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(54) **Title:** LTM EARLY MEASUREMENT MAINTENANCE

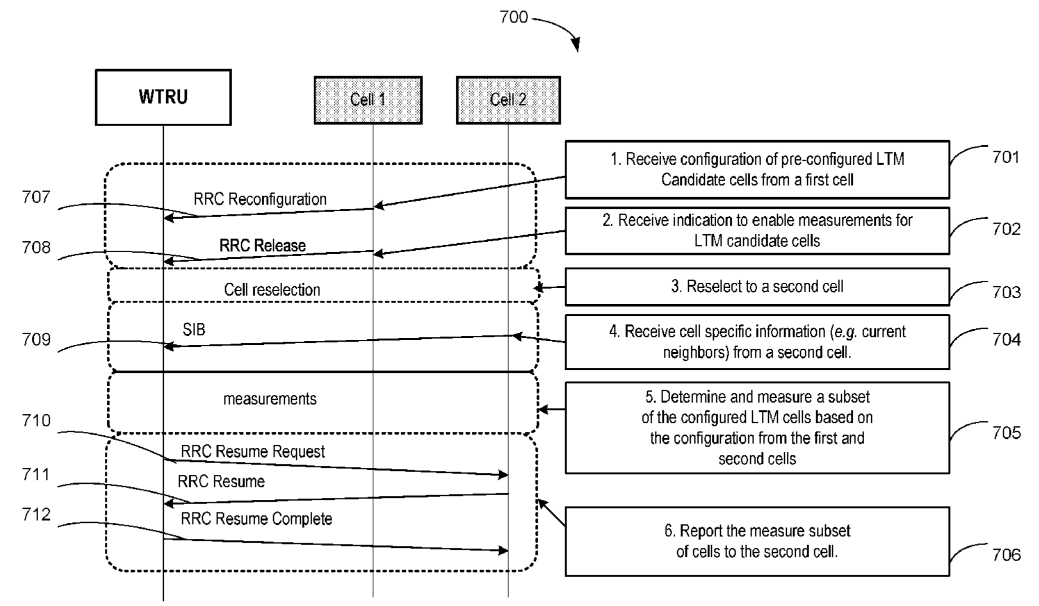

FIG. 7

(57) **Abstract:** A wireless transmit/receive unit (WTRU) may receive configuration information from a first cell. The configuration information may indicate a plurality of LTM candidate cells. The WTRU may receive an indication from the first cell to enable measurements for the list of LTM candidate cells. The WTRU may receive system information from a second cell and determine a subset of cells of the plurality of LTM candidate cells based on the system information. The WTRU may perform measurements on the subset of cells while in an active mode or an inactive mode. The WTRU may send an indication of the measurements of the subset of cells to the second cell in response to entering a connected mode with the second cell. In some cases, the WTRU report the measurements performed on the subset of cells to a network.

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LTM EARLY MEASUREMENT MAINTENANCE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of United States Provisional Patent Application No. 63/445,560, filed on February 14, 2023, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0002] This disclosure pertains to devices, methods, and systems for fast Secondary Cell (SCell) and Secondary Cell Group (SCG) setup and resume.

SUMMARY

[0003] Devices, methods, and systems for enabling fast Secondary Cell (SCell) and Secondary Cell Group (SCG) setup and resume are discussed herein. A wireless transmit/receive unit (WTRU) may be configured for Layer 1 (L1) and Layer 2 (L2) based inter-cell mobility, measurements, and RRC_INACTIVE. In some implementations the WTRU may be configured for fast setup/resume (*e.g.*, early measurements and a L1/L2 Triggered Mobility (LTM) trigger during random access procedure). The WTRU may be configured for updating an LTM candidate in RRC_INACTIVE. The WTRU may be configured for maintaining LTM early measurement in RRC_INACTIVE.

[0004] Devices, methods, and systems for fast SCG and SCell setup and resume based on early measurements and/or an LTM trigger during a random access (RA) procedure are discussed herein. In some implementations, the WTRU may receive pre-configuration of LTM candidate cells (*e.g.*, configuration information) in RRC_CONNECTED. The WTRU may receive a measurement configuration in RRC Release. The WTRU may perform the measurements in RRC_INACTIVE. The WTRU may report the measurements related to the LTM candidate cells during the random access procedure. For example, the WTRU may report the measurements related to the LTM candidate cells during the random access procedure (*e.g.*, in a Medium Access Control (MAC) Control Element (CE) with Msg3 (4 step RA) or Msg A (for 2 step RA)). The WTRU may optionally perform early synchronization to a set of best candidate cells. In some implementations, the WTRU may receive an indication of candidate configuration and SCell activation and/or deactivation during the random access procedure (*e.g.*, candidate configuration information). For example, the WTRU may receive the indication of candidate configuration and SCell activation or deactivation during the random access procedure (*e.g.*, in MAC CE with Msg4 (4 step RA) or MsgB (2 step RA)). In some implementations, the WTRU may execute an LTM procedure upon transition to RRC_CONNECTED. For example, the WTRU may apply stored LTM Primary Cell (PCell) configuration, with immediate SCell/SCG activation upon entering RRC_CONNECTED.

[0005] In some cases, a WTRU may receive configuration information from a first cell when in an active mode. The configuration information may indicate a plurality of LTM candidate cells. The WTRU may receive an indication from the first cell to enable measurements for the list of LTM candidate cells. The WTRU may receive system information from a second cell. The WTRU may determine a subset of cells of the plurality of LTM candidate cells based on the system information from the second cell. The WTRU may perform measurements on the subset of cells. The WTRU may perform such measurements while in an active mode or an inactive mode. The WTRU may send (e.g., via a medium access control (MAC) control element (CE)) an indication of the measurements of the subset of cells to the second cell in response to entering a connected mode with the second cell. In some cases, the WTRU may report the measurements performed on the subset of cells to a network.

[0006] The system information may comprise a list of neighbor cells for the second cell. In some examples, the configuration information may be received via an RRC reconfiguration message or an RRC release message. The WTRU may determine the subset of cells of the plurality of LTM candidate cells based on the system information from the second cell (e.g., while the WTRU is in an inactive mode).

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings, in which like reference numerals in the figures indicate like elements.

[0008] FIG. 1A is a system diagram illustrating an example communications system in which one or more disclosed embodiments may be implemented.

[0009] FIG. 1B is a system diagram illustrating an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A.

[0010] FIG. 1C is a system diagram illustrating an example radio access network (RAN) and an example core network (CN) that may be used within the communications system illustrated in FIG. 1A.

[0011] FIG. 1D is a system diagram illustrating a further example RAN and a further example CN that may be used within the communications system illustrated in FIG. 1A.

[0012] FIG. 2 illustrates an example high-level measurement model.

[0013] FIG. 3 illustrates example Radio Resource Control (RRC) states and the transitions between the RRC states.

[0014] FIG. 4 illustrates an example Layers 1 and 2 Triggered Mobility (LTM) using Carrier Aggregation (CA).

[0015] FIG. 5 illustrates an example LTM baseline procedure.

[0016] FIG. 6 illustrates examples of using early measurements for a quick setup of CA and Dual Connectivity (DC) when a WTRU switches from an inactive mode (*e.g.*, RRC_INACTIVE) to a connected mode (*e.g.*, RRC_CONNECTED).

[0017] FIG. 7 illustrates an example procedure and signaling for LTM early measurement maintenance in RRC_INACTIVE.

[0018] FIG.8 illustrates an example procedure for LTM early measurement maintenance in RRC_INACTIVE.

DETAILED DESCRIPTION

[0019] FIG. 1A is a diagram illustrating an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), zero-tail unique-word DFT-Spread OFDM (ZT UW DTS-s OFDM), unique word OFDM (UW-OFDM), resource block-filtered OFDM, filter bank multicarrier (FBMC), and the like.

[0020] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a RAN 104/113, a CN 106/115, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d, any of which may be referred to as a "station" and/or a "STA", may be configured to transmit and/or receive wireless signals and may include a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a subscription-based unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, a hotspot or Mi-Fi device, an Internet of Things (IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device and applications (e.g., remote surgery), an industrial device and applications (e.g., a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. Any of the WTRUs 102a, 102b, 102c and 102d may be interchangeably referred to as a WTRU.

[0021] The communications systems 100 may also include a base station 114a and/or a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the CN 106/115, the Internet 110, and/or the other networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a gNB, a NR NodeB, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0022] The base station 114a may be part of the RAN 104/113, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals on one or more carrier frequencies, which may be referred to as a cell (not shown). These frequencies may be in licensed spectrum, unlicensed spectrum, or a combination of licensed and unlicensed spectrum. A cell may provide coverage for a wireless service to a specific geographical area that may be relatively fixed or that may change over time. The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, e.g., one for each sector of the cell. In an embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and may utilize multiple transceivers for each sector of the cell. For example, beamforming may be used to transmit and/or receive signals in desired spatial directions.

[0023] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 116, which may be any suitable wireless communication link (e.g., radio frequency (RF), microwave, centimeter wave, micrometer wave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 116 may be established using any suitable radio access technology (RAT).

[0024] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104/113 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink (DL) Packet Access (HSDPA) and/or High-Speed UL Packet Access (HSUPA).

[0025] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 116 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A) and/or LTE-Advanced Pro (LTE-A Pro).

[0026] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as NR Radio Access, which may establish the air interface 116 using New Radio (NR).

[0027] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement multiple radio access technologies. For example, the base station 114a and the WTRUs 102a, 102b, 102c may implement LTE radio access and NR radio access together, for instance using dual connectivity (DC) principles. Thus, the air interface utilized by WTRUs 102a, 102b, 102c may be characterized by multiple types of radio access technologies and/or transmissions sent to/from multiple types of base stations (e.g., an eNB and a gNB).

[0028] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.11 (e.g., Wireless Fidelity (WiFi), IEEE 802.16 (e.g., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0029] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, an industrial facility, an air corridor (e.g., for use by drones), a roadway, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In an embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g., WCDMA, CDMA2000, GSM, LTE, LTE-A, LTE-A Pro, NR etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the CN 106/115.

[0030] The RAN 104/113 may be in communication with the CN 106/115, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. The data may have varying quality of service (QoS) requirements, such as differing throughput requirements, latency requirements, error tolerance requirements, reliability requirements, data throughput requirements, mobility requirements, and the like. The CN 106/115 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 104/113 and/or the CN 106/115 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104/113 or a different RAT. For example, in addition to being connected to the RAN 104/113, which may be utilizing a NR radio technology, the CN 106/115 may also be in communication with another RAN (not shown) employing a GSM, UMTS, CDMA 2000, WiMAX, E-UTRA, or WiFi radio technology.

[0031] The CN 106/115 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or the other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and/or the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired and/or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another CN connected to one or more RANs, which may employ the same RAT as the RAN 104/113 or a different RAT.

[0032] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities (e.g., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links). For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0033] FIG. 1B is a system diagram illustrating an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and/or other peripherals 138, among others. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0034] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0035] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g., the base station 114a) over the air interface 116. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In an embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and/or receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0036] Although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g., multiple antennas) for transmitting and receiving wireless signals over the air interface 116.

[0037] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as NR and IEEE 802.11, for example.

[0038] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g., a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0039] The processor 118 may receive power from the power source 134 and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g., nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0040] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g., longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 116 from a base station (e.g., base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0041] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs and/or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, a Virtual Reality and/or Augmented Reality (VR/AR) device, an activity tracker, and the like. The peripherals 138 may include one or more sensors, the sensors may be one or more of a gyroscope, an accelerometer, a hall effect sensor, a magnetometer, an orientation sensor, a proximity sensor, a temperature sensor, a time sensor; a geolocation sensor; an altimeter, a light sensor, a touch sensor, a magnetometer, a barometer, a gesture sensor, a biometric sensor, and/or a humidity sensor.

[0042] The WTRU 102 may include a full duplex radio for which transmission and reception of some or all of the signals (e.g., associated with particular subframes for both the UL (e.g., for transmission) and downlink (e.g., for reception) may be concurrent and/or simultaneous. The full duplex radio may include an interference management unit 139 to reduce and or substantially eliminate self-interference via either hardware (e.g., a choke) or signal processing via a processor (e.g., a separate processor (not shown) or via processor 118). In an embodiment, the WRTU 102 may include a half-duplex radio for which transmission and reception of some or all of the signals (e.g., associated with particular subframes for either the UL (e.g., for transmission) or the downlink (e.g., for reception)).

[0043] FIG. 1C is a system diagram illustrating the RAN 104 and the CN 106 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the CN 106.

[0044] The RAN 104 may include eNode-Bs 160a, 160b, 160c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 160a, 160b, 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 160a, 160b, 160c may implement MIMO technology. Thus, the eNode-B 160a, for example, may use multiple antennas to transmit wireless signals to, and/or receive wireless signals from, the WTRU 102a.

[0045] Each of the eNode-Bs 160a, 160b, 160c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the UL and/or DL, and the like. As shown in FIG. 1C, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0046] The CN 106 shown in FIG. 1C may include a mobility management entity (MME) 162, a serving gateway (SGW) 164, and a packet data network (PDN) gateway (or PGW) 166. While each of the foregoing elements are depicted as part of the CN 106, it will be appreciated that any of these elements may be owned and/or operated by an entity other than the CN operator.

[0047] The MME 162 may be connected to each of the eNode-Bs 162a, 162b, 162c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 162 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 162 may provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM and/or WCDMA.

[0048] The SGW 164 may be connected to each of the eNode Bs 160a, 160b, 160c in the RAN 104 via the S1 interface. The SGW 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The SGW 164 may perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when DL data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0049] The SGW 164 may be connected to the PGW 166, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0050] The CN 106 may facilitate communications with other networks. For example, the CN 106 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the CN 106 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the CN 106 and the PSTN 108. In addition, the CN 106 may provide the WTRUs 102a, 102b, 102c with access to the other networks 112, which may include other wired and/or wireless networks that are owned and/or operated by other service providers.

