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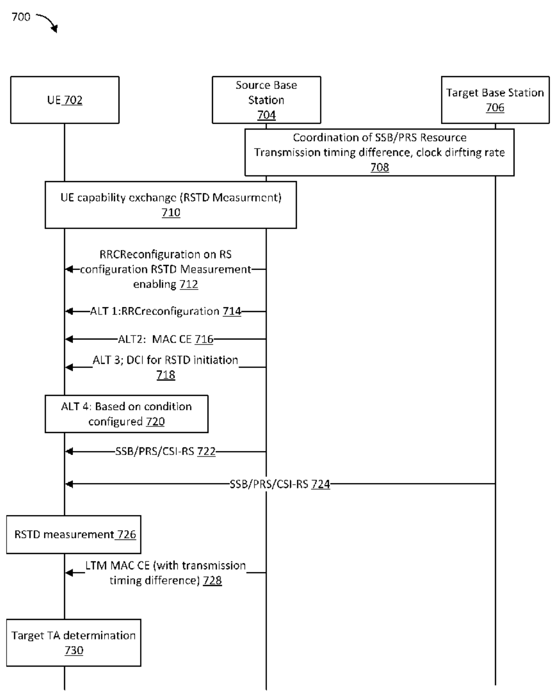

FIG. 7

(57) **Abstract:** Techniques are described for a reference signal time difference time advance. A user equipment (UE) can receive, from a source cell, a radio resource control reconfiguration message including a triggering condition for initiating a determination of a reference signal time difference (RSTD). The UE can detect the triggering condition for initiating determination of the RSTD. The UE can measure a first reference signal transmitted from the source cell and measure a second reference signal transmitted from a target cell. The UE can determine the RSTD based on the measuring the first reference signal and the second reference signal. The UE can determine a timing advance (TA) for the target cell based on the RSTD and a source cell TA.

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REFERENCE SIGNAL TIME DIFFERENCE BASED TIMING ADVANCE

FIELD

[0001] This application relates to the field of networks, in particular, reference signal time difference based timing advance in said networks.

BACKGROUND

[0002] Cellular communications can be defined in various standards to enable communications between a user equipment and a cellular network. For example, a long-term evolution (LTE) network and Fifth generation mobile network (5G) are wireless standards that aim to improve upon data transmission speed, reliability, availability, and more.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Figure 1 is an illustration of a network, according to one or more embodiments.

[0004] Figure 2 is a signaling diagram for a user equipment (UE)-based initiation of a reference signal timing difference (RSTD) measurement, according to one or more embodiments.

[0005] Figure 3 is a signaling diagram for a network-based initiation of an RSTD measurement, according to one or more embodiments.

[0006] Figure 4 is an illustration directed toward asynchronous deployment support, according to one or more embodiments.

[0007] Figure 5 is an illustration directed toward asynchronous deployment support, according to one or more embodiments.

[0008] Figure 6 is a signaling diagram for a RSTD measurement, according to one or more embodiments.

[0009] Figure 7 is a signaling diagram for a RSTD measurement, according to one or more embodiments.

[0010] Figure 8 is a process flow for RTSD measurement, according to one or more embodiments.

[0011] Figure 9 is a process flow for RTSD measurement, according to one or more embodiments.

[0012] Figure 10 is a process flow for RTSD measurement, according to one or more embodiments.

[0013] Figure 11 illustrates an example of receive components, in accordance with some embodiments.

[0014] Figure 12 illustrates an example of a UE, in accordance with some embodiments.

[0015] Figure 13 illustrates an example of a network node, in accordance with some embodiments.

DETAILED DESCRIPTION

[0016] The following detailed description refers to the accompanying drawings. The same reference numbers may be used in different drawings to identify the same or similar elements. In the following description, for purposes of explanation and not limitation, specific details are set forth, such as particular structures, architectures, interfaces, techniques, etc., in order to provide a thorough understanding of the various aspects of various embodiments. However, it will be apparent to those skilled in the art having the benefit of the present disclosure that the various aspects of the various embodiments may be practiced in other examples that depart from these specific details. In certain instances, descriptions of well-known devices, circuits, and methods are omitted so as not to obscure the description of the various embodiments with unnecessary detail. For the purposes of the present document, the phrase “A or B” means (A), (B), or (A and B); and the phrase “based on A” means “based at least in part on A,” for example, it could be “based solely on A” or it could be “based in part on A.”

[0017] The following is a glossary of terms that may be used in this disclosure.

[0018] The term “circuitry” as used herein refers to, is part of, or includes hardware components such as an electronic circuit, a logic circuit, a processor (shared, dedicated, or group) or memory (shared, dedicated, or group), an Application Specific Integrated Circuit (ASIC), a field-programmable device (FPD) (e.g., a field-programmable gate array (FPGA), a programmable logic device (PLD), a complex PLD (CPLD), a high-capacity PLD (HCPLD), a structured ASIC, or a programmable system-on-a-chip (SoC)), digital signal processors (DSPs), etc., that are configured to provide the described functionality. In some embodiments, the circuitry may execute one or more software or firmware programs to provide at least some of the described functionality. The term "circuitry" may also refer to a combination of one or more hardware elements (or a combination of circuits used in an electrical or electronic system) with the program code used to carry out the functionality of that program code. In these embodiments, the combination of hardware elements and program code may be referred to as a particular type of circuitry.

[0019] The term "processor circuitry" as used herein refers to, is part of, or includes circuitry capable of sequentially and automatically carrying out a sequence of arithmetic or logical operations, or recording, storing, or transferring digital data. The term "processor circuitry" may refer to an application processor, baseband processor, a central processing unit (CPU), a graphics processing unit, a single-core processor, a dual-core processor, a triple-core processor, a quad-core processor, or any other device capable of executing or otherwise operating computer-executable instructions, such as program code, software modules, or functional processes.

[0020] The term "interface circuitry" as used herein refers to, is part of, or includes circuitry that enables the exchange of information between two or more components or devices. The term "interface circuitry" may refer to one or more hardware interfaces, for example, buses, I/O interfaces, peripheral component interfaces, network interface cards, or the like.

[0021] The term "user equipment" or "UE" as used herein refers to a device with radio communication capabilities and may describe a remote user of network resources in a communications network. The term "user equipment" or "UE" may be considered synonymous to, and may be referred to as, client, mobile, mobile device, mobile terminal, user terminal, mobile unit, mobile station, mobile user, subscriber, user, remote station, access agent, user agent, receiver, radio equipment, reconfigurable radio equipment, reconfigurable mobile device, etc. Furthermore, the term "user equipment" or "UE" may include any type of wireless/wired device or any computing device including a wireless communications interface.

[0022] The term "base station" as used herein refers to a device with radio communication capabilities, that is a network component of a communications network (or, more briefly, a network), and that may be configured as an access node in the communications network. A UE's access to the communications network may be managed at least in part by the base station, whereby the UE connects with the base station to access the communications network. Depending on the radio access technology (RAT), the base station can be referred to as a gNodeB (gNB), eNodeB (eNB), access point, etc.

[0023] The term "network" as used herein reference to a communications network that includes a set of network nodes configured to provide communications functions to a plurality of user equipment via one or more base stations. For instance, the network can be a public land mobile network (PLMN) that implements one or more communication technologies including, for instance, 5G communications.

[0024] The term "computer system" as used herein refers to any type of interconnected electronic devices, computer devices, or components thereof. Additionally, the term "computer system" or "system" may refer to various components of a computer that are communicatively coupled with one another. Furthermore, the term "computer system" or "system" may refer to multiple computer devices or multiple computing systems that are communicatively coupled with one another and configured to share computing or networking resources.

[0025] The term "resource" as used herein refers to a physical or virtual device, a physical or virtual component within a computing environment, or a physical or virtual component within a particular device, such as computer devices, mechanical devices, memory space, processor/CPU time, processor/CPU usage, processor and accelerator loads, hardware time or usage, electrical power, input/output operations, ports or network sockets, channel/link allocation, throughput, memory usage, storage, network, database and applications, workload units, or the like. A "hardware resource" may refer to compute, storage, or network resources provided by physical hardware element(s). A "virtualized resource" may refer to compute, storage, or network resources provided by virtualization infrastructure to an application, device, system, etc. The term "network resource" or "communication resource" may refer to resources that are accessible by computer devices/systems via a communications network. The term "system resources" may refer to any kind of shared entities to provide services and may include computing or network resources. System resources may be considered as a set of coherent functions, network data objects or services, accessible through a server where such system resources reside on a single host or multiple hosts and are clearly identifiable.

[0026] The term “channel” as used herein refers to any transmission medium, either tangible or intangible, which is used to communicate data or a data stream. The term “channel” may be synonymous with or equivalent to “communications channel,” “data communications channel,” “transmission channel,” “data transmission channel,” “access channel,” “data access channel,” “link,” “data link,” “carrier,” “radio-frequency carrier,” or any other like term denoting a pathway or medium through which data is communicated. Additionally, the term “link” as used herein refers to a connection between two devices for the purpose of transmitting and receiving information.

[0027] The terms “instantiate,” “instantiation,” and the like as used herein refer to the creation of an instance. An “instance” also refers to a concrete occurrence of an object, which may occur, for example, during execution of program code.

[0028] The term “connected” may mean that two or more elements, at a common communication protocol layer, have an established signaling relationship with one another over a communication channel, link, interface, or reference point.

[0029] The term “network element” as used herein refers to physical or virtualized equipment or infrastructure used to provide wired or wireless communication network services. The term “network element” may be considered synonymous to or referred to as a networked computer, networking hardware, network equipment, network node, virtualized network function, or the like.

[0030] The term “information element” refers to a structural element containing one or more fields. The term “field” refers to individual contents of an information element, or a data element that contains content. An information element may include one or more additional information elements.

[0031] The term “3GPP Access” refers to accesses (e.g., radio access technologies) that are specified by 3GPP standards. These accesses include, but are not limited to, GSM/GPRS, LTE,

LTE-A, 5G NR, or 6G. In general, 3GPP access refers to various types of cellular access technologies.

[0032] The term "Non-3GPP Access" refers to any accesses (e.g., radio access technologies) that are not specified by 3GPP standards. These accesses include, but are not limited to, WiMAX, CDMA2000, Wi-Fi, WLAN, or fixed networks. Non-3GPP accesses may be split into two categories, "trusted" and "untrusted." Trusted non-3GPP accesses can interact directly with an evolved packet core (EPC) or a 5G core (5GC), whereas untrusted non-3GPP accesses interwork with the EPC/5GC via a network entity, such as an Evolved Packet Data Gateway or a 5G NR gateway. In general, non-3GPP access refers to various types on non-cellular access technologies.

[0033] Figure 1 is an illustration of a network 100 that may utilize a timing advance acquisition, according to one or more embodiments. An objective of 3GPP is to support L1/L2 triggered mobility (LTM). The main motivation for supporting LTM is to reduce latency. One contributor for latency is timing advance (TA) information acquisition. A user equipment (UE) 102 can acquire TA information from a target cell 104 through a variety of techniques. One technique is that a source cell 106 can indicate the TA information to the UE 102 using a physical downlink control channel transmission. Upon receipt of the TA information, the UE 102 can initiate a random access channel transmission to establish a connection with the target cell 104. Another technique is that the network can provide the TA information to the UE 102 during a cell switch using a medium access control (MAC) control element (CE) (e.g., an LTM MAC CE) with values, where a '0' indicates that the UE 102 shall apply the TA of the source cell 106. A third technique has been suggested is that UE 102 can derive the TA based on reference signal timing difference between the source cell 106 and the candidate target cell (e.g., the target cell 104) as well as TA value for the source cell 106.

[0034] During a conventional LTM mobility procedure, the UE 102 can perform an early TA acquisition with candidate target cells, including the target cell 104, prior to receiving a cell switch command from a network. The UE 102 is triggered by a PDCCH to perform the early TA acquisition via a contention-free random access (CFRA) procedure. During the CFRA procedure the UE 102 sends a preamble to the candidate target cell. During this CFRA procedure the UE 102 does not receive a random access response (RAR) for TA acquisition. Furthermore, the UE

102 can receive the TA information via the cell switch command. The UE 102 does not maintain a TA timer for the candidate target cell 104 and relies on the network for determination of the validity of the TA information.

[0035] Issues with the above suggested third technique can include determining how to initiate a reference signal timing difference (RSTD) measurement and how a RSTD measurement operates. Other issues include determining which entity (e.g., UE 102 or network) maintains the TA information and determining a validity of the RSTD. Yet other issues include gap configuration when the UE 102 cannot maintain its communication with the source cell 106 while performing a RSTD measurement and whether the UE has the capability for RSTD measurement. Yet even other issues include determining a timing difference between the source cell 106 and the target cell 104 due to network synchronization issues. For example, due to an asynchronous deployment where to base stations have a timing difference on a slot boundary, or due to clock drifting on the source cell 106 and the target cell 104.

