

WTRU TRIGGERED CSI-RS SELECTION DURING HANDOVER**CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims the benefit of United States Provisional Application No. 63/535,030 filed on August 28, 2023, the entire contents of which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] A wireless transmit/receive unit (WTRU) measures one or more beams of a cell and the measurements results are averaged to derive the cell quality. In doing so, the WTRU is configured to consider a subset of the detected beams. Filtering takes place at two different levels: at the physical layer to derive beam quality and at the RRC level to derive cell quality from multiple beams. Cell quality from beam measurements is 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 the X best beams if the WTRU is configured to do so by the gNB.

SUMMARY

[0003] A wireless transmit/receive unit (WTRU) may be configured to perform a handover from a first cell to a second cell. The WTRU may receive configuration information from the first cell. The configuration information may include an association of a synchronization signal block (SSB) of the second cell with channel state information reference signals (CSI-RSs) of the second cell. The configuration information may include an indication of the uplink resources associated with the selected CSI-RS. The configuration information may include one or more configured grants associated with the SSB of the second cell.

[0004] The WTRU may initiate a handover to the second cell. The handover to the second cell may be initiated in response to receipt of a physical downlink control channel (PDCCH) order from the first cell. The WTRU may determine, based on the SSB, a subset of the CSI-RSs of the second cell that are associated with the SSB. The WTRU may determine to measure the subset of the CSI-RSs of the second cell based on one or more of a measurement (e.g., such as RSRP) of the SSB being greater than a first threshold associated with the SSB, the measurement of the SSB being greater than a second threshold associated with the SSB, or the handover being initiated. The WTRU may measure

a reference signal received power (RSRP) of the subset of the CSI-RSs of the second cell. The WTRU may transmit an indication of a selected CSI-RS of the subset of the CSI-RSs to the second cell. The indication of the selected CSI-RS may be sent using uplink resources associated with the SSB. The selected CSI-RS is a best CSI-RS of the subset of CSI-RSs. The WTRU may receive a scheduling grant from the second cell. The scheduling grant is based on the selected CSI-RS.

[0005] The WTRU may select the best CSI-RS based on the measured RSRP of the subset of the CSI-RSs of the second cell. The best CSI-RS may be selected autonomously by the processor. The best CSI-RS may be selected based on network instructions received based on RSRP measurements sent to the network. The WTRU may measure the SSB of the second cell. The WTRU may transmit a channel state information (CSI) report to the first cell. The CSI report may include measurements of the SSB.

BRIEF DESCRIPTION OF THE DRAWINGS

[0001] A more detailed understanding may be had from the detailed description below, given by way of example in conjunction with the drawings appended hereto. Figures in such drawings, like the detailed description, are exemplary. As such, the Figures and the detailed description are not to be considered limiting, and other equally effective examples are possible and likely. Furthermore, like reference numerals ("ref.") in the Figures ("FIGs.") indicate like elements, and wherein:

[0002] FIG. 1A is a system diagram illustrating an example communications system in which one or more disclosed embodiments may be implemented;

[0003] 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 according to an embodiment;

[0004] 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 according to an embodiment;

[0005] 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 according to an embodiment;

[0006] FIG. 2 is a block diagram illustrating an example measurement model;

[0007] FIG. 3 is an example L1/L2 triggered mobility (LTM) using carrier aggregation (CA) according to an embodiment;

[0008] FIG. 4 is an example signal diagram of an LTM baseline procedure according to an embodiment;

[0009] FIG. 5 is an example depiction of a beam refinement;

[0010] FIG. 6 is an example procedure of a first solution according to an embodiment;

[0011] FIG. 7 is a first example signal diagram of a beam refinement performed during LTM execution according to an embodiment;

[0012] FIG. 8 is an example procedure of a second solution according to an embodiment;

[0013] FIG. 9 is a second example signal diagram of a beam refinement performed during LTM execution according to an embodiment;

[0014] FIG. 10 is an example procedure of a third solution according to an embodiment;

[0015] FIG. 11 is an example signal diagram showing a fallback to RACH based LTM execution according to an embodiment;

[0016] FIG. 12 is an example signal diagram showing fallback from beam refinement during LTM preparation to beam refinement during LTM execution.

DETAILED DESCRIPTION

[0017] In the following detailed description, numerous specific details are set forth to provide a thorough understanding of embodiments and/or examples disclosed herein. However, it will be understood that such embodiments and examples may be practiced without some or all of the specific details set forth herein. In other instances, well-known methods, procedures, components, and circuits have not been described in detail, so as not to obscure the following description. Further, embodiments and examples not specifically described herein may be practiced in lieu of, or in combination with, the embodiments and other examples described, disclosed, or otherwise provided explicitly, implicitly and/or inherently (collectively "provided") herein.

[0018] 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.

[0019] 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 UE.

[0020] 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.

[0021] 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, i.e., 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.

[0022] 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).

[0023] 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 116 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 Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0024] 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).

[0025] 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).

[0026] 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).

[0027] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.11 (i.e., Wireless Fidelity (WiFi)), IEEE 802.16 (i.e.,

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.

[0028] 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.

[0029] 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.

[0030] 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.

[0031] 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.

[0032] 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.

[0033] 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.

[0034] 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.

[0035] 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.

[0036] 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.

[0037] 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).

[0038] 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.

[0039] 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.

[0040] 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.

[0041] 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 uplink (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 WTRU 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 uplink (e.g., for transmission) or the downlink (e.g., for reception)).

[0042] 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.

[0043] 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.

[0044] 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 uplink (UL) and/or downlink (DL), and the like. As shown in FIG. 1C, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0045] 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.

[0046] 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.

[0047] 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.

[0048] 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.

[0049] 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.

[0050] 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.

[0051] In representative embodiments, the other network 112 may be a WLAN.

[0052] 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, where 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.

[0053] 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 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.

[0054] 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.

[0055] 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).

[0056] 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).

[0057] 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.

[0058] 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.

[0059] 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.

[0060] 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, 180b 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).

[0061] 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).

[0062] 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.

[0063] 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 uplink (UL) and/or downlink (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.

[0064] 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.

[0065] 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 182a, 182b 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.

[0066] 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 UE 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.

[0067] 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.

[0068] 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.

[0069] In view of Figs. 1A-1D, and the corresponding description of Figs. 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-b, 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.

[0070] 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 performing testing using over-the-air wireless communications.

[0071] 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.

[0072] Examples provided herein do not limit applicability of the subject matter to other wireless technologies, e.g., using the same or different principles as may be applicable.

[0073] As explained herein, a wireless transmit/receive unit (WTRU) may be an example of a user equipment (UE). Hence the terms UE and WTRU may be used with equal scope herein.

[0074] In RRC_CONNECTED, the WTRU measures multiple beams (e.g., at least one) of a cell and the measurements results (power values) are averaged to derive the cell quality. In doing so, the WTRU is configured to consider a subset of the detected beams. Filtering takes place at two different levels: at the physical layer to derive beam quality and then at RRC level to derive cell quality from multiple beams. Cell quality from beam measurements is derived in the same way for the serving cell(s) and for the non-serving cell(s). Measurement reports may include the measurement results of the X best beams if the WTRU is configured to do so by the gNB.

[0075] FIG. 2 depicts an example high-level measurement model 200.

[0076] Inter-cell beam management may be used to manage the beams in the carrier aggregation (CA) case, but no cell change/add is supported.

[0077] Mechanisms and procedures of L1/L2 based inter-cell mobility for mobility latency reduction may include: (a) Configuration and maintenance for multiple candidate cells to allow fast application of configurations for candidate cells [RAN2, RAN3]. (b) Dynamic switch mechanism among candidate serving cells (including Special Cell (SpCell) and Secondary Cell (SCell)) for the potential applicable scenarios based on L1/L2 signalling [RAN2, RAN1]. (c) L1 enhancements for inter-cell beam management, including L1 measurement and reporting, and beam indication [RAN1, RAN2]. Note 1: Early RAN2 involvement is necessary, including the possibility of further clarifying the interaction between (b) and (c). (d) Timing Advance management [RAN1, RAN2]. (e) CU-DU interface signaling to support L1/L2 mobility, if needed [RAN3].

[0078] FR2 specific enhancements are not precluded, if any. The procedure of L1/L2 based inter-cell mobility are applicable to the following scenarios: (a) Standalone, CA and NR-DC case with serving cell change within one CG. (b) Intra-Distributed Unit (Intra-DU) case and Intra-Distributed Unit (intra-

CU) inter-DU case (applicable for Standalone and CA: no new RAN interfaces are expected). (c) Both intra-frequency and inter-frequency. (d) Both FR1 and FR2. (e) Source and target cells may be synchronized or non-synchronized. (f) Inter-CU case is not included.

[0079] L1/L2 based mobility was originally started in R17 and inter-cell beam management in R17 addresses intra-DU and intra-frequency scenarios. In this case the serving cell remains unchanged (i.e. there is no possibility to change the serving cell using L1/2 based mobility). In FR2 deployments, CA is typically used in order to exploit the available bandwidth, e.g. to aggregate multiple CCs in one band. These CCs are typically transmitted with the same analog beam pair (gNB beam and WTRU beam). The WTRU is configured with TCI states (can have fairly large number, e.g. 64) for reception of physical downlink Control channel (PDCCH) and physical downlink shared channel (PDSCH). Each TCI state includes a reference signal (RS) or synchronization signal block (SSB) that the WTRU refers to for setting its beam. For R17, the SSB can be associated with a non-serving PCI. MAC signaling ("TCI state indication for WTRU-specific PDCCH MAC CE") activates the TCI state for a Coreset/PDCCH. Reception of PDCCH from a non-serving cell is supported by MAC CE indicating a TCI state associated to non-serving PCI. MAC signaling ("TCI States Activation/Deactivation for WTRU-specific PDSCH") activates a subset of (up to) 8 TCI states for PDSCH reception. DCI indicates which of the 8 TCI states. R17 also supports "unified TCI state" with a different updating mechanism (DCI-based), but without multi-TRP. R18 will support unified TCI state with multi-TRP.