[0051] Although the WTRU is described in FIGS. 1A-1D as a wireless terminal, it is contemplated that in certain representative embodiments that such a terminal may use (e.g., temporarily or permanently) wired communication interfaces with the communication network.

[0052] In representative embodiments, the other network 112 may be a WLAN.

[0053] A WLAN in Infrastructure Basic Service Set (BSS) mode may have an Access Point (AP) for the BSS and one or more stations (STAs) associated with the AP. The AP may have an access or an interface to a Distribution System (DS) or another type of wired/wireless network that carries traffic in to and/or out of the BSS. Traffic to STAs that originates from outside the BSS may arrive through the AP and may be delivered to the STAs. Traffic originating from STAs to destinations outside the BSS may be sent to the AP to be delivered to respective destinations. Traffic between STAs within the BSS may be sent through the AP, for example, in which the source STA may send traffic to the AP and the AP may deliver the traffic to the destination STA. The traffic between STAs within a BSS may be considered and/or referred to as peer-to-peer traffic. The peer-to-peer traffic may be sent between (e.g., directly between) the source and destination STAs with a direct link setup (DLS). In certain representative embodiments, the DLS may use an 802.11e DLS or an 802.11z tunneled DLS (TDLS). A WLAN using an Independent BSS (IBSS) mode may not have an AP, and the STAs (e.g., all of the STAs) within or using the IBSS may communicate directly with each other. The IBSS mode of communication may sometimes be referred to herein as an "ad-hoc" mode of communication.

[0054] When using the 802.11ac infrastructure mode of operation or a similar mode of operations, the AP may transmit a beacon on a fixed channel, such as a primary channel. The primary channel may be a fixed width (e.g., 20 MHz wide bandwidth) or a dynamically set width via signaling. The primary channel may be the operating channel of the BSS and may be used by the STAs to establish a connection with the AP. In certain representative embodiments, Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) may be implemented, for example in in 802.11 systems. For CSMA/CA, the STAs (e.g., every STA), including the AP, may sense the primary channel. If the primary channel is sensed/detected and/or determined to be busy by a particular STA, the particular STA may back off. One STA (e.g., only one station) may transmit at any given time in a given BSS.

[0055] High Throughput (HT) STAs may use a 40 MHz wide channel for communication, for example, via a combination of the primary 20 MHz channel with an adjacent or nonadjacent 20 MHz channel to form a 40 MHz wide channel.

[0056] Very High Throughput (VHT) STAs may support 20MHz, 40 MHz, 80 MHz, and/or 160 MHz wide channels. The 40 MHz, and/or 80 MHz, channels may be formed by combining contiguous 20 MHz channels. A 160 MHz channel may be formed by combining 8 contiguous 20 MHz channels, or by combining two non-contiguous 80 MHz channels, which may be referred to as an 80+80 configuration. For the 80+80 configuration, the data, after channel encoding, may be passed through a segment parser that may divide the data into two streams. Inverse Fast Fourier Transform (IFFT) processing, and time domain processing, may be done on each stream separately. The streams may be mapped on to the two 80 MHz channels, and the data may be transmitted by a transmitting STA. At the receiver of the receiving STA, the above described operation for the 80+80 configuration may be reversed, and the combined data may be sent to the Medium Access Control (MAC).

[0057] Sub 1 GHz modes of operation are supported by 802.11af and 802.11ah. The channel operating bandwidths, and carriers, are reduced in 802.11af and 802.11ah relative to those used in 802.11n, and 802.11ac. 802.11af supports 5 MHz, 10 MHz and 20 MHz bandwidths in the TV White Space (TVWS) spectrum, and 802.11ah supports 1 MHz, 2 MHz, 4 MHz, 8 MHz, and 16 MHz bandwidths using non-TVWS spectrum. According to a representative embodiment, 802.11ah may support Meter Type Control/Machine-Type Communications, such as MTC devices in a macro coverage area. MTC devices may have certain capabilities, for example, limited capabilities including support for (e.g., only support for) certain and/or limited bandwidths. The MTC devices may include a battery with a battery life above a threshold (e.g., to maintain a very long battery life).

[0058] WLAN systems, which may support multiple channels, and channel bandwidths, such as 802.11n, 802.11ac, 802.11af, and 802.11ah, include a channel which may be designated as the primary channel. The primary channel may have a bandwidth equal to the largest common operating bandwidth supported by all STAs in the BSS. The bandwidth of the primary channel may be set and/or limited by a STA, from among all STAs in operating in a BSS, which supports the smallest bandwidth operating mode. In the example of 802.11ah, the primary channel may be 1 MHz wide for STAs (e.g., MTC type devices) that support (e.g., only support) a 1 MHz mode, even if the AP, and other STAs in the BSS support 2 MHz, 4 MHz, 8 MHz, 16 MHz, and/or other channel bandwidth operating modes. Carrier sensing and/or Network Allocation Vector (NAV) settings may depend on the status of the primary channel. If the primary channel is busy, for example, due to a STA (which supports only a 1 MHz operating mode), transmitting to the AP, the entire available frequency bands may be considered busy even though a majority of the frequency bands remains idle and may be available.

[0059] In the United States, the available frequency bands, which may be used by 802.11ah, are from 902 MHz to 928 MHz. In Korea, the available frequency bands are from 917.5 MHz to 923.5 MHz. In Japan, the available frequency bands are from 916.5 MHz to 927.5 MHz. The total bandwidth available for 802.11ah is 6 MHz to 26 MHz depending on the country code.

[0060] FIG. 1D is a system diagram illustrating the RAN 113 and the CN 115 according to an embodiment. As noted above, the RAN 113 may employ an NR radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 113 may also be in communication with the CN 115.

[0061] The RAN 113 may include gNBs 180a, 180b, 180c, though it will be appreciated that the RAN 113 may include any number of gNBs while remaining consistent with an embodiment. The gNBs 180a, 180b, 180c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the gNBs 180a, 180b, 180c may implement MIMO technology. For example, gNBs 180a, 108b may utilize beamforming to transmit signals to and/or receive signals from the gNBs 180a, 180b, 180c. Thus, the gNB 180a, for example, may use multiple antennas to transmit wireless signals to, and/or receive wireless signals from, the WTRU 102a. In an embodiment, the gNBs 180a, 180b, 180c may implement carrier aggregation technology. For example, the gNB 180a may transmit multiple component carriers to the WTRU 102a (not shown). A subset of these component carriers may be on unlicensed spectrum while the remaining component carriers may be on licensed spectrum. In an embodiment, the gNBs 180a, 180b, 180c may implement Coordinated Multi-Point (CoMP) technology. For example, WTRU 102a may receive coordinated transmissions from gNB 180a and gNB 180b (and/or gNB 180c).

[0062] The WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c using transmissions associated with a scalable numerology. For example, the OFDM symbol spacing and/or OFDM subcarrier spacing may vary for different transmissions, different cells, and/or different portions of the wireless transmission spectrum. The WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c using subframe or transmission time intervals (TTIs) of various or scalable lengths (e.g., containing varying number of OFDM symbols and/or lasting varying lengths of absolute time).

[0063] The gNBs 180a, 180b, 180c may be configured to communicate with the WTRUs 102a, 102b, 102c in a standalone configuration and/or a non-standalone configuration. In the standalone configuration, WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c without also accessing other RANs (e.g., such as eNode-Bs 160a, 160b, 160c). In the standalone configuration, WTRUs 102a, 102b, 102c may utilize one or more of gNBs 180a, 180b, 180c as a mobility anchor point. In the standalone configuration, WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c using signals in an unlicensed band. In a non-standalone configuration WTRUs 102a, 102b, 102c may communicate with/connect to gNBs 180a, 180b, 180c while also communicating with/connecting to another RAN such as eNode-Bs 160a, 160b, 160c. For example, WTRUs 102a, 102b, 102c may implement DC principles to communicate with one or more gNBs 180a, 180b, 180c and one or more eNode-Bs 160a, 160b, 160c substantially simultaneously. In the non-standalone configuration, eNode-Bs 160a, 160b, 160c may serve as a mobility anchor for WTRUs 102a, 102b, 102c and gNBs 180a, 180b, 180c may provide additional coverage and/or throughput for servicing WTRUs 102a, 102b, 102c.

[0064] Each of the gNBs 180a, 180b, 180c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the UL and/or DL, support of network slicing, dual connectivity, interworking between NR and E-UTRA, routing of user plane data towards User Plane Function (UPF) 184a, 184b, routing of control plane information towards Access and Mobility Management Function (AMF) 182a, 182b and the like. As shown in FIG. 1D, the gNBs 180a, 180b, 180c may communicate with one another over an Xn interface.

[0065] The CN 115 shown in FIG. 1D may include at least one AMF 182a, 182b, at least one UPF 184a,184b, at least one Session Management Function (SMF) 183a, 183b, and possibly a Data Network (DN) 185a, 185b. While each of the foregoing elements are depicted as part of the CN 115, it will be appreciated that any of these elements may be owned and/or operated by an entity other than the CN operator.

[0066] The AMF 182a, 182b may be connected to one or more of the gNBs 180a, 180b, 180c in the RAN 113 via an N2 interface and may serve as a control node. For example, the AMF 182a, 182b may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, support for network slicing (e.g., handling of different

PDU sessions with different requirements), selecting a particular SMF 183a, 183b, management of the registration area, termination of NAS signaling, mobility management, and the like. Network slicing may be used by the AMF 182a, 182b in order to customize CN support for WTRUs 102a, 102b, 102c based on the types of services being utilized WTRUs 102a, 102b, 102c. For example, different network slices may be established for different use cases such as services relying on ultra-reliable low latency (URLLC) access, services relying on enhanced massive mobile broadband (eMBB) access, services for machine type communication (MTC) access, and/or the like. The AMF 162 may provide a control plane function for switching between the RAN 113 and other RANs (not shown) that employ other radio technologies, such as LTE, LTE-A, LTE-A Pro, and/or non-3GPP access technologies such as WiFi.

[0067] The SMF 183a, 183b may be connected to an AMF 182a, 182b in the CN 115 via an N11 interface. The SMF 183a, 183b may also be connected to a UPF 184a, 184b in the CN 115 via an N4 interface. The SMF 183a, 183b may select and control the UPF 184a, 184b and configure the routing of traffic through the UPF 184a, 184b. The SMF 183a, 183b may perform other functions, such as managing and allocating WTRU IP address, managing PDU sessions, controlling policy enforcement and QoS, providing downlink data notifications, and the like. A PDU session type may be IP-based, non-IP based, Ethernet-based, and the like.

[0068] The UPF 184a, 184b may be connected to one or more of the gNBs 180a, 180b, 180c in the RAN 113 via an N3 interface, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The UPF 184, 184b may perform other functions, such as routing and forwarding packets, enforcing user plane policies, supporting multi-homed PDU sessions, handling user plane QoS, buffering downlink packets, providing mobility anchoring, and the like.

[0069] The CN 115 may facilitate communications with other networks. For example, the CN 115 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the CN 115 and the PSTN 108. In addition, the CN 115 may provide the WTRUs 102a, 102b, 102c with access to the other networks 112, which may include other wired and/or wireless networks that are owned and/or operated by other service providers. In one embodiment, the WTRUs 102a, 102b, 102c may be connected to a local Data Network (DN) 185a, 185b through the UPF 184a, 184b via the N3 interface to the UPF 184a, 184b and an N6 interface between the UPF 184a, 184b and the DN 185a, 185b.

[0070] In view of Figures 1A-1D, and the corresponding description of Figures 1A-1D, one or more, or all, of the functions described herein with regard to one or more of: WTRU 102a-d, Base Station 114a-b, eNode-B 160a-c, MME 162, SGW 164, PGW 166, gNB 180a-c, AMF 182a-ab, UPF 184a-b, SMF 183a-b, DN 185a-b, and/or any other device(s) described herein, may be performed by one or more emulation devices (not shown). The emulation devices may be one or more devices configured to emulate one or more, or all, of the functions described herein. For example, the emulation devices may be used to test other devices and/or to simulate network and/or WTRU functions.

[0071] The emulation devices may be designed to implement one or more tests of other devices in a lab environment and/or in an operator network environment. For example, the one or more emulation devices may perform the one or more, or all, functions while being fully or partially implemented and/or deployed as part of a wired and/or wireless communication network in order to test other devices within the communication network. The one or more emulation devices may perform the one or more, or all, functions while being temporarily implemented/deployed as part of a wired and/or wireless communication network. The emulation device may be directly coupled to another device for purposes of testing and/or may perform testing using over-the-air wireless communications.

[0072] The one or more emulation devices may perform the one or more, including all, functions while not being implemented/deployed as part of a wired and/or wireless communication network. For example, the emulation devices may be utilized in a testing scenario in a testing laboratory and/or a non-deployed (e.g., testing) wired and/or wireless communication network in order to implement testing of one or more components. The one or more emulation devices may be test equipment. Direct RF coupling and/or wireless communications via RF circuitry (e.g., which may include one or more antennas) may be used by the emulation devices to transmit and/or receive data.