[0036] Embodiments described herein address the above referenced issues. The UE 102 can measure reference signals, such a positioning reference signal (PRS), a synchronization signal block (SSB), or a channel state information (CSI) reference signal (RS). The network can transmit a configuration to the UE 102 as to the measurement of the reference signal. For example, the network can configure the UE 102 with reference signal resources for SSB index, CSI-RS resources, cell identifier (ID), carrier frequency via radio resource control (RRC) messaging or via a MAC CE. The network transmitted the configuration to the UE 102 can be implemented as RRC providing full list of resources and the MAC CE triggering the use of the resources for measurement. The network can explicitly trigger the UE 102 to perform a RSTD measurement, or the UE 102 can be configured to autonomously perform the RSTD measurement. In some instance, the UE may need a gap between uplink (UL) and downlink (DL) and the RSTD measurement. The UE 102 can be triggered to perform a single RSTD measurement, or the UE 102 can be configured to perform periodic measurement. The UE can maintain the RSTD measurement or the network can maintain the RSTD measurement.

[0037] The UE 102 should not expend too much power continuously performing an RSTD measurement. Therefore, the network can configure the UE 102 to perform the RSTD measurement in response to a condition being met. Or the network can trigger the UE to perform the RSTD measurement. The network trigger can trigger the UE 102 to perform the RSTD measurement via an RRC configuration., a DLinformationTransfer, a MAC CE, or downlink control information (DCI).

[0038] Figure 2 is a signaling diagram 200 for a UE-based initiation of a RSTD measurement, according to one or more embodiments. As illustrated a UE 202, a source base station 204, and a target base station 206 can be in operable communication. At 208, the source base station 204 and the target base station 206 can coordinate as to which resources to use for a SSB, PRS or CSI reference signal.

[0039] At 210 the source base station 204 can transmit a configuration for reference signal resources to the UE 202. The source base station 204 can transmit the reference signal resource configuration information via an RRC message, such as RRCReconfiguration messaging. The RRC messaging can further include a condition to trigger the UE 202 to perform the RSTD measurement, a configuration as to whether the RSTD is a single RSTD or a periodic RSTD. The RRC message can further include a configuration as to a gap between RSTD measurement and any UL or DL transmissions.

[0040] The condition to trigger the UE 202 to perform the RSTD can include a legacy S-measure criteria (e.g., comparing a reference signal received power (RSRP), reference signal received quality (RSRQ), or a signal to interference noise ratio (SINR) to a respective threshold) based on measuring a reference signal from the source cell. The condition to trigger the UE 292 to perform the RSTD can also a L3 measurement criteria (e.g., comparing a RSRP, RSRQ, or a SINR to a respective threshold) based on the source cell or target cell channel quality.

[0041] The condition to trigger the UE 202 to perform the RSTD can also include an L1 measurement criteria based on a channel state information (CSI). For example, the trigger can be the UE 202 can determine than the target cell has a better signal quality that a threshold. The UE 202 can also determine that the source cell has worse signal quality than a threshold.

[0042] The condition to trigger the UE 292 to perform the RSTD can also include a UE mobility status, a UE height above a ground surface, and a UE moving direction.

[0043] At 212, the UE 202 can perform layer 3 (L3) or L1 measurements on the source cell and the neighbor cell (e.g., candidate target cell).

[0044] At 214, the UE 202 can detect that a condition has been met for initiating the RSTD measurement. At step 216, the source base station 204 can transmit a reference signal (e.g., SSB, PRS, or CSI-RS). At step 218, the target base station 206 can transmit a reference signal (e.g., SSB, PRS, or CSI-RS). The UE 202 can perform RSTD measurement.

[0045] At 216, the UE 202 can detect that the condition to trigger RSTD measurement is no longer met, and the UE can stop measurement of reference signals from the source base station 204 and the target base station 206.

[0046] Figure 3 is a signaling diagram 300 for network-based initiation of a RSTD measurement, according to one or more embodiments. As illustrated a UE 302, a source base station 304, and a target base station 306 can be in operable communication. At 308, the source base station 304 and the target base station 306 can coordinate as to which resources to use for a SSB or PRS reference signal.

[0047] At 310 the source base station 204 can transmit a configuration for reference signal resources to the UE 302. The source base station 304 can transmit the reference signal resource configuration information via an RRCReconfiguration messaging. The RRCReconfiguration messaging can further include a condition to trigger the UE 302 to perform the RSTD measurement, a configuration as whether the RSTD is a single RSTD or a periodic RSTD. The RRCReconfiguration message can further include a configuration as to a gap between RSTD measurement and any UL or DL transmissions.

[0048] Steps 312, 314, and 316 describe alternative network-based mechanisms to trigger the UE 302 to perform RSTD measurement. At 312, the source base station 304 can transmit an RRCReconfiguration message to trigger the UE 302 to perform RSTD measurement.

[0049] At 314, the source base station 304 can transmit a MAC CE to trigger the UE 302 to perform RSTD measurement. The MAC CE can be a transmission configuration indicator (TCI) MAC CE. Alternatively, the MAC CE be another MAC CE type for triggering the UE to perform RSTD measurement. For this MAC CE, the network can indicate that the cell ID carrier frequency and the reference signal to use for RSTD measurement. The MAC Ce can also be a TA command MAC CE. For this MAC CE, the UE can calculate the target cell's TA each time that the source cell's TA is updated.

[0050] At 316, the source base station 304 can transmit downlink control information (DCI) to trigger the UE 302 to perform RSTD measurement.

[0051] At step 318, the source base station 304 can transmit a reference signal (e.g., SSB,PRS, or CSI-RS). At step 320, the target base station 306 can transmit a reference signal (e.g., SSB, PRS, or CSI-RS).

[0052] At step 322, the UE can determine that either step 312, 314, or 316 have occurred and initiate RSTD measurement.

[0053] For conventional PDCCH based early TA acquisition, the network maintains the TA value and maintains a timing alignment timer (TAT) to determine the validity of the TA. In this scenario, the UE is not privy to the TA information. The TA may become invalid based on expiration of the TAT based on the UE's movement or network clock drifting.

[0054] As described herein, a source network can maintain the RSTD measurement result similar to conventional PDCCH based early TA acquisition. The UE can report the RSTD measurements for multiple candidate target cells to the source network and the source network can maintain each RSTD measurement result. The source network can use a respective TAT to determine the validity of each RSTD measurement result. Or the source network can use a respective another timer (e.g., a validity timer) to determine the validity of each RSTD measurement result. In any case, when the timer is about to expire, the UE can perform another RSTD measurement for each candidate target cell and report the results to the source network. If the UE is configured to perform RSTD measurement based on a trigger, the UE can be triggered to perform the RSTD measurements based on an RRC message, a MAC CE, or DCI, as described above. The source network can use various criteria for determining to trigger the UE to perform RSTD measurement (e.g., an L3 measurement result, UL channel quality based on sounding reference signal (SRS, or other appropriate criteria). If the UE is configured for periodic RSTD measurement, the source base station can transmit configuration information to set the period at smaller length of time than the time for the timer to expire.

[0055] As described herein, the UE can also maintain the RSTD measurement result. In this scenario, the UE can initiate an RSTD measurement based on various triggers. For example, the UE can maintain a validity timer and initiate an RSTD measurement based on the timer. Or the source network can configure the UE for periodic RSTD measurement. In the instance the UE maintain a timer, the UE can start a timer upon determining a RSTD measurement result. The UE can initiate a subsequent RSTD measurement based on expiration of the timer.

[0056] Another trigger can be that the UE detects that a source cell "filtered" threshold is greater or smaller than a threshold. For example, the UE can use an L3 measurement derived from an average of multiple L1 measurements of reference signals. The UE can then use an L3 filter to determine a value to reduce any fluctuation in values from the L1 measurements. Another trigger can be the UE detects that the source cell TA has changed greater than a threshold value, regardless of whether TA has increased or decreased. Another trigger can be that a candidate target cell (on which the UE has measured a RSTD), has a RSRP or RSRQ that changed by a threshold value. Another trigger can be that the UE moves from an original source cell and establishes a connection with a new source cell. The network can configure the UE to use any of the above triggers. In addition, the UE can adjust the frequency or periodicity of the RSTD measurement based on the UE's movements. For example, the UE can increase the frequency of RSTD measurement based on moving over a threshold number of cells in a given time interval. Or the UE can reduce the frequency of RSTD measurement based on reducing speed and no longer moving over a threshold number of cells in a given time interval.

[0057] In some instances, the UE may not support the capability for simultaneous performance of RSTD measurement and communication (e.g., UL and DL transmissions). Furthermore, the UE's capability may be asked on whether the communication is intra-frequency or inter-frequency scenarios. Additionally, the UE may only have the capability to support a finite number of RSTD measurements simultaneously.

[0058] The UE can report RSTD measurement capability and a need for a gap between RSTD measurement and communication for either intra-frequency scenarios or inter-frequency scenarios. The UE can also report its capability for the total number of RSTD measurements its can perform simultaneously. The UE can report its capabilities for the total number of RSTD measurements in intra-frequency scenarios and inter-frequency scenarios together or separately. The UE can also report its capability for the total number of RSTD measurements as a total number without distinguishing between intra-frequency scenarios and inter-frequency scenarios.

The UE can also report the capability to configure a gap between RSTD measurement and communication autonomously.

[0059] The network can transmit configuration information to the UE for the gap, which can be a gap for a particular RSTD measurement, or a periodic gap for periodic RSTD measurement. The network can transmit the configuration information via uplink control information (UCI), an RRC message, and a MAC CE. The network can also transmit configuration information to permit the UE to autonomously configure a gap.

[0060] Figure 4 is an illustration directed toward asynchronous deployment support, according to one or more embodiments. In some instances, a UE RSTD measurement result incudes a transmission time difference and propagation delay difference. In these instances, the UE can calculate the TA by deducting the transmission time difference from the RSTD. The transmission time difference can be based on inherent/fixe time differences of the source cell and candidate target cell or a variant difference based on clock drifting. In Figure 4, a source cell reference signal 402 is illustrated next to a target cell reference signal 404. A delta 406 representing an asynchronous timing difference and clock drifting is also illustrated.

[0061] The network can indicate the delta 406 to the UE using a LTM MAC CE or RRC message. The delta 406 can be a positive or a negative value. The UE can use the delta value 406, the measured RSTD value, and source cell TA to drive the candidate target cell TA value.

[0062] Another approach is illustrated by Figure 5, in which a reception source cell reference signal 502, a first reception target cell reference signal 504, and a second reception target cell reference signal 504 are illustrated. A delta 508 representing an asynchronous timing difference and clock drifting is also illustrated. The UE can derive the transmission timing difference from a reference time information element element (ReferenceTimeInfo) in system information block (SIB) 9, if available and the parameter referenceSFN (3GPP Technical Specification (T.S.) 38.331 V17.5.0 (2023-06)) . A formula for deriving the TA can be as follows:

$$\text{Target cell TA} = \text{Source cell TA} + 2*(\text{RSTD measurement value} - \text{Delta})$$

[0063] Figure 6 is a signaling diagram for a RSTD measurement, according to one or more embodiments. As illustrated a UE 602, a source base station 604, and a target base station 606 can be in operable communication. At 608, the source base station 604 and the target base station

606 can coordinate as to which resources to use for a SSB or PRS reference signal. The source base station 604 and the target base station 606 can further coordinate a transmission timing difference and clock drifting rate.

[0064] At 610, the UE 602 can exchange RSTD capability information with the source base station 604.

[0065] At 612 the source base station 604 can transmit a configuration for reference signal resources to the UE 602. The source base station 604 can transmit the reference signal resource configuration information via an RRCReconfiguration messaging. The RRCReconfiguration messaging can further include a condition to trigger the UE 602 to perform the RSTD measurement, a configuration as whether the RSTD is a single RSTD or a periodic RSTD. The RRCReconfiguration message can further include a configuration as to a gap between RSTD measurement and any UL or DL transmissions.

[0066] 614, 616, and 618 describe alternative network-based mechanisms to trigger the UE 602 to perform RSTD measurement. At 614, the source base station 604 can transmit an RRCReconfiguration message to trigger the UE 602 to perform RSTD measurement.

[0067] At 616, the source base station 604 can transmit a MAC CE to trigger the UE 602 to perform RSTD measurement. The MAC CE can be a transmission configuration indicator (TCI) MAC CE. Alternatively, the MAC CE be another MAC CE type for triggering the UE to perform RSTD measurement. For this MAC CE, the network can indicate that the cell ID carrier frequency and the reference signal to use for RSTD measurement. The MAC CE can also be a TA command MAC CE. For this MAC CE, the UE can calculate the target cell's TA each time that the source cell's TA is updated.

[0068] At 618, the source base station 604 can transmit downlink control information (DCI) to trigger the UE 602 to perform RSTD measurement.

[0069] At 620, the UE can detect one of the triggers described in 614, 616, and 618 for RSTD measurement initiation.

[0070] At 622, the source base station 604 can transmit a reference signal (e.g., SSB, PRS, or CSI-RS). At 624, the target base station(s) 606 can transmit a reference signal(s) (e.g., SSB, PRS, or CSI-RS).

[0071] At 626, the UE can perform an RSTD measurement based on the reference signals transmitted at 622 and 624.

[0072] At 628, the UE can transmit the RSTD measurement value(s) to the source base station.

[0073] At 630, the source base station can use the RSTD measurement value(s) to calculate a TA for each candidate target cell.

[0074] At 632, the source base station 604 can transmit the TA value(s) to the UE 602 using, for example, an LTM MAC CE.

[0075] Figure 7 is a signaling diagram for a RSTD measurement, according to one or more embodiments. As illustrated a UE 702, a source base station 704, and a target base station 706 can be in operable communication. At 708, the source base station 704 and the target base station 706 can coordinate as to which resources to use for a SSB or PRS reference signal. The source base station 704 and the target base station 706 can further coordinate a transmission timing difference and clock drifting rate.

