SEQUENCE {
  lastCalibrationTime-r17    CHOICE {
                        utcTime-r17     UTCTime,
                        sfnTime-r17     SEQUENCE {
                                           nr-SFN-r17 INTEGER (0..1023),
                                           nr-Slot-r17  CHOICE {
                                              scs15-r17  INTEGER (0..9),
                                              scs30-r17  INTEGER (0..19),
                                              scs60-r17  INTEGER (0..39),
                                              scs120-r17 INTEGER (0..79)
                                           },
                    }                                 OPTIONAL,
}
```

FIG. 7

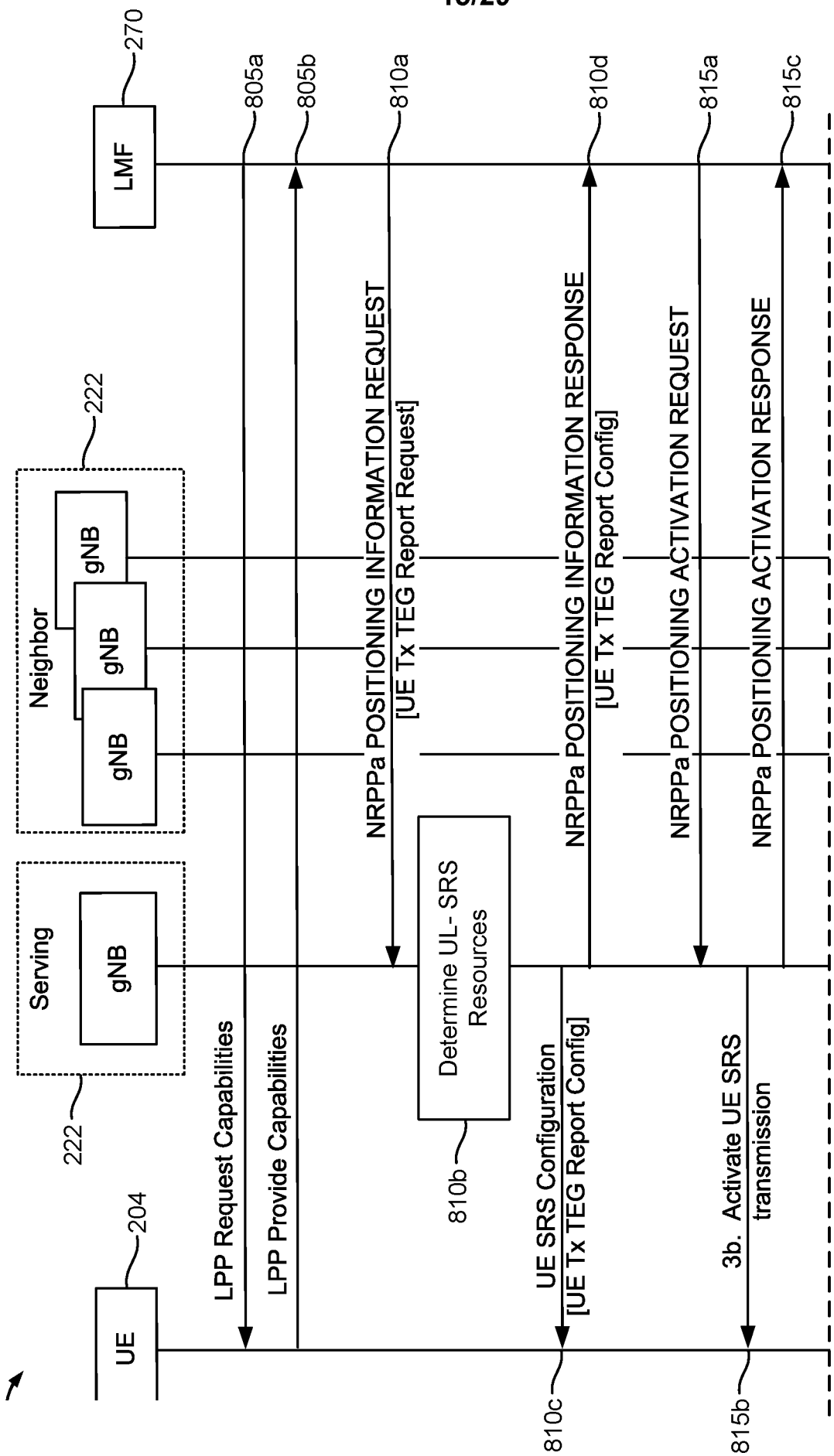

UE
204
LMF
270
Serving
gNB
222
Neighbor
gNB
gNB
gNB
222
805a
805b
810a
810b
810c
810d
815a
815b
815c
LPP Request Capabilities
LPP Provide Capabilities
NRPPa POSITIONING INFORMATION REQUEST
[UE Tx TEG Report Request]
Determine UL- SRS Resources
NRPPa POSITIONING INFORMATION RESPONSE
[UE Tx TEG Report Config]
UE SRS Configuration
[UE Tx TEG Report Config]
NRPPa POSITIONING ACTIVATION REQUEST
NRPPa POSITIONING ACTIVATION RESPONSE
3b. Activate UE SRS transmission

FIG. 8A

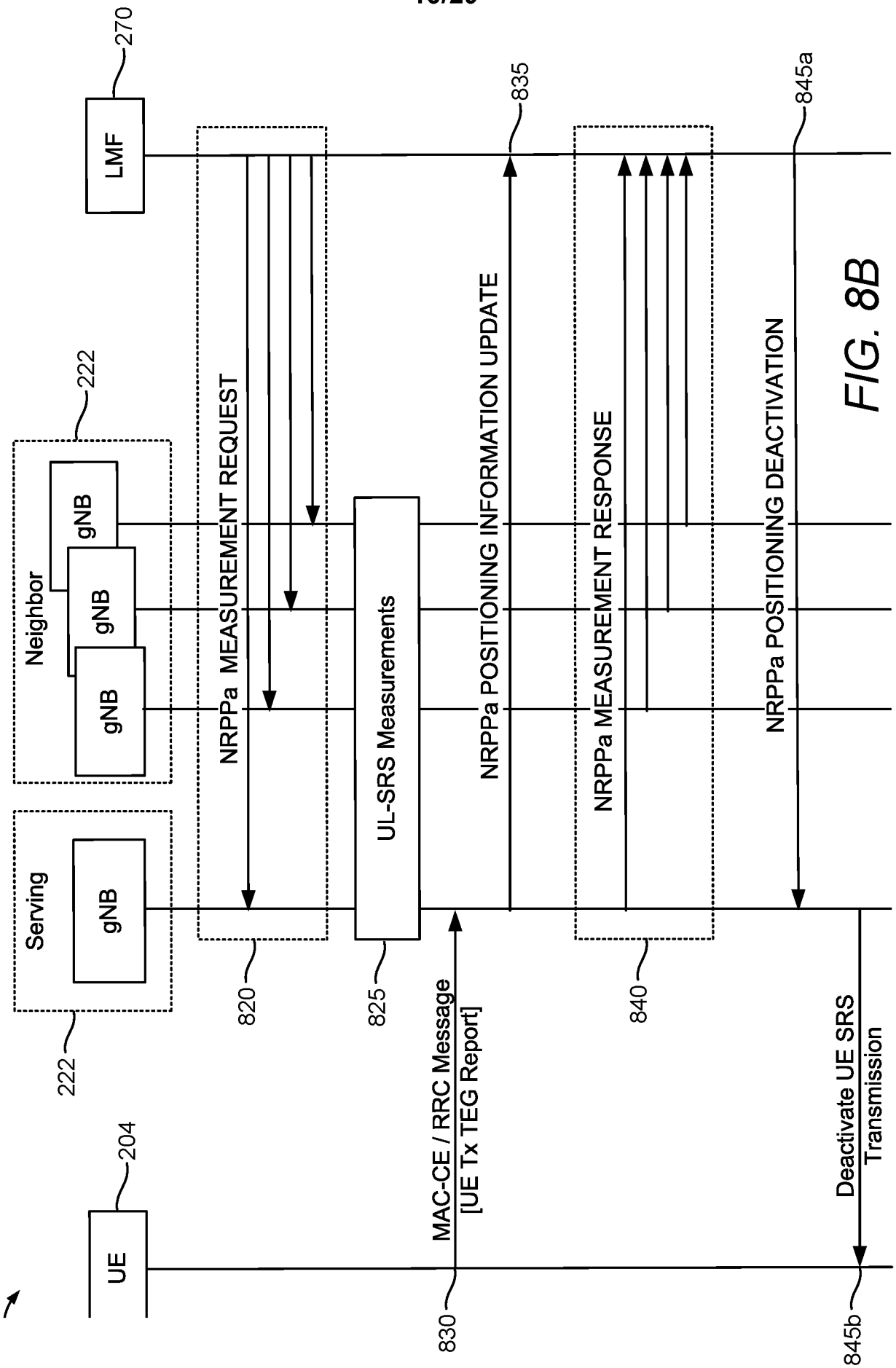

LMF
270
835
845a
Neighbor
222
gNB
gNB
gNB
Serving
gNB
222
NRPPa MEASUREMENT REQUEST
UL-SRS Measurements
NRPPa POSITIONING INFORMATION UPDATE
NRPPa MEASUREMENT RESPONSE
NRPPa POSITIONING DEACTIVATION
820
825
840
UE
204
MAC-CE / RRC Message
[UE Tx TEG Report]
830
Deactivate UE SRS
Transmission
845b

FIG. 8B

```
SRS-Tx-TEG-ReportConfig-r17 ::= SEQUENCE {
   tegTimer-r17                ENUMERATED { sf1, sf5, sf10, sf16, sf20, sf32, sf40, sf64,
                                            sf80, sf128, sf160, sf320, sf640, sf1280, sf2560 }
                                                                   OPTIONAL,
   periodicTegTimer-r17  ENUMERATED { sf1, sf5, sf10, sf16, sf20, sf32, sf40, sf64,
                                      sf80, sf128, sf160, sf320, sf640, sf1280, sf2560 }
                                                                   OPTIONAL,
   numberOfPeridiocTegReports-r17   INTEGER (2..129)               OPTIONAL,
   ...