[0080] The overall objective of LTM is to improve handover latency; with a conventional L3 handover or conditional the WTRU will typically first send a measurement report using RRC signalling. In response to this 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 signalling that the cell meets a configured radio quality criteria. With conditional handover, in order to reduce the handover failure rate due to the delay in sending a measurement report then receiving an RRC reconfiguration the network provides, in advance, a target cell configuration as well as a measurement criteria which determines when the WTRU should trigger the CHO configuration. Both of these L3 methods, however, do suffer from some amount of delay due to the sending of measurement reports and receiving of target configurations, particularly in case of the conventional (non-conditional) handover.

[0081] In particular, the aim of LTM is to allow a fast application of configurations for candidate cells, including dynamically switching between SCells and switching of the primary cell (PCell) (e.g. switch the roles between SCell and PCell) without performing RRC signalling. The inter-CU case is not

included, as this requires relocation of the PDCP anchor and has already been excluded from the work item. Therefore, an RRC based approach is needed at least to support inter-CU handover.

[0082] Furthermore, with the legacy L3 handover mechanisms, any currently active SCell(s) are released before the WTRU moves completes the handover to a target cell in the coverage area of a new site, and can only be added back after successful handover, which leads to throughput degradation during handover. One of the aims of L1/2 is therefore to enable CA operation to be enabled instantaneously upon serving cell change.

[0083] FIG. 3 shows an example of LTM operation 300, whereby the candidate cell group is configured by RRC and a dynamic switch of PCell and SCell is achieved using L1/2 signalling.

[0084] FIG. 4 depicts an example LTM baseline procedure 400. The procedure 400 for LTM is as follows. At FIG. 4, step 1, The WTRU sends a Measurement Report message to the gNB. The gNB decides to use LTM and initiates LTM candidate preparation. At FIG. 4 step 2, The gNB transmits an RRCReconfiguration message to the WTRU including the configuration of one or multiple LTM candidate target cells. At step 3, The WTRU stores the configuration of LTM candidate target cell(s) and transmits a RRCReconfigurationComplete message to the gNB. At step 4, The WTRU may perform DL synchronization and TA acquisition with candidate target cell(s) before receiving the LTM cell switch command. Here, DL synchronization for candidate cell(s) before cell switch command is supported, at least based on SSB. FFS necessary mechanism. Also, TA acquisition of candidate cell(s) before LTM cell switch command is supported, at least based on PDCCH ordered RACH, where the PDCCH order is triggered (e.g., only triggered) by source cell. FFS detailed mechanism. At step 5, The WTRU performs L1 measurements on the configured LTM candidate target cell(s), and transmits lower-layer measurement reports to the gNB. Here, FFS whether the lower-layer measurement reports are carried on L1 or MAC. At step 6, The gNB decides to execute LTM cell switch to a target cell, and transmits a 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. Here, FFS how beam indication is done. At step 7, The WTRU performs random access procedure towards the target cell, if TA is not available. At step 8, The WTRU indicates successful completion of the LTM cell switch towards target cell. Here, FFS whether a uplink signal or message after the WTRU has switched to the target cell is used to indicate successful completion of the LTM cell switch.

[0085] The WTRU may perform early TA acquisition with candidate cell(s) before receiving the cell switch command. This is done via contention-free random access (CFRA) triggered by a PDCCH order from the source cell, following which the WTRU sends preamble towards a candidate cell. The information that identifies the allocated CFRA resource can be indicated in the PDCCH order to enable

shared preamble resource among multiple WTRUs in the RRC configuration - the source gNB dynamically indicates which WTRU uses the resource at any specific time. In order to minimize the data interruption of the source cell due to CFRA towards the candidate cell(s), the WTRU doesn't receive random access response (RAR) at all. Source cell may trigger a preamble retransmission/power ramping using another PDCCH order, e.g. if the preamble was not received. If the timing advance (TA) value of the candidate cell is indicated in the cell switch command then the WTRU performs a RACH-less handover.

[0086] The L1/2 triggered mobility (LTM) procedure being standardised in R18 improves mobility latency, by preconfiguring multiple target cells prior to handover, early DL/UL sync of target cells, L1 measurement reports, MAC CE to indicate cell switch.

[0087] Conditional LTM may improve robustness. There are different possible options/enhancements: (a) L1 based condition for triggering the HO. (b) LTM candidate cell configurations applied upon trigger. (c) RACH-less CHO. (d) Beam refinement ahead of CHO.

[0088] CSI-RS measurements may be provided for LTM preparation. A configured grant may be used for RACH-less LTM, for the first UL data transmission to the target cell, the WTRU selects the configured grant occasion, which is associated with the beam indicated in the LTM MAC CE (as set by source cell). FFS further optimization is possible.

[0089] Herein, the phrase "perform LTM" or "perform LTM" procedures refers to performing any/all of the steps described in FIG. 4. Specifically, 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, switching (e.g., performing handover) between candidate cells (e.g., "Perform LTM" herein may mean that the WTRU moves/switches between multiple candidate cells during the procedure).

[0090] The one or more candidate cell sets may be groups of more than one RRC configuration corresponding to a handover configuration for one or more candidate SpCells and optionally SCells. This may be modelled or received as one or more complete RRC Reconfiguration messages, one or more cell group configurations, or one or more cell configurations. Each of the candidate cell configurations may include a candidate configuration identifier, and 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 or candidate configuration indexes which are used in L1 and MAC signalling to refer to specific indexes (for example a MAC CE triggering the reconfiguration may include a candidate configuration index informing the WTRU which cell to perform the reconfiguration to).

[0091] 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 - what this means is that the candidate cell set may be considered as a single group in terms of an RRC configuration list or group, while the cells selected for performing early sync, L1 measurements, and LTM execution depend on a further grouping into multiple subsets of the overall candidate cell list. In other words the grouping itself may not be modelled at RRC using candidate configuration identifiers, but the grouping is executed as part of the early sync or the LTM execution procedure.

[0092] Throughout this disclosure, when referring to an LTM candidate configuration, this may apply to any type of preconfigured cell information. For example, a WTRU may be configured with one or more conditional reconfigurations such as conditional handover (CHO), conditional primary SCG cell (PSCell) addition (CPA) or conditional PSCell change (CPC) which are valid before and/or after a cell change, or valid in certain cells.

[0093] An L1 measurement herein may include a measurement of Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), Received Signal Strength Indicator (RSSI), etc, performed by a WTRU of a cell, beam, set of cells, or set of beams. Such L1 measurement may be similar to L3 measurements reported in radio resource management (RRM), with differences in the filtering, reference signals measured, reporting mechanisms, etc.

[0094] Herein, measurements refers to L1 measurements for LTM. However, certain solutions herein may apply also to RRM/L3 measurements, as well as other measurements (e.g., measurements of speed, location, height, traffic, etc).

[0095] Herein, the LTM cell switch refers to L1/2 triggered mobility whereby a preconfigured RRC configuration is applied when the WTRU receives an indication using MAC CE or when a certain condition is met at the WTRU. However, certain solutions may also apply to an RRC reconfiguration, an RRC conditional reconfiguration, as well as any other type of mobility procedure.

[0096] The solutions provide improved robustness with reduced interruption and latency, WTRU with a valid TA acquired before cell change criteria is met can immediately trigger the RACH-less LTM handover when the criteria is met, without the delay associated with reporting measurements and receiving an explicit cell switch command. For some options the network can prepare multiple cells with a TA value for RACH-less, WTRU triggers cell switch to the best one based on evaluation, without reporting/receiving explicit trigger.

[0097] The gNB (e.g. a CU in case of CU/DU split architecture - note: RRC resides in CU) configures potential LTM candidates using RRC signalling. In one solution the WTRU receives the LTM

candidate configurations using an RRC Reconfiguration message, for example during the "LTM preparation" phase shown in FIG. 4. The WTRU may store the LTM candidate configurations to later apply upon receiving an indication using L1/2 signalling (e.g., MAC CE) to perform a cell switch, for example in the "LTM execution" phase shown in FIG. 4.

[0098] In one solution, the configuration of potential LTM candidates may include candidate sets -> for example a first set which may e.g. be suitable for a first path (for example, a WTRU turns left and takes first road) and a second set which may e.g. be suitable for a second path (e.g. WTRU turns right and takes second road)

[0099] In one solution, some or all of the candidate set information is broadcast in system information, and the WTRU enables the pre-configuration of these broadcast configurations upon receiving an indication in dedicated signalling (E.g. RRC Reconfiguration) which refers to the broadcast one or more configurations (E.g. using an index or identifier)

[00100] In one solution, the configuration may include all or a subset of the potential cells in a specific area (for example all cells belonging to the CU with which the WTRU is currently connected or cells within a particular geographical area). These cells may not yet have been detected or measured by the WTRU, but are configured in advance. In one solution, after the initial configuration of LTM candidate configurations, the WTRU may receive an update to the configuration to modify, add, remove, or replace any part of the LTM candidate configurations.