[0076] At 710, the UE 702 can exchange RSTD capability information with the source base station 704.

[0077] At 712 the source base station 704 can transmit a configuration for reference signal resources to the UE 702. The source base station 704 can transmit the reference signal resource configuration information via an RRCReconfiguration messaging. The RRCReconfiguration messaging can further include a condition to trigger the UE 602 to perform the RSTD measurement, a configuration as whether the RSTD is a single RSTD or a periodic RSTD. The RRCReconfiguration message can further include a configuration as to a gap between RSTD measurement and any UL or DL transmissions.

[0078] 714, 716, and 718 describe alternative network-based mechanisms to trigger the UE 702 to perform RSTD measurement. At 714, the source base station 704 can transmit an RRCReconfiguration message to trigger the UE 702 to perform RSTD measurement.

[0079] At 716, the source base station 704 can transmit a MAC CE to trigger the UE 702 to perform RSTD measurement. The MAC CE can be a transmission configuration indicator (TCI) MAC CE. Alternatively, the MAC CE be another MAC CE type for triggering the UE to perform RSTD measurement. For this MAC CE, the network can indicate that the cell ID carrier frequency and the reference signal to use for RSTD measurement. The MAC CE can also be a TA command MAC CE. For this MAC CE, the UE can calculate the target cell's TA each time that the source cell's TA is updated.

[0080] At 718, the source base station 704 can transmit downlink control information (DCI) to trigger the UE 702 to perform RSTD measurement.

[0081] At 720, the UE can detect one of the triggers described in 714, 716, and 718 for RSTD measurement initiation.

[0082] At 722, the source base station 704 can transmit a reference signal (e.g., SSB, PRS, or CSI-RS). At 724, the target base station(s) 706 can transmit a reference signal(s) (e.g., SSB, PRS, or CSI-RS).

[0083] At 726, the UE can perform an RSTD measurement based on the reference signals transmitted at steps 722 and 724.

[0084] At 728, the source base station 704 can transmit transmission timing difference information to the UE 702.

[0085] At 730, the UE 702 can use the RSTD measurement value(s) and the transmission timing difference information to calculate a TA for each candidate target cell.

[0086] Figure 8 is a process flow 800 for RTSD measurement, according to one or more embodiments. At 802, the method can include a UE receiving, from a source cell, an RRC reconfiguration message including a triggering condition for initiating a determination of a RSTD.

[0087] At 804, the method can include the UE detecting the triggering condition for initiating determination of the RSTD.

[0088] At 806, the method can include the UE measuring a first reference signal transmitted from the source cell.

[0089] At 808, the method can include the UE measuring a second reference signal transmitted from a target cell.

[0090] At 810 the method can include the UE determining the RSTD based on the measuring the first reference signal and the second reference signal.

[0091] At 812, the method can include the UE determining a TA for the target cell based on the RSTD.

[0092] Figure 9 is a process flow 900 for RTSD measurement, according to one or more embodiments. At 902, the method can include a network node transmitting , to a UE, a configuration to initiate determining a RSTD between a source cell and a target cell.

[0093] At 904, the method can include the network node receiving, from the UE, a first RSTD between the source cell and the target cell based on the configuration.

[0094] At 906, the method can include the network node starting a timer based on receiving the first RSTD from the UE.

[0095] At 908, the method can include the network node determining the first RSTD is invalid based on an expiration of the timer.

[0096] At 910, the method can include the network node receiving, from the UE, a second RSTD between the source cell and the target cell based on the configuration.

[0097] Figure 10 is a process flow 1000 for RTSD measurement, according to one or more embodiments. At 1002, the method can include a UE receiving, from a source cell, a configuration including a triggering condition to initiate determining a RSTD between the source cell and a candidate target cell.

[0098] At 1004, the method can include the UE detecting a triggering condition instance to initiate determining a first reference signal RSTD.

[0099] At 1006, the method can include the UE measuring a first reference signal transmitted from the source cell.

[0100] At 1008, the method can include the UE measuring a second reference signal transmitted from a target cell.

[0101] At 1010, the method can include the UE determining a first RSTD based on the measuring the first reference signal and the second reference signal, wherein the UE maintains the first RSTD.

[0102] At 1012, the method can include the UE determining a TA for the target cell based on the first RSTD.

[0103] Figure 11 illustrates receive components 1100 of the UE 1106, in accordance with some embodiments. The receive components 1100 may include an antenna panel 1104 that includes a number of antenna elements. The panel 1104 is shown with four antenna elements, but other embodiments may include other numbers. The antenna panel 1104 may be coupled to analog beamforming (BF) components that include a number of phase shifters 1108(1) – 1108(4). The phase shifters 1108(1) – 1108(4) may be coupled with a radio-frequency (RF) chain 1112. The RF chain 1112 may amplify a receive analog RF signal, downconvert the RF signal to baseband, and convert the analog baseband signal to a digital baseband signal that may be provided to a baseband processor for further processing.

[0104] In various embodiments, control circuitry, which may reside in a baseband processor, may provide BF weights (e.g., W1 – W4), which may represent phase shift values, to the phase shifters 1108(1) – 1108(4) to provide a receive beam at the antenna panel 1104. These BF weights may be determined based on the channel-based beamforming.

[0105] Figure 12 illustrates a UE 1200, in accordance with some embodiments. The UE 1200 may be similar to and substantially interchangeable with UE 1106 of Figure 11.

[0106] Similar to that described above with respect to UE 1200, the UE 1200 may be any mobile or non-mobile computing device, such as, for example, mobile phones, computers, tablets, industrial wireless sensors (for example, microphones, carbon dioxide sensors, pressure sensors, humidity sensors, thermometers, motion sensors, accelerometers, laser scanners, fluid level sensors, inventory sensors, electric voltage/current meters, actuators, etc.), video surveillance/monitoring devices (for example, cameras, video cameras, etc.), wearable devices, or relaxed-IoT devices. In some embodiments, the UE may be a reduced capacity UE or NR-Light UE.

[0107] The UE 1200 may include processors 1204, RF interface circuitry 1208, memory/storage 1212, user interface 1216, sensors 1220, driver circuitry 1222, power management integrated circuit (PMIC) 1224, and battery 1228. The components of the UE 1200 may be implemented as integrated circuits (ICs), portions thereof, discrete electronic devices, or other modules, logic, hardware, software, firmware, or a combination thereof. The block diagram of Figure 12 is intended to show a high-level view of some of the components of the UE 1200. However, some of the components shown may be omitted, additional components may be present, and different arrangements of the components shown may occur in other implementations.

[0108] The components of the UE 1200 may be coupled with various other components over one or more interconnects 1232, which may represent any type of interface, input/output, bus (local, system, or expansion), transmission line, trace, optical connection, etc. that allows various circuit components (on common or different chips or chipsets) to interact with one another.

[0109] The processors 1204 may include processor circuitry such as, for example, baseband processor circuitry (BB) 1204A, central processor unit circuitry (CPU) 1204B, and graphics processor unit circuitry (GPU) 1204C. The processors 1204 may include any type of circuitry or processor circuitry that executes or otherwise operates computer-executable instructions, such as program code, software modules, or functional processes from memory/storage 1212 to cause the UE 1200 to perform operations as described herein.

[0110] In some embodiments, the baseband processor circuitry 1204A may access a communication protocol stack 1236 in the memory/storage 1212 to communicate over a 3GPP compatible network. In general, the baseband processor circuitry 1204A may access the communication protocol stack to: perform user plane functions at a PHY layer, MAC layer, RLC layer, PDCP layer, SDAP layer, and PDU layer; and perform control plane functions at a PHY layer, MAC layer, RLC layer, PDCP layer, RRC layer, and a non-access stratum “NAS” layer. In some embodiments, the PHY layer operations may additionally/alternatively be performed by the components of the RF interface circuitry 1208.

[0111] The baseband processor circuitry 1204A may generate or process baseband signals or waveforms that carry information in 3GPP-compatible networks. In some embodiments, the waveforms for NR may be based on cyclic prefix OFDM (CP-OFDM) in the uplink or downlink, and discrete Fourier transform spread OFDM (DFT-S-OFDM) in the uplink.

[0112] The memory/storage 1212 may include any type of volatile or non-volatile memory that may be distributed throughout the UE 1200. In some embodiments, some of the memory/storage 1212 may be located on the processors 1204 themselves (for example, L1 and L2 cache), while other memory/storage 1212 is external to the processors 1204 but accessible thereto via a memory interface. The memory/storage 1212 may include any suitable volatile or non-volatile memory such as, but not limited to, dynamic random access memory (DRAM), static random access memory (SRAM), erasable programmable read only memory (EPROM), electrically erasable programmable read only memory (EEPROM), Flash memory, solid-state memory, or any other type of memory device technology.

[0113] The RF interface circuitry 1208 may include transceiver circuitry and a radio frequency front module (RFEM) that allows the UE 1200 to communicate with other devices over a radio access network. The RF interface circuitry 1208 may include various elements arranged in transmit or receive paths. These elements may include, for example, switches, mixers, amplifiers, filters, synthesizer circuitry, control circuitry, etc.

[0114] In the receive path, the RFEM may receive a radiated signal from an air interface via an antenna 1224 and proceed to filter and amplify (with a low-noise amplifier) the signal. The signal may be provided to a receiver of the transceiver that down-converts the RF signal into a baseband signal that is provided to the baseband processor of the processors 1204.

[0115] In the transmit path, the transmitter of the transceiver up-converts the baseband signal received from the baseband processor and provides the RF signal to the RFEM. The RFEM may amplify the RF signal through a power amplifier prior to the signal being radiated across the air interface via the antenna 1224.

[0116] In various embodiments, the RF interface circuitry 1208 may be configured to transmit/receive signals in a manner compatible with NR access technologies.

[0117] The antenna 1224 may include a number of antenna elements that each convert electrical signals into radio waves to travel through the air and to convert received radio waves into electrical signals. The antenna elements may be arranged into one or more antenna panels.

The antenna 1224 may have antenna panels that are omnidirectional, directional, or a combination thereof to enable beamforming and multiple input, multiple output communications. The antenna 1224 may include microstrip antennas, printed antennas fabricated on the surface of one or more printed circuit boards, patch antennas, phased array antennas, etc. The antenna 1224 may have one or more panels designed for specific frequency bands including bands in FR1 or FR2.

[0118] The user interface circuitry 1216 includes various input/output (I/O) devices designed to enable user interaction with the UE 1200. The user interface 1216 includes input device circuitry and output device circuitry. Input device circuitry includes any physical or virtual means for accepting an input including, inter alia, one or more physical or virtual buttons (for example, a reset button), a physical keyboard, keypad, mouse, touchpad, touchscreen, microphones, scanner, headset, or the like. The output device circuitry includes any physical or virtual means for showing information or otherwise conveying information, such as sensor readings, actuator position(s), or other like information. Output device circuitry may include any number or combinations of audio or visual display, including, inter alia, one or more simple visual outputs/indicators (for example, binary status indicators such as light emitting diodes (LEDs) and multi-character visual outputs, or more complex outputs such as display devices or touchscreens (for example, liquid crystal displays (LCDs), LED displays, quantum dot displays, projectors, etc.), with the output of characters, graphics, multimedia objects, and the like being generated or produced from the operation of the UE 1200.

[0119] The sensors 1220 may include devices, modules, or subsystems whose purpose is to detect events or changes in its environment and send the information (sensor data) about the detected events to some other device, module, subsystem, etc. Examples of such sensors include, inter alia, inertia measurement units comprising accelerometers; gyroscopes; or magnetometers; microelectromechanical systems or nanoelectromechanical systems comprising 3-axis accelerometers; 3-axis gyroscopes; or magnetometers; level sensors; flow sensors; temperature sensors (for example, thermistors); pressure sensors; barometric pressure sensors; gravimeters; altimeters; image capture devices (for example; cameras or lensless apertures); light detection and ranging sensors; proximity sensors (for example, infrared radiation detector and the like);

depth sensors; ambient light sensors; ultrasonic transceivers; microphones or other like audio capture devices; etc.

[0120] The driver circuitry 1222 may include software and hardware elements that operate to control particular devices that are embedded in the UE 1200, attached to the UE 1200, or otherwise communicatively coupled with the UE 1200. The driver circuitry 1222 may include individual drivers allowing other components to interact with or control various input/output (I/O) devices that may be present within, or connected to, the UE 1200. For example, driver circuitry 1222 may include a display driver to control and allow access to a display device, a touchscreen driver to control and allow access to a touchscreen interface, sensor drivers to obtain sensor readings of sensor circuitry 1220 and control and allow access to sensor circuitry 1220, drivers to obtain actuator positions of electro-mechanic components or control and allow access to the electro-mechanic components, a camera driver to control and allow access to an embedded image capture device, audio drivers to control and allow access to one or more audio devices.

[0121] The PMIC 1224 may manage power provided to various components of the UE 1200. In particular, with respect to the processors 1204, the PMIC 1224 may control power-source selection, voltage scaling, battery charging, or DC-to-DC conversion.