}
```

00

FIG. 9

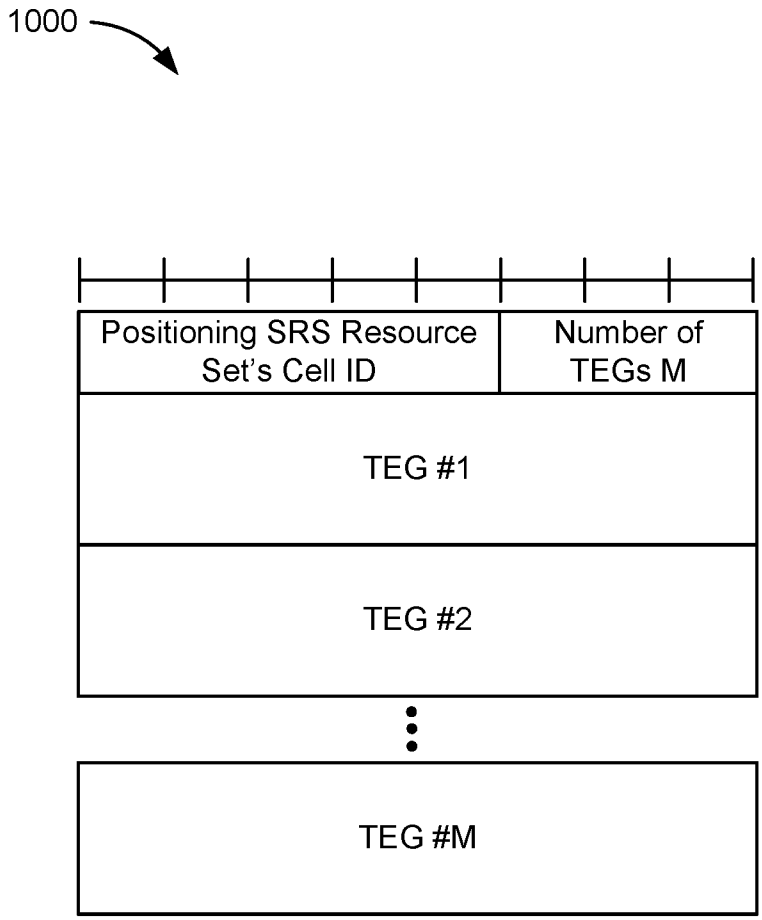

1000
Positioning SRS Resource Set's Cell ID
Number of TEGs M
TEG #1
TEG #2
TEG #M

FIG. 10

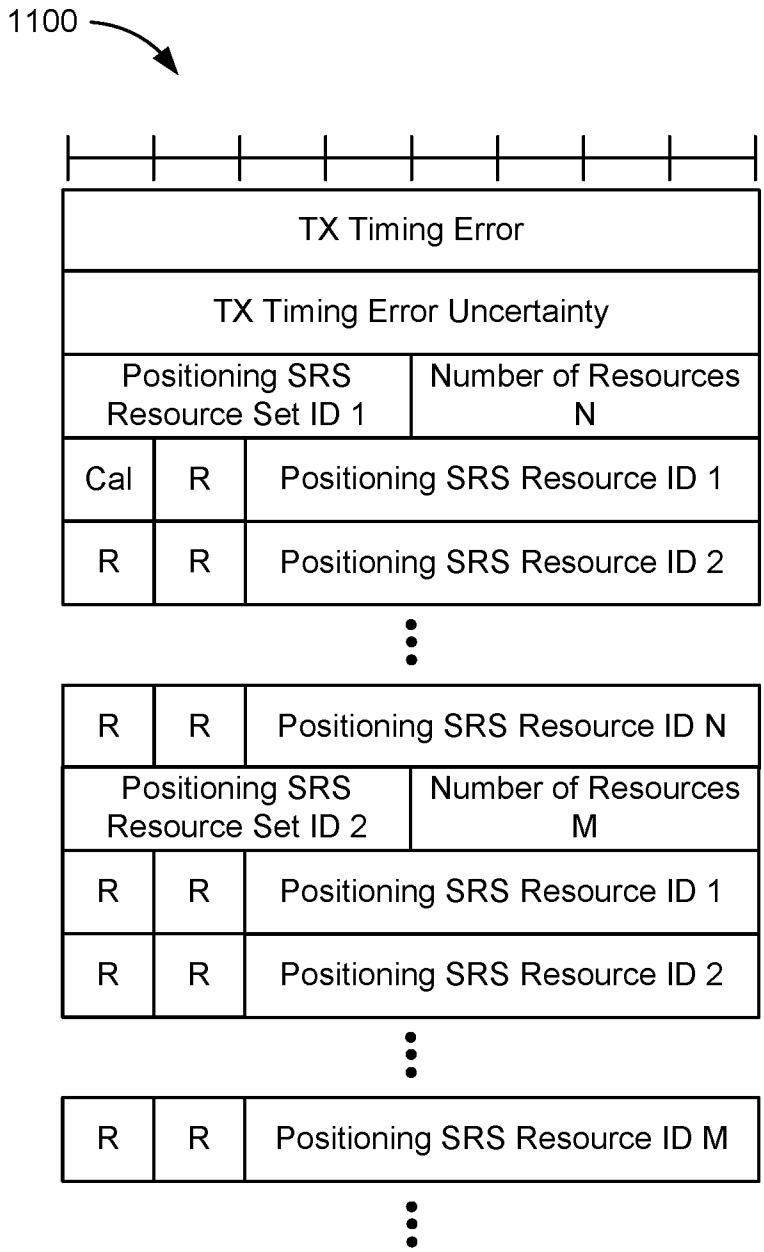

1100
TX Timing Error
TX Timing Error Uncertainty
Positioning SRS Resource Set ID 1
Number of Resources N
Cal
R
Positioning SRS Resource ID 1
R
R
Positioning SRS Resource ID 2
R
R
Positioning SRS Resource ID N
Positioning SRS Resource Set ID 2
Number of Resources M
R
R
Positioning SRS Resource ID 1
R
R
Positioning SRS Resource ID 2
R
R
Positioning SRS Resource ID M

FIG. 11

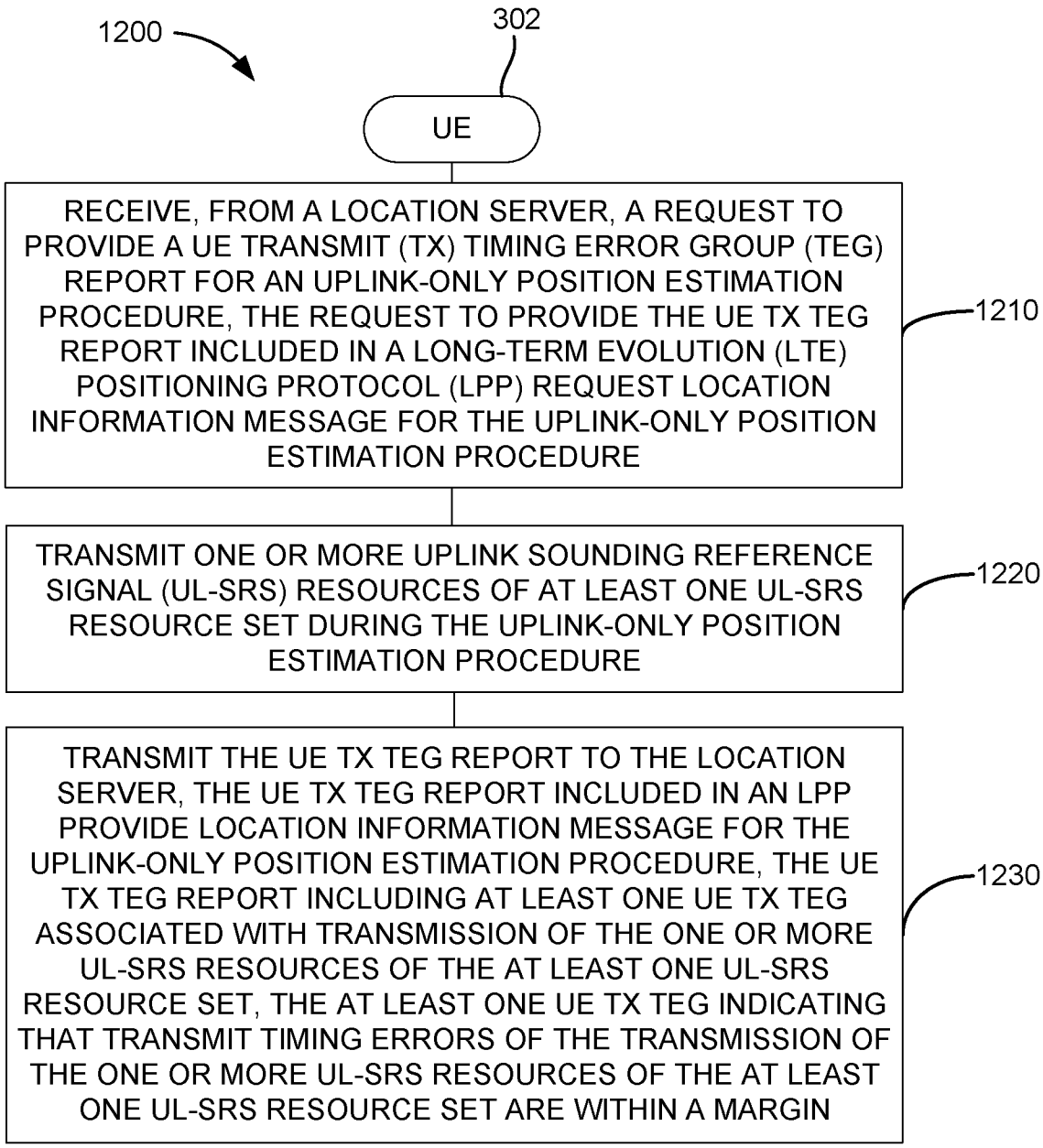

1200
302
UE
RECEIVE, FROM A LOCATION SERVER, A REQUEST TO PROVIDE A UE TRANSMIT (TX) TIMING ERROR GROUP (TEG) REPORT FOR AN UPLINK-ONLY POSITION ESTIMATION PROCEDURE, THE REQUEST TO PROVIDE THE UE TX TEG REPORT INCLUDED IN A LONG-TERM EVOLUTION (LTE) POSITIONING PROTOCOL (LPP) REQUEST LOCATION INFORMATION MESSAGE FOR THE UPLINK-ONLY POSITION ESTIMATION PROCEDURE
1210
TRANSMIT ONE OR MORE UPLINK SOUNDING REFERENCE SIGNAL (UL-SRS) RESOURCES OF AT LEAST ONE UL-SRS RESOURCE SET DURING THE UPLINK-ONLY POSITION ESTIMATION PROCEDURE
1220
TRANSMIT THE UE TX TEG REPORT TO THE LOCATION SERVER, THE UE TX TEG REPORT INCLUDED IN AN LPP PROVIDE LOCATION INFORMATION MESSAGE FOR THE UPLINK-ONLY POSITION ESTIMATION PROCEDURE, THE UE TX TEG REPORT INCLUDING AT LEAST ONE UE TX TEG ASSOCIATED WITH TRANSMISSION OF THE ONE OR MORE UL-SRS RESOURCES OF THE AT LEAST ONE UL-SRS RESOURCE SET, THE AT LEAST ONE UE TX TEG INDICATING THAT TRANSMIT TIMING ERRORS OF THE TRANSMISSION OF THE ONE OR MORE UL-SRS RESOURCES OF THE AT LEAST ONE UL-SRS RESOURCE SET ARE WITHIN A MARGIN
1230

FIG. 12