[00101] In one solution, the WTRU may receive an indication to enable or disable some or all of the LTM configurations. For example, if it is predicted that the WTRU mobility would be better handled using L3 (e.g. RRC measurement report, RRC reconfiguration, conditional reconfiguration) then LTM may be disabled, and on the other hand if it is predicted that LTM would better suit the WTRU mobility then LTM may be enabled (e.g. a previously configured and disabled LTM configuration may be re-enabled).

[00102] The configuration may in one solution be based on a prediction model internal to, and determined by, the network (e.g. gNB). This prediction may, for example, be based on what it (the NW prediction model) determines to be the WTRUs most likely paths.

[00103] In some solutions, the candidate cell configurations include all or part of the information necessary to complete a reconfiguration (e.g. handover) to the candidate cell, such as channel configurations (e.g. PRACH, DPCCH, DPSCH), CORESET, BWP, security parameters, L2 parameters (E.g. MAC, RLC, PDCP), radio bearer configurations, and so on.

[00104] LTM execution trigger herein refers to a condition for performing LTM (e.g. a conditional handover trigger or measurement report trigger), which is either configured or indicated by the network to the WTRU, or estimated/determined by the WTRU.

[00105] A trigger may be based on any of the following: (a) Time, e.g. Absolute or relative time measured time at WTRU, SFN, Subframe number. (b) Radio quality measurement or predicted radio quality one or more of the serving cells or target cells, E.g.: RSRP (beam or cell), Reference Signal Received Quality (RSRQ) (beam or cell), cri-RI-PMI-CQI, cri-RI-i1, cri-RI-i1-CQI, cri-RI-CQI, cri-RSRP, ssb-Index-RSRP, cri-RI-LI-PMI-CQI. (c) Position, E.g. an area (e.g. defined by reference point and radius) or range of co-ordinates, a distance threshold from a reference location. (d) Any L3 measurement event, for example : Event A1 (Serving becomes better than threshold), Event A2 (Serving becomes worse than threshold), Event A3 (Neighbor becomes offset better than SpCell), Event A4 (Neighbor becomes better than threshold), Event A5 (SpCell becomes worse than threshold1 and neighbor becomes better than threshold2), Event A6 (Neighbour becomes offset better than SCell), Event B1 (Inter RAT neighbour becomes better than threshold), Event B2 (PCell becomes worse than threshold1 and inter RAT neighbor becomes better than threshold2). (e) Any L1 measurement event or condition, for example any event defined which utilizes L1 beam measurements to evaluate whether a criteria or condition is met. (f) Any predicted event, for example using any of the measurement quantities previously listed under "Measured or predicted CSI information" (g) An explicit indication from the network. For example, the WTRU may enable CSI reporting based on an explicit indication (e.g. a MAC CE) received from the network, then execute LTM cell switch upon receiving a second MAC CE from the network. (h) A measured, predicted, or estimated throughput, error rate, buffer status, or QoS parameter. (i) An evaluation metric, for example a time-to-trigger, a hysteresis, offset (e.g. a radio quality measurement offset), a measurement filtering configuration.

[00106] The trigger may include one or more conditions under which the WTRU is allowed to any action related to LTM. For example, the WTRU may perform one or more of the following procedures. (a) Early TA acquisition. WTRU may trigger a RACH to a target LTM cell. WTRU may receive a TA value in a RAR. RAR may come from target cell, or via source cell. WTRU may receive a TA value in a MAC CE triggering the cell switch. WTRU may perform power ramping and preamble retransmission on the target if a RAR / MAC CE is not received. (b) Switching off CSI reporting. The WTRU may be allowed to, or required to, switch off CSI reporting in order to reduce reporting overhead in the uplink. The CSI reporting may be reduced rather than switched off. For example, reduced number of cells or beams reporting, or a reduced frequency of reporting. The WTRU may resume CSI reporting when the condition is no longer met. (c) Switching on or updating the CSI reporting configuration. For example,

the WTRU may be required to perform and report CSI measurements on one or a subset of LTM candidate cells during the window. (d) Performing LTM cell switch. Conditions or criteria under which the WTRU is allowed to trigger LTM cell switch. (e) Monitoring PDCCH on a target cell. The WTRU may be configured to monitor on a target cell for a DCI scheduling PDSCH or indicating one or more actions on the target cell, for example to initiate the cell switch procedure. (f) Performing BFR or RLM on a target cell. The WTRU may be configured to monitor BFD (beam failure detection) resources on a target cell, or perform RLM (radio link monitoring) on a target cell during the window. (g) Activating or deactivating certain SCells. The WTRU may be configured with one or more specific SCells which should be active or not active during the window.

[00107] In one solution an explicit or conditional LTM indication includes one or more of an SSB, or a subset (E.g. a smaller set of CSI-RS than the subset measured and reported) such that the WTRU performs a beam refinement step upon LTM execution.

[00108] To enable RACH-less conditional handover, whereby the WTRU is not required to send a random access preamble or perform a random access procedure on the target cell following a reconfiguration trigger but rather the WTRU performs PDCCH reception and uplink transmission using the TA already provided, the WTRU may perform an early TA acquisition procedure with candidate cell(s) before receiving the cell switch command or before triggering a conditional reconfiguration.

[00109] In one solution, an early TA acquisition may be performed using contention-free random access (CFRA) triggered by a PDCCH order from the source cell, following which the WTRU may send a preamble towards a candidate cell. The information that identifies the allocated CFRA resource may be indicated in the PDCCH order to enable shared preamble resource among multiple WTRUs in the RRC configuration - the source gNB dynamically indicates which WTRU uses the resource at any specific time.

[00110] In one solution, this may be performed upon receiving a MAC CE indicating to perform a RACH transmission on a target cell.

[00111] In one solution, this may be performed by transmitting using a contention-based random access (CBRA) preamble.

[00112] In one solution, and in order to minimize the data interruption of the source cell due to CFRA towards the candidate cell(s), the WTRU doesn't receive RAR at all. Source cell may trigger a preamble retransmission/power ramping using another PDCCH order, e.g. if the preamble was not received. In this case, the TA may be provided from the target cell to the source cell, and provided to the WTRU in a MAC CE triggering cell switch or enabling conditional LTM to one or more target cells.

[00113] In one solution, the WTRU may receive a TA value from the target cell in a random access response (RAR). In one solution, the WTRU may receive a TA value from the source cell in a random access response (RAR). If the WTRU does not receive a RAR in response to transmitting the preamble (e.g. within a prescribed time), the WTRU may retransmit a preamble using a higher transmission power.

[00114] In one solution, the WTRU may store the received TA value to be used later when a reconfigure trigger occurs. The WTRU may store the TA value for a limited period of time (E.g. a validity timer) and may trigger or be triggered to perform a new TA acquisition procedure when the time expires.

[00115] In one solution, the WTRU may receive and/or stored multiple TA values associated with more than one cell.

[00116] If the WTRU has stored a valid TA value of a candidate cell when a cell switch is triggered towards that candidate cell (either triggered by the NW using an explicit cell switch command, or triggered by the WTRU upon meeting a trigger condition), then the WTRU performs a RACH-less handover. For example, the WTRU may execute LTM (e.g. apply a pre-configured RRC configuration to a new SpCell) upon determining that a measured radio quality of the target cell is above a threshold.

[00117] FIG. 5 is a diagram that illustrates the general concept of beam refinement 500 in NR. A WTRU 502 may measure SSBs 506A, 506B, 506C before/during initial access and indicates (E.g. by selecting a random access resource corresponding to the best measured SSB) to the gNB 504. For example, the WTRU 502 may measure a first SSB 506A (e.g., SSB 1), a second SSB 506B (e.g., SSB 2), and a third SSB 506C (e.g., SSB 3) before/during initial access. The beam may be further refined once the WTRU 502 is in RRC_CONNECTED by configuring the WTRU 502 to measure a set of CSI-RS 508A, 508B, 508C, 508D, 508E and reporting the measurements (E.g. the best CSI-RS index / CRI index or indicating the RSRP). An SSB resource (e.g., such as SSBs 506A, 506B, 506C) may be transmitted by the gNB 504 using a wider beam, and multiple CSI-RS resources (e.g., such as CSI-RSs 508A, 508B, 508C, 508D, 508E) may be transmitted using a narrower beam. Hence the beam may be refined using a wider SSB beam first, then selecting one of the multiple narrower CSI-RS beams afterwards.

[00118] Aspects of the present disclosure describe beam refinement on a target cell before or during a handover and before the WTRU accesses the target cell, such that a WTRU first performs measurement of SSB resources, then selects a subset of CSI-RS resources to measure based on the SSB measurements (E.g. based on the best SSB measured). Then the WTRU performs measurements on the selected subset of CSI-RS resource and determines a best CSI-RS resource. The selected best

CSI-RS resource can be indicated before a handover takes place (e.g., to a source cell), or upon initial access (e.g., to a target cell), rather than performing the beam refinement (e.g., beam refinement only) after a connection to a target cell is completed.

[00119] In one solution, the WTRU reports the measurements of the subset of CSI-RS resources using CSI reporting on physical uplink control channel (PUCCH) to the source cell. The report may alternatively be transmitted using a MAC CE or an RRC measurement report, or any other type of uplink signaling. The report may include one or more of: RSRP (beam or cell), RSRQ (beam or cell), cri-RI-PMI-CQI, cri-RI-i1, cri-RI-i1-CQI, cri-RI-CQI, cri-RSRP, ssb-Index-RSRP, and/or cri-RI-LI-PMI-CQI.

[00120] In one solution the WTRU determines, based on a trigger (For example any trigger listed in this section) a subset of CSI-RS to measure. For example, the WTRU may determine based on a pre-configured association (E.g. configured by RRC) between SSB and CSI-RS resources. The WTRU may determine based on an indication of an SSB or determining a best SSB from performed SSB measurements.