[0122] In some embodiments, the PMIC 1224 may control, or otherwise be part of, various power saving mechanisms of the UE 1200. For example, if the platform UE is in an RRC_Connected state, where it is still connected to the radio access network (RAN) node as it expects to receive traffic shortly, then it may enter a state known as Discontinuous Reception Mode (DRX) after a period of inactivity. During this state, the UE 1200 may power down for brief intervals of times and thus save power. If there is no data traffic activity for an extended period of time, then the UE 1200 may transition off to an RRC_Idle state, where it disconnects from the network and does not perform operations such as channel quality feedback, handover, etc. The UE 1200 goes into a very low power state and it performs paging where again it periodically wakes up to listen to the network and then powers down again. The UE 1200 may not receive data in this state; in order to receive data, it must transition back to RRC_Connected state. An additional power saving mode may allow a device to be unavailable to the network for periods longer than a paging interval (ranging from seconds to a few hours). During this time, the device is totally unreachable to the network and may power down completely. Any data sent during this time incurs a large delay and it is assumed the delay is acceptable.

[0123] A battery 1228 may power the UE 1200, although in some examples the UE 1200 may be mounted deployed in a fixed location, and may have a power supply coupled to an electrical grid. The battery 1228 may be a lithium ion battery, a metal-air battery, such as a zinc-air battery, an aluminum-air battery, a lithium-air battery, and the like. In some implementations, such as in vehicle-based applications, the battery 1228 may be a typical lead-acid automotive battery.

[0124] Figure 13 illustrates a network node 1300, in accordance with some embodiments. The network node 1300 may include processors 1304, RF interface circuitry 1308, core network (CN) interface circuitry 1312, and memory/storage circuitry 1316. The network node 1300 can be a node of a RAN or a CN.

[0125] The components of the network node 1300 may be coupled with various other components over one or more interconnects 1328.

[0126] The processors 1304, RF interface circuitry 1308, memory/storage circuitry 1316 (including communication protocol stack 1310), antenna 1324, and interconnects 1328 may be similar to like-named elements shown and described with respect to Figure 11.

[0127] The CN interface circuitry 1312 may provide connectivity to a CN, for example, a 4th Generation Core network (5GC) using a 4GC-compatible network interface protocol such as carrier Ethernet protocols, or some other suitable protocol. Network connectivity may be provided to/from the network node 1300 via a fiber optic or wireless backhaul. The CN interface circuitry 1312 may include one or more dedicated processors or FPGAs to communicate using one or more of the aforementioned protocols. In some implementations, the CN interface circuitry 1312 may include multiple controllers to provide connectivity to other networks using the same or different protocols.

[0128] As indicated above, in other embodiments, the network node 1300 can be a CN node. These embodiments include RF interface circuitry 1308 for connectivity with a RAN. The RF interface circuitry 1308 may include one or more dedicated processors or FPGAs to communicate using one or more of the aforementioned protocols. In some implementations, the

RF interface circuitry 1308 may include multiple controllers to provide connectivity to other networks using the same or different protocols.

[0129] It is well understood that the use of personally identifiable information should follow privacy policies and practices that are generally recognized as meeting or exceeding industry or governmental requirements for maintaining the privacy of users. In particular, personally identifiable information data should be managed and handled so as to minimize risks of unintentional or unauthorized access or use, and the nature of authorized use should be clearly indicated to users.

[0130] For one or more embodiments, at least one of the components set forth in one or more of the preceding figures may be configured to perform one or more operations, techniques, processes, or methods as set forth in the example section below. For example, the baseband circuitry as described above in connection with one or more of the preceding figures may be configured to operate in accordance with one or more of the examples set forth below. For another example, circuitry associated with a UE, base station, network element, etc. as described above in connection with one or more of the preceding figures may be configured to operate in accordance with one or more of the examples set forth below in the example section.

[0131] Examples

[0132] In the following sections, further example embodiments are provided.

[0133] [This section to be completed upon approval of the claims]

[0134] Any of the above-described examples may be combined with any other example (or combination of examples), unless explicitly stated otherwise. The foregoing description of one or more implementations provides illustration and description, but is not intended to be exhaustive or to limit the scope of embodiments to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practice of various embodiments.

[0135] Although the embodiments above have been described in considerable detail, numerous variations and modifications will become apparent to those skilled in the art once the above disclosure is fully appreciated. It is intended that the following claims be interpreted to embrace all such variations and modifications.

CLAIMS

What is claimed is:

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

receiving, from a source cell, a radio resource control (RRC) reconfiguration message including a triggering condition for initiating a determination of a reference signal time difference (RSTD);

detecting the triggering condition for initiating determination of the RSTD;

measuring a first reference signal transmitted from the source cell;

measuring a second reference signal transmitted from a target cell;

determining the RSTD based on the measuring the first reference signal and the second reference signal; and

determining a timing advance (TA) for the target cell based on the RSTD and a source cell TA.

2. The method of claim 1, further comprising:

determining a signal quality of the source cell;

determining a signal quality of the target cell; and

detecting the triggering condition based on the signal quality of the source cell or the signal quality of the target cell.

3. The method of claim 1 or 2, wherein detecting the triggering condition for initiating the determination of the RSTD comprises:

determining that the signal quality of the target cell is better than the signal quality of the source cell by a first threshold;

determining that the signal quality of the source cell is worse than a second threshold; or

determining that the signal quality of the target cell is better than a third threshold.

4. The method of claim 1 or 2, wherein determining the triggering condition for initiating the determination of the RSTD includes:

determining that a legacy S-measure criteria has been met based on the measurement of the first reference signal transmitted from the source cell.

5. The method of claim 1 or 2, wherein determining the triggering condition for initiating the determination of the RSTD includes determining a UE mobility status, a UE elevation from a ground surface, or a UE moving direction.

6. The method of claim 1 or 2, wherein determining the triggering condition for initiating the determination of the RSTD includes receiving a medium access control (MAC) control element (CE) message from the source cell, the MAC CE message trigging the UE to initiate determining the RSTD.

7. The method of claim 6, wherein the MAC CE message is a transmission configuration indicator (TCI) MAC CE message, a MAC CE message configured for RSTD measurement, or a timing advance (TA) command MAC CE message.

8. The method of claim 1 or 2, wherein determining the triggering condition for initiating the determination of the RSTD includes receiving a radio resource control (RRC) message, the RRC message triggering the UE to initiate the determination of the RSTD.

9. The method of claim 1 or 2, wherein determining the triggering condition for initiating the determination of the RSTD includes receiving downlink control information (DCI) indicating the UE to initiate the determination of the RSTD.

10. The method of claim 1 or 2, wherein the reference signal transmitted from the source cell is a synchronization system block (SSB), a positioning reference signal (PRS), or a channel state information (CSI) reference signal (RS).

11. The method of claim 1 or 2, wherein the reference signal transmitted from the target cell is a synchronization system block (SSB) a positioning reference signal (PRS)), or a CSI-RS.

12. A network node, comprising:

an interface; and

processing circuitry, coupled with the interface, the processing circuitry to:

transmit, to a user equipment (UE), a configuration to initiate determining a reference signal timing difference (RSTD) between a source cell and a target cell;

receive, from the UE, a first RSTD between the source cell and the target cell based on the configuration;

start a timer based on receiving the first RSTD from the UE;

determine the first RSTD is invalid based on an expiration of the timer; and

receive, from the UE, a second RSTD between the source cell and the target cell based on the configuration.

13. The network node of claim 12, wherein configuring the UE to determine the RSTD between the source cell and the target cell includes:

configuring the UE to determine to initiate determining the RSTD based on receiving, from the source cell, an indication as part of a radio resource control (RRC) message, a medium access control (MAC) control element (CE) message, or a downlink control information (DCI) message.

14. The network node of claim 12 or 13, wherein configuring the UE to determine the RSTD between the source cell and the target cell includes:

configuring the UE to periodically initiate the determination of the RSTD.

15. The network node of claim 12 or 13, wherein the timer is a timing alignment timer (TAT) or an RSTD timer.

16. A user equipment (UE), comprising:

an interface; and

processing circuitry, coupled with the interface, the processing circuitry to:

receive, from a source cell, a configuration including a triggering condition to initiate determining a reference signal timing difference (RSTD) between the source cell and a candidate target cell;

detect a triggering condition instance to initiate determining a first reference signal RSTD;

measure a first reference signal transmitted from the source cell;

measure a second reference signal transmitted from a target cell,

determine a first RSTD based on the measuring the first reference signal and the second reference signal, wherein the UE maintains the first RSTD; and

determine a timing advance (TA) for the target cell based on the first RSTD.

17. The UE of claim 16, wherein the processing circuitry further to:

detect a second triggering condition instance to initiate determining a second reference signal RSTD;

measure the first reference signal transmitted from the source cell;

measure the second reference signal transmitted from a target cell; and

determine the second RSTD based on the measuring the first reference signal and the second reference signal.

18. The UE of claim 16 or 17, wherein receiving the configuration includes receiving a validity timer configuration, and wherein the processing circuitry further to:

start the validity timer upon determining the first RSTD; and

detect an expiration of the validity timer, wherein detecting the expiration of the validity timer is the triggering condition.

19. The UE of claim 16 or 17, wherein detecting the second triggering condition is based on a movement of the UE from a first position to a second position, wherein movement causes:

a threshold change in a source cell filtered threshold,

a timing advance (TA) change for the source cell,

a reference signal receive power (RSRP) change for the target cell, or

or a change of the UE being connected to the source cell to being connected to a different source cell.

20. A user equipment (UE), comprising:

an interface; and

processing circuitry, coupled with the interface, the processing circuitry to:

transmit, to a source cell, a message indicating UE capability for determination of a reference signal timing difference (RSTD), wherein the message includes an indication of:

a need for a timing gap between initiation of determination of RSTD and a communication with the source cell; and

a number of candidate target cells for which the UE can simultaneously determine a respective RSTD; and

receive, from the source cell, a configuration for the timing gap between the initiation of determination of RSTD and the communication with the source cell.

21. The UE of claim 20, wherein the need for the timing gap between initiation of determination of RSTD and the communication includes:

a need for a first timing gap for determination of an intra-frequency RSTD; and

a need for a second timing gap for determination of an inter-frequency RSTD.

22. A user equipment (UE), comprising:

an interface; and

processing circuitry, coupled with the interface, the processing circuitry to transmit, to a source cell, a message indicating UE capability for determination of a reference signal timing difference (RSTD), wherein the message includes an indication of:

a capability for autonomously configuring a timing gap between initiation of determination of RSTD and a communication with the source cell, or

an autonomous configuration of the timing gap between the initiation of determination of RSTD and the communication with the source cell.

23. One or more computer-readable media having stored thereon a sequence of instructions which, when executed by one or more processors, cause a user equipment (UE) to:

determine a reference signal timing difference (RSTD) between a source cell and a target cell, wherein the RSTD includes a transmission time difference and propagation delay difference;

determine the transmission time difference included in the RSTD; and

determining a timing advance (TA) for the target cell based on a TA of the source cell, the RSTD, and the transmission time difference.

24. The one or more computer-readable media of claim 23, determining the transmission time difference includes:

receiving the transmission time difference from the source cell, or determining transmission time difference based on a ReferenceTimeInfo included in a system information block (SIB).