[0073] The following abbreviations and acronyms, among others, are used herein: Acknowledgement (ACK); Block Error Rate (BLER); Bandwidth Part (BWP); Carrier Aggregation (CA); Channel Access Priority (CAP); Channel access priority class (CAPC); Component Carrier (CC); Clear Channel Assessment (CCA); Control Channel Element (CCE); Control Element (CE); Configured Grant or Cell Group (CG); Conditional Handover (CHO); Cyclic Prefix (CP); Conventional OFDM (relying on cyclic prefix) (CP-OFDM); Conditional PsCell addition (CPA); Conditional PsCell addition/change (CPAC); Conditional PsCell change (CPC); Channel Quality Indicator (CQI); Cyclic Redundancy Check (CRC); Channel State Information (CSI); Centralized Unit (CU); Contention Window (CW); Contention Window Size (CWS); Channel Occupancy (CO); Downlink Assignment Index (DAI); Dual Connectivity (DC); Downlink Control Information (DCI); Downlink feedback information (DFI); Dynamic grant (DG); Downlink (DL); Demodulation Reference Signal (DM-RS); Data Radio Bearer (DRB); enhanced Licensed Assisted Access (eLAA); Further enhanced Licensed Assisted Access (FeLAA); Hybrid Automatic Repeat Request (HARQ); License Assisted Access (LAA); Listen Before Talk (LBT); Long Term Evolution (*e.g.*, from

3GPP LTE Release 8 and up) (LTE); Layers 1 and 2 triggered mobility (LTM); Layer 1 (L1); Layer 2 (L2); Negative ACK (NACK); Master cell group (MCG); Medium Access Control (MAC); Modulation and Coding Scheme (MCS); Multiple Input Multiple Output (MIMO); New Radio (NR); Orthogonal Frequency-Division Multiplexing (OFDM); Primary cell (PCell); Physical cell identity (PCI); Physical Layer (PHY); Process ID (PID); Paging Occasion (PO); Physical Random Access Channel (PRACH); Primary SCG Cell (PSCell); Primary Synchronization Signal (PSS); Random Access (or procedure) (RA); Random Access Channel (RACH); Random Access Response (RAR); Radio access network Central Unit (RCU); Radio Front end (RF); Radio Link Control (RLC); Radio Link Failure (RLF); Radio Link Monitoring (RLM); Radio Network Identifier (RNTI); RACH occasion (RO); Radio Resource Control (RRC); Radio Resource Management (RRM); Reference Signal (RS); Reference Signal Received Power (RSRP); Received Signal Strength Indicator (RSSI); Secondary Cell (SCell); Secondary cell group (SCG); Service Data Unit (SDU); Special Cell (SpCell); Sounding Reference Signal (SRS); Synchronization Signal (SS); Secondary Synchronization Signal (SSS); Switching Gap (in a self-contained subframe) (SWG); Semi-persistent scheduling (SPS); Supplemental Uplink (SUL); Transport Block (TB); Transport Block Size (TBS); Transmission-Reception Point (TRP); Time-sensitive communications (TSC); Time-sensitive networking (TSN); Uplink (UL); Ultra-Reliable and Low Latency Communications (URLLC); Wide Bandwidth Part (WBWP); Wireless Local Area Networks and related technologies (IEEE 802.xx domain) (WLAN). SpCell may refer to either the PCell of the MCG or the PSCell of the SCG depending on whether the MAC entity is associated with the MCG or the SCG.

[0074] In RRC_CONNECTED, the WTRU may measure one or more beams of a cell. The WTRU may average the measurements results (e.g., power values) to derive the cell quality. In some cases, the WTRU may be configured to consider a subset of the detected beams. The WTRU may filter at two different levels: at the physical layer to derive beam quality and at RRC level to derive cell quality from multiple beams. Cell quality from beam measurements may be derived in the same way for the serving cell(s) and for the non-serving cell(s). Measurement reports may contain the measurement results of one or more beams (e.g., the *X* best beams) if the WTRU is configured to do so by the gNB. FIG. 2 shows an example of the corresponding high-level measurement model.

[0075] In some cases, the WTRU may be configured for RRC Connection states and state transitions. In NR, the WTRU may be configured in one of the following three RRC states: RRC_CONNECTED; RRC_INACTIVE; and RRC_IDLE. RRC_CONNECTED may also be referred to as “CONNECTED mode”. RRC_INACTIVE may also be referred to as "INACTIVE mode” in this document. RRC_IDLE may also be referred to as “IDLE mode”. FIG. 3 illustrates an example of the different RRC states and the transitions between them.

[0076] In some cases, the WTRU may be configured for inter-cell L1/2 triggered mobility (LTM). The WTRU may use inter-cell beam management that may manage the beams in CA. The WTRU may use mechanisms and procedures associated with L1/L2 based inter-cell mobility for mobility latency reduction. Mechanisms and procedures of L1/L2 based inter-cell mobility for mobility latency reduction configuration and maintenance for multiple candidate cells may allow fast application of configurations for candidate cells. Further, mechanisms and procedures of L1/L2 based inter-cell mobility for mobility latency reduction may determine a dynamic switch mechanism among candidate serving cells, including SpCells and SCells (e.g., for the potential applicable scenarios based on L1/L2 signaling). Further, mechanisms and procedures of L1/L2 based inter-cell mobility for mobility latency reduction may provide L1 enhancements for inter-cell beam management, including L1 measurement and reporting, and beam indication. Further, mechanisms and procedures of L1/L2 based inter-cell mobility for mobility latency reduction may provide timing Advance management. Further, mechanisms and procedures of L1/L2 based inter-cell mobility for mobility latency reduction may provide CU-DU interface signaling to support L1/L2 mobility, if needed. Frequency Range 2 (FR2) specific enhancements are not precluded. Further, In some cases, the procedure of L1/L2 based inter-cell mobility may be applicable to one or more of the following scenarios: a standalone, CA and NR-DC case with a serving cell change within one CG; an Intra-DU case and intra-CU inter-DU case (*e.g.*, cases applicable for Standalone and CA and no new RAN interfaces are expected); both intra-frequency and inter-frequency; both Frequency Range 1 (FR1) and FR2; source and target cells that are synchronized or non-synchronized; and/or an inter-CU case is not included.

[0077] L1/L2 based mobility and inter-cell beam management may address intra-DU and intra-frequency scenarios. In such cases, the serving cell may remain unchanged (*e.g.*, there is no possibility to change the serving cell using L1/2 based mobility). In FR2 deployments, CA may be used to exploit the available bandwidth to aggregate multiple CCs in one band. These CCs may be transmitted with the same analog beam pair (*e.g.*, a gNB beam and WTRU beam). The WTRU may be configured with TCI states for reception of PDCCH and PDSCH. The TCI states may be fairly large number (e.g., 64). Each TCI state may include a RS or SSB that the WTRU refers to set its beam. The SSB may be associated with a non-serving PCI. MAC signaling (*e.g.*, a “TCI state indication for WTRU -specific PDCCH MAC CE”) may activate the TCI state for a Coreset and/or PDCCH. Reception of PDCCH from a non-serving cell may be supported by MAC CE indicating a TCI state associated to non-serving PCI. MAC signaling (*e.g.*, a “TCI States Activation/Deactivation for WTRU -specific PDSCH”) may activate a subset of (up to) 8 TCI states for PDSCH reception. DCI may indicate the 8 TCI states. A WTRU may also support “unified TCI state” with a different updating mechanism (*e.g.*, DCI-based), but without multi-TRP. A WTRU may support unified TCI state with multi-TRP.

[0078] A WTRU may use LTM to improve handover latency. With a conventional L3 handover or conditional configuration, the WTRU may first send a measurement report using RRC signaling. In response to sending the measurement, the network may provide a further measurement configuration and potentially a conditional handover configuration. With a conventional handover, the network provides a configuration for a target cell after the WTRU reports, using RRC signaling, that the cell meets configured radio quality criteria. With a conditional handover, the network provides a target cell configuration as well as a measurement criteria which determines when the WTRU should trigger the CHO configuration in advance, in order to reduce the handover failure rate due to the delay in sending a measurement report, receiving an RRC reconfiguration from. Both of these L3 methods may suffer from some amount of delay associated with sending the measurement reports and receiving of the target configurations, particularly in case of the conventional (non-conditional) handover. LTM may allow a fast application of configurations for candidate cells by dynamically switching between SCells and switching of the PCell (*e.g.*, switching the roles between SCell and PCell) without performing RRC signaling. The inter-CU case may not be included, as this requires relocation of the PDCP anchor. As such, an RRC-based approach may be needed to support inter-CU handover.

[0079] With legacy L3 handover mechanisms, any currently active SCell(s) may be released before the WTRU completes the handover to a target cell in the coverage area of a new site. The active SCell(s) may only be added back after successful handover, which leads to throughput degradation during handover. As such, one of the aims of L1/2 is to enable a CA operation to be enabled instantaneously upon serving cell change.

[0080] FIG. 4 illustrates an example of LTM operation. In FIG. 4, the candidate cell group is configured by RRC and a dynamic switch of PCell and SCell is achieved using L1/2 signaling. FIG. 5 illustrates an example LTM baseline procedure 500. The WTRU sends a *MeasurementReport* message to the gNB at 501. The gNB decides to use LTM and initiates LTM candidate preparation at 502. The gNB transmits an *RRCReconfiguration* message to the WTRU including the configuration of one or multiple LTM candidate target cells at 503. The WTRU stores the configuration of LTM candidate target cell(s) and transmits a *RRCReconfigurationComplete* message to the gNB at 504. The WTRU may perform DL synchronization and TA acquisition with candidate target cell(s) before receiving the LTM cell switch command at 505. In some cases, the WTRU may be configured to support DL synchronization for candidate cell(s) before cell switch command based on SSB. In some cases, the WTRU may be configured to support TA acquisition of candidate cell(s) before LTM cell switch command based on PDCCH ordered RACH. The PDCCH order may be triggered by source cell. At 506, the WTRU may perform L1 measurements on the configured LTM candidate target cell(s) and transmit lower-layer measurement reports to the gNB. In some cases, the WTRU may be configured to carry the lower-layer measurement reports on L1 or MAC. At 507, the gNB may decide to execute LTM cell switch to a target cell and transmit a MAC CE triggering LTM cell switch. The gNB may transmit the MAC CE triggering LTM cell switch by including the candidate configuration index of the target cell. The WTRU switches to the configuration of the LTM candidate target cell. The WTRU may receive a beam indication. At 508, the WTRU may perform random access procedure towards the target cell, if TA is not available. At 509, the WTRU may indicate successful completion of the LTM cell switch towards target cell. An uplink signal or message after the WTRU has switched to the target cell may be used to indicate successful completion of the LTM cell switch.

[0081] In some cases, the WTRU may be configured for NR early measurement. The network may configure the WTRU with Carrier Aggregation (CA) or/and Dual Connectivity (DC) to increase the data rate per user (and in some cases, increase reliability as well). In CA, the WTRU may simultaneously send or receive data to or from multiple cells of a given gNB that are operating at different carrier frequencies. In DC, on the other hand, the WTRU may be connected to two serving gNBs, known as the master node (MN) and the secondary node (SN). When operating in DC, the WTRU may be further configured in CA within the MN and/or SN. The set of cells under the MN that are configured for the WTRU are known as Master Cell Group (MCG), and the ones under the SN are referred to as Secondary Cell Group (SCG). The primary cell in the MCG is referred to as PCell, and the primary cell in the SCG is known as PSCell. The term SPCell (special Cell) is used to refer to either the PCell or the PSCell. The cells other than the SPCells are known as SCells (Secondary Cells).

[0082] The network may decide to setup CA and/or DC for the WTRU based on measurement reports received from the WTRU regarding neighbouring cells. It is noted that there is nothing preventing the network from configuring CA or/and DC blindly (*e.g.*, without receiving a measurement report).

[0083] Early measurement reporting may be used to enable the quick setup of CA and/or DC as soon as the WTRU transitions into RRC_CONNECTED (*e.g.*, IDLE/INACTIVE measurements). The WTRU may be configured to perform measurements on neighbouring cells while the WTRU is in RRC_INACTIVE or RRC_IDLE. The measurements may be performed on intra-frequency, inter-frequency, or/and inter-RAT neighbour cells. When the WTRU transitions to RRC_CONNECTED state, the WTRU may send the measurements, letting the network know if there are candidate neighbour cells that can be configured in CA or DC mode for the WTRU.

[0084] FIG. 6 illustrates an example of a procedure 600 for using early measurements for a quick setup of CA/DC when the WTRU switches to RRC_CONNECTED from RRC_INACTIVE at 600. The WTRU is provided with an early measurement configuration upon transitioning to RRC_INACTIVE at 601. The WTRU performs the measurements while the WTRU is in RRC_INACTIVE at 602. When the WTRU transitions to

RRC_CONNECTED mode (*e.g.*, when the WTRU received a paging due to DL data arrival 603 or UL data needs to be sent, etc.), the WTRU triggers the RRC Resume procedure by sending the RRC Resume Request message at 604. The network may request the WTRU to send the measurements performed during RRC_INACTIVE mode in the RRC Resume message 605, which the WTRU provides in the RRC Resume Complete message 606. Based on the RRC Resume Complete message 606, the network may immediately configure CA/DC at 607, if such candidate cells are available. The network may send an RRCReconfiguration message including CA/DC configuration at 608, and the WTRU may respond with an RRCReconfigurationComplete message at 609 and begin operating in CA/DC. Without early measurements the setup of CA/DC may have been considerably delayed as the WTRU would have to be configured with measurements to perform after the transition to RRC_CONNECTED, and the network would need to wait until the WTRU has performed these measurements and sent the measurement report before configuring CA/DC.

[0085] The IDLE/INACTIVE measurement configuration may be provided to the WTRU via dedicated message (e.g., in *measIdleConfig information element (IE)* in the RRCRelease message when the WTRU is transitioned to IDLE/INACTIVE). Additionally, or alternatively, the WTRU may get the IDLE/INACTIVE measurement configuration from SIB 11 (e.g., in *measIdleConfig-SIB* IE).

[0086] The *measIdleConfig* IE may include one or more of the following: a list of NR carrier frequencies to be measured; a list of Evolved Universal mobile telecommunications system Terrestrial Access EUTRA (*e.g.*, LTE) frequencies; an idle measurement duration; and/or a validity area.

[0087] The list of NR carrier frequencies may be measured for CA and/or DC candidate NR cells. In some cases, the list of NR carrier frequencies may include additional information including but not limited to one or more of the following: the list of cells to be measured, the quality to be measured (*e.g.*, RSRP or RSRQ), RSRP/RSRQ thresholds indicating which cells are to be included in the measurement report, details of SSB and beam configurations, etc.