[00121] The subset of CSI-RS may be indicated explicitly in a random access response (E.g. using a pointer to one of multiple subsets) or may be indicated implicitly (E.g. the WTRU enables a subset of CSI-RS depending on a reported or indicated SSB when the RAR is received). In one solution, the WTRU alternatively enables the subset of CSI-RS measurements when the WTRU receives a PDCCH order triggering early TA acquisition, while the RAR or MAC CE including a TA in response to the PRACH preamble transmission for TA acquisition activates the configured grant.

[00122] The CSI-RS measurements may be configured temporarily. For example, the WTRU may activate CSI-RS measurements for a certain time period, or a certain number of reports, which may be configured or predefined. The WTRU may deactivate CSI-RS measurements, for example, when a best SSB changes, or when an SSB or CSI-RS measurement goes below a threshold.

[00123] The WTRU may receive an indication to activate a grant from either a source or a target cell this may be E.g. a type 2 configured grant, whereby the first cell configures the grant and the second cell activates the grant, an explicit grant (a direct indication of the grant to use), a pointer to one or more preconfigured grants (e.g. previously configured by RRC)

[00124] An indication of the grant may be a pointer to a configured grant corresponding to a reported SSB, or may be a set of configured grants corresponding to multiple CSI-RS associated with a reported SSB.

[00125] The configured grant activation may be received in a PDCCH order (E.g. triggering TA acquisition), in a MAC CE (e.g. triggering LTM), or in a RAR (e.g. received from the source or the target, including a TA value to use for RACH-less handover).

[00126] The WTRU may autonomously activate a configured grant based on a condition. For example, any of the LTM execution triggers listed in this section.

[00127] A summary of a first solution featuring WTRU triggering of a CSI-RS selection and reporting to a target includes a Source that pre-configures the configured grant, CSI-RS-SSB association. The WTRU selects SSB (coarse beam), then, the WTRU triggers CSI-RS measurement, and selects best CSI-RS during HO execution. The WTRU indicates best CSI-RS beam to the target. Note that the first solution is Applicable to L3 HO, CHO, LTM.

[00128] A WTRU may receive a configuration of SSB vs. CSI-RS association for a second cell (target) from a first cell (source).

[00129] The WTRU may select and/or receive an indication of the second cell (target) SSB and may initiate a reconfiguration (handover) to the second cell. E.g. CHO case or L3 target cell indication, the WTRU may select the target SSB during execution. E.g. LTM case the WTRU may receive the target SSB indication in MAC CE. The target SSB indication may include a TA for RACHless. The target SSB indication may include an indication enabling beam refinement or type (e.g., option A/B - explicit/implicit). The target SSB indication may enable the CG in the MAC CE or DCI from source. The target SSB indication may activate CG and/or CSI-RS, etc using DCI then MAC CE to enable CHO.

[00130] The WTRU may determine and select the CSI-RS resource subset based on the selected SSB.

[00131] The WTRU may perform measurement of the selected CSI-RS subset. The WTRU may apply filtering to CSI-RS measurement. The WTRU may trigger the CSI-RS measurement based on a first threshold of SSB (e.g., a higher threshold of SSB RSRP). The WTRU may execute the conditional LTM itself based on a second threshold of SSB or CSI-RS RSRP. The WTRU may trigger the CSI-RS measurement after cell switching (e.g., change cell, measure).

[00132] In a first example (e.g., option A) the WTRU may transmit an indication of the best CSI-RS (e.g., +or indication of RSRP for CSI-RS associated with this SSB) to the second cell (target) using the UL resources (CG) associated with the best SSB. e.g. using a small indication, MAC CE, PUCCH, small data on PUSCH. In a second example (e.g., option B) the WTRU may transmit the indication of the best CSI-RS to the second cell using the UL resources (CG) associated with the best CSI-RS.

[00133] The WTRU receives a scheduling grant based on the indicated CSI-RS.

[00134] FIG. 6 is a flowchart depicting an example WTRU triggering 600 of CSI-RS selection and reporting.

[00135] At 602, A WTRU may receive a configuration from a first cell (E.g. a current or source cell) which associates one or more SSB resources of a second cell (E.g. a candidate or target cell) with one or more CSI-RS resources of the second cell. For example, as shown in FIG. 5 the SSB with ID 2 (SSB2) may be associated with CSI-RS with IDs 6,7,8,9,10. SSB2 being the wider beam and CSI-RS 6-10 being narrower beams spanning the width of SSB2. The association may be through defining a QCL source; for example, the QCL source of a CSI-RS may be a SSB and/or another CSI-RS.

[00136] In examples, the WTRU may receive configuration from a first cell which associates one or more CSI-RS resources of a second cell with one or more CSI-RS resources of the second cell. The methods disclosed herein may be applicable similarly when the WTRU selects a CSI-RS or receives an indication of a CSI-RS (e.g., instead of a SSB) and initiates a reconfiguration.

[00137] At 604, the WTRU may select an SSB and/or receive an indication and initiate the reconfiguration to this second cell.

[00138] The reconfiguration trigger may, in examples, be received from a second (e.g., source) cell towards a third (e.g., target) cell, which are either the same or different cells compared to the first cell on which the configuration was initially received.

[00139] In examples, the WTRU may select the SSB based on a condition, for example the SSB with the strongest measured radio quality on one or more candidate cells, using a conditional reconfiguration trigger, e.g., using any of the triggers described in discussed in the section entitled Common Solution Components above).

[00140] In examples, the WTRU may receive an explicit indication, for example a MAC CE with an indication of a target candidate configuration and an indication of an SSB.

[00141] The indication may include a TA value enabling RACH-less handover, or RACH-less conditional handover.

[00142] The indication may include an indication of a configured grant to use on the target cell. In examples, the WTRU may receive an activation command in the MAC CE, or in a DCI (e.g. PDCCH order to perform early TA acquisition) to activate one or more of the CSI-RS subset measurements or the configured grant on the target.

[00143] The indication may include a type of indication to use for reporting a best CSI-RS to the target. For example, the indication may enable selection between an explicit reporting method and an implicit reporting method.

[00144] Separate indications may be received to perform any of the above actions. For example, a DCI (e.g., PDCCH order) may activate CSI-RS measurements, while a MAC CE may enable a conditional handover evaluation.

[00145] At 606, the WTRU may determine, based on the selected or indicated SSB, a subset of CSI-RS. For example, if the WTRU has selected SSB 2 then CSI-RS 5-10 may be selected as a subset of CSI-RS.

[00146] At 608, the WTRU may measure the selected CSI-RS subset on the target cell.

[00147] The WTRU may measure for a configured or predefined period of time. The WTRU may filter a certain number of samples using a configured or predefined filter. The WTRU may first execute a reconfiguration then start measurements, or the WTRU may perform measurements before executing the reconfiguration. The actions in 606, 608, 610 may occur in any order.

[00148] In examples, the WTRU may trigger CSI-RS measurements based on a first condition (E.g. a first RSRP threshold based on SSB measurement, or any of the triggers in discussed in the section entitled Common Solution Components above) and then may trigger a reconfiguration based on a second condition (e.g. a second SSB RSRP measurement threshold or any of the triggers in discussed in the section entitled Common Solution Components above)).

[00149] The CSI-RS measurements may be used to estimate channel quality for the target cell where the channel quality may include RI, MCS, PMI, etc.

[00150] At 610, the WTRU may execute the reconfiguration (E.g. LTM cell switch or conditional reconfiguration) if this has not been done earlier. The WTRU may transmit an indication of the best CSI-RS (e.g., CRI), or an indication of the beam measurement value for one or more of the selected subset of CSI-RS to the second cell. The WTRU may transmit the associated CQI. The contents of the CSI report may have been configured.

[00151] The WTRU may explicitly indicate the CSI-RS measurement result using the configured grant associated with the selected or indicated SSB. For example, a MAC CE may be used to indicate CSI-RS measurement results, or an uplink control information (UCI) transmitted on PUCCH may be used.

[00152] The MAC layer may prioritize (e.g. using logical channel prioritisation) the transmission of the CSI-RS measurement result, such that the results are included in an uplink transmission with a higher priority than e.g. data.

[00153] The WTRU may implicitly indicate the best CSI-RS by selecting one from multiple configured grants associated with the different CSI-RS in the subset.

[00154] At 612, the WTRU may receive a scheduling grant based on the indicated CSI-RS.

[00155] FIG. 7 is a diagram depicting an example beam refinement 700 during LTM execution. In this example, a WTRU 702 is configured to perform LTM, and an early TA acquisition has been performed in order to enable a RACH-less handover. The PDCCH order triggering early TA acquisition indicates a RACH resource to use based on reported SSB measurements prior to this trigger. The WTRU 702 transmits a PRACH preamble to the target gNB (e.g., cell B 706) using this indicated resource in order that the target gNB 706 can estimate a TA for the WTRU. The TA is provided to the source gNB (e.g., cell A 704).

[00156] At 710, the WTRU 702 may receive configuration information from a first cell 704 (e.g., Cell A). For example, the WTRU 702 may receive an RRC reconfiguration message from the first cell. The RRC configuration message may include the configuration information. The configuration information may preconfigure one or more LTM candidates. The configuration information may include an association of an SSB of a second cell 706 (e.g., Cell B) with one or more CSI-RSs of the second cell 706. The configuration information may include one or more configured grants associated with SSB for each candidate. For example, the configuration information may include indications of uplink resources associated with each of the one or more CSI-RSs.