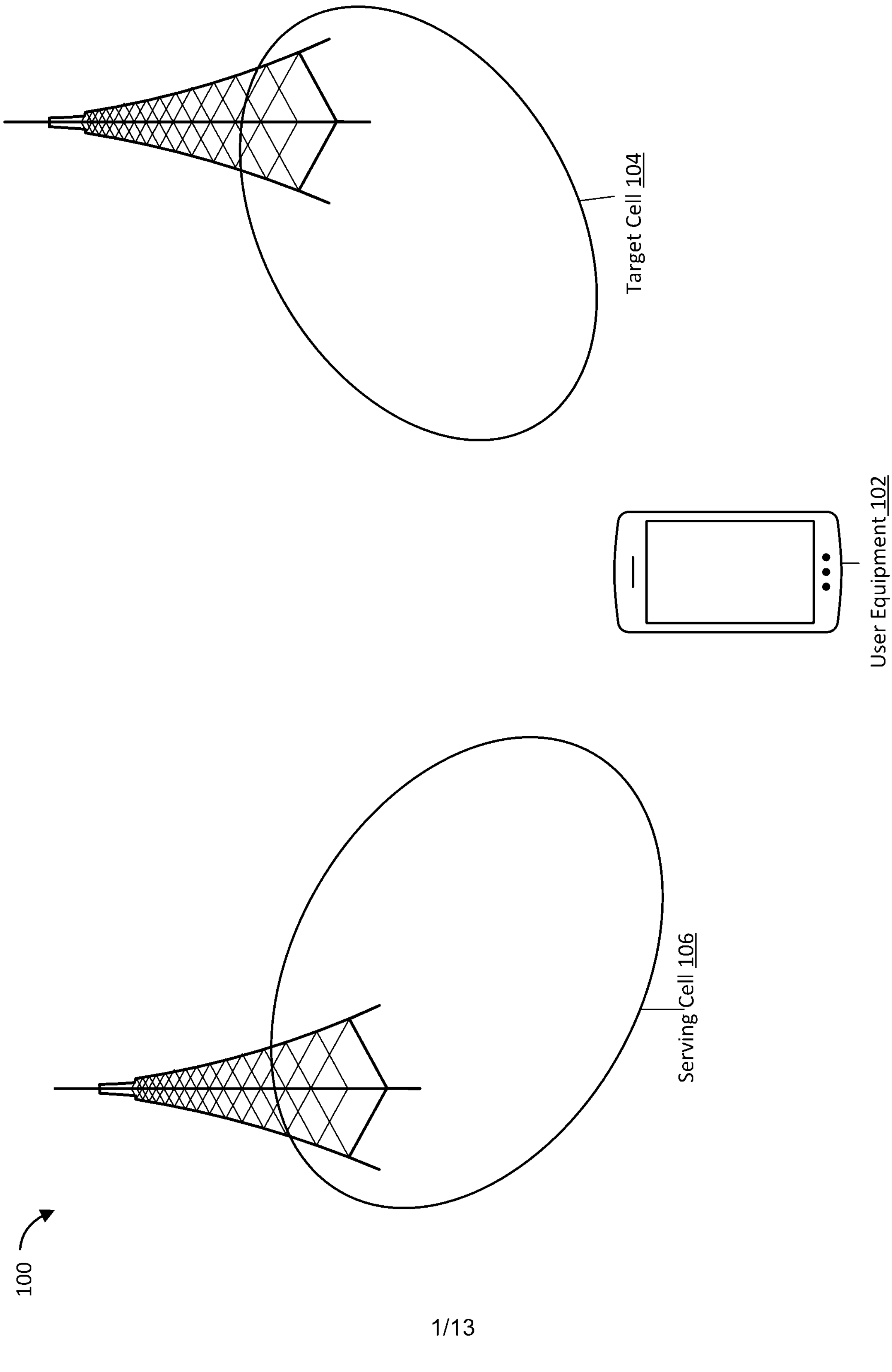


FIG. 1

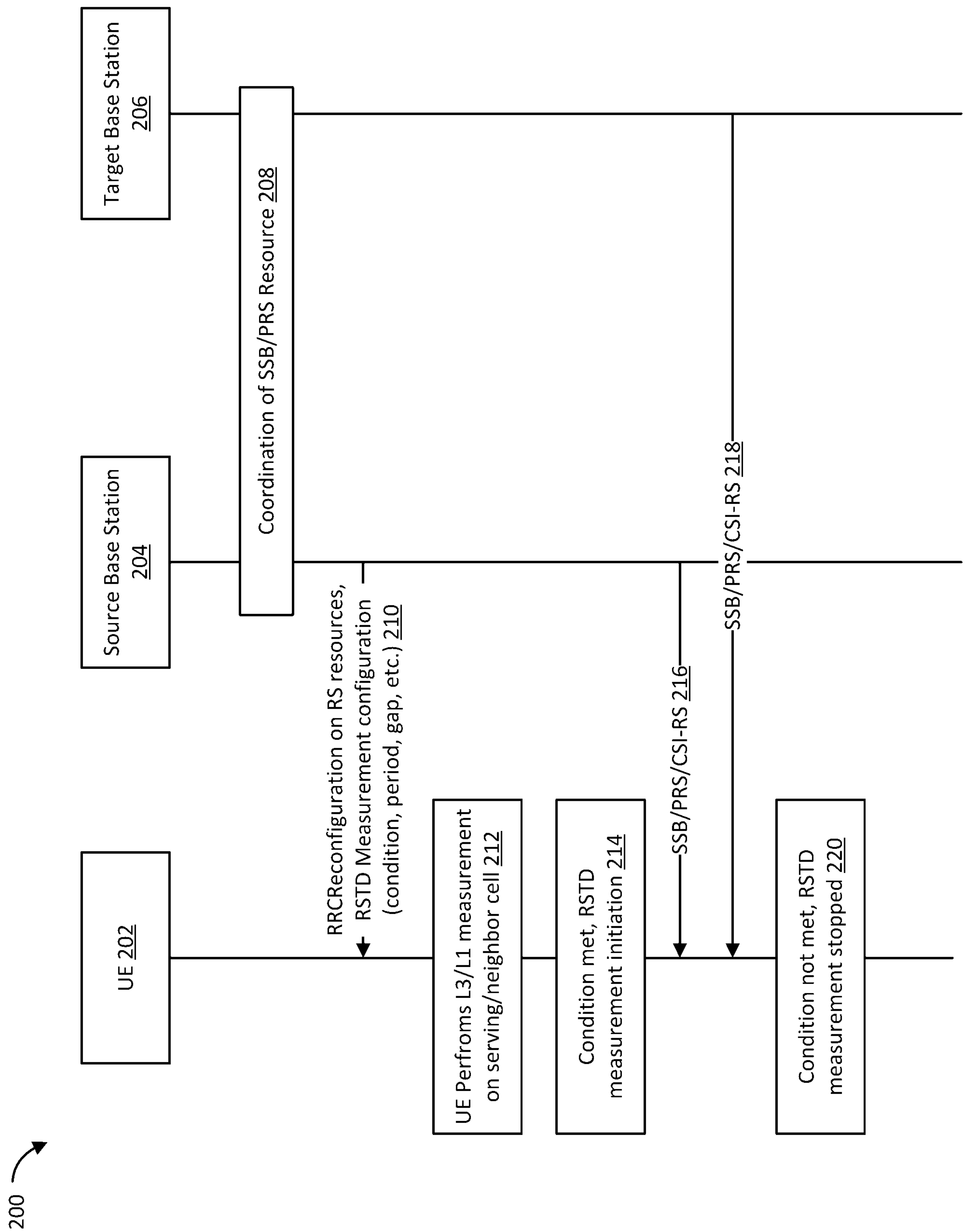

200
UE 202
Source Base Station 204
Target Base Station 206
Coordination of SSB/PRS Resource 208
RRCReconfiguration on RS resources, RSTD Measurement configuration (condition, period, gap, etc.) 210
UE Perfroms L3/L1 measurement on serving/neighbor cell 212
Condition met, RSTD measurement initiation 214
SSB/PRS/CSI-RS 216
SSB/PRS/CSI-RS 218
Condition not met, RSTD measurement stopped 220

FIG. 2

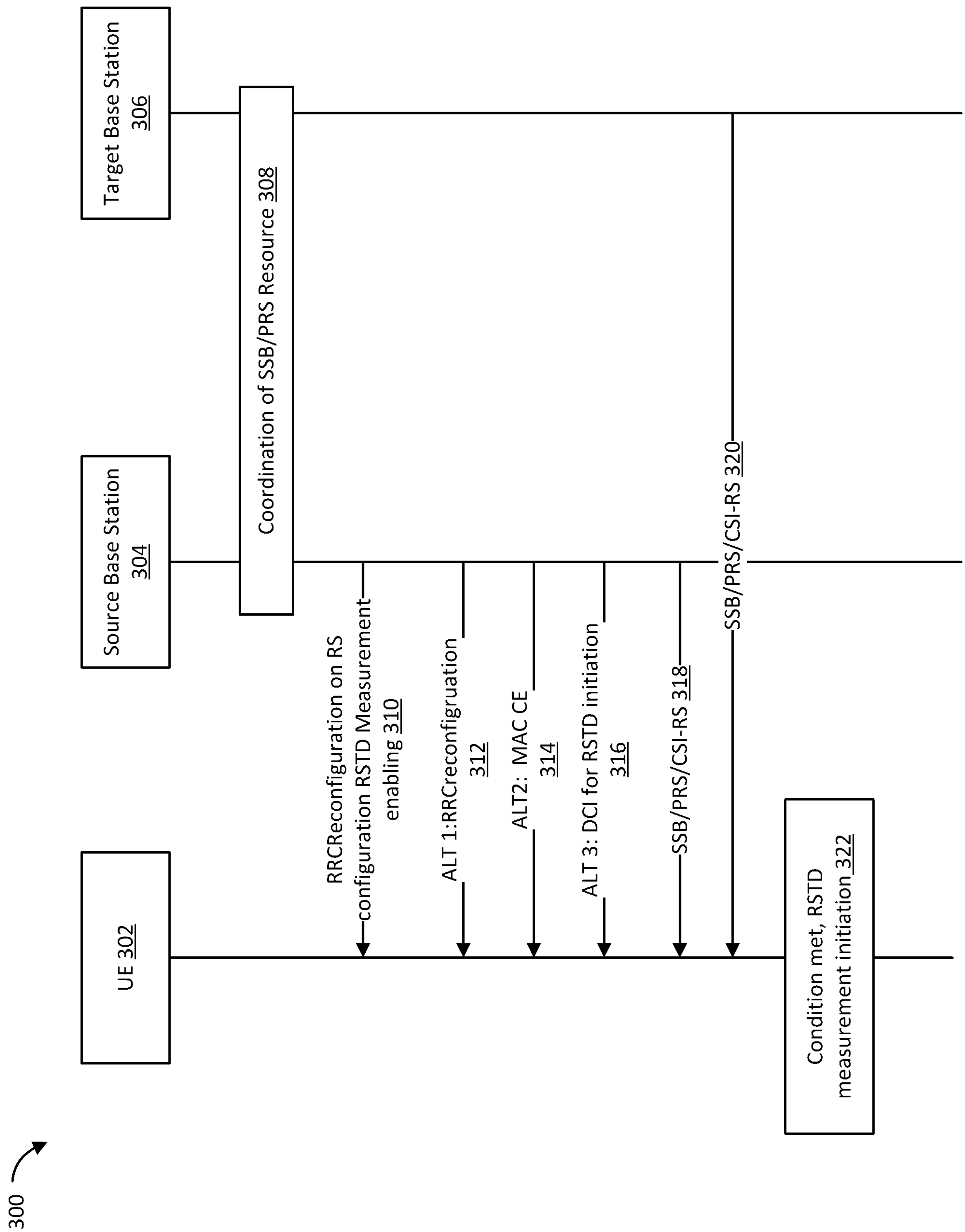

300
UE 302
Source Base Station 304
Target Base Station 306
Coordination of SSB/PRS Resource 308
RRCReconfiguration on RS configuration RSTD Measurement enabling 310
ALT 1:RRCreconfigruation 312
ALT2: MAC CE 314
ALT 3: DCI for RSTD initiation 316
SSB/PRS/CSI-RS 318
SSB/PRS/CSI-RS 320
Condition met, RSTD measurement initiation 322