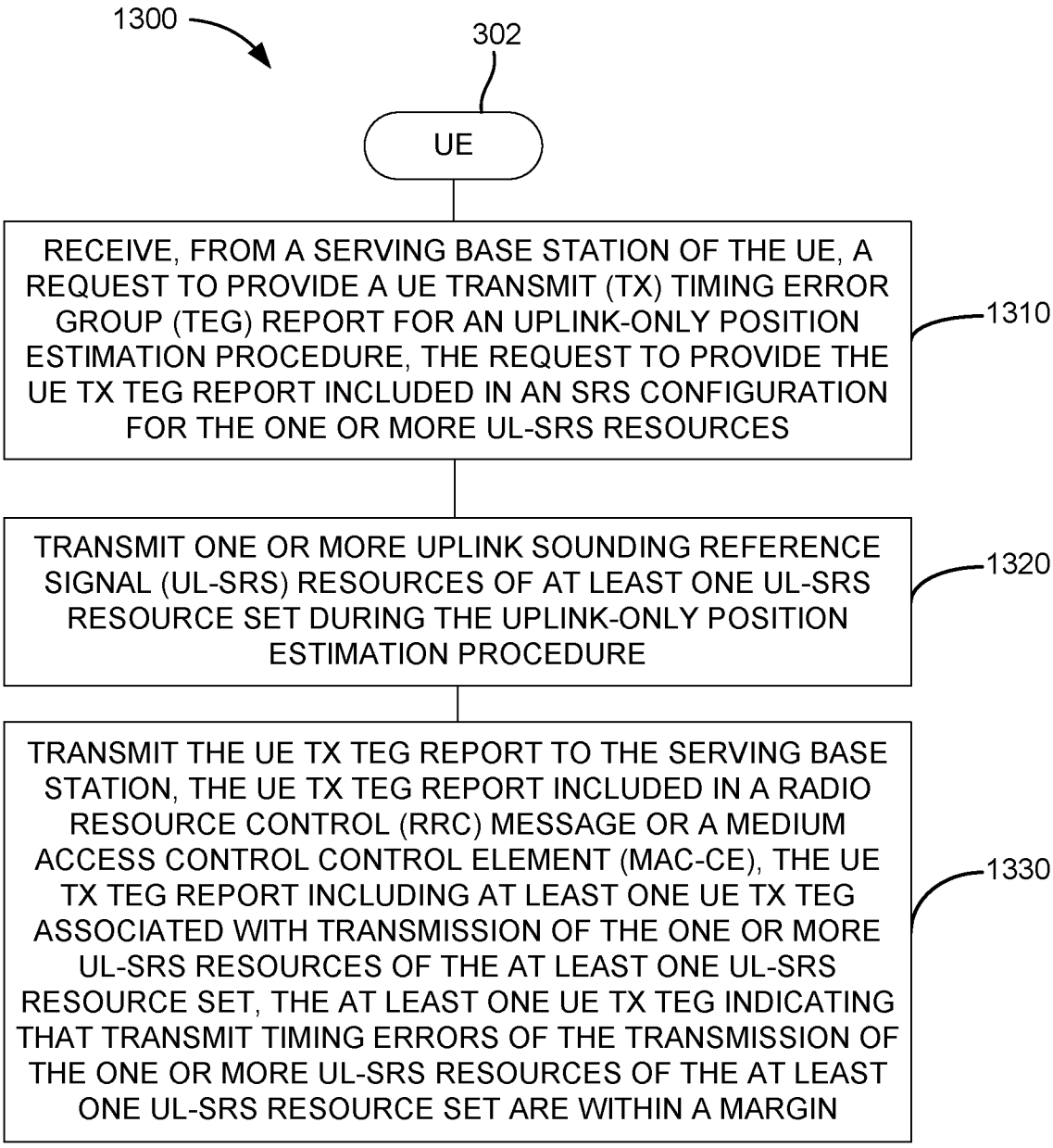

1300
302
UE
RECEIVE, FROM A SERVING BASE STATION OF THE UE, A REQUEST TO PROVIDE A UE TRANSMIT (TX) TIMING ERROR GROUP (TEG) REPORT FOR AN UPLINK-ONLY POSITION ESTIMATION PROCEDURE, THE REQUEST TO PROVIDE THE UE TX TEG REPORT INCLUDED IN AN SRS CONFIGURATION FOR THE ONE OR MORE UL-SRS RESOURCES
1310
TRANSMIT ONE OR MORE UPLINK SOUNDING REFERENCE SIGNAL (UL-SRS) RESOURCES OF AT LEAST ONE UL-SRS RESOURCE SET DURING THE UPLINK-ONLY POSITION ESTIMATION PROCEDURE
1320
TRANSMIT THE UE TX TEG REPORT TO THE SERVING BASE STATION, THE UE TX TEG REPORT INCLUDED IN A RADIO RESOURCE CONTROL (RRC) MESSAGE OR A MEDIUM ACCESS CONTROL CONTROL ELEMENT (MAC-CE), THE UE TX TEG REPORT INCLUDING AT LEAST ONE UE TX TEG ASSOCIATED WITH TRANSMISSION OF THE ONE OR MORE UL-SRS RESOURCES OF THE AT LEAST ONE UL-SRS RESOURCE SET, THE AT LEAST ONE UE TX TEG INDICATING THAT TRANSMIT TIMING ERRORS OF THE TRANSMISSION OF THE ONE OR MORE UL-SRS RESOURCES OF THE AT LEAST ONE UL-SRS RESOURCE SET ARE WITHIN A MARGIN
1330

FIG. 13

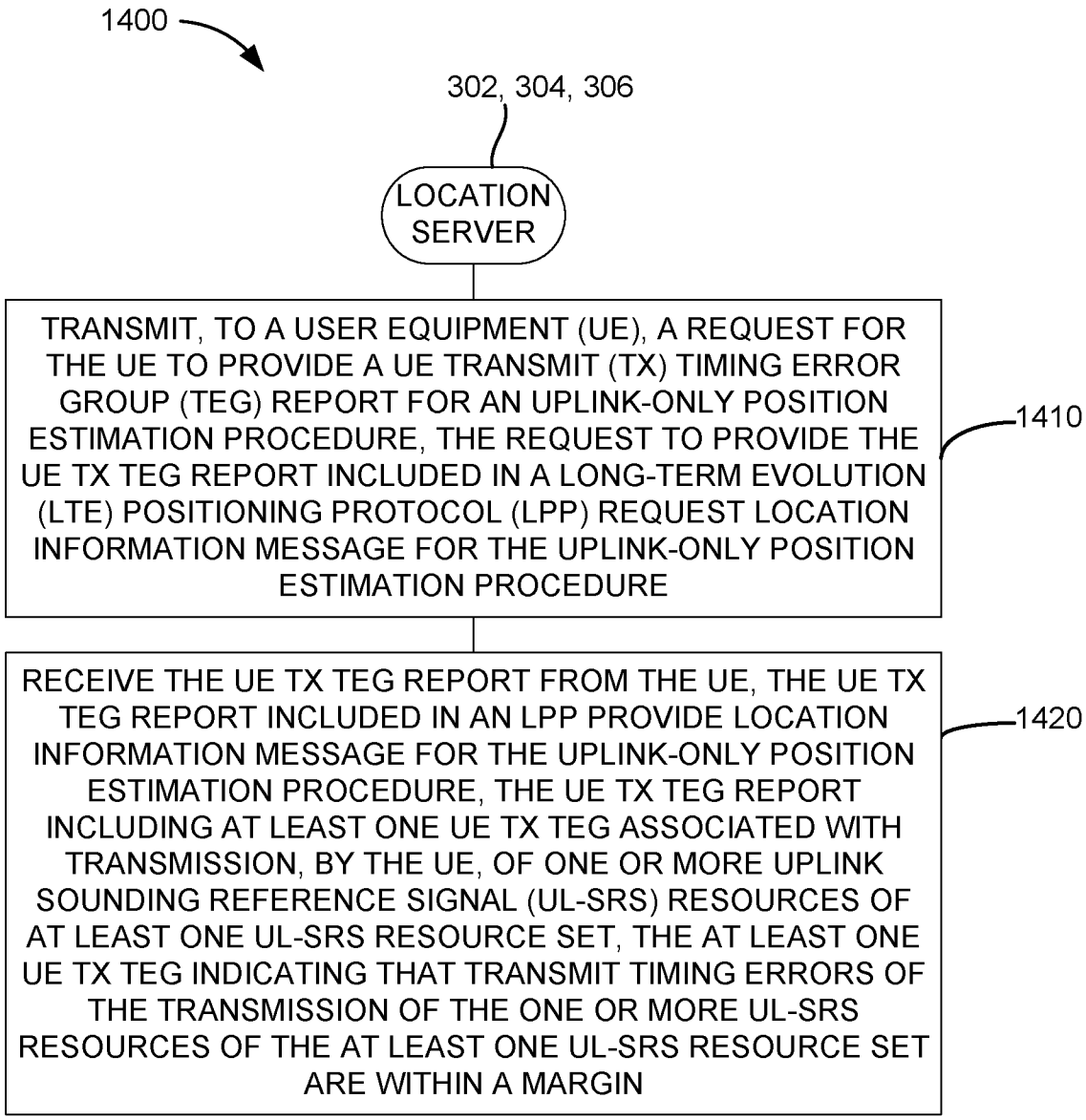

1400
302, 304, 306
LOCATION SERVER
TRANSMIT, TO A USER EQUIPMENT (UE), A REQUEST FOR THE UE TO PROVIDE A UE TRANSMIT (TX) TIMING ERROR GROUP (TEG) REPORT FOR AN UPLINK-ONLY POSITION ESTIMATION PROCEDURE, THE REQUEST TO PROVIDE THE UE TX TEG REPORT INCLUDED IN A LONG-TERM EVOLUTION (LTE) POSITIONING PROTOCOL (LPP) REQUEST LOCATION INFORMATION MESSAGE FOR THE UPLINK-ONLY POSITION ESTIMATION PROCEDURE
1410