[00157] At 712, the WTRU 702 may send an RRC reconfiguration complete message to the first cell 704. At 714, the WTRU 702 may perform measurements on an SSB transmission from a second cell 706 (e.g., Cell B). At 716, the WTRU 702 may send a CSI report to the first cell 704. The CSI report may include measurements on the SSB transmission from the second cell 706. At 718, the WTRU 702 may receive the PDCCH order from the first cell 704. The PDCCH order may trigger RACH to the second cell 706. At 720, the WTRU 702 may send the PRACH preamble to the second cell 706. At 722, the second cell 706 may send the TA to the first cell 704. At 724, the WTRU 702 may receive a MAC CE from the first cell 704 that indicates the TA. The MAC CE may include a cell switch indication and/or a target SSB beam. The WTRU 702 may initiate a handover to the second cell 706, for example, in response to receipt of the cell switch indication.

[00158] The WTRU 702 may determine and/or select a subset of CSI-RS resources based on the selected SSB. For example, the WTRU 702 may determine, based on a measurement (e.g., RSRP) of the selected SSB, the subset of the one or more CSI-RSs of the second cell 706 that are associated with the selected SSB. The WTRU 702 may determine to measure the subset of the one or more CSI-RSs of the second cell 706 based on the measurement of the selected SSB being greater than a first threshold associated with the selected SSB and/or the measurement of the selected SSB being greater than a second threshold associated with the selected SSB. The WTRU 702 may determine a

configured grant associated with the selected SSB. The WTRU 702 may execute LTM (e.g., reconfiguration to the second cell 706).

[00159] At 726, the WTRU 702 may perform measurements on the determined subset of CSI-RSs. For example, the WTRU 702 may measure a RSRP of the determined subset of the CSI-RSs of the second cell 706. The WTRU 702 may select a CSI-RS based on the measured RSRP of the determined subset of the CSI-RS of the second cell 706. For example, the WTRU 702 may select the CSI-RS either WTRU-autonomously or based on network instructions, where the instructions are provided on the basis of WTRU reported measurements. At 728, the WTRU 702 may send an indication of the selected (e.g., best) CSI-RS (e.g., CSI-RS beam) to the second cell 706, for example, using the configured grant associated with the selected SSB. The indication of the selected CSI-RS (e.g., CSI-RS beam) may be sent in a first uplink transmission from the WTRU 702 to the second cell 706. The indication of the selected CSI-RS (e.g., CSI-RS beam) is provided via a transmission of uplink resources associated with the CSI-RS (e.g., CSI-RS beam). At 730, the WTRU 702 may receive a scheduling grant from the second cell 706. The scheduling grant may be based on the selected CSI-RS. At 732, the WTRU 702 may send uplink data to the second cell 706.

[00160] In this example, the MAC CE which triggers LTM cell switch indicates a target SSB beam to use, in addition to a TA value to use in order to enable a RACH-less handover.

[00161] Based on the indicated target SSB the WTRU triggers the cell switch (reconfiguration) and selects the subset of CSI-RS to measure.

[00162] The WTRU performs measurements on the selected subset of CSI-RS, and in the first uplink transmission to the target cell, the WTRU transmits an indication of the best measured CSI-RS using the configured grant associated with the SSB indicated in the LTM cell switch MAC CE.

[00163] Following this the WTRU may be scheduled based on the initial CSI-RS measurement indication.

[00164] The solution may enable the WTRU to perform beam refinement during LTM execution, hence enabling e.g. a RACH-less CHO to be performed with initial access on the new cell already using a narrow beam based on CSI-RS measurement, enabling higher throughput and performance during a conditional reconfiguration while also improving latency and reducing interruption. This may also be suitable for fallback cases or cases whereby the source cell quality is not suitable to perform a long preparation phase.

[00165] CSI-RS selection may be triggered by the network. NW triggering of a CSI-RS selection and reporting to a target may include a Target that configures grant and/or CSI-RS to use during early sync procedure based on SSB. The NW triggers the CSI-RS measurement. The WTRU indicates best CSI-

RS beam to the source before the WTRU executes the reconfiguration. Note that this second solution is Applicable to LTM case or R19 RACH-less CHO/LTM.

[00166] The WTRU receives a configuration of SSB vs. CSI-RS association for a second cell (target) from a first cell (source).

[00167] The WTRU performs SSB measurements on the second cell (target) and reports to the first cell (source).

[00168] The WTRU receives a PDCCH order from the first cell (source) to trigger RA on the second cell (target) with an indication of a RA resource corresponding to SSB reported measurements. This may occur for for early TA acquisition using best coarse beam/SSB.

[00169] The WTRU transmits random access preamble on the second cell (target) using the indicated RA resource.

[00170] The WTRU receives a random access response from the second cell (on target or forwarded via source) indicating the TA value for the second cell (target), configuring the grant to use when LTM is executed and a subset of CSI-RS to measure. (a) May be type2 CG whereby the first cell configures the grant and a RAR on the second cell activates. (b) Could be explicit grant in RAR with predefined timing association. (c) May be pointer to one of multiple preconfigured CGs e.g. based on the subset of CSI-RS. (d) May be a CG corresponding to the best SSB. (e) May be a set of CG corresponding to multiple CSI-RS

[00171] The WTRU performs measurements of the CSI-RSs indicated in the RAR.

[00172] The WTRU reports the subset of CSI-RS measurements or best beam of the indicated subset to the first cell (source).

[00173] The WTRU executes LTM and transmits on the second cell using the grant or the selected one of multiple grants. (a) May be explicit LTM trigger - LTM MAC CE indicating an index corresponding to best CSI-RS reported. (b) May be conditional trigger: (i) trigger based on CSI-RS measurement - when one of the indicated subset of CSI-RS meets criteria, (e.g., radio quality such as RSRP, SINR, or CQI above a threshold, RSRP of target CSI-RS higher than a current CSI-RS) send on associated CG. (ii) trigger based on SSB measurement. MAC CE may enable a SSB based trigger and include indication of further subset of CSI-RS to consider - final refinement step may be performed by WTRU.

[00174] FIG. 8 is a flowchart depicting an example NW triggered CSI-RS selection 800.

[00175] At 802, the WTRU may receive a configuration from a first cell (E.g. a current or source cell) which associates one or more SSB resources of a second cell (E.g. a candidate or target cell) with one or more CSI-RS resources of the second cell. For example, as shown in FIG. 5 the SSB with ID 2

(SSB2) may be associated with CSI-RS with IDs 6,7,8,9,10. SSB2 being the wider beam and CSI-RS 6-10 being narrower beams spanning the width of SSB2.

[00176] At 804, the WTRU may perform measurements of one or more SSB resources on one or more target cells. The WTRU may report the SSB measurements to the first cell (source), including measurements of at least one SSB on the second cell (target). The report may be, for example, provided in a CSI report on PUCCH, in a MAC CE, or in an RRC measurement report.

[00177] At 806, the WTRU may receive a PDCCH order from the first cell including an indication to transmit a random access preamble on the second cell, and an indication of a random access resource which corresponds to a reported SSB (e.g. the best SSB) from the second cell.

[00178] At 808, the WTRU may transmit a preamble to a target cell using the indicated random access resource (E.g. an early sync procedure intended to allow the target gNB to determine a TA value for the WTRU).

[00179] At 810, the WTRU may receive a random access response from the second cell, either directly, or sent via the first cell (E.g. the second cell forwards information to the first cell, and the first cell transmits a RAR to the WTRU). The random access response may include one or more of a TA value for the second cell, an indication to activate a grant (E.g. a type 2 configured grant, whereby the first cell configures the grant and the second cell activates the grant), an explicit grant, a pointer to one or more preconfigured grants, and an indication of a subset of CSI-RS to measure.

[00180] An indication of the grant may be to a configured grant corresponding to a reported SSB, or may be a set of configured grants corresponding to multiple CSI-RS associated with a reported SSB.

[00181] The subset of CSI-RS may be indicated explicitly in the random access response (E.g. using a pointer to one of multiple subsets) or may be indicated implicitly (E.g. the WTRU enables a subset of CSI-RS depending on a reported or indicated SSB when the RAR is received). In one solution, the WTRU alternatively enables the subset of CSI-RS measurements when the WTRU receives the PDCCH order at 806, while the RAR received at 810 activates the configured grant.

[00182] The RAR (and/or the DCI scheduling the RAR) may include a codepoint (e.g., a 1-bit) to activate (e.g., enable/disable) CSI-RS measurements and/or CSI reporting for the target cell.

[00183] The RAR may include a pointer to an aperiodic CSI-RS resource trigger list. The WTRU may measure the aperiodic CSI-RS indicated in the pointer.

[00184] At 812, the WTRU may perform measurements on the indicated or determined subset of CSI-RS.

[00185] At 814, the WTRU may report the subset of CSI-RS measurements to the first cell (Source). Performing the measurements at 812 and reporting the measurements 814 may occur in parallel or repeatedly.

[00186] At 816, the WTRU may receive one or more indications to perform a conditional LTM cell switch, or an explicit LTM cell switch, including an indication of the target cell/beam or cells/beams. In examples, the explicit or conditional LTM indication includes a resource corresponding to a reported (E.g. best) CSI-RS, or an SSB.

[00187] FIG. 9 is a diagram depicting an example beam refinement 900 during LTM preparation. At 910, the WTRU 902 may receive a RRC reconfiguration message from a first cell 904 (e.g., Cell A). For example, the WTRU 902 may be configured to perform LTM, may be configured with an association between SSB and CSI-RS resources, and may be configured with type 2 configured grants for each candidate cell (a type 2 configured grant may be configured by RRC then activated using e.g. DCI or in an alternative enabled by MAC CE). At 912, the WTRU 902 may send an RRC reconfiguration complete message to the first cell 904.