FIG. 3

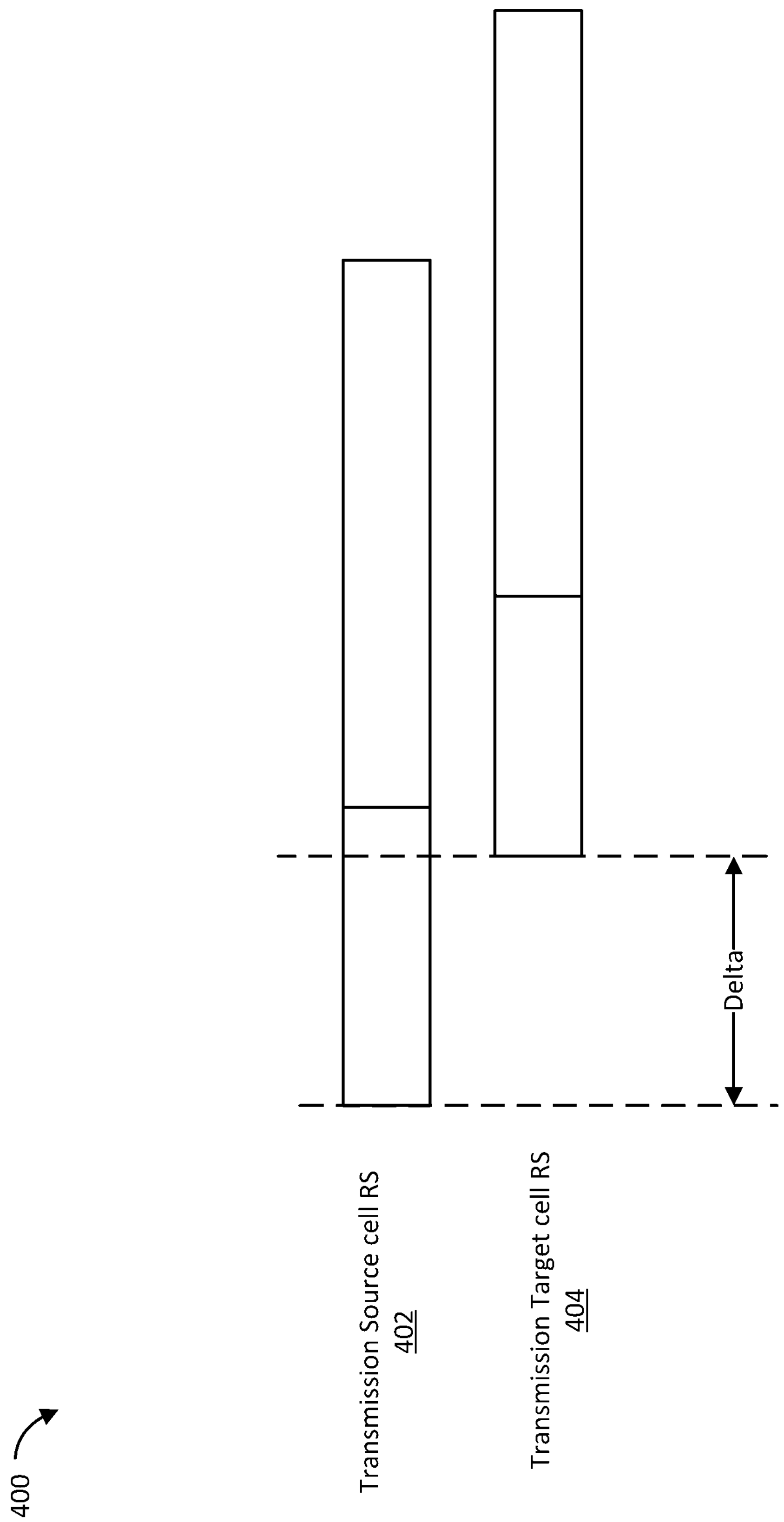

400
Delta
Transmission Source cell RS
402
Transmission Target cell RS
404

FIG. 4

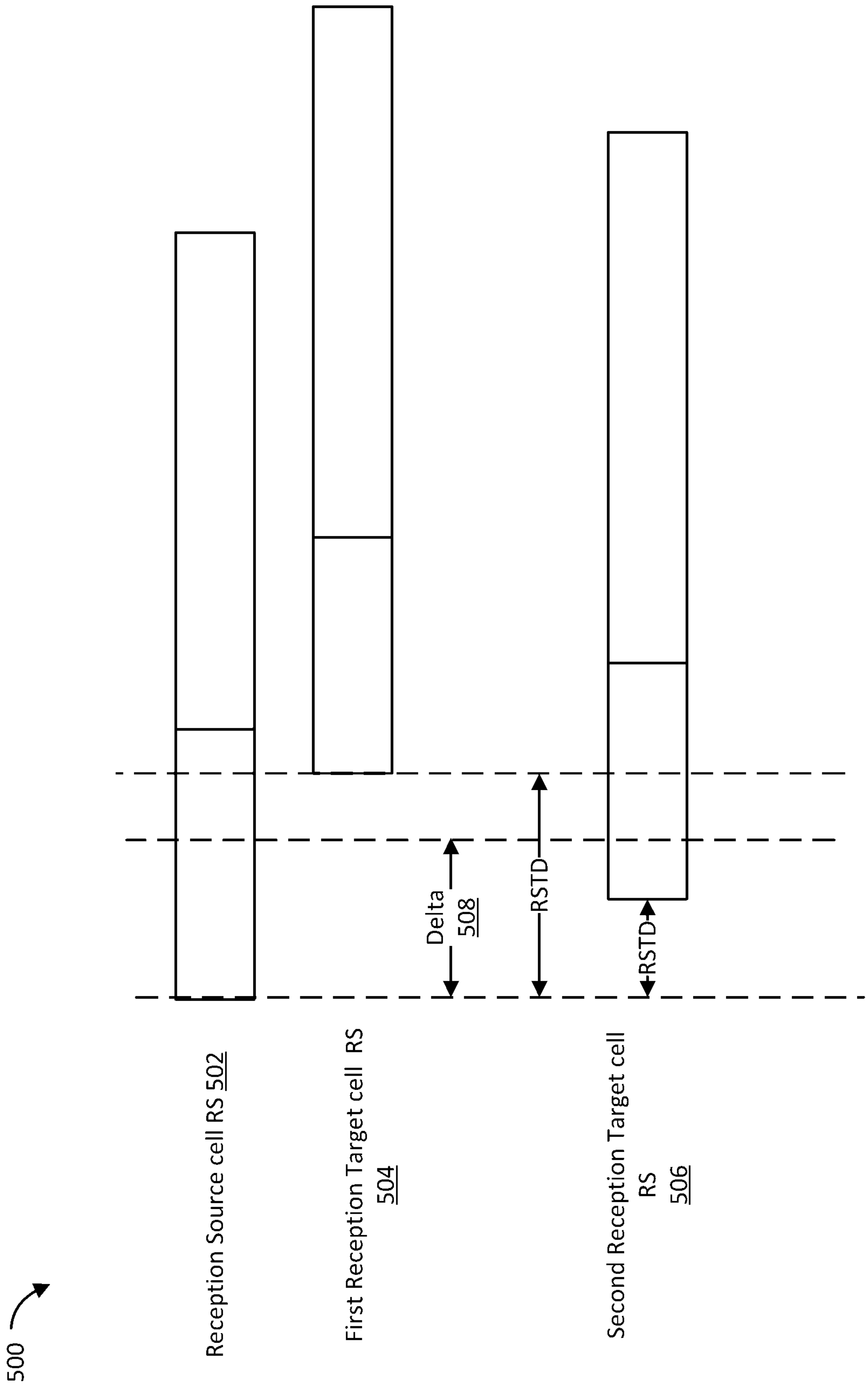

Reception Source cell RS 502
First Reception Target cell RS 504
Second Reception Target cell RS 506
Delta 508
RSTD
RSTD
500

FIG. 5

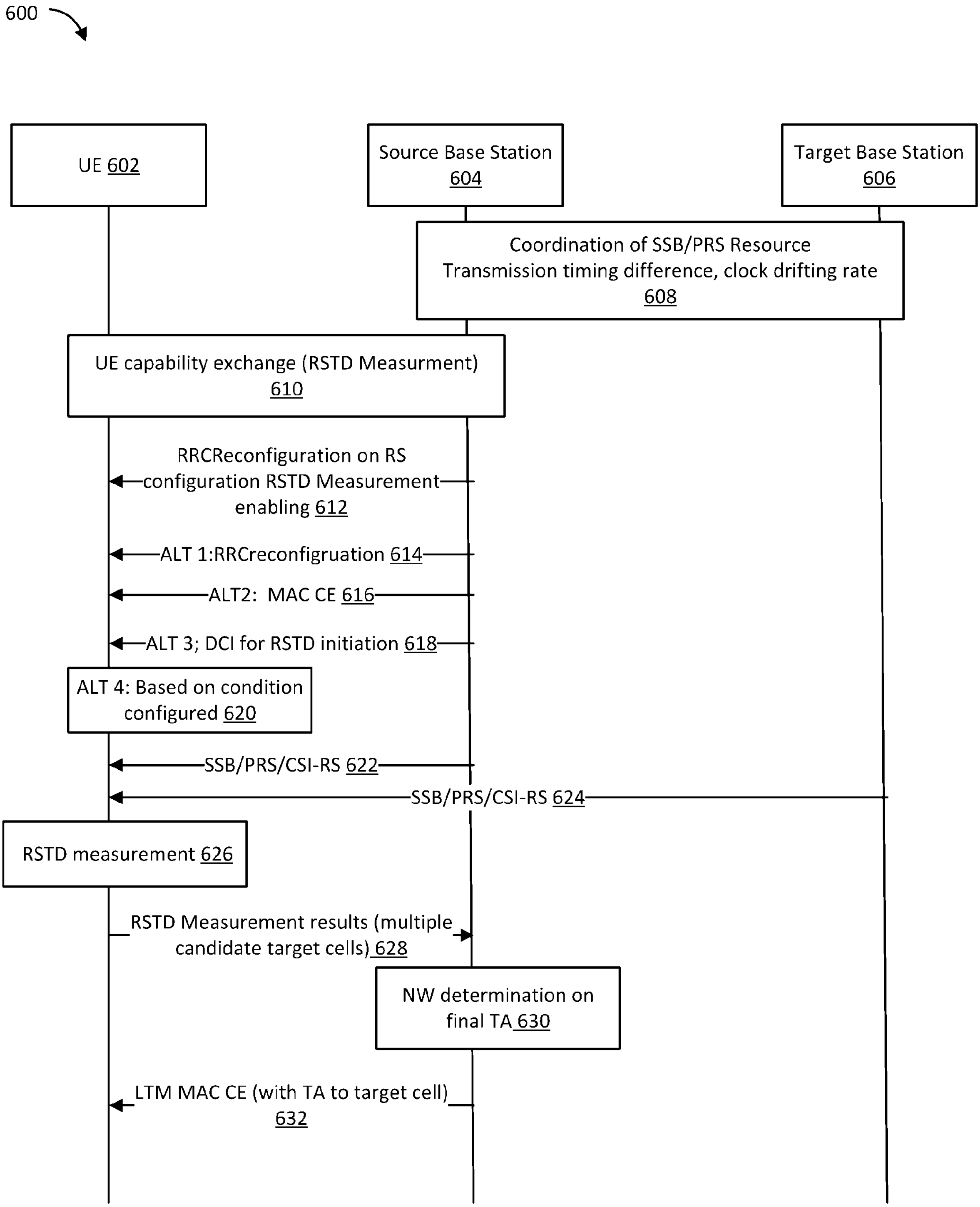

600
UE 602
Source Base Station 604
Target Base Station 606
Coordination of SSB/PRS Resource Transmission timing difference, clock drifting rate 608
UE capability exchange (RSTD Measurment) 610
RRCReconfiguration on RS configuration RSTD Measurement enabling 612
ALT 1:RRCreconfigruation 614
ALT2: MAC CE 616
ALT 3; DCI for RSTD initiation 618
ALT 4: Based on condition configured 620
SSB/PRS/CSI-RS 622
SSB/PRS/CSI-RS 624
RSTD measurement 626
RSTD Measurement results (multiple candidate target cells) 628
NW determination on final TA 630
LTM MAC CE (with TA to target cell) 632

FIG. 6

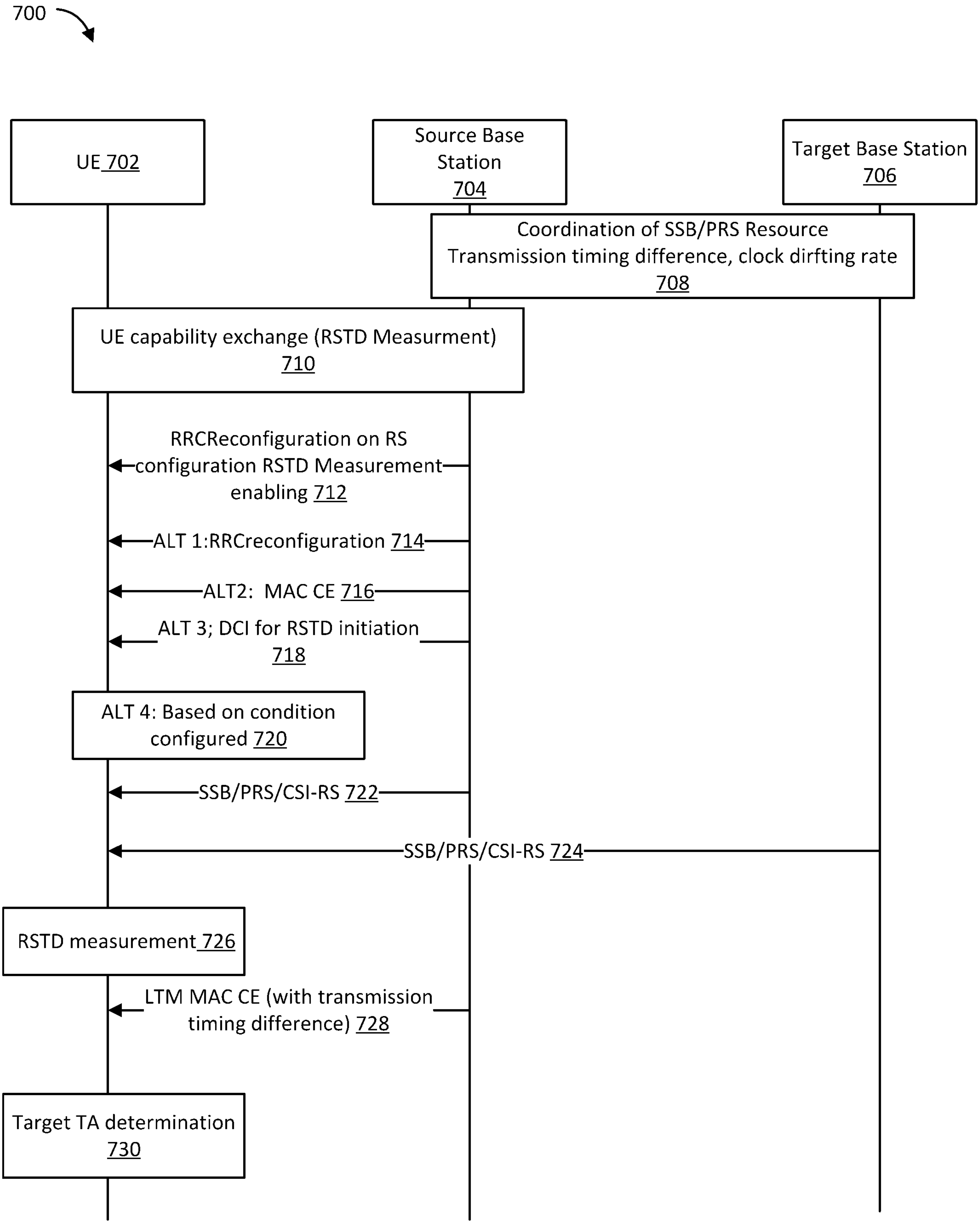

700
UE 702
Source Base Station 704
Target Base Station 706
Coordination of SSB/PRS Resource Transmission timing difference, clock dirfting rate 708
UE capability exchange (RSTD Measurment) 710
RRCReconfiguration on RS configuration RSTD Measurement enabling 712
ALT 1:RRCreconfiguration 714
ALT2: MAC CE 716
ALT 3; DCI for RSTD initiation 718
ALT 4: Based on condition configured 720
SSB/PRS/CSI-RS 722
SSB/PRS/CSI-RS 724
RSTD measurement 726
LTM MAC CE (with transmission timing difference) 728
Target TA determination 730