RECEIVE THE UE TX TEG REPORT FROM THE UE, THE UE TX TEG REPORT INCLUDED IN AN LPP PROVIDE LOCATION INFORMATION MESSAGE FOR THE UPLINK-ONLY POSITION ESTIMATION PROCEDURE, THE UE TX TEG REPORT INCLUDING AT LEAST ONE UE TX TEG ASSOCIATED WITH TRANSMISSION, BY THE UE, OF ONE OR MORE UPLINK SOUNDING REFERENCE SIGNAL (UL-SRS) RESOURCES OF AT LEAST ONE UL-SRS RESOURCE SET, THE AT LEAST ONE UE TX TEG INDICATING THAT TRANSMIT TIMING ERRORS OF THE TRANSMISSION OF THE ONE OR MORE UL-SRS RESOURCES OF THE AT LEAST ONE UL-SRS RESOURCE SET ARE WITHIN A MARGIN
1420

FIG. 14

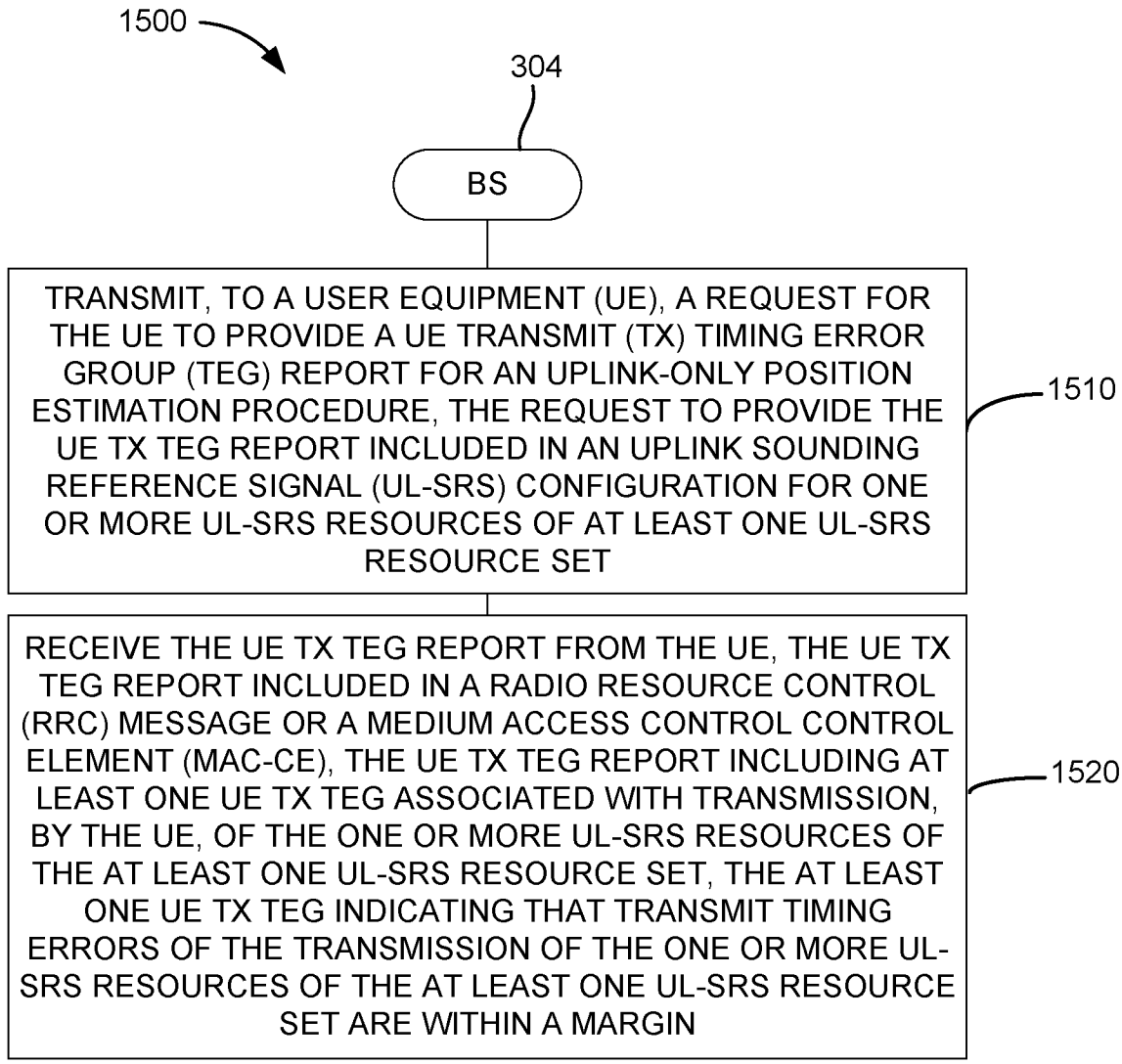

1500
304
BS
TRANSMIT, TO A USER EQUIPMENT (UE), A REQUEST FOR THE UE TO PROVIDE A UE TRANSMIT (TX) TIMING ERROR GROUP (TEG) REPORT FOR AN UPLINK-ONLY POSITION ESTIMATION PROCEDURE, THE REQUEST TO PROVIDE THE UE TX TEG REPORT INCLUDED IN AN UPLINK SOUNDING REFERENCE SIGNAL (UL-SRS) CONFIGURATION FOR ONE OR MORE UL-SRS RESOURCES OF AT LEAST ONE UL-SRS RESOURCE SET
1510
RECEIVE THE UE TX TEG REPORT FROM THE UE, THE UE TX TEG REPORT INCLUDED IN A RADIO RESOURCE CONTROL (RRC) MESSAGE OR A MEDIUM ACCESS CONTROL CONTROL ELEMENT (MAC-CE), THE UE TX TEG REPORT INCLUDING AT LEAST ONE UE TX TEG ASSOCIATED WITH TRANSMISSION, BY THE UE, OF THE ONE OR MORE UL-SRS RESOURCES OF THE AT LEAST ONE UL-SRS RESOURCE SET, THE AT LEAST ONE UE TX TEG INDICATING THAT TRANSMIT TIMING ERRORS OF THE TRANSMISSION OF THE ONE OR MORE UL-SRS RESOURCES OF THE AT LEAST ONE UL-SRS RESOURCE SET ARE WITHIN A MARGIN
1520

FIG. 15

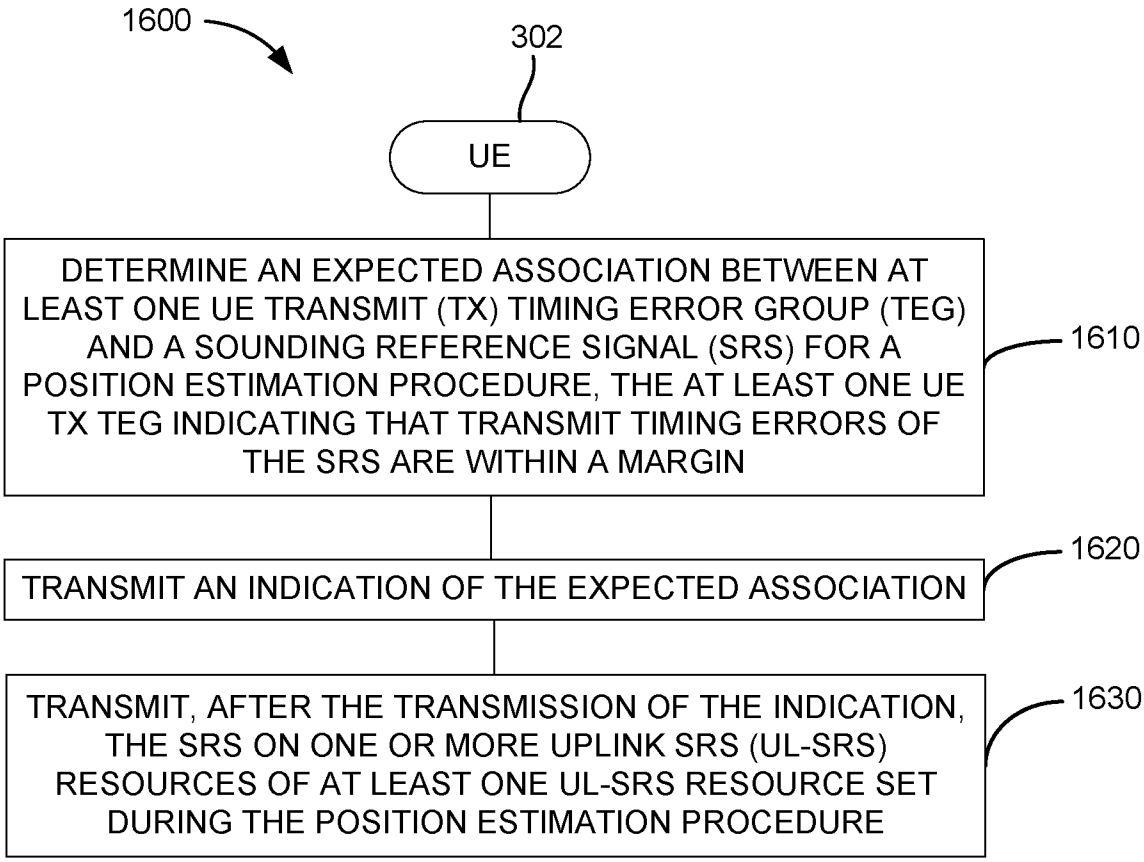

1600
302
UE
DETERMINE AN EXPECTED ASSOCIATION BETWEEN AT LEAST ONE UE TRANSMIT (TX) TIMING ERROR GROUP (TEG) AND A SOUNDING REFERENCE SIGNAL (SRS) FOR A POSITION ESTIMATION PROCEDURE, THE AT LEAST ONE UE TX TEG INDICATING THAT TRANSMIT TIMING ERRORS OF THE SRS ARE WITHIN A MARGIN
1610
TRANSMIT AN INDICATION OF THE EXPECTED ASSOCIATION
1620