[00188] At 914, the WTRU 902 may measure one or more SSBs from a second cell 906 (e.g., Cell B). At 916, the WTRU 902 may send a CSI report to the first cell 904. For example, the WTRU 902 may be configured to perform SSB measurements and may reports, using CSI reporting on PUCCH, the SSB measurement results.

[00189] At 918, the WTRU 902 may receive a PDCCH order from the first cell 904. The PDCCH order may trigger early TA acquisition which indicates a RACH resource to use based on reported SSB measurements prior to this trigger. At 920, the WTRU 902 may transmit a PRACH preamble to the second cell 906, for example, using this indicated resource in order that the target gNB can estimate a TA for the WTRU 902. At 922, the WTRU 902 may receive a TA value from the second cell 906. At 924, the WTRU 902 may receive a random access response from the first cell 904 or the second cell 906. The received random access response may include an indication to activate one or more configured grants on the second cell 906, for example, a set of configured grants corresponding to each of the CSI-RS resources in the subset of CSI-RS resources selected for measurement. Based on the random access response, which may include an indication to select a subset of CSI-RS resources, the WTRU 902 may determine (e.g., select) a subset of CSI-RS resources to measure.

[00190] At 926, the WTRU 902 may measure the determined subset of CSI-RS resources. At 928, the WTRU 902 may send an indication of a best CSI-RS beam. For example, the WTRU 902 may perform CSI-RS resource measurements and reports to the first cell 904, for example, using CSI reporting or a MAC CE.

[00191] At 930, the WTRU 902 may receive a MAC CE from the first cell 904. The MAC CE may trigger LTM execution. The MAC CE may include an indication of a resource corresponding to at least one of the reported CSI-RS.

[00192] The WTRU 902 may execute LTM. At 932, the WTRU 902 may send uplink data to the second cell 906. For example, the WTRU 902 may perform the first uplink transmission (e.g., send the uplink data at 932) using a configured grant corresponding to a selected or indicated CSI-RS.

[00193] In this solution, the WTRU performs beam refinement before triggering the LTM. This enables beam refinement with a shorter interruption time during the handover execution, because measurements on the target CSI-RS are performed before the handover rather than during the handover. This approach may be more suitable for a more network controlled handover procedure for example LTM, or conditional LTM which uses a preparation (E.g. early UL sync).

[00194] Selection and switching/fallback of the beam refinement procedure may be provided. A WTRU may select a beam refinement procedure (e.g., solution 1 or solution 2) based on a first condition. The WTRU may switch from one procedure to another based on a second condition.

[00195] The WTRU may receive a configuration of SSB vs. CSI-RS association for a second cell (target) from a first cell (source).

[00196] The WTRU may receive a PDCCH order to trigger RA for early TA. (best coarse beam/SSB)

[00197] The WTRU may determine based on a first condition to perform a first beam refinement procedure on the second cell. For example, the WTRU may select whether to perform WTRU based beam refinement. The first beam refinement procedure may be a CSI-RS beam refinement procedure. A second procedure may be a SSB procedure without beam refinement (e.g., SSB only). The first condition may be speed dependent, for example, if above a threshold then may disable beam refinement altogether. The first condition may be dependent on source RSRP threshold, for example, if source is below a threshold then do not enable beam refinement (e.g. not enough time left on source cell to report CSI-RS before HO trigger). The first condition may depend on TA validity remaining time (e.g., not enough time left to maintain UL sync condition on target cell to complete beam refinement). The first condition may depend on SSB measurement threshold on target (e.g., SSB too low to perform further refinement autonomously). The WTRU may select a type of beam refinement procedure (e.g., a first procedure or a second procedure). The first condition may be whether the cell is inter-CU, and if so then do not enable CSI-RS measurements (e.g., use solution 1). The first condition may be dependent on WTRU capabilities, for example, if for this band combination the WTRU does not support simultaneous reception for source and target then use solution 1. Beam refinement types may have individual capabilities (e.g., supports type 1 but not type 2).

[00198] The WTRU may enable CSI-RS measurement and refinement procedure.

Maybe also dependent on procedure type selection (e.g. to the source as per solution 2, or to the target as per solution 1).

[00199] The WTRU may determine based on a second condition to stop performing the first procedure and start performing the second procedure

[00200] FIG. 10 is a flowchart depicting an example selection and switching 1000 of the beam refinement procedure.

[00201] At 1002, the WTRU may receive a configuration from a first cell (e.g., a current or source cell) which associates one or more SSB resources of a second cell (e.g., a candidate or target cell) with one or more CSI-RS resources of the second cell. For example, as shown in FIG. 5 the SSB with ID 2 (SSB2) may be associated with CSI-RS with IDs 6,7,8,9,10. SSB2 being the wider beam and CSI-RS 6-10 being narrower beams spanning the width of SSB2.

[00202] At 1004, the WTRU may receive a PDCCH order from the first cell including an indication to transmit a random access preamble on the second cell, and an indication of a random access resource which corresponds to a reported SSB (e.g., the best SSB) from the second cell.

[00203] At 1006, the WTRU may determine based on a first condition to perform a first beam refinement procedure on the second cell. For example, The WTRU may determine, at 1006, whether or not to perform beam refinement, or determine, at 1006, which type of beam refinement procedure to perform.

[00204] At 1008, the WTRU may enable the selected beam refinement procedure and may start performing CSI-RS measurements.

[00205] At 1010 the WTRU may determine, based on a second condition, (e.g., a failure condition) to stop performing the first procedure (e.g., a beam refinement procedure or a first beam refinement procedure) and may start performing a second procedure (e.g., a procedure which does not perform beam refinement, or a second beam refinement procedure).

[00206] FIG. 11 is a diagram depicting an example fallback to RACH based LTM execution 1100. At 1110, a WTRU 1102 may receive an RRC reconfiguration message from a first cell 904 (e.g., Cell A). The WTRU 1102 may determine to perform a beam refinement according to a first condition. The first condition in this example may include that a target cell SSB measurement is above a threshold.

[00207] The WTRU 1102 may be configured to perform LTM, may be configured with an association between SSB and CSI-RS resources, and may be configured with type 2 configured grants for each candidate cell (a type 2 configured grant may be configured by RRC then activated using e.g. DCI or in

an alternative enabled by MAC CE). At 1112, the WTRU 1102 may send an RRC reconfiguration complete message to the first cell 1104.

[00208] At 1114, the WTRU 1102 may measure one or more SSBs from a second cell 1106 (e.g., Cell B). At 1116, the WTRU 1102 may send a CSI report to the first cell 1104. For example, the WTRU 1102 may be configured to perform SSB measurements and may report, using CSI reporting on PUCCH, the SSB measurement results.

[00209] At 1118, the WTRU 1102 may receive a PDCCH order from the first cell 1104. The WTRU 1102 may be configured to determine that an early TA acquisition has been performed in order to enable a RACH-less handover. The PDCCH order triggering early TA acquisition indicates a RACH resource to use based on reported SSB measurements prior to this trigger. At 1120, the WTRU 1102 may transmit a PRACH preamble to the second cell 1106, for example, using this indicated resource in order that the second cell 1106 can estimate a TA for the WTRU 1102. At 1122, the second cell 1106 may send the TA to the first cell 1104.

[00210] At 1124, the WTRU 1102 may receive a MAC CE from the first cell 1104. The MAC CE may trigger an LTM cell switch. The MAC CE may indicate a target SSB beam to use and/or a TA value to use in order to enable a RACH-less handover.

[00211] Based on the indicated target SSB the WTRU 1102 may trigger a cell switch (e.g., reconfiguration). The WTRU 1102 may determine that the indicated SSB has a measurement above a threshold. The WTRU 1102 may determine to perform beam refinement. The WTRU 1102 may select a subset of CSI-RS to measure and may start to perform CSI-RS measurements. For example, at 1126, the WTRU 1102 may measure the selected subset of CSI-RSs from the second cell 1106. At 1128, the WTRU 1102 may measure one or more SSBs from the second cell 1106.

[00212] The WTRU 1102 may determine a second condition is met. The second condition in this example is that, based on SSB measurement, the best SSB has changed. In response to detecting a change of best SSB the WTRU 1102 may determine that the selected CSI-RS subset is no longer valid, and the indicated target resource (e.g., which is based on the reported best SSB in a previous step) is no longer valid. Based on detecting the second condition the WTRU 1102 may determine that a RACH-less handover with beam refinement can no longer be performed. At 1130, the WTRU 1102 may send a random access preamble to the second cell 1106, for example, to access the second cell 1106 using a random access procedure.

[00213] FIG. 12 is a diagram depicting an example fallback 1200 from beam refinement during LTM preparation to beam refinement during LTM execution.

[00214] A WTRU 1202 may be configured with a first condition for determining which type of beam refinement to initiate and a second condition for determining under which circumstances to switch between beam refinement procedures.

[00215] In this example, the WTRU 1202 may follow a procedure similar to that described in FIG. 11. at 1210, the WTRU may receive an RRC reconfiguration message from a first cell 1204 (e.g., Cell A). The RRC reconfiguration message may include configuration information. The configuration information may preconfigure one or more LTM candidates. The configuration information may include an association of an SSB of a second cell 1206 (e.g., Cell B) with one or more CSI-RSs of the second cell 1206, one or more configured grants associated with the SSB for each candidate, and/or indications of uplink resources associated with each of the one or more CSI-RSs. For example, the WTRU 1202 may be configured to perform LTM, is configured with an association between SSB and CSI-RS resources, and is configured with type 2 configured grants for each candidate cell (e.g., a type 2 configured grant may be configured by RRC then activated using e.g. DCI or in an alternative enabled by MAC CE).