FIG. 7

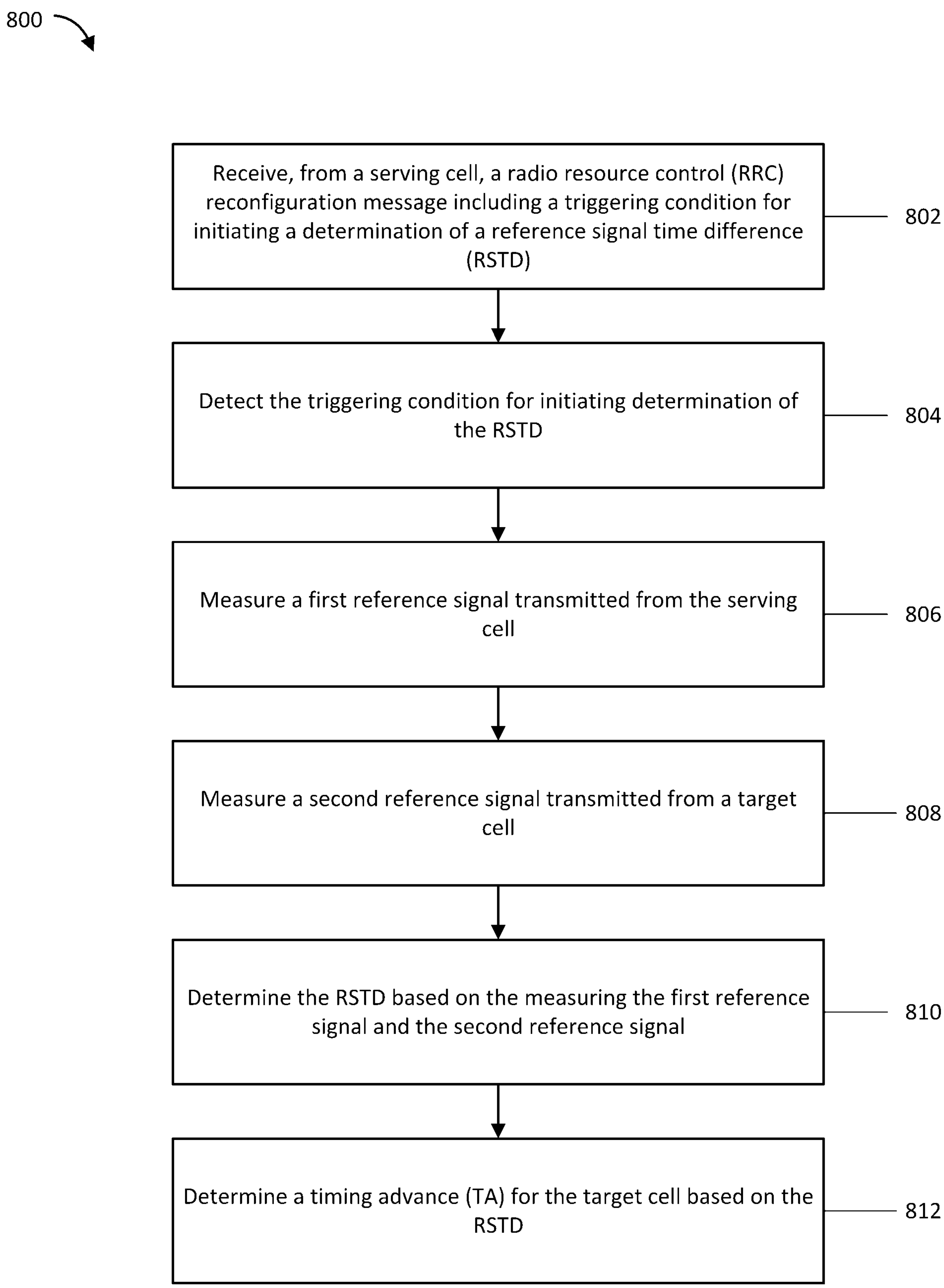

800
Receive, from a serving cell, a radio resource control (RRC) reconfiguration message including a triggering condition for initiating a determination of a reference signal time difference (RSTD)
802
Detect the triggering condition for initiating determination of the RSTD
804
Measure a first reference signal transmitted from the serving cell
806
Measure a second reference signal transmitted from a target cell
808
Determine the RSTD based on the measuring the first reference signal and the second reference signal
810
Determine a timing advance (TA) for the target cell based on the RSTD
812

FIG. 8

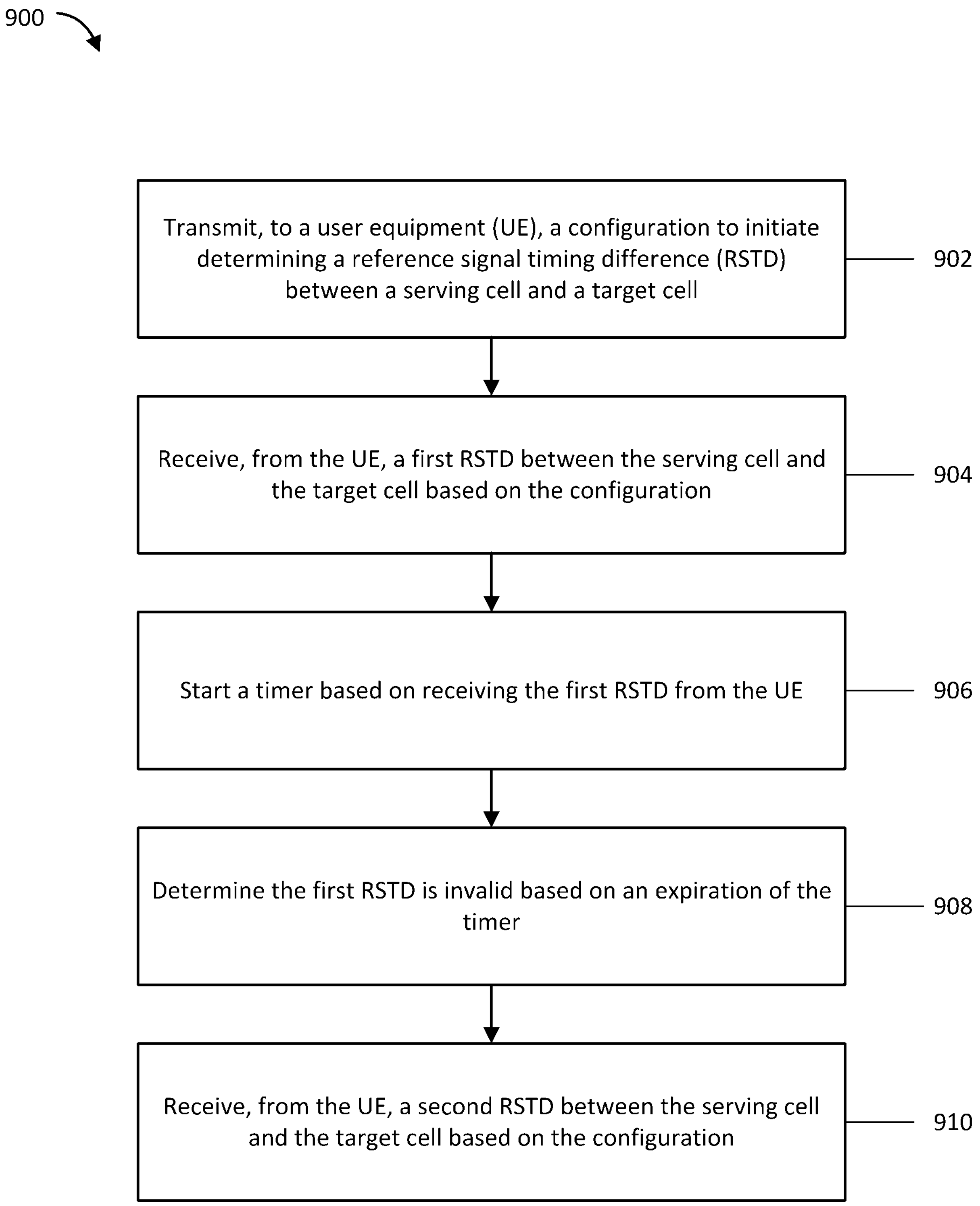

900
Transmit, to a user equipment (UE), a configuration to initiate determining a reference signal timing difference (RSTD) between a serving cell and a target cell
902
Receive, from the UE, a first RSTD between the serving cell and the target cell based on the configuration
904
Start a timer based on receiving the first RSTD from the UE
906
Determine the first RSTD is invalid based on an expiration of the timer
908
Receive, from the UE, a second RSTD between the serving cell and the target cell based on the configuration
910

FIG. 9

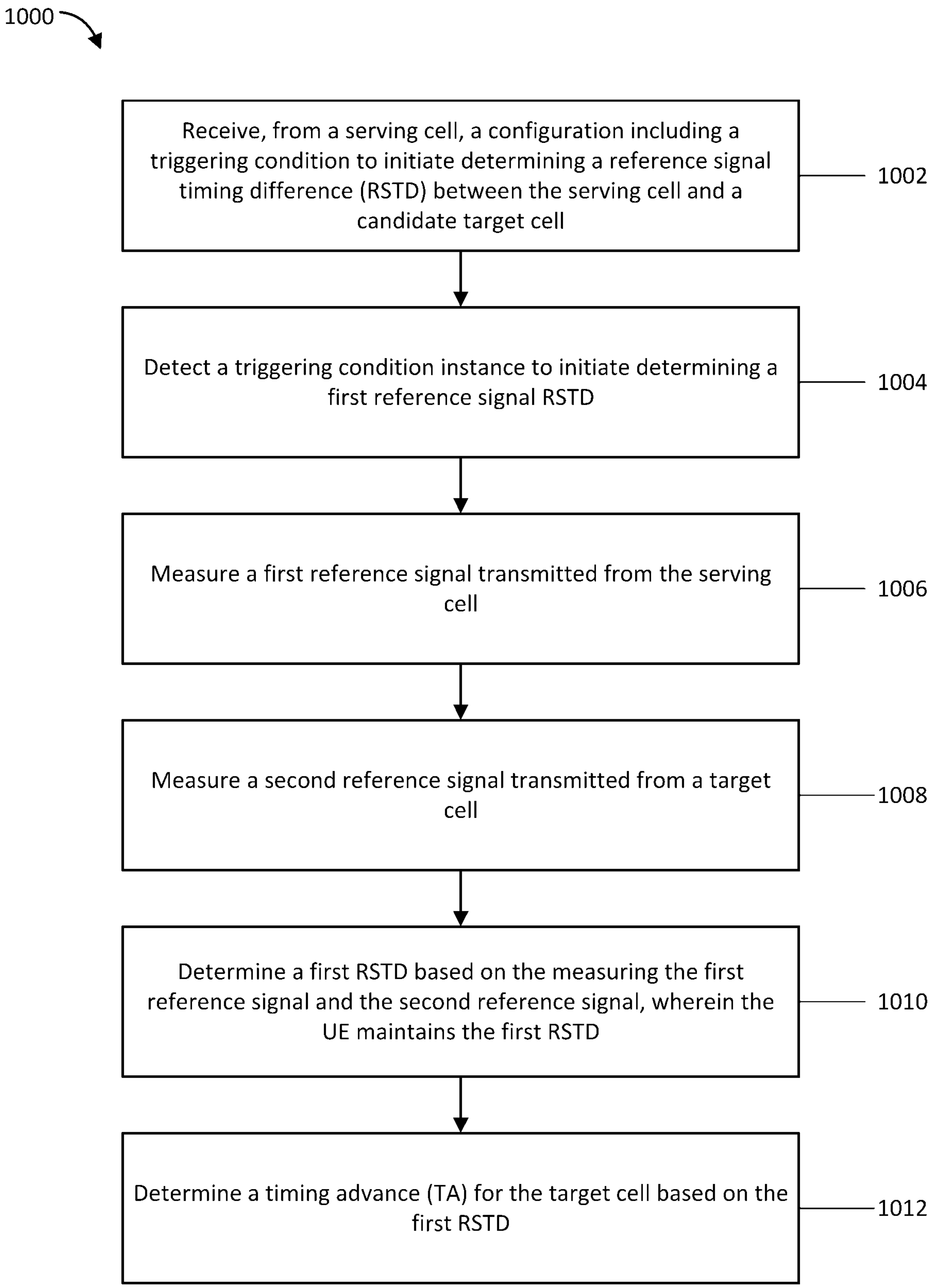

1000
Receive, from a serving cell, a configuration including a triggering condition to initiate determining a reference signal timing difference (RSTD) between the serving cell and a candidate target cell
1002
Detect a triggering condition instance to initiate determining a first reference signal RSTD
1004
Measure a first reference signal transmitted from the serving cell
1006
Measure a second reference signal transmitted from a target cell
1008
Determine a first RSTD based on the measuring the first reference signal and the second reference signal, wherein the UE maintains the first RSTD
1010
Determine a timing advance (TA) for the target cell based on the first RSTD
1012