TRANSMIT, AFTER THE TRANSMISSION OF THE INDICATION, THE SRS ON ONE OR MORE UPLINK SRS (UL-SRS) RESOURCES OF AT LEAST ONE UL-SRS RESOURCE SET DURING THE POSITION ESTIMATION PROCEDURE
1630

FIG. 16

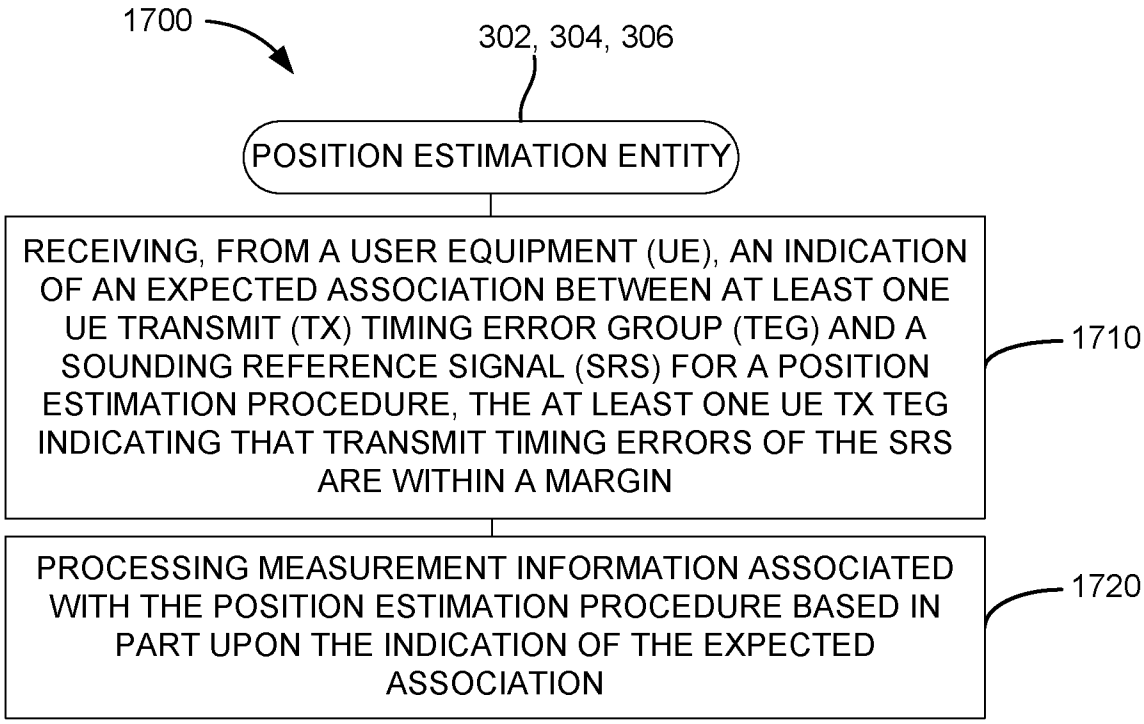

1700
302, 304, 306
POSITION ESTIMATION ENTITY
RECEIVING, FROM A USER EQUIPMENT (UE), AN INDICATION OF AN EXPECTED ASSOCIATION BETWEEN AT LEAST ONE UE TRANSMIT (TX) TIMING ERROR GROUP (TEG) AND A SOUNDING REFERENCE SIGNAL (SRS) FOR A POSITION ESTIMATION PROCEDURE, THE AT LEAST ONE UE TX TEG INDICATING THAT TRANSMIT TIMING ERRORS OF THE SRS ARE WITHIN A MARGIN
1710
PROCESSING MEASUREMENT INFORMATION ASSOCIATED WITH THE POSITION ESTIMATION PROCEDURE BASED IN PART UPON THE INDICATION OF THE EXPECTED ASSOCIATION
1720

FIG. 17

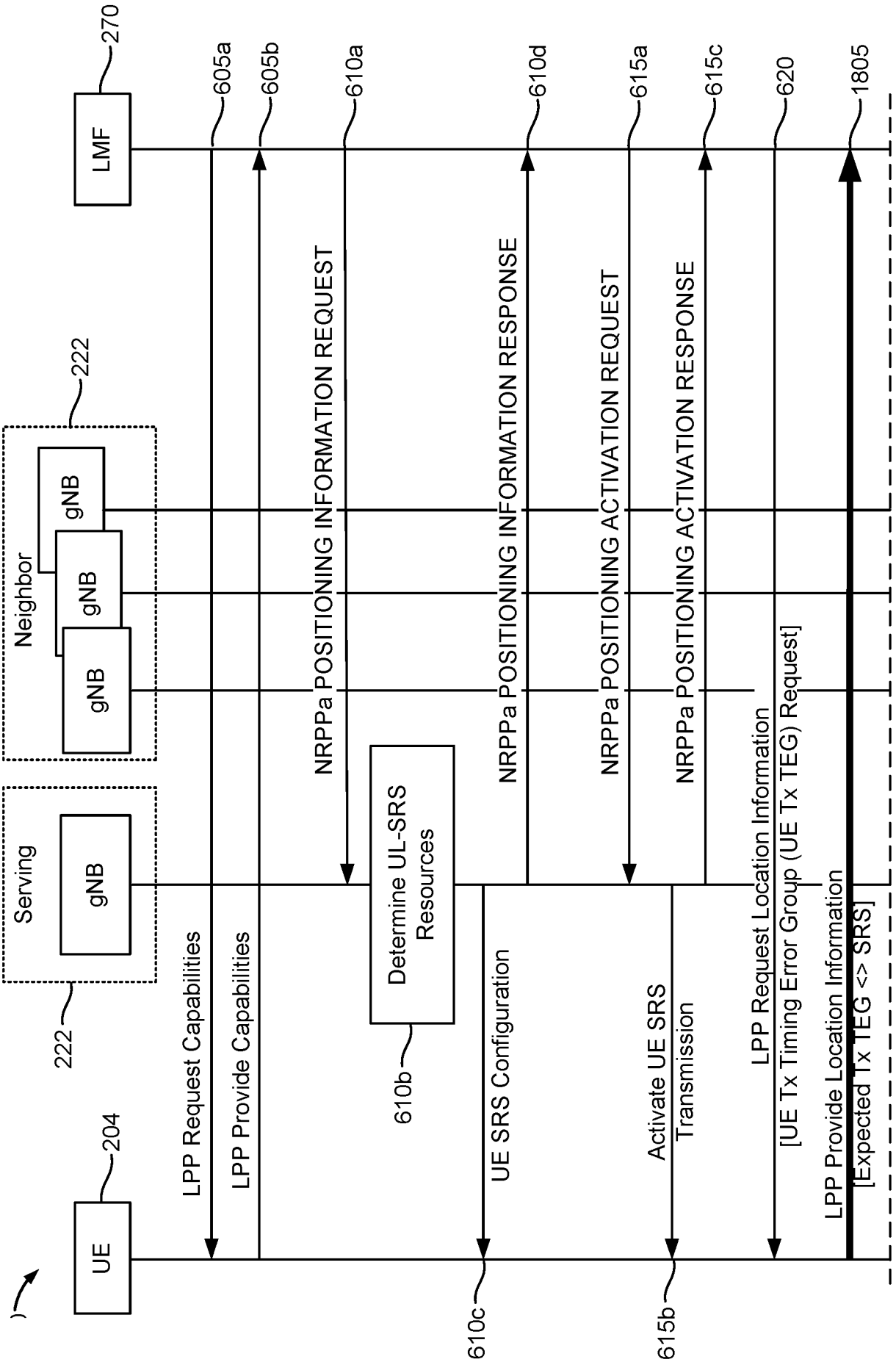

UE
204
LMF
270
Serving
gNB
222
Neighbor
gNB
gNB
gNB
222
605a
605b
610a
610d
615a
615c
620
1805
LPP Request Capabilities
LPP Provide Capabilities
NRPPa POSITIONING INFORMATION REQUEST
NRPPa POSITIONING INFORMATION RESPONSE
NRPPa POSITIONING ACTIVATION REQUEST
NRPPa POSITIONING ACTIVATION RESPONSE
Determine UL-SRS Resources
610b
UE SRS Configuration
610c
Activate UE SRS Transmission
615b
LPP Request Location Information
[UE Tx Timing Error Group (UE Tx TEG) Request]
LPP Provide Location Information
[Expected Tx TEG <> SRS]

FIG. 18A

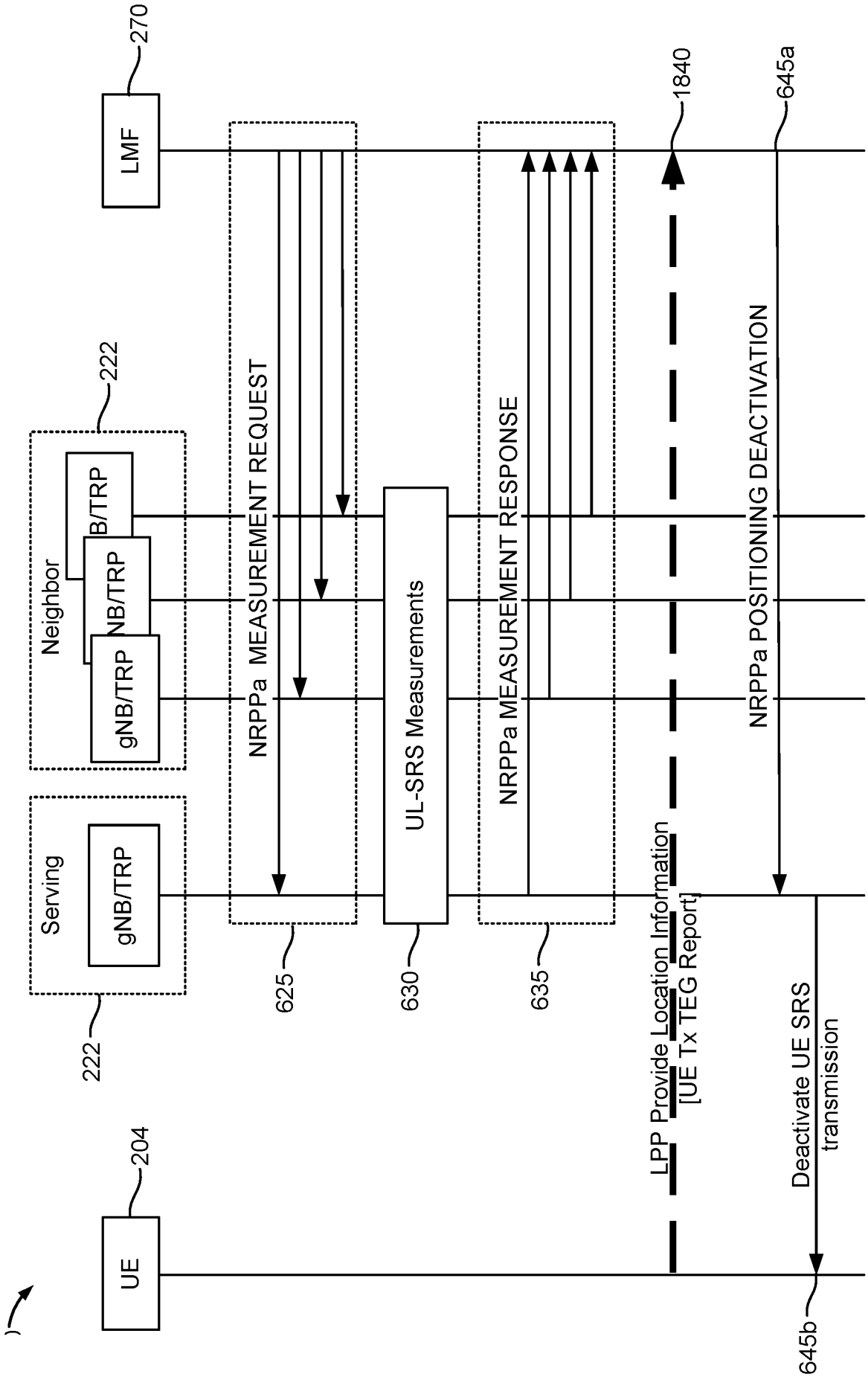

LMF
270
1840
645a
222
Neighbor
B/TRP
NB/TRP
gNB/TRP
Serving
gNB/TRP
222
NRPPa MEASUREMENT REQUEST
625
UL-SRS Measurements
630
NRPPa MEASUREMENT RESPONSE
635
NRPPa POSITIONING DEACTIVATION
LPP Provide Location Information
[UE Tx TEG Report]
Deactivate UE SRS
transmission
UE
204
645b

FIG. 18B

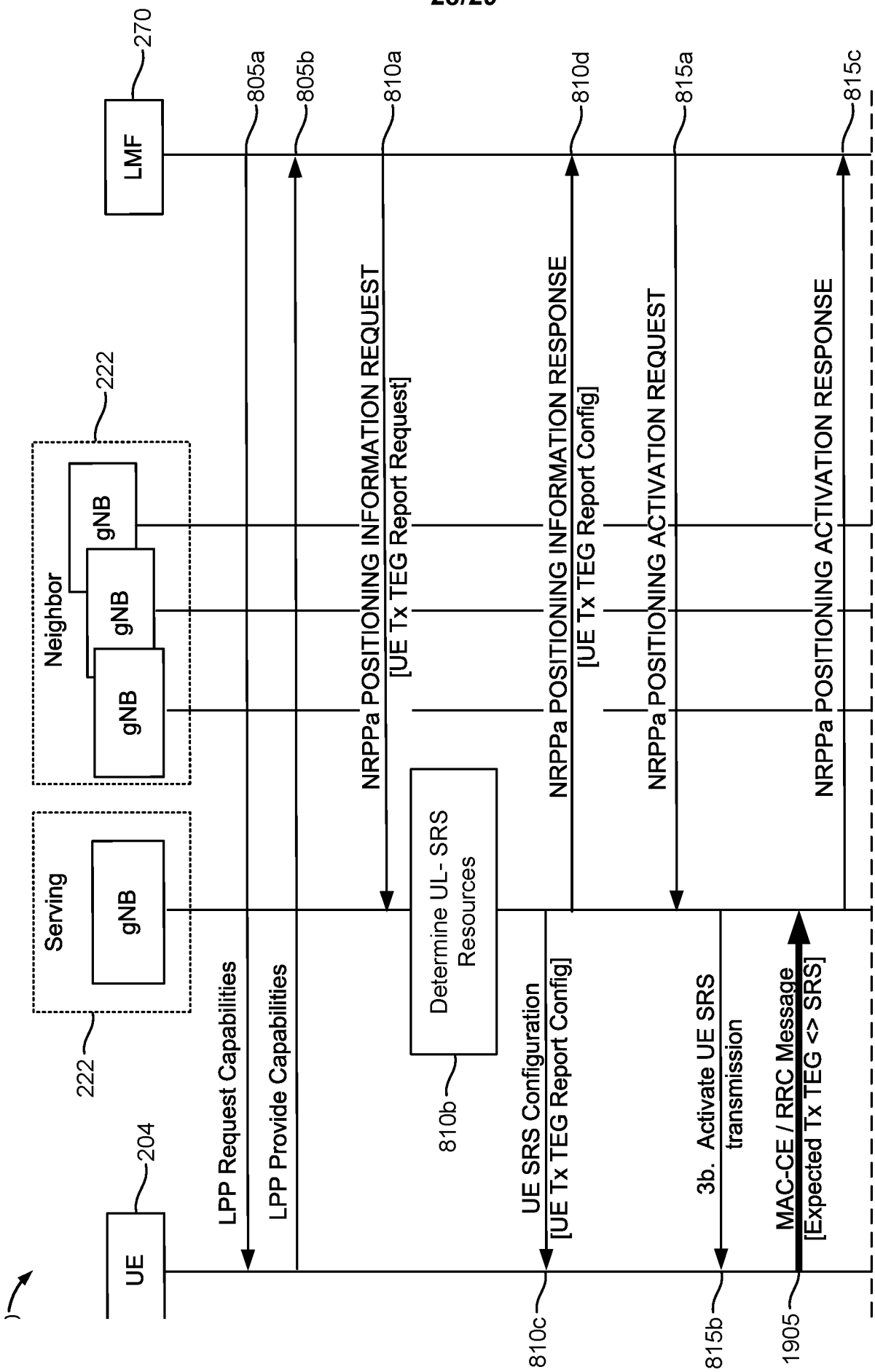