[00216] At 1214, the WTRU 1202 may perform SSB measurements. At 1216, the WTRU 1202 may send a CSI report to the first cell 1204, for example using CSI reporting on PUCCH. The CSI report may include the SSB measurements.

[00217] At 1218, the WTRU 1202 may receive a PDCCH order from the first cell 1204. The PDCCH order may trigger early TA acquisition which indicates a RACH resource to use based on reported SSB measurements prior to this trigger. At 1220, the WTRU 1202 may transmit a PRACH preamble to the second cell 1206, for example, using this indicated resource in order that the second cell 1206 can estimate a TA for the WTRU 1202. At 1224, the WTRU 1202 may receive a random access response from the second cell 1206 or the first cell 1204.

[00218] The WTRU 1202 may determine based on the first condition, to initiate a beam refinement procedure during LTM preparation. The first condition may be, for example, based on an SSB measurement result of the target or the source cell. For example the WTRU may determine that the source cell RSRP is sufficiently good (e.g. above a threshold) to report CSI-RS measurement results for a period of time ahead of LTM cell switch. The condition may simply be related to the confirmation (e.g. reception of RAR) that a configured grant is available on a particular cell. The WTRU 1202 may determine a first subset of CSI-RSs.

[00219] At 1226, the WTRU 1202 may measure the determined first subset of CSI-RSs. proceeds to perform CSI-RS resource measurements and reports to the source cell, for example using CSI

reporting or a MAC CE. At 1228, the WTRU 1202 may send an indication of a best CSI-RS beam of the first subset of CSI-RSs.

[00220] At 1230, the WTRU 1202 may receive a MAC CE from the second cell 1206. The MAC CE may trigger LTM execution. The MAC CE may include an indication of a resource corresponding to at least one of the reported CSI-RS.

[00221] The WTRU 1202 may determine according to the second condition, that the beam refinement during LTM execution cannot be completed, and may initiate a beam refinement procedure upon LTM cell switch, similar to that described in FIG. 7. The second condition may be, for example, that the best SSB on the target cell has changed.

[00222] The first condition is a condition that the WTRU 1202 may use to determine whether to enable beam refinement before, during or after a handover or reconfiguration. The first condition may be evaluated at any point in the procedure, before initiating a beam refinement. For example, the first condition may be determined when the LTM configuration is received, when an early TA acquisition is initiated or completed, or when an LTM cell switch indication is received.

[00223] The first condition may be speed dependent - e.g. if above a threshold then may disable beam refinement altogether.

[00224] The first condition may be dependent on source RSRP threshold - e.g. if source is below a threshold then do not enable beam refinement (e.g. not enough time left on source cell to report CSI-RS before HO trigger)

[00225] The first condition may depend on SSB measurement threshold on target (E.g. SSB too low to perform further refinement autonomously)

[00226] The first condition may depend on TA validity remaining time (not enough time left to maintain UL sync condition on target cell to complete beam refinement)

[00227] The WTRU 1202 may select a type of beam refinement procedure (e.g., first procedure is solution 1 vs. second procedure is solution 2)

[00228] The first condition may be whether cell is inter-CU, and if so then do not enable CSI-RS measurements (e.g., use solution 1)

[00229] The first condition may be dependent on WTRU capabilities - if for this band combination the WTRU 1202 does not support simultaneous reception for source and target then use solution 1.

[00230] The second condition may be a condition that the WTRU 1202 may use to determine whether to switch between different beam refinement procedures, or switch between different handover procedures (E.g. use beam refinement or not, or use RACH-less or not). The second condition may be evaluated throughout the procedure, or at any specific point in the procedure. For example, the WTRU

1202 may start evaluating the second condition immediately after selecting the beam refinement procedure based on the first condition. The WTRU 1202 may determine after enabling the CSI-RS reporting, or after initiating the LTM cell switch. At 1232, the WTRU 1202 may measure one or more SSBs from the second cell 1206. At 1234, the WTRU 1202 may measure the selected second subset of CSI-RSs and may determine a best CSI-RS of the selected second subset of CSI-RSs. At 1236, the WTRU 1202 may send an indication of the best CSI-RS of the selected second subset of CSI-RSs to the second cell 1206. At 1238, the WTRU 1202 may receive a scheduling grant from the second cell 1206. At 1240, the WTRU 1202 may send uplink data to the second cell 1206.

[00231] The WTRU 1202 may detect that the SSB used for selecting the subset of CSI-RS is no longer meeting the criteria (e.g., best, threshold, etc), before using the CG to transmit the initial uplink data or message. In this case the WTRU 1202 may select another SSB, then the WTRU 1202 may initiate a RACH-based handover, initiate another RACH for TA acquisition, use SSB without beam refinement (e.g., SSB only), or report new best SSB to source.

[00232] If the WTRU 1202 detects a timer expiry (e.g., expiration of the TA validity timer or expiration of a CG validity timer) before transmitting on the CG (e.g., the one indicated by the source in solution 1, or the target in solution 2), the WTRU 1202 may perform a RACH-based HO, or request a new CG /restart the procedure, for example, because the CG is no longer valid.

[00233] The WTRU 1202 may stop reporting CSI-RS measurement to the first cell 1204, and instead may perform autonomous beam refinement and report to the second cell 1206 (e.g., switch from solution 2 to solution 1).

[00234] The WTRU 1202 may detect a BFR or radio link failure (RLF) on the first cell 1204. In this case, the CSI-RS report may no longer be possible and the WTRU 1202 may execute LTM to target (e.g. autonomously, as a BFR or RLF recovery mechanism) and perform autonomous beam refinement, RACH, or an SSB procedure without beam refinement (e.g., SSB only).

[00235] The WTRU 1202 may select the most appropriate procedure to use in different handover scenarios, for example depending on whether the second cell 1206 is inter-DU (or CU) or intra-DU (or CU), depending on the first cell 1204 and/or second cell 1206 or beam quality, and so on. Also allows for fallback in case the condition change.

[00236] Although features and elements are provided 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. The present disclosure is not to be limited in terms of the particular embodiments described in this application, which are intended as illustrations of various aspects. Many modifications and variations may be made without departing from its spirit and

scope, as will be apparent to those skilled in the art. No element, act, or instruction used in the description of the present application should be construed as critical or essential to the invention unless explicitly provided as such. Functionally equivalent methods and apparatuses within the scope of the disclosure, in addition to those enumerated herein, will be apparent to those skilled in the art from the foregoing descriptions. Such modifications and variations are intended to fall within the scope of the appended claims. The present disclosure is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. It is to be understood that this disclosure is not limited to particular methods or systems.

[00237] The foregoing embodiments are discussed, for simplicity, with regard to the terminology and structure of infrared capable devices, i.e., infrared emitters and receivers. However, the embodiments discussed are not limited to these systems but may be applied to other systems that use other forms of electromagnetic waves or non-electromagnetic waves such as acoustic waves.

[00238] It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting. As used herein, the term "video" or the term "imagery" may mean any of a snapshot, single image and/or multiple images displayed over a time basis. As another example, when referred to herein, the terms "user equipment" and its abbreviation "UE", the term "remote" and/or the terms "head mounted display" or its abbreviation "HMD" may mean or include (i) a wireless transmit and/or receive unit (WTRU); (ii) any of a number of embodiments of a WTRU; (iii) a wireless-capable and/or wired-capable (e.g., tetherable) device configured with, inter alia, some or all structures and functionality of a WTRU; (iii) a wireless-capable and/or wired-capable device configured with less than all structures and functionality of a WTRU; or (iv) the like. Details of an example WTRU, which may be representative of any WTRU recited herein, are provided herein with respect to FIGs. 1A-1D. As another example, various disclosed embodiments herein supra and infra are described as utilizing a head mounted display. Those skilled in the art will recognize that a device other than the head mounted display may be utilized and some or all of the disclosure and various disclosed embodiments can be modified accordingly without undue experimentation. Examples of such other device may include a drone or other device configured to stream information for providing the adapted reality experience.

[00239] In addition, the methods provided 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, UE, terminal, base station, RNC, MME, EPC, AMF, or any host computer.

[00240] Variations of the method, apparatus and system provided above are possible without departing from the scope of the invention. In view of the wide variety of embodiments that can be applied, it should be understood that the illustrated embodiments are examples only and should not be taken as limiting the scope of the following claims. For instance, the embodiments provided herein include handheld devices, which may include or be utilized with any appropriate voltage source, such as a battery and the like, providing any appropriate voltage.

[00241] Moreover, in the embodiments provided above, processing platforms, computing systems, controllers, and other devices that include processors are noted. These devices may include at least one Central Processing Unit ("CPU") and memory. In accordance with the practices of persons skilled in the art of computer programming, reference to acts and symbolic representations of operations or instructions may be performed by the various CPUs and memories. Such acts and operations or instructions may be referred to as being "executed," "computer executed" or "CPU executed."

[00242] One of ordinary skill in the art will appreciate that the acts and symbolically represented operations or instructions include the manipulation of electrical signals by the CPU. An electrical system represents data bits that can cause a resulting transformation or reduction of the electrical signals and the maintenance of data bits at memory locations in a memory system to thereby reconfigure or otherwise alter the CPU's operation, as well as other processing of signals. The memory locations where data bits are maintained are physical locations that have particular electrical, magnetic, optical, or organic properties corresponding to or representative of the data bits. It should be understood that the embodiments are not limited to the above-mentioned platforms or CPUs and that other platforms and CPUs may support the provided methods.