[0088] The list of EUTRA (*e.g.*, LTE) frequencies may correspond to inter-RAT candidate cells for DC with NR (*e.g.*, EN-DC, NE-DC). The list of EUTRA frequencies may include additional information including but not limited to one or more of the following: the list of cells to be measured, the quality to be measured (*e.g.*, RSRP and/or RSRQ), RSRP/RSRQ thresholds indicating which cells are to be included in the measurement report, etc.

[0089] In some examples, the idle measurement duration may be a value ranging from 10 seconds to 300 seconds. The idle measurement may specify how long the WTRU performs the measurements while in IDLE/INACTIVE.

[0090] The validity area may specify a list of frequencies (e.g., and optionally cells within that frequency). The WTRU may stop the measurements if the WTRU reselects to a cell that is not included in this validity area. In some cases, the validity area is optional. In such cases, the WTRU may be configured with one or both of a list of NR and/or a list of EUTRA frequencies.

[0091] For FR2, IDLE/INACTIVE mode measurement results reported during and/or after RRC connection setup or resume may be reused in order to improve SCell and/or SCG setup delay. New measurement requirements for FR2 may be determined such that measurements are taken more quickly, and are more "fresh" when reported, in order to account for FR2 the radio conditions that are likely to change quickly due to shorter range and smaller coverage of cells. In addition, a signaling mechanism may be introduced such that the measurements can be reported earlier. L1/2 triggered mobility (LTM) may be used to reduce mobility latency. In some cases, the WTRU may be configured to utilize early measurements and LTM features together to improve the setup time when transitioning to RRC_CONNECTED from RRC_INACTIVE.

[0092] The term "early measurements" may refer to radio quality measurements that the WTRU is configured to perform while in RRC_IDLE or RRC_INACTIVE, and report during or after RRC connection Setup or Resume.

[0093] The terms "perform LTM" or "perform LTM procedures" may refer to performing one or more (e.g., all) of the steps described in FIG. 5. In particular, "perform LTM" or "perform LTM procedures" may refer to performing early synchronization in DL and/or UL to one or more of the candidate cells, performing L1 measurements and reporting on one or more of the candidate cells, and switching (*e.g.*, performing a handover) between candidate cells. Further, "perform LTM" may refer to the WTRU moving or switching between multiple candidate cells during the procedure.

[0094] The one or more candidate cell sets may be groups of one or more RRC configurations corresponding to a handover configuration for one or more candidate SpCells and optionally SCells. The RRC configurations may be modelled or received as one or more complete RRC Reconfiguration messages, one or more cell group configurations, and/or one or more cell configurations. Each of the candidate cell configurations (e.g., candidate configuration information) may include a candidate configuration identifier. Each of the candidate cell groups may include a candidate cell group identifier. If the grouping is performed at RRC, the switching between different sets of candidate cells may include updating the serving cell indexes and/or candidate configuration indexes. The serving cell indexes, or candidate configuration indexes may be used in L1. MAC signaling may be used to refer to specific indexes. For example, a MAC CE triggering the reconfiguration may include a candidate configuration index informing the WTRU to perform the reconfiguration on a particular cell.

[0095] The one or more candidate cell groups may be configured as a single list or group of candidate cell configurations at RRC. The grouping may occur at the early sync or LTM execution phase rather than the configuration phase. As such, the candidate cell set may be considered as a single group in terms of an RRC configuration list or group. Further, the cells selected for performing early sync, L1 measurements, and LTM execution may depend on a further grouping into multiple subsets of the overall candidate cell list. That is, the grouping itself may not be modelled at RRC using candidate configuration identifiers. However, the grouping may be executed as part of the early sync or the LTM execution procedure.

[0096] As provided herein, an LTM candidate configuration may apply to any type of preconfigured cell information. For example, the WTRU may be configured with one or more conditional reconfigurations including but not limited to, a conditional handover (CHO), conditional PSCell addition (CPA) and/or conditional PSCell change (CPC). Each such conditional reconfiguration may be valid before and/or after a cell change, or valid in certain cells.

[0097] With the introduction of LTM, the WTRU may perform inter-cell mobility procedures with a much lower latency. Pre-configured RRC reconfigurations to new cells may be triggered by MAC CE based on L1 measurement reporting, and may be controlled by DU instead of the CU. In RRC_CONNECTED, the WTRU configured with LTM may maintain the configuration for multiple SpCells and SCells even though the SpCells and SCells are not currently active.

[0098] A WTRU transitioning to RRC_INACTIVE to save power may release conditional reconfigurations (*e.g.*, CHO, CPAC) configurations. The transition to RRC_INACTIVE may require an RRC procedure to return to RRC_CONNECTED and/or an RRC procedure to (re)setup candidates. LTM candidates may also be released upon transition to RRC_INACTIVE. However, in some embodiments, overhead and latency may be reduced by enabling the storing of multiple candidate cells in RRC_INACTIVE state to be applied upon reconfiguration (handover) triggered by lower layers (*e.g.*, MAC CE).

[0099] In addition, the early measurement enhancements for FR2 to support faster SCG and SCell setup may likely introduce new, more challenging measurement requirements in RRC_IDLE and RRC_INACTIVE. As such, the WTRU processing requirements, and therefore power consumption, may be increased. Additionally, in FR2, the cell coverage is smaller than, for example, in FR1. As a result, the WTRU may be configured with a relatively high number of neighbor cells for measurements which, along with the more challenging measurement performance requirements, may have a significant contribution to WTRU power consumption.

[0100] In some cases, the WTRU may be configured to store some or all of the LTM candidate cell configurations even when the connection is suspended, and the WTRU is moved to RC_INACTIVE. This may enable the WTRU to perform a faster RRC reconfiguration in the case of handover. Additionally, or alternatively, this may allow LTM procedures to resume immediately or almost immediately upon resuming the RRC connection, thereby avoiding the need to perform RRC reconfiguration to set up the candidates again. Furthermore, storing the candidate cell configurations in RRC_INACTIVE may enable the use of LTM procedures, or procedures similar to LTM, during RRC state change. These procedures may be used to activate an RRC reconfiguration based on a stored configuration, to configure the SpCell (e.g. the cell on which the connection is being resumed), and/or to configure SCells. This may improve the transition from RRC_INACTIVE to RRC_CONNECTED, since limited RRC messages are needed to perform the setup (or resume), because the configuration has already been stored. The burden on WTRU processing may be limited by maintaining and determining optimal target configurations while in RRC_INACTIVE, and/or considering only the candidate configurations that are relevant for the current cell after performing a cell reselection in RRC_INACTIVE.

[0101] For a fast RRC resume, storing only the current cell's (e.g., LTM) SpCell configuration may be sufficient to provide some benefit to increase the transition speed to RRC_CONNECTED, as it is possible to apply a preconfigured RRC configuration for the SpCell (e.g., PCell) upon resuming the RRC connection. As such, signaling all or part of the configuration in the RRC Resume message may be avoided as the current cell RRC configuration is already stored. To enable faster SCG and/or SCell setup, in addition to faster PCell setup, multiple target configurations may be stored. By utilizing early measurements in combination with storing candidate cell configurations, SCells may be activated very quickly during or after RRC Connection resume without the need to perform the relatively slow RRC reconfiguration procedures to provide the complete configurations after resuming an RRC connection to the current cell (SpCell).

[0102] In some cases, the WTRU may be configured to disable and/or remove LTM candidate cells while remaining in RRC_INACTIVE state. The WTRU may dynamically disable and/or delete one or more LTM candidate configurations while remaining in RRC_INACTIVE state. In some cases, the WTRU may delete one or more LTM configurations based on satisfaction of some condition. For example, a candidate configuration may be considered valid for a given time period. In examples, the WTRU may start this time period upon transition to RRC_INACTIVE (*e.g.*, upon reception of a suspend configuration), and may delete the configuration upon expiry of the time period. Upon completion of the time period (or some time before expiry), the WTRU may initiate a resume procedure to indicate that one or more LTM candidate configurations is about to expire.

[0103] In some cases, the WTRU may receive a message from the network indicating that one or more LTM configurations is to be deleted and/or removed while in RRC_INACTIVE. In examples, the WTRU may receive a paging message from the network indicating (*e.g.*, within a short message) that retaining LTM candidate cells in INACTIVE is disabled, and/or that the WTRU should delete one or more (e.g., all) stored candidate configurations. In examples, the WTRU may receive the indication via an alternative DL message (e.g., RAR, MSG4, or MSGB). In examples, the WTRU may receive an indication to remove and/or delete one or more LTM candidates. The WTRU may receive the indication to remove and/or delete one or more LTM candidates, via an index pointing to a specific LTM candidate configuration.

[0104] In some cases, the WTRU may disable and/or delete one or more LTM candidate configurations based on an indication within system information. For example, the WTRU may be released from one cell (*e.g.*, via reception of an RRC Release message) and perform cell reselection to a new cell. If the system information of the current serving cell indicates that stored LTM candidate configuration is not supported on the new cell, the WTRU may reselect another cell or may release the stored LTM candidate configurations.

[0105] In some cases, the WTRU may disable and/or delete one or more LTM candidate configurations based on a characteristic of the WTRU. For example, the WTRU may be considered “high mobility” (*e.g.*, based on the maintained Mobility State Estimation (MSE) value) and may choose to delete one, a subset of, or all of the LTM candidate configurations. Alternatively, the WTRU may be provided with a dedicated parameter (*e.g.*, configured within the RRC Release message), which is used to evaluate where the WTRU is in a high mobility state. In examples, this may be based on WTRU GNSS location information, WTRU sensor data, and/or a number of cell reselections performed within a time period.

[0106] In some cases, the WTRU may be configured for LTM early measurement maintenance in RRC_INACTIVE. In some cases, the WTRU may be configured to receive configuration information (*e.g.*, via RRC reconfiguration) of pre-configured LTM candidate cells from a first cell. In some cases, the WTRU may be configured to receive an indication (*e.g.*, via RRC release) to enable measurements for pre-configured LTM candidate cells in RRC_INACTIVE. In some cases, the WTRU may be configured to reselect to a second cell. In some cases, the WTRU may be configured to receive cell specific information (*e.g.*, current neighbors) from a second cell. In some cases, the WTRU may be configured to determine a subset of cells based on the pre-configured LTM candidate cells and the cell-specific information from the second cell and perform radio quality measurements on the subset of cells. The WTRU may send an RRC Resume Request message to the gNB and may receive in response an RRC Resume message. In some cases, the WTRU may be configured to resume the RRC Connection on the second cell and report the radio quality measurements corresponding to the subset of cells to the second cell (e.g., in an RRC Resume Complete message).

[0107] FIG. 7 and FIG. 8 illustrate example procedures and signaling for LTM early measurement maintenance in RRC_INACTIVE. At 701 and 801, the WTRU may be configured to receive pre-configuration of LTM candidate cells in RRC_CONNECTED. The WTRU may receive a configuration of one or more candidate cells (*e.g.*, SpCells and/or SCells). For example, the WTRU may receive a configuration of one or more candidate cells using RRC Connection Reconfiguration 707. The WTRU stores the candidate configurations (*e.g.*, Candidate cells) in which a handover or RRC reconfiguration may be triggered using lower layer signalling (*e.g.*, a MAC CE).

[0108] At 702 and 802, the WTRU may be configured to receive measurement configuration for LTM cells in RRC Release 708. The WTRU may receive a measurement configuration for performing early measurements. In particular, the WTRU may receive measurement configuration for performing early measurements on LTM candidate cells. In some cases, the measurement configuration may be received in the RRC Reconfiguration message 707. In other cases, the measurement configuration may be received separately in an RRC Release message 708 containing a suspend configuration. The measurement configuration may include a list of carriers and/or cells on which to perform measurements while in RRC_INACTIVE state. The measurement configuration may additionally include a validity area. For example, the validity area may be a list of cells or carriers on which the WTRU may be camped when the measurements are performed. The measurement configuration may additionally include measurement parameters to determine how the WTRU performs the measurements. The measurement parameters may include, for example, but are not limited to, one or more of radio quality thresholds for including a report, an averaging or filtering parameters, and/or prioritization of measurements. The WTRU may determine to report the measurements based on radio quality thresholds for including the measurements in the report (e.g., the WTRU may report a cell if the measurement is above an RSRP threshold). The WTRU may determine to perform the measurements based on averaging or filtering parameters that include an indication of how many samples to use in measurement averaging. The WTRU may determine to report the measurements based on the prioritization of measurements of cells to report if more than a maximum number of measurements may be reported.

[0109] In some cases, the measurement configuration may indicate that the WTRU should perform measurements of all LTM candidate cells. In other cases, the measurement configuration may indicate that the WTRU should perform measurements on a subset of LTM candidate cells. The measurement configuration may include a configuration to measure cells outside of the LTM candidate set. In some cases, the measurement configuration may include one or more of a relative priority for measurements, a reporting of different sets of LTM, and/or non-LTM candidate cells.

[0110] At 703 and 803, the WTRU may be configured to reselect to a second cell. In RRC_INACTIVE, the WTRU may perform cell reselection measurements and evaluation. In some cases, the WTRU may determine that a new (*e.g.*, a second) cell is more suitable than the current (*e.g.*, a first) cell and perform cell reselection to the second cell.

[0111] At 704 and 804, the WTRU may be configured to receive cell specific information (*e.g.*, current neighbors) from a second cell. When the WTRU performs cell reselection, the WTRU may acquire system information of the second cell. The WTRU may receive a list of neighbor carriers and/or cells. In some cases, the neighbor list may be the existing idle mode neighbor cells. In some cases, the neighbor list may be a separate list for determining early measurement neighbors.