UE
204
Serving
gNB
222
Neighbor
gNB
gNB
gNB
222
LMF
270
LPP Request Capabilities
LPP Provide Capabilities
805a
805b
NRPPa POSITIONING INFORMATION REQUEST
[UE Tx TEG Report Request]
810a
Determine UL- SRS Resources
810b
NRPPa POSITIONING INFORMATION RESPONSE
[UE Tx TEG Report Config]
810d
UE SRS Configuration
[UE Tx TEG Report Config]
810c
NRPPa POSITIONING ACTIVATION REQUEST
815a
3b. Activate UE SRS transmission
815b
MAC-CE / RRC Message
[Expected Tx TEG <> SRS]
1905
NRPPa POSITIONING ACTIVATION RESPONSE
815c

FIG. 19A

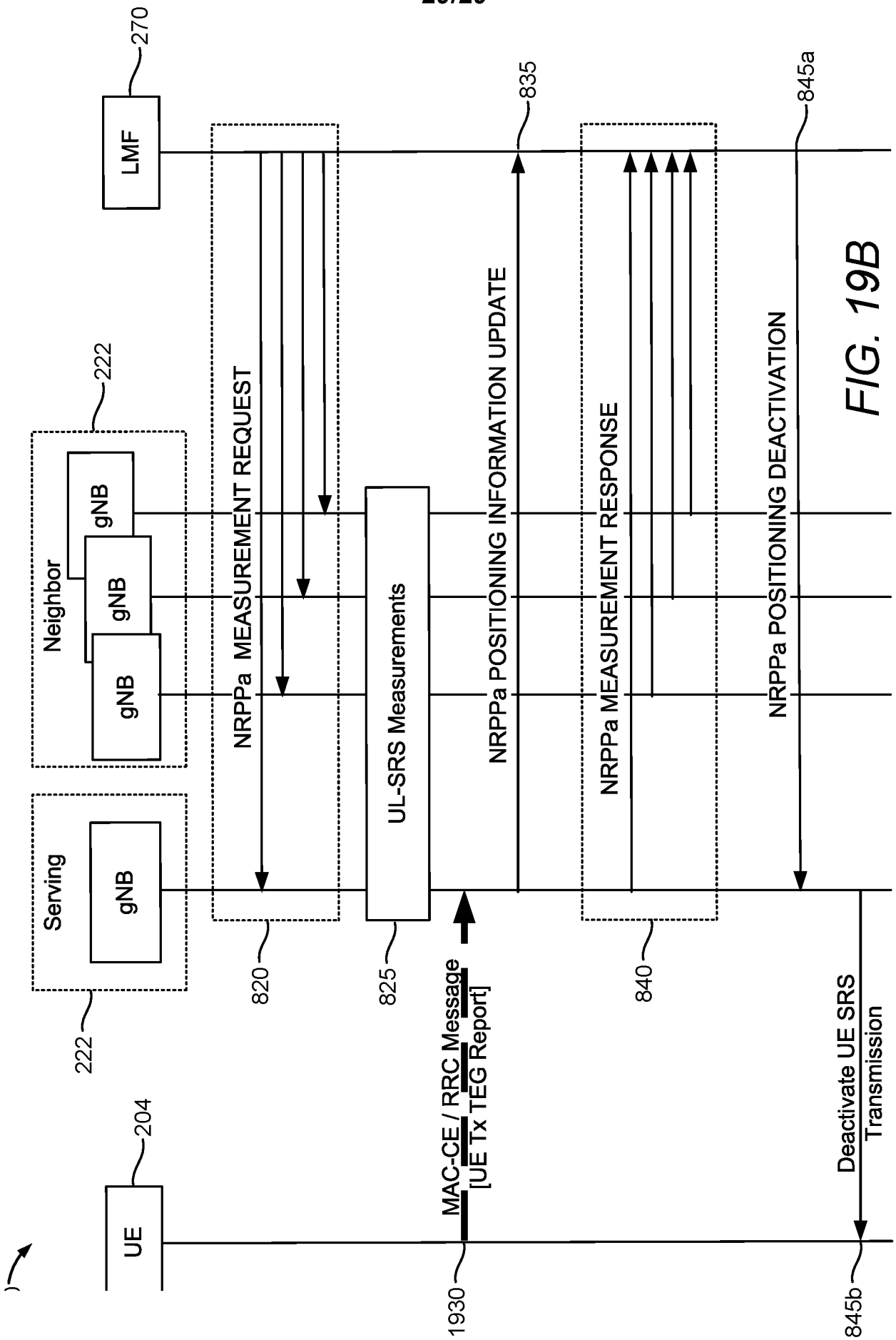

LMF
270
835
845a
Neighbor
222
gNB
gNB
gNB
Serving
gNB
222
NRPPa MEASUREMENT REQUEST
UL-SRS Measurements
NRPPa POSITIONING INFORMATION UPDATE
NRPPa MEASUREMENT RESPONSE
NRPPa POSITIONING DEACTIVATION
820
825
840
MAC-CE / RRC Message
[UE Tx TEG Report]
Deactivate UE SRS
Transmission
UE
204
1930
845b

FIG. 19B

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2022/073203

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00 G01S5/00 H04W64/00
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)
H04L G01S H04W H04B

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	MODERATOR (CATT): "FL Summary #4 for accuracy improvements by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays", 3GPP DRAFT; R1-2103992, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. e-meeting; 20210412 - 20210420 20 April 2021 (2021-04-20), XP051996599, Retrieved from the Internet: URL:https://ftp.3gpp.org/tsg_ran/WG1_RL1/TSGR1_104b-e/Inbox/R1-2103992.zip R1-2103992 FL Summary #4 for accuracy improvements by mitigating UE RxTx andor gNB RxTx timing delays.docx [retrieved on 2021-04-20] -/--	1-10, 18-25, 29-38, 46-53, 57,58, 60,61