FIG. 10

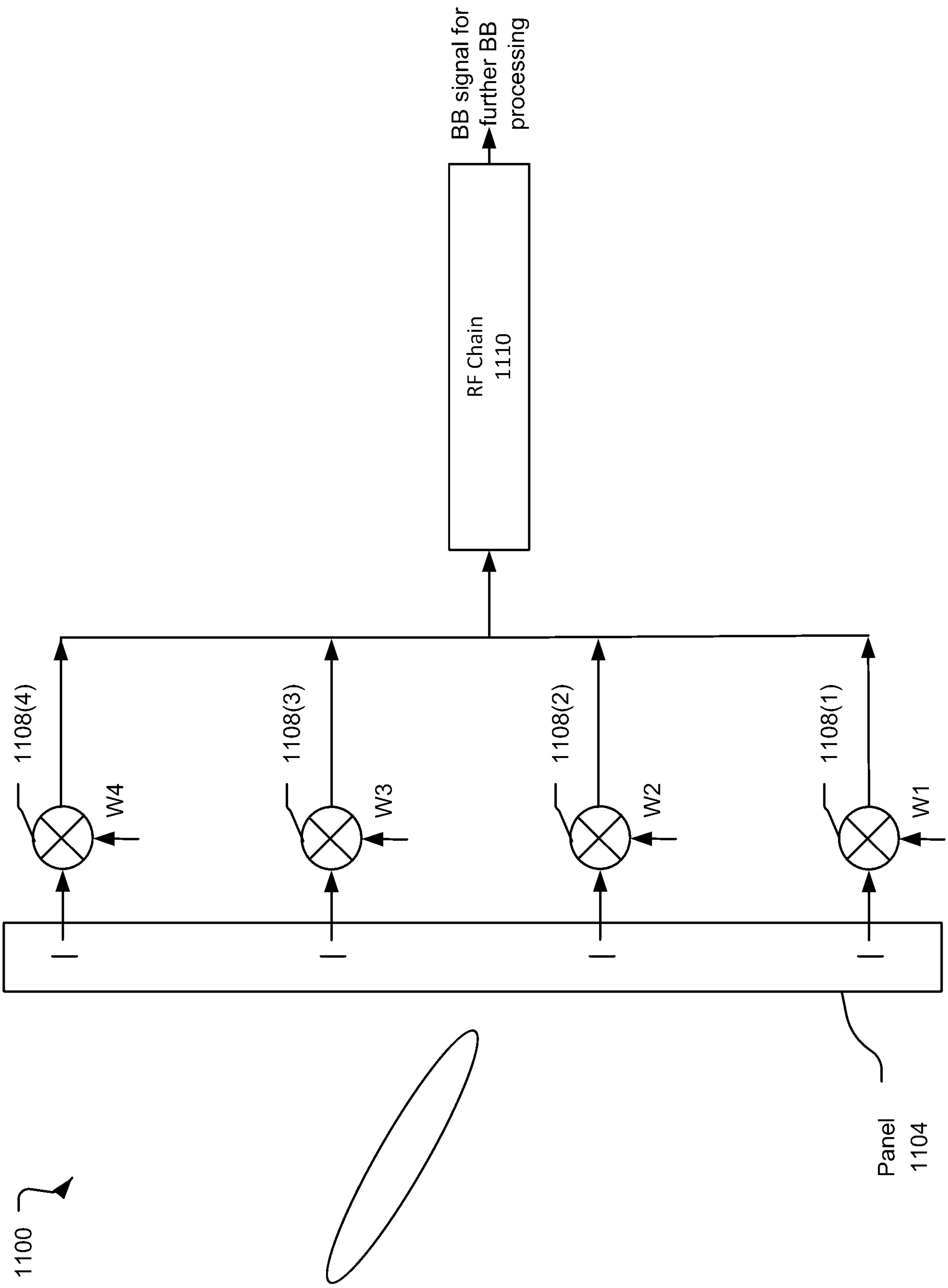

1100
BB signal for further BB processing
RF Chain
1110
1108(4)
1108(3)
1108(2)
1108(1)
W4
W3
W2
W1
Panel
1104

FIG. 11

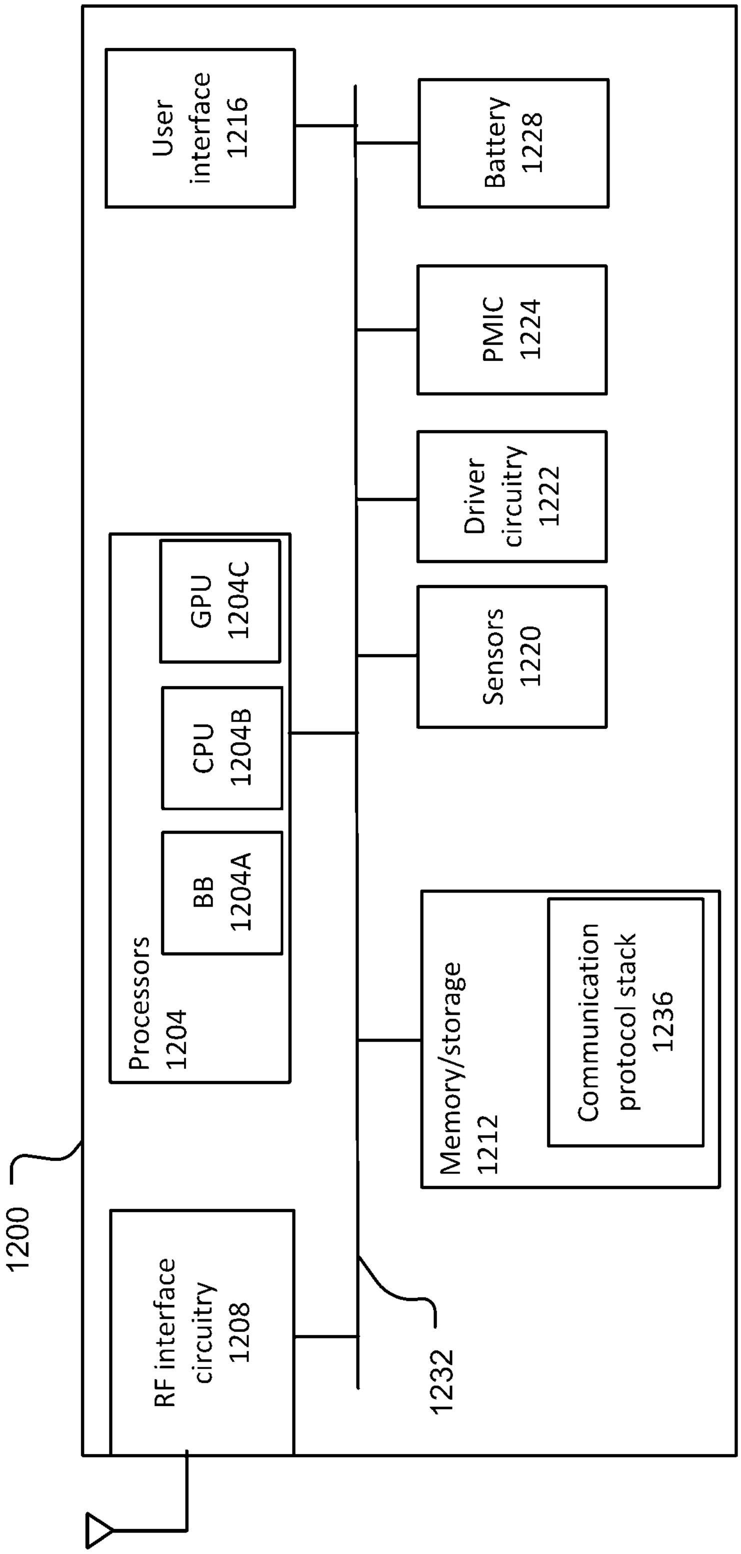
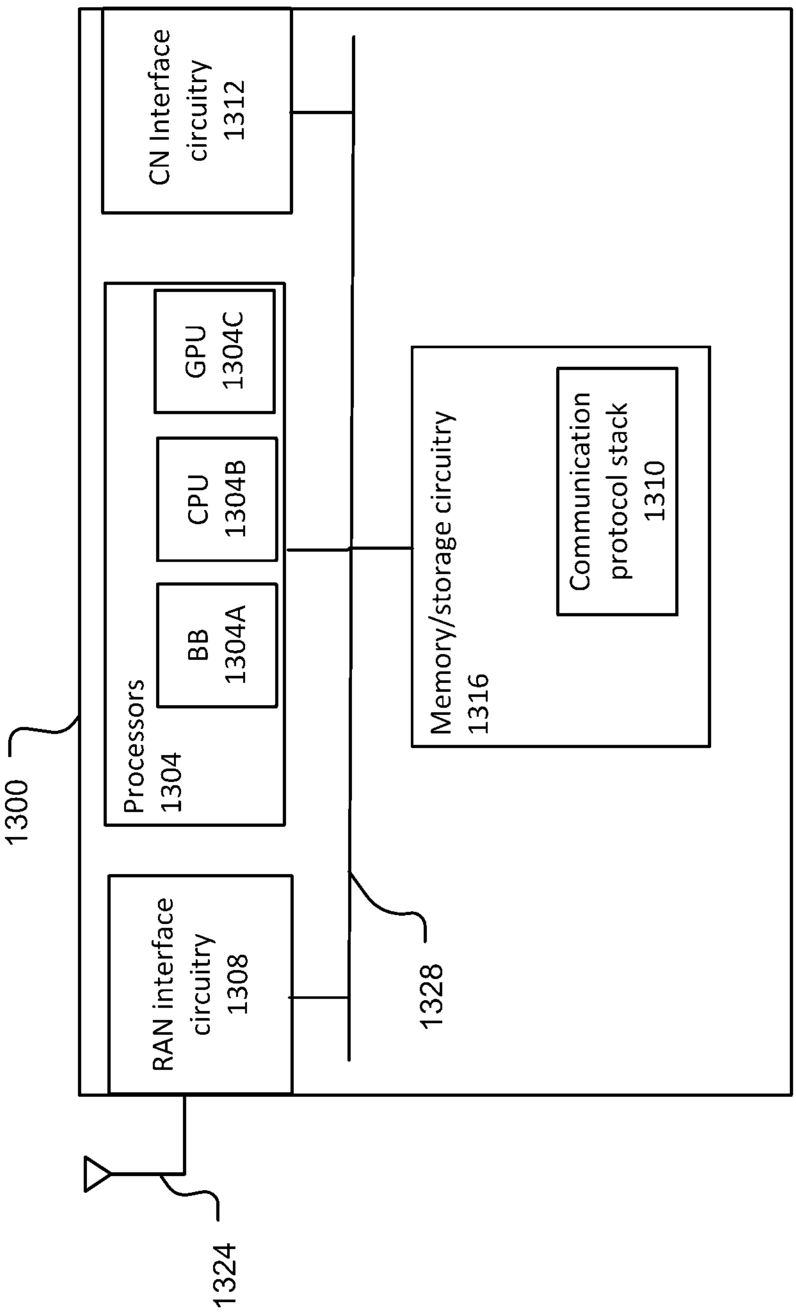

User interface 1216
Battery 1228
PMIC 1224
Driver circuitry 1222
Sensors 1220
GPU 1204C
CPU 1204B
BB 1204A
Processors 1204
Memory/storage 1212
Communication protocol stack 1236
1200
RF interface circuitry 1208
1232

FIG. 12



CN Interface circuitry 1312
GPU 1304C
CPU 1304B
BB 1304A
Processors 1304
Memory/storage circuitry 1316
Communication protocol stack 1310
RAN interface circuitry 1308
1300
1328
1324

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/112432

A. CLASSIFICATION OF SUBJECT MATTER

H04W36/08(2009.01)i； H04W24/08(2009.01)i

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)

IPC： H04W H04L

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)

CNTXT, ENTXT, ENTXTC, WPABS, 3GPP: RSTD, TA, tim???, advance, source, target, verif+, expire+, expira+, timer, TAT, ??correct, ??valid, false

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2023010228 A1 (QUALCOMM INCORPORATED) 09 February 2023 (2023-02-09) paragraphs [0060]-[0079] in description, figures 7-8,16-17	1-11,16-19,23-24
X	US 2021058891 A1 (INTEL CORPORATION) 25 February 2021 (2021-02-25) paragraphs [0036]-[0037] in description, figures 2,5	20-22
A	US 2022094508 A1 (NOKIA TECHNOLOGIES OY) 24 March 2022 (2022-03-24) the whole document	1-24
A	WO 2023086143 A1 (QUALCOMM INCORPORATED) 19 May 2023 (2023-05-19) the whole document	1-24
A	CN 116058001 A (QUALCOMM INCORPORATED) 02 May 2023 (2023-05-02) the whole document	1-24
A	CN 102869038 A (HUAWEI TECHNOLOGIES CO., LTD.) 09 January 2013 (2013-01-09) the whole document	1-24

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 April 2024	**10 April 2024**

Name and mailing address of the ISA/CN	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/112432

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2023010228 A1	09 February 2023	None	
US 2021058891 A1	25 February 2021	US 2023397157 A1	07 December 2023
US 2022094508 A1	24 March 2022	WO 2020188144 A1	24 September 2020
WO 2023086143 A1	19 May 2023	None	
CN 116058001 A	02 May 2023	US 2022046491 A1	10 February 2022
		WO 2022032275 A1	10 February 2022
		KR 20230047365 A	07 April 2023
		EP 4193673 A1	14 June 2023
CN 102869038 A	09 January 2013	US 2014057664 A1	27 February 2014