[0112] At 705 and 805, the WTRU may be configured to determine and measure a subset of the LTM cells based on the configuration from the first and second cells. In some cases, the WTRU may determine and update the valid (e.g., in use) early measurements from the list of neighbor carriers and/or cells. For example, the WTRU may use a first set of early measurement candidates while camped on a first cell and a second set of early measurement candidates after performing reselection to a second cell (*e.g.*, cell 1: measurement set1, cell2: measurement set2). The determination may be based on checking which measurement configurations received at 701 or 801 are also broadcast in the new/second cell system information as neighboring cells. In some cases, if the cell configured for early measurement appears in the neighbor list, the WTRU may be considered valid in the second cell. In some cases, if the cell configured for early measurement does not appear in the neighbor list, the WTRU may be considered not valid in the second cell.

[0113] Upon determining the cells configured for which early measurements are valid in the new cell, the WTRU may perform measurements on those cells according to the relevant measurement requirements. In some cases, the set of requirements valid for LTM candidate cells may be different than those for non-LTM cells. In examples, the set of requirements valid for LTM candidate cells may have a higher sampling rate, shorter filtering, and/or a shorter timescale. In some cases, the WTRU may perform a different type of measurement for LTM candidate cells and non-LTM candidate cells. In examples, the WTRU may perform L1 beam RSRP measurements on LTM candidate cells. In examples, the WTRU performs L3 (*e.g.*, L3 filtered) measurements or cell level RSRP measurements on non-LTM candidate cells. The cell level RSRP measurements may be, for example, an averaged RSRP amongst multiple beams. The WTRU may additionally or alternatively be configured to perform different measurement types on different LTM candidate cells. For example, cells belonging to the same DU as the current cell may be configured with one type of measurement, while cells belonging to another DU than the current cell may be configured with another type of measurement. The specific cells for which a particular measurement type applies may depend on a configured relationship between that cell and the current cell. For example, LTM and/or non-LTM cells may be configured as groups. If the current and measured cell belongs to the same group, one type of measurement may apply. Otherwise, a different type of measurement may apply. The measurement may depend on the frequency band of the neighbor cell. For example, FR2 carriers may use one set of measurement requirements, and FR1 carriers may use another set of measurement requirements. In some cases, limits may be configured for measurements (e.g., to maximize the number of cells or carriers measured, or maximize the number of cells or carriers from a particular group measured).

[0114] In some cases, if the WTRU is configured with LTM and sent to the INACTIVE state, the WTRU may continue to perform the early measurement for the whole duration of the INACTIVE state. That is, the WTRU may perform the early measurement until the WTRU transitions to CONNECTED state. As such, the WTRU may disregard any *measIdleDuration* configuration that is associated with early measurements. Alternatively, the WTRU may be explicitly configured with a very long *measIdleDuration* (*e.g.*, a duration infinity) to effectively disable the time duration limitation.

[0115] In some cases , the WTRU may stop early measurements for a given cell configured for early measurement if the cell does not belong to the saved LTM candidate set according to the legacy *measIdleDuration* The WTRU may stop early measurements for the given cell while the WTRU may continue early measurements for a given cell configured for early measurement if the cell belongs to the saved LTM candidate set even after the *measIdleDuration* has elapsed.

[0116] At 706 and 806, the WTRU may be configured to report the measured subset of cells to the second cell. The WTRU may report the stored measurements of the subset of cells to the second cell. In some cases, the report may be transmitted, for example, as a MAC CE with Msg3, Msg5, or another uplink RRC Message. In some cases, this report may be an RRC message, or an extension of an RRC message, including but not limited to, an RRC Resume Request 710, RRC Resume Complete 712, and/or WTRU information response. In examples, in case the WTRU measures LTM and non-LTM candidate cells while in RRC_INACTIVE, and the uplink grant provided for sending a Msg3 or a Msg5 including measurement results is not sufficient to include all of the results, the WTRU may prioritize including the LTM candidate cell measurements over non-LTM cell measurements. In examples, a limit may be configured in the reporting configuration specifying the maximum number of measurement results to include. The limit may be configured to report the configuration as part of step 2. In examples, multiple limits may be specified, for example, to include X cells belonging to one group and Y cells belonging to another group in the report. As such, the specified multiple limits may be used by the gNB to determine, for example, whether to set up one or another CSG based on the SCell measurements for each group.

[0117] In some cases, the WTRU may be configured for a validity area RAU update. In some examples, the WTRU may determine after a cell reselection that the cell does not correspond to any of the LTM candidate cells. In examples, the WTRU may determine that no SpCell configuration is stored for the cell and/or no valid target cell candidates are stored for the cell. In examples, the WTRU may determine that the WTRU is outside of the set of configured early measurements. For example, the WTRU may determine that the WTRU is outside of the early measurements validity area. In such cases, the WTRU may initiate an RRC Resume to inform the network that the WTRU is outside of the LTM early measurements validity area. In some cases, the LTM validity area may be a list of carriers or cells. In one or more other cases, the LTM validity area may be a specific to one or more RAN notification areas (RNA). If the newly selected cell does not belong to the validity area, the WTRU may initiate an RRC Resume. In some cases, the RRC Resume may indicate a new cause value (*e.g.*, out of LTM validity area). In other cases, the WTRU may send an uplink indication following RRC Resume, for example in a UE/WTRU Assistance information message. In some cases, the WTRU may release some or all of the configured LTM candidate configurations. Following the indication, the WTRU may receive a new LTM candidate set and a new validity area. In such cases, the connection may be suspended again.

[0118] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, WTRU, terminal, base station, RNC, or any host computer.

CLAIMS

What is Claimed is:

1. A wireless transmit/receive unit (WTRU) comprising:

a processor configured to:

receive configuration information from a first cell when in an active mode, wherein the configuration information indicates a plurality of L1/L2-triggered mobility (LTM) candidate cells;

receive an indication from the first cell to enable measurements for the list of LTM candidate cells;

receive system information from a second cell;

determine a subset of cells of the plurality of LTM candidate cells based on the system information from the second cell;

perform measurements on the subset of cells; and

send an indication of the measurements of the subset of cells to the second cell in response to entering a connected mode with the second cell.

2. The WTRU of claim 1, wherein the system information comprises a list of neighbor cells for the second cell.

3. The WTRU of claim 1 or 2, wherein the measurements comprise Layer 1 beam reference signal received power (RSRP) measurements for the subset of cells.

4. The WTRU of any of claims 1 to 3, wherein the processor is configured to send the indication of the measurements of the subset of cells via a MAC CE.

5. The WTRU of any of claims 1 to 4, wherein the configuration information is received via an RRC reconfiguration message.

6. The WTRU of any of claims 1 to 5, wherein the configuration information is received via an RRC release message.

7. The WTRU of any of claims 1 to 6, wherein the processor is configured to determine the subset of cells of the plurality of LTM candidate cells based on the system information from the second cell while the WTRU in an inactive mode.

8. The WTRU of any of claims 1 to 7, wherein the processor is configured to perform measurements on the subset of cells while the WTRU is in an inactive mode.

9. The WTRU of any of claims 1 to 8, wherein the processor is configured to report the measurements performed on the subset of cells to a network.

10. A method to be performed by a wireless transmit/receive unit (WTRU), the method comprising:

receiving configuration information from a first cell when in an active mode, wherein the configuration information indicates a plurality of L1/L2-triggered mobility (LTM) candidate cells;

receiving an indication from the first cell to enable measurements for the list of LTM candidate cells;

receiving system information from a second cell;

determining a subset of cells of the plurality of LTM candidate cells based on the system information from the second cell;

performing measurements on the subset of cells; and

sending an indication of the measurements of the subset of cells to the second cell in response to entering a connected mode with the second cell.

11. The method of claim 10, wherein the system information comprises a list of neighbor cells for the second cell.

12. The method of claim 10 or 11, wherein the measurements comprise Layer 1 beam reference signal received power (RSRP) measurements for the subset of cells.

13. The method of any of claims 10 to 12, wherein the indication of the measurements of the subset of cells is sent via a MAC CE.

14. The method of any of claims 10 to 13, wherein the configuration information is received via an RRC reconfiguration message.

15. The method of any of claims 10 to 14, wherein the configuration information is received via an RRC release message.

16. The method of any of claims 10 to 15, wherein the step of determining the subset of cells of the plurality of LTM candidate cells based on the system information from the second cell is performed while the WTRU in an inactive mode.

17. The method of any of claims 10 to 16, wherein the step of performing measurements on the subset of cells is performed while the WTRU is in an inactive mode.

18. The method of any of claims 10 to 17, further comprising reporting the measurements performed on the subset of cells to a network.

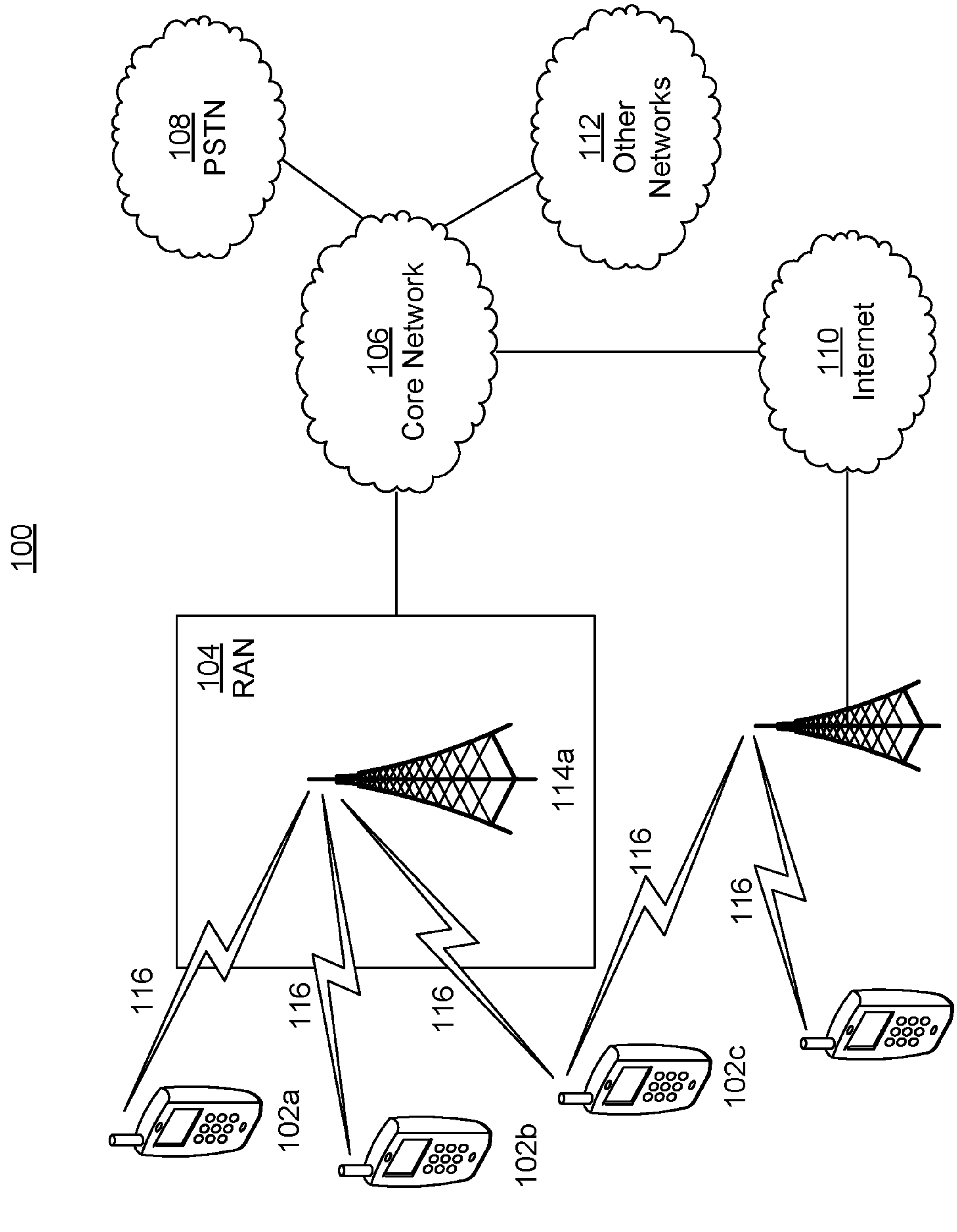
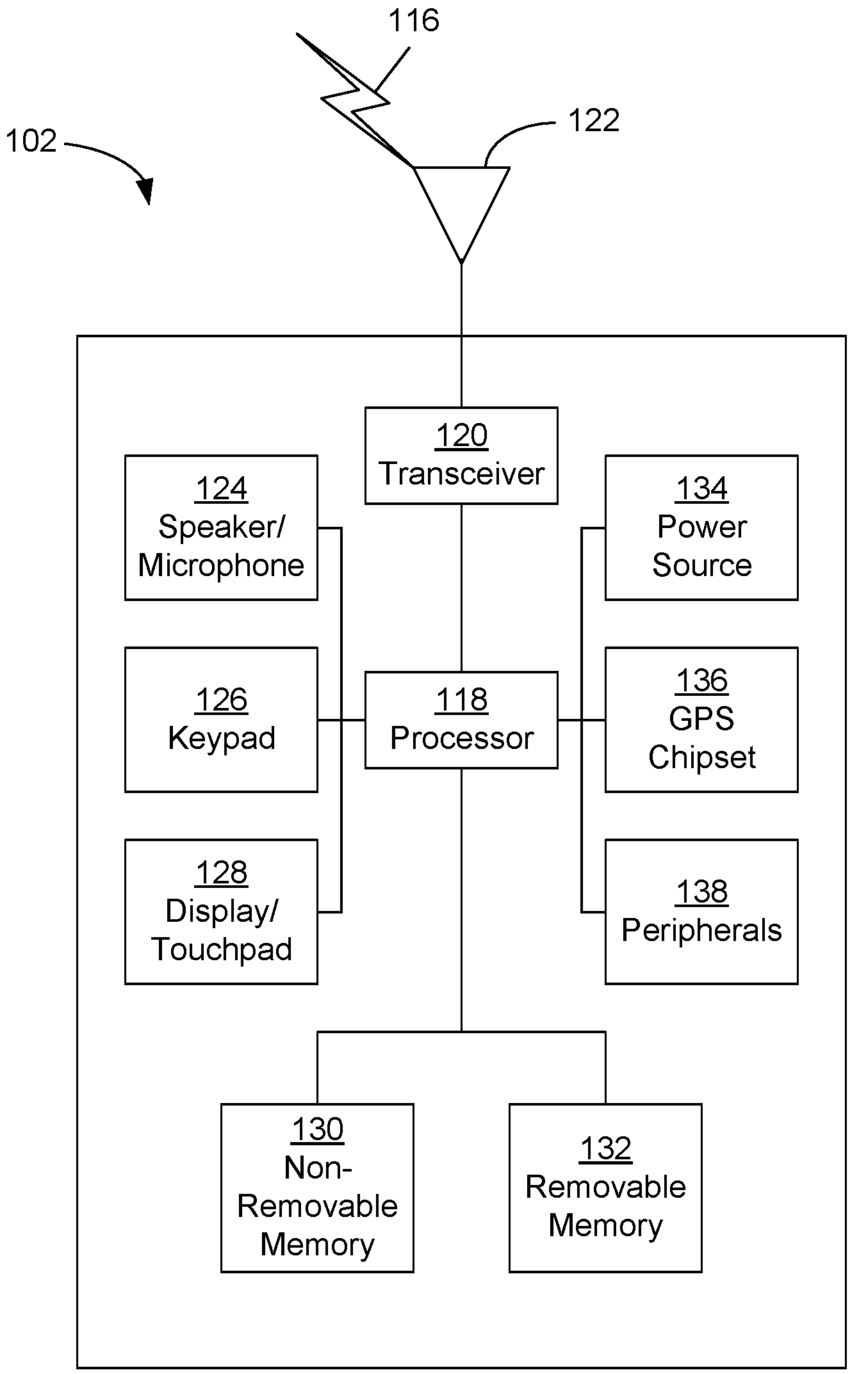