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

[x] See patent family annex.

* Special categories of cited documents :

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 October 2022	17/10/2022

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

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	the whole document	11-17, 26-28, 39-45, 54-56, 59,62

Y	WO 2020/229567 A1 (ERICSSON TELEFON AB L M [SE]) 19 November 2020 (2020-11-19)	11, 13-16, 26,27, 39, 41-44, 54,55
A	page 18, line 28 - line 30	10,25, 38,53

X	QUALCOMM INCORPORATED: "Enhancements on Timing Error Mitigations for improved Accuracy", 3GPP DRAFT; R1-2104671, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. e-Meeting; 20210510 - 20210527 12 May 2021 (2021-05-12), XP052010922, Retrieved from the Internet: URL:https://ftp.3gpp.org/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104671.zip R1-2104671.docx [retrieved on 2021-05-12] the whole document	1,2,6-9, 13,18, 19, 22-24, 29,30, 34-37, 41,46, 47,51, 52,57, 58,60,61

X	VIVO: "RRM impacts overview for NR positioning enhancements", 3GPP DRAFT; R4-2109945, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG4, no. Electronic Meeting; 20210519 - 20210527 11 May 2021 (2021-05-11), XP052008606, Retrieved from the Internet: URL:https://ftp.3gpp.org/tsg_ran/WG4_Radio/TSGR4_99-e/Docs/R4-2109945.zip R4-2109945 RRM impacts overview for positioning enhancement_v2.docx [retrieved on 2021-05-11] the whole document	1-3,9, 10,18, 19,24, 25, 29-31, 37,38, 46-48, 52,53, 57,58, 60,61

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2022/073203