100
104
RAN
106
Core Network
108
PSTN
110
Internet
112
Other
Networks
114a
114b
116
116
116
116
116
102a
102b
102c
102d

FIG. 1A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122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS
Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

FIG. 1B

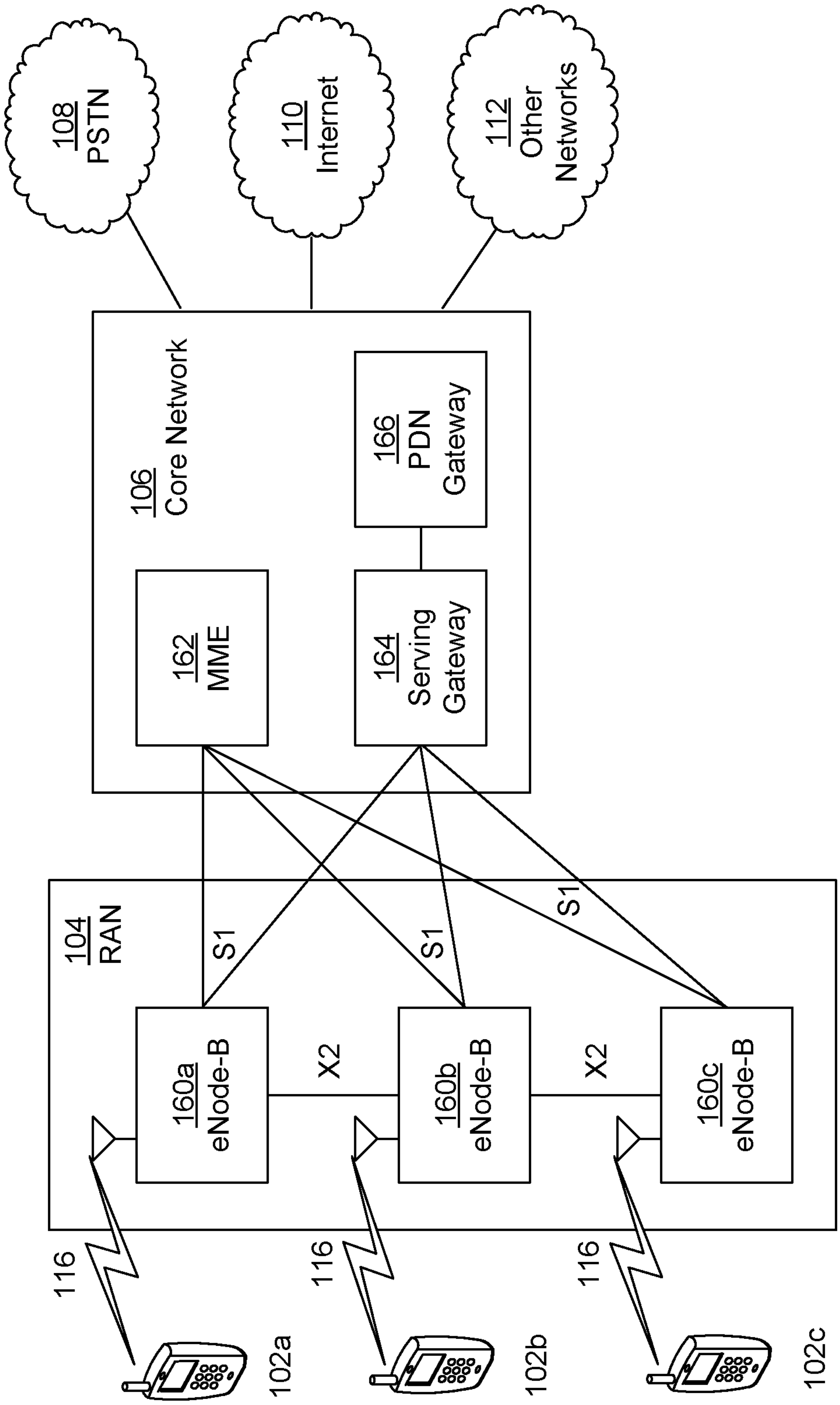
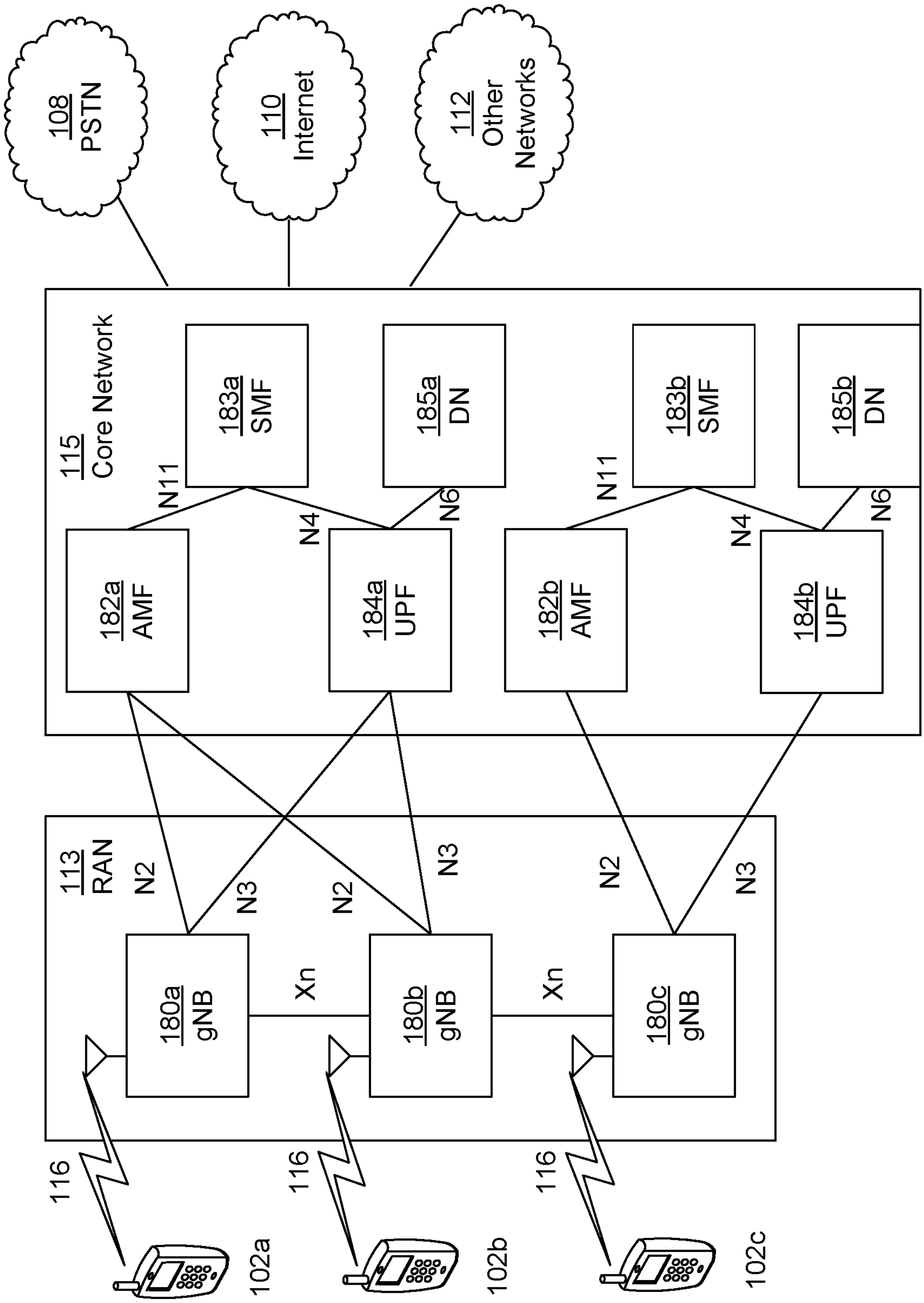

108
PSTN
110
Internet
112
Other
Networks
106
Core Network
162
MME
164
Serving
Gateway
166
PDN
Gateway
104
RAN
S1
S1
S1
160a
eNode-B
X2
160b
eNode-B
X2
160c
eNode-B
116
116
116
102a
102b
102c

FIG. 1C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110 Internet
112 Other Networks
115 Core Network
183a SMF
185a DN
183b SMF
185b DN
N11
N4
N6
N11
N4
N6
182a AMF
184a UPF
182b AMF
184b UPF
113 RAN
N2
N3
N2
N3
N2
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Xn
180b gNB
Xn
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102b
102c

FIG. 1D

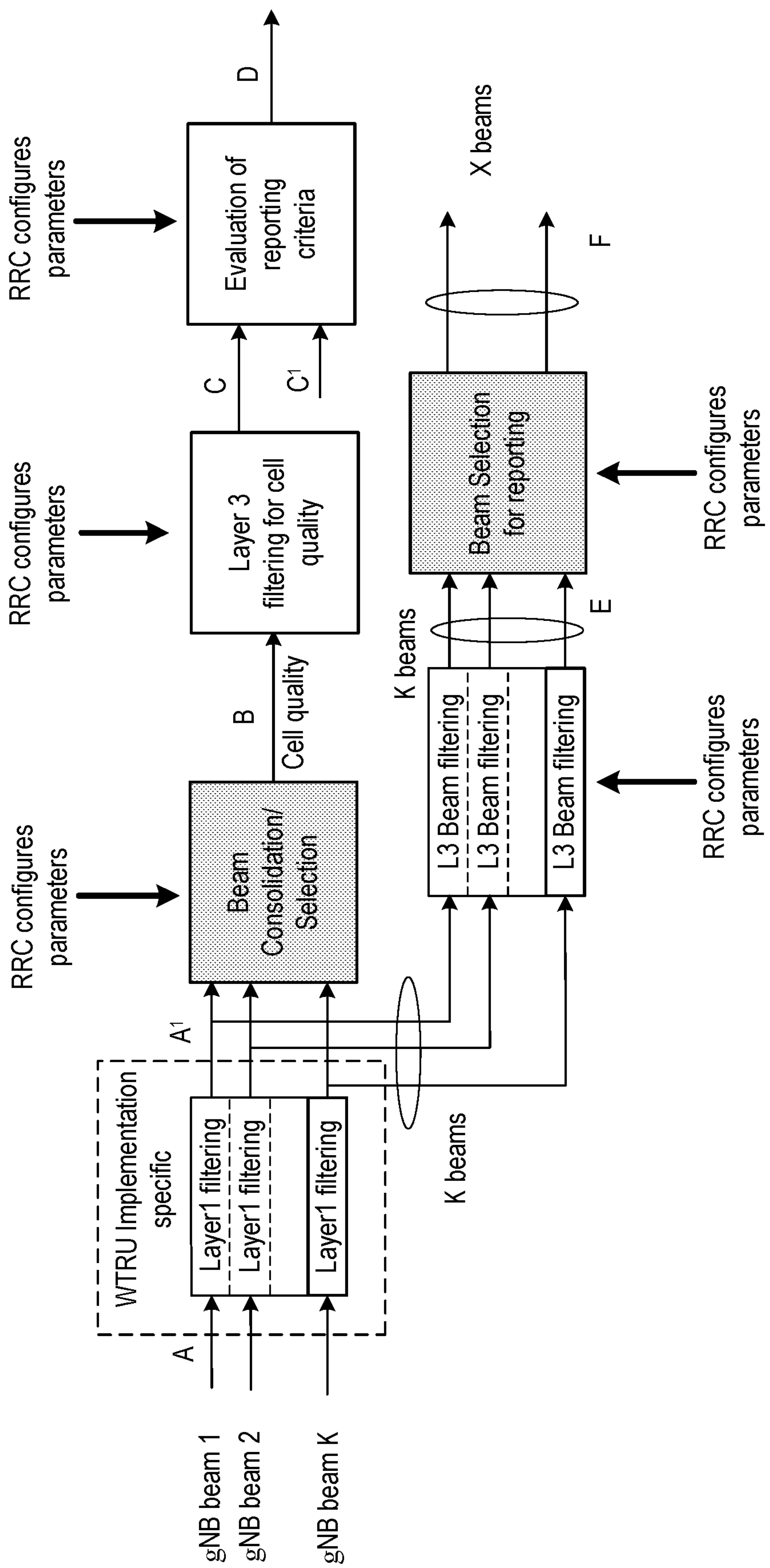
gNB beam 1
gNB beam 2
gNB beam K
A
WTRU Implementation specific
Layer1 filtering
Layer1 filtering
Layer1 filtering
A1
K beams
RRC configures parameters
Beam Consolidation/ Selection
B
Cell quality
RRC configures parameters
Layer 3 filtering for cell quality
C
C1
RRC configures parameters
Evaluation of reporting criteria
D
L3 Beam filtering
L3 Beam filtering
L3 Beam filtering
RRC configures parameters
K beams
E
Beam Selection for reporting
RRC configures parameters
F
X beams

FIG. 2

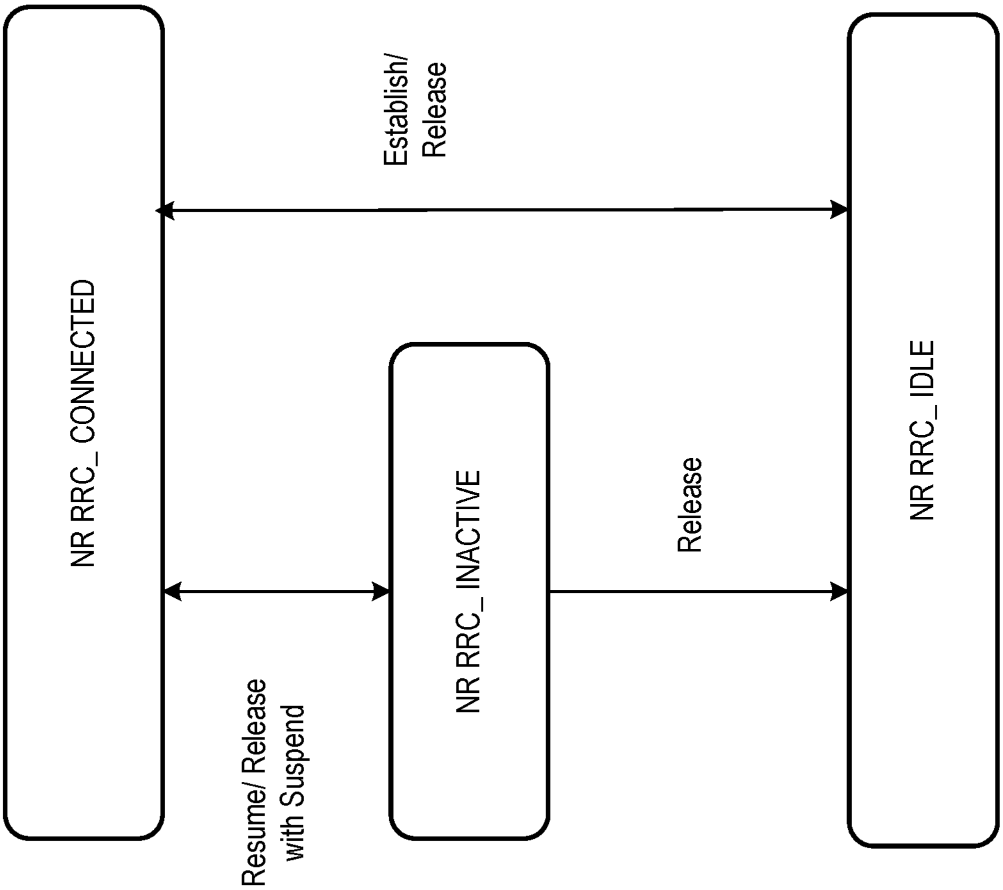
NR RRC_ CONNECTED
Establish/
Release
NR RRC_ INACTIVE
Resume/ Release
with Suspend
Release
NR RRC_ IDLE

FIG. 3

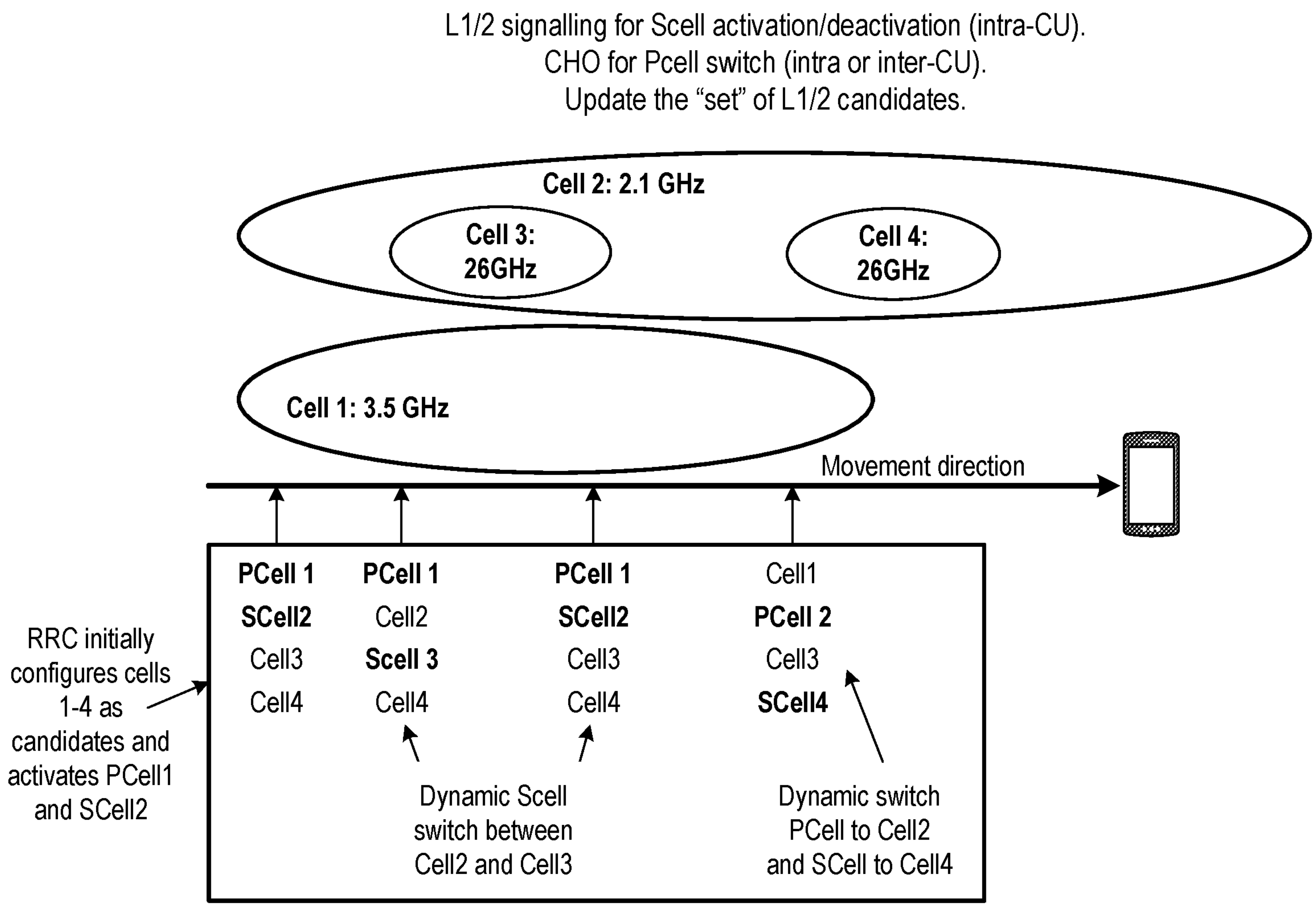
L1/2 signalling for Scell activation/deactivation (intra-CU).
CHO for Pcell switch (intra or inter-CU).
Update the “set” of L1/2 candidates.
Cell 2: 2.1 GHz
Cell 3: 26GHz
Cell 4: 26GHz
Cell 1: 3.5 GHz
Movement direction
RRC initially configures cells 1-4 as candidates and activates PCell1 and SCell2
PCell 1
SCell2
Cell3
Cell4
PCell 1
Cell2
Scell 3
Cell4
PCell 1
SCell2
Cell3
Cell4
Cell1
PCell 2
Cell3
SCell4
Dynamic Scell switch between Cell2 and Cell3
Dynamic switch PCell to Cell2 and SCell to Cell4

FIG. 4

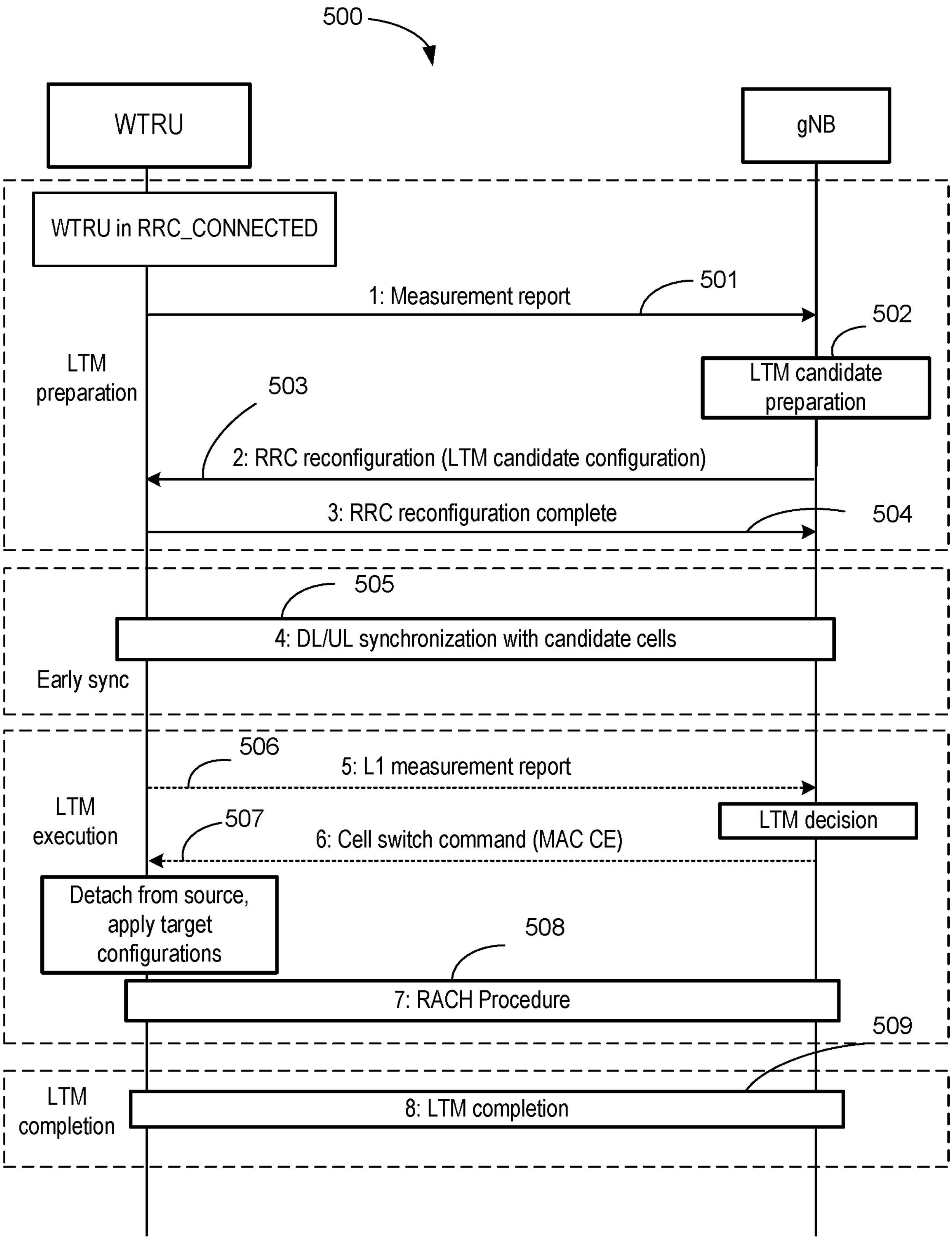
500
WTRU
gNB
WTRU in RRC_CONNECTED
LTM preparation
1: Measurement report
501
502
LTM candidate preparation
503
2: RRC reconfiguration (LTM candidate configuration)
3: RRC reconfiguration complete
504
505
4: DL/UL synchronization with candidate cells
Early sync
506
5: L1 measurement report
LTM execution
LTM decision
507
6: Cell switch command (MAC CE)
Detach from source, apply target configurations
508
7: RACH Procedure
509
LTM completion
8: LTM completion