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	NOKIA ET AL: "Work plan on Rel-17 NR Positioning Enhancements", 3GPP DRAFT; R4-2110016, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG4, no. Electronic Meeting; 20210519 - 20210527 11 May 2021 (2021-05-11), XP052008654, Retrieved from the Internet: URL:https://ftp.3gpp.org/tsg_ran/WG4_Radio/TSGR4_99-e/Docs/R4-2110016.zip R4-2110016 Rel-17 NR positioning work plan and LS discussion.docx [retrieved on 2021-05-11] -----	10,25, 38,53
Y	VIVO: "Further discussion on multi beam enhancement", 3GPP DRAFT; R1-2102506, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. e-Meeting; 20210412 - 20210420 6 April 2021 (2021-04-06), XP051993112, Retrieved from the Internet: URL:https://ftp.3gpp.org/tsg_ran/WG1_RL1/TSGR1_104b-e/Docs/R1-2102506.zip R1-2102506 Further discussion on multi beam enhancement.docx [retrieved on 2021-04-06] paragraph [0004] - paragraph [0007] -----	11-16, 26,27, 39-44, 54,55
Y	MODERATOR (CATT): "FL Summary #5 for accuracy improvements by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays", 3GPP DRAFT; R1-2106339, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. e-meeting; 20210519 - 20210527 28 May 2021 (2021-05-28), XP052015849, Retrieved from the Internet: URL:https://ftp.3gpp.org/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2106339.zip R1-2106339 FL Summary #5 accuracy improvements by mitigating UEgNB RxTx timing delays.docx [retrieved on 2021-05-28] page 25, line 21 - line 23 -----	17,28, 45,56, 59,62

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2022/073203

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2020229567 A1	19-11-2020	CO 2021016852 A2	17-01-2022
		EP 3970302 A1	23-03-2022
		KR 20220007732 A	18-01-2022
		US 2022209927 A1	30-06-2022
		WO 2020229567 A1	19-11-2020