FIG. 5

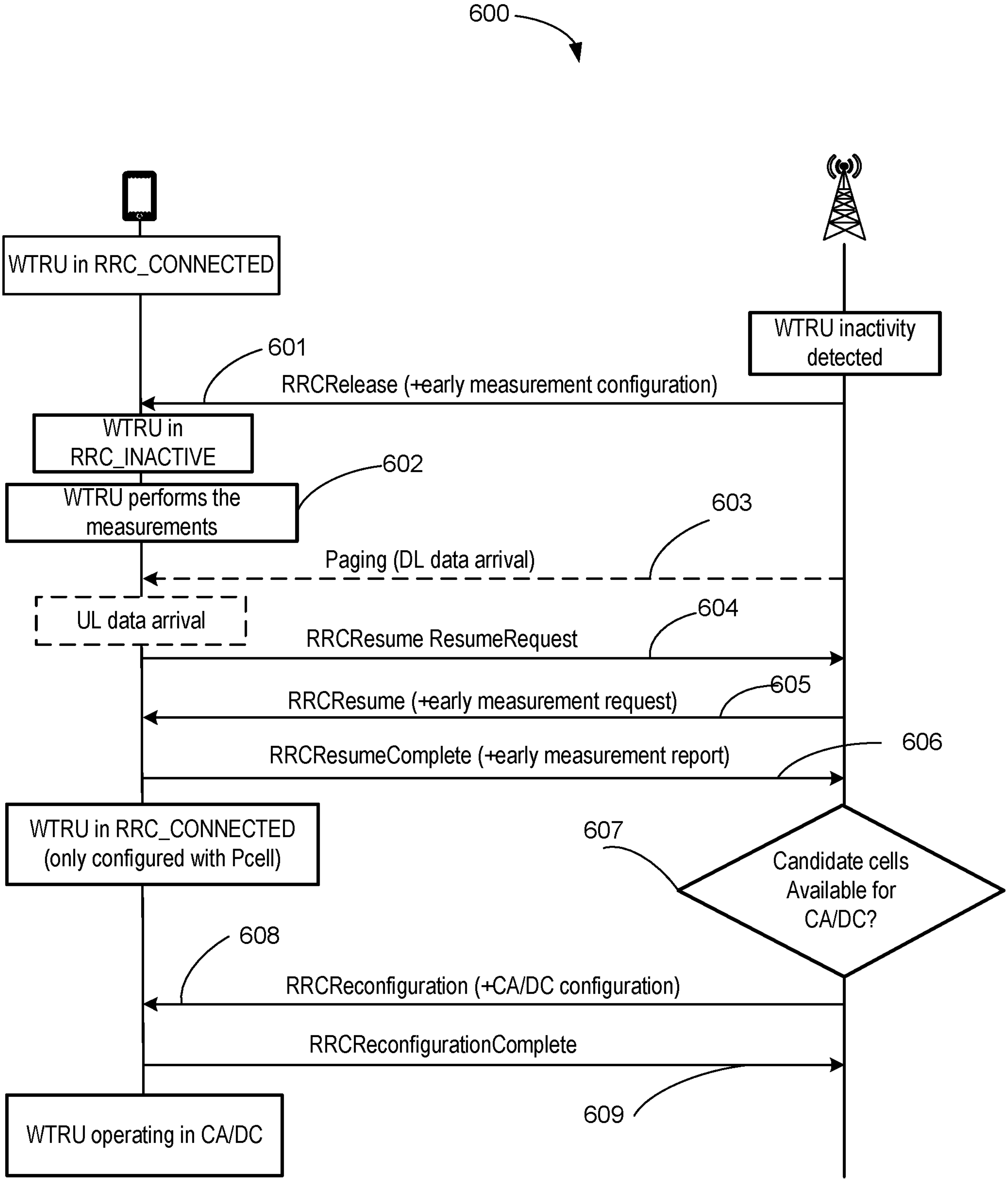
600
WTRU in RRC_CONNECTED
WTRU inactivity detected
601
RRCRelease (+early measurement configuration)
WTRU in RRC_INACTIVE
602
WTRU performs the measurements
603
Paging (DL data arrival)
UL data arrival
604
RRCResume ResumeRequest
605
RRCResume (+early measurement request)
606
RRCResumeComplete (+early measurement report)
WTRU in RRC_CONNECTED (only configured with Pcell)
607
Candidate cells Available for CA/DC?
608
RRCReconfiguration (+CA/DC configuration)
RRCReconfigurationComplete
609
WTRU operating in CA/DC

FIG. 6

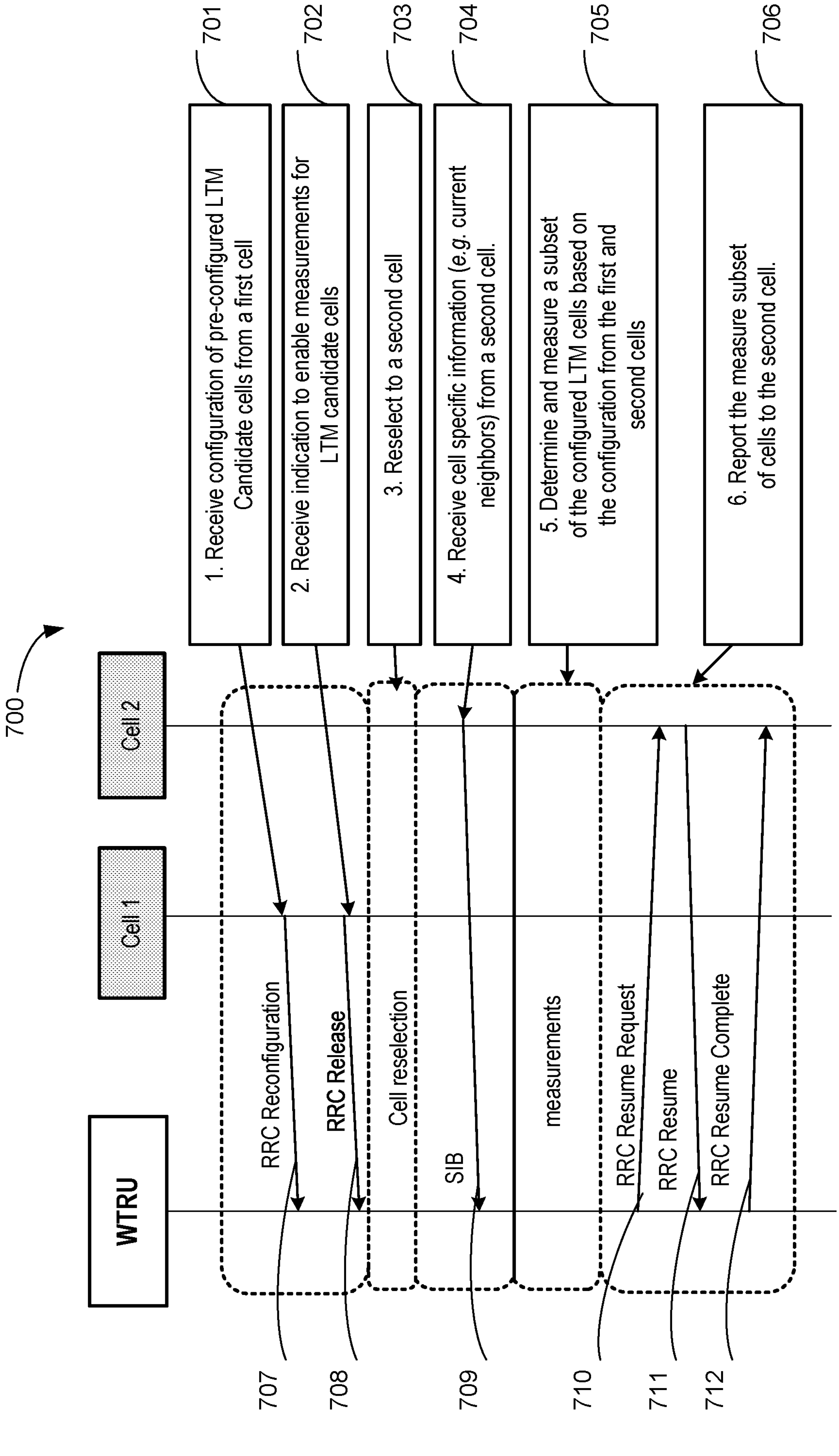
700
WTRU
Cell 1
Cell 2
1. Receive configuration of pre-configured LTM Candidate cells from a first cell
2. Receive indication to enable measurements for LTM candidate cells
3. Reselect to a second cell
4. Receive cell specific information (e.g. current neighbors) from a second cell.
5. Determine and measure a subset of the configured LTM cells based on the configuration from the first and second cells
6. Report the measure subset of cells to the second cell.
701
702
703
704
705
706
RRC Reconfiguration
RRC Release
Cell reselection
SIB
measurements
RRC Resume Request
RRC Resume
RRC Resume Complete
707
708
709
710
711
712

FIG. 7

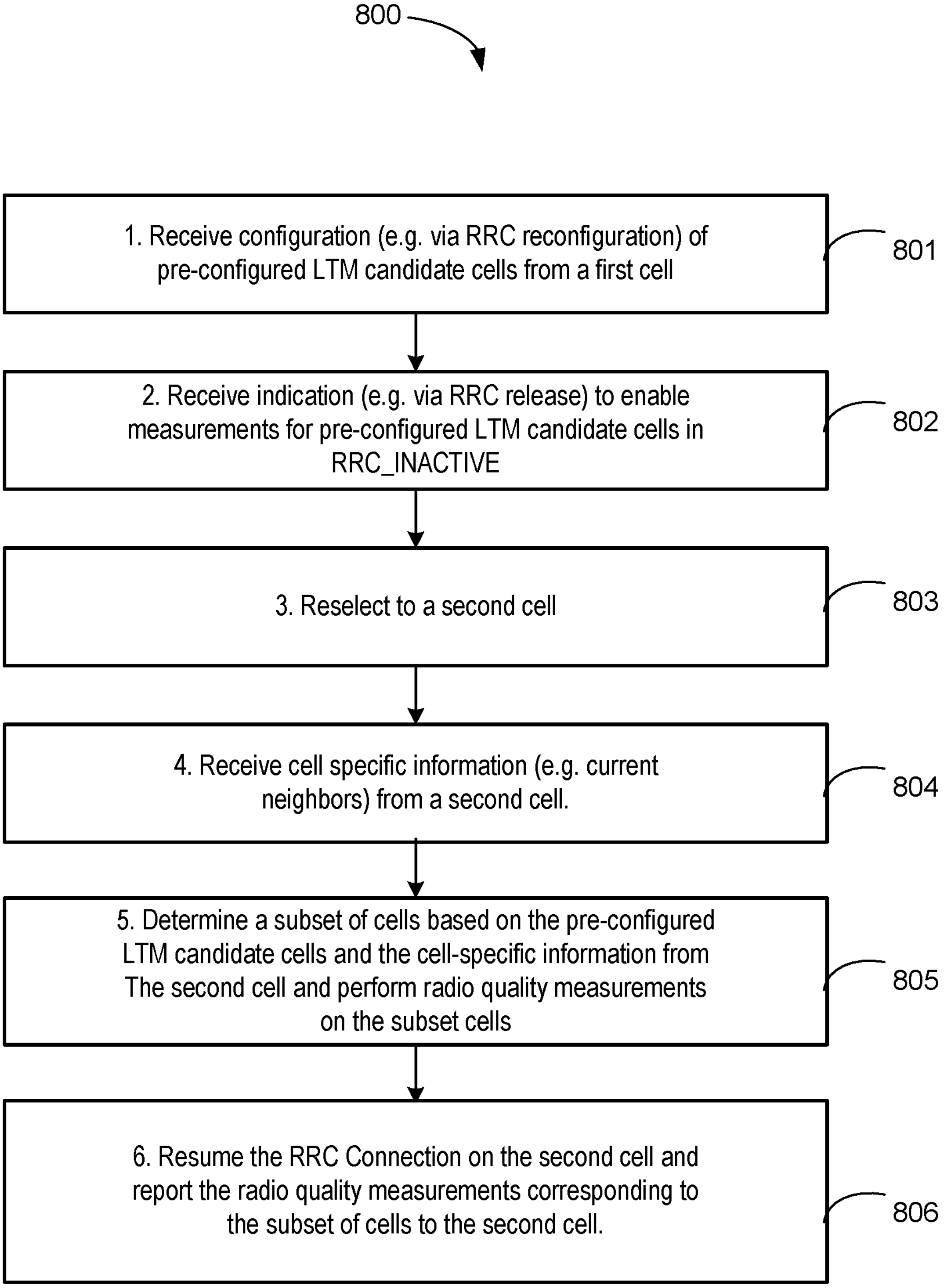
800
1. Receive configuration (e.g. via RRC reconfiguration) of pre-configured LTM candidate cells from a first cell
801
2. Receive indication (e.g. via RRC release) to enable measurements for pre-configured LTM candidate cells in RRC_INACTIVE
802
3. Reselect to a second cell
803
4. Receive cell specific information (e.g. current neighbors) from a second cell.
804
5. Determine a subset of cells based on the pre-configured LTM candidate cells and the cell-specific information from The second cell and perform radio quality measurements on the subset cells
805
6. Resume the RRC Connection on the second cell and report the radio quality measurements corresponding to the subset of cells to the second cell.
806

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/015294

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W48/16
ADD.

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

B. FIELDS SEARCHED

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2020/305038 A1 (TOOHER J PATRICK [CA] ET AL) 24 September 2020 (2020-09-24) paragraphs [0216] - [0229], [0062] - [0063], [0167] - [0169], [0263]; figure 13 -----	1-18

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

[x] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 June 2024	17/06/2024

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	Cremer, Jan

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/015294

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JUHA KORHONEN ET AL: "38.300 running CR for introduction of NR further mobility enhancements", 3GPP DRAFT; R2-2213292; TYPE DRAFTCR; NR_MOB_ENH2-CORE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. 3GPP RAN 2, no. Toulouse, FR; 20221114 - 20221118 17 November 2022 (2022-11-17), XP052228553, Retrieved from the Internet: URL:https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_120/Docs/R2-2213292.zip R2-2213292 38.300 Running CR for feMob_rev2.docx [retrieved on 2022-11-17] paragraph [9.2.3.x.2] -----	1-18
A	WO 2022/264106 A1 (ERICSSON TELEFON AB L M [SE]) 22 December 2022 (2022-12-22) paragraph [0200]; figure 7 -----	1-18

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International application No
PCT/US2024/015294

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			EP	4356683	A1	24-04-2024
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