[00243] The data bits may also be maintained on a computer readable medium including magnetic disks, optical disks, and any other volatile (e.g., Random Access Memory (RAM)) or non-volatile (e.g., Read-Only Memory (ROM)) mass storage system readable by the CPU. The computer readable medium may include cooperating or interconnected computer readable medium, which exist exclusively on the processing system or are distributed among multiple interconnected processing systems that may be local or remote to the processing system. It should be understood that the

embodiments are not limited to the above-mentioned memories and that other platforms and memories may support the provided methods.

[00244] In an illustrative embodiment, any of the operations, processes, etc. described herein may be implemented as computer-readable instructions stored on a computer-readable medium. The computer-readable instructions may be executed by a processor of a mobile unit, a network element, and/or any other computing device.

[00245] There is little distinction left between hardware and software implementations of aspects of systems. The use of hardware or software is generally (but not always, in that in certain contexts the choice between hardware and software may become significant) a design choice representing cost versus efficiency tradeoffs. There may be various vehicles by which processes and/or systems and/or other technologies described herein may be effected (e.g., hardware, software, and/or firmware), and the preferred vehicle may vary with the context in which the processes and/or systems and/or other technologies are deployed. For example, if an implementer determines that speed and accuracy are paramount, the implementer may opt for a mainly hardware and/or firmware vehicle. If flexibility is paramount, the implementer may opt for a mainly software implementation. Alternatively, the implementer may opt for some combination of hardware, software, and/or firmware.

[00246] The foregoing detailed description has set forth various embodiments of the devices and/or processes via the use of block diagrams, flowcharts, and/or examples. Insofar as such block diagrams, flowcharts, and/or examples include one or more functions and/or operations, it will be understood by those within the art that each function and/or operation within such block diagrams, flowcharts, or examples may be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or virtually any combination thereof. In an embodiment, several portions of the subject matter described herein may be implemented via Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), digital signal processors (DSPs), and/or other integrated formats. However, those skilled in the art will recognize that some aspects of the embodiments disclosed herein, in whole or in part, may be equivalently implemented in integrated circuits, as one or more computer programs running on one or more computers (e.g., as one or more programs running on one or more computer systems), as one or more programs running on one or more processors (e.g., as one or more programs running on one or more microprocessors), as firmware, or as virtually any combination thereof, and that designing the circuitry and/or writing the code for the software and or firmware would be well within the skill of one of skill in the art in light of this disclosure. In addition, those skilled in the art will appreciate that the mechanisms of the subject matter described herein may be distributed as a program product in a variety of forms, and that an illustrative

embodiment of the subject matter described herein applies regardless of the particular type of signal bearing medium used to actually carry out the distribution. Examples of a signal bearing medium include, but are not limited to, the following: a recordable type medium such as a floppy disk, a hard disk drive, a CD, a DVD, a digital tape, a computer memory, etc., and a transmission type medium such as a digital and/or an analog communication medium (e.g., a fiber optic cable, a waveguide, a wired communications link, a wireless communication link, etc.).

[00247] Those skilled in the art will recognize that it is common within the art to describe devices and/or processes in the fashion set forth herein, and thereafter use engineering practices to integrate such described devices and/or processes into data processing systems. That is, at least a portion of the devices and/or processes described herein may be integrated into a data processing system via a reasonable amount of experimentation. Those having skill in the art will recognize that a typical data processing system may generally include one or more of a system unit housing, a video display device, a memory such as volatile and non-volatile memory, processors such as microprocessors and digital signal processors, computational entities such as operating systems, drivers, graphical user interfaces, and applications programs, one or more interaction devices, such as a touch pad or screen, and/or control systems including feedback loops and control motors (e.g., feedback for sensing position and/or velocity, control motors for moving and/or adjusting components and/or quantities). A typical data processing system may be implemented utilizing any suitable commercially available components, such as those typically found in data computing/communication and/or network computing/communication systems.

[00248] The herein described subject matter sometimes illustrates different components included within, or connected with, different other components. It is to be understood that such depicted architectures are merely examples, and that in fact many other architectures may be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively "associated" such that the desired functionality may be achieved. Hence, any two components herein combined to achieve a particular functionality may be seen as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermedial components. Likewise, any two components so associated may also be viewed as being "operably connected", or "operably coupled", to each other to achieve the desired functionality, and any two components capable of being so associated may also be viewed as being "operably couplable" to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically mateable and/or physically

interacting components and/or wirelessly interactable and/or wirelessly interacting components and/or logically interacting and/or logically interactable components.

[00249] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[00250] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, where only one item is intended, the term "single" or similar language may be used. As an aid to understanding, the following appended claims and/or the descriptions herein may include usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim including such introduced claim recitation to embodiments including only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should be interpreted to mean "at least one" or "one or more"). The same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together,

etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B." Further, the terms "any of" followed by a listing of a plurality of items and/or a plurality of categories of items, as used herein, are intended to include "any of," "any combination of," "any multiple of," and/or "any combination of multiples of" the items and/or the categories of items, individually or in conjunction with other items and/or other categories of items. Moreover, as used herein, the term "set" is intended to include any number of items, including zero. Additionally, as used herein, the term "number" is intended to include any number, including zero. And the term "multiple", as used herein, is intended to be synonymous with "a plurality".

[00251] In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[00252] As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, etc. As a non-limiting example, each range discussed herein may be readily broken down into a lower third, middle third and upper third, etc. As will also be understood by one skilled in the art all language such as "up to," "at least," "greater than," "less than," and the like includes the number recited and refers to ranges which can be subsequently broken down into subranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual member. Thus, for example, a group having 1-3 cells refers to groups having 1, 2, or 3 cells. Similarly, a group having 1-5 cells refers to groups having 1, 2, 3, 4, or 5 cells, and so forth.

[00253] Moreover, the claims should not be read as limited to the provided order or elements unless stated to that effect. In addition, use of the terms "means for" in any claim is intended to invoke 35 U.S.C. §112, ¶ 6 or means-plus-function claim format, and any claim without the terms "means for" is not so intended.

[00254] Suitable processors include, by way of example, 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), Application Specific Standard Products

(ASSPs); Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), and/or a state machine.

[00255] The WTRU may be used in conjunction with modules, implemented in hardware and/or software including a Software Defined Radio (SDR), and other components such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands free headset, a keyboard, a Bluetooth® module, a frequency modulated (FM) radio unit, a Near Field Communication (NFC) Module, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit, a digital music player, a media player, a video game player module, an Internet browser, and/or any Wireless Local Area Network (WLAN) or Ultra Wide Band (UWB) module.

[00256] Although the various embodiments have been described in terms of communication systems, it is contemplated that the systems may be implemented in software on microprocessors/general purpose computers (not shown). In certain embodiments, one or more of the functions of the various components may be implemented in software that controls a general-purpose computer.

[00257] In addition, although the invention is illustrated and described herein with reference to specific embodiments, the invention is not intended to be limited to the details shown. Rather, various modifications may be made in the details within the scope and range of equivalents of the claims and without departing from the invention.

CLAIMS

1. A wireless transmit/receive unit (WTRU) configured to perform a handover from a first cell to a second cell, the WTRU comprising:
 - a processor configured to:
 - receive configuration information from the first cell, wherein the configuration information comprises an association of a synchronization signal block (SSB) of the second cell with channel state information reference signals (CSI-RSs) of the second cell;
 - initiate a handover to the second cell;
 - determine, based on the SSB, a subset of the CSI-RSs of the second cell that are associated with the SSB;
 - determine to measure the subset of the CSI-RSs of the second cell based on one or more of a measurement of the SSB being greater than a first threshold associated with the SSB, the measurement of the SSB being greater than a second threshold associated with the SSB, or the handover being initiated;
 - measure a reference signal received power (RSRP) of the subset of the CSI-RSs of the second cell;
 - transmit an indication of a selected CSI-RS of the subset of the CSI-RSs to the second cell, wherein the indication of the selected CSI-RS is sent using uplink resources associated with the SSB; and
 - receive a scheduling grant from the second cell.
2. The WTRU of claim 1, wherein the selected CSI-RS is a best CSI-RS of the subset of CSI-RSs.
3. The WTRU of claim 2, wherein the processor is further configured to select the best CSI-RS based on the measured RSRP of the subset of the CSI-RSs of the second cell, wherein the selected CSI-RS has the highest measured RSRP of the subset of CSI-RSs.
4. The WTRU of claim 3, wherein the best CSI-RS is selected autonomously by the processor.
5. The WTRU of claim 3, wherein the best CSI-RS is selected based on network instructions received based on RSRP measurements sent to the network.

6. The WTRU of claim 1, wherein the configuration information comprises an indication of the uplink resources associated with the selected CSI-RS.
7. The WTRU of claim 1, wherein the determination to measure the CSI-RSs of the second cell is based on the RSRP of the SSB being greater than the first threshold associated with the SSB.
8. The WTRU of claim 1, wherein the configuration information comprises one or more configured grants associated with the SSB of the second cell.
9. The WTRU of claim 1, wherein handover to the second cell is initiated in response to receipt of a physical downlink control channel (PDCCH) order from the first cell.
10. The WTRU of claim 1, wherein the processor is further configured to:
 - measure the SSB of the second cell; and
 - transmit a channel state information (CSI) report to the first cell, the CSI report comprising measurements of the SSB.
11. A method performed by a wireless transmit/receive unit (WTRU) configured to perform a handover from a first cell to a second cell, the method comprising:
 - receiving configuration information from the first cell, wherein the configuration information comprises an association of a synchronization signal block (SSB) of the second cell with channel state information reference signals (CSI-RSs) of the second cell;
 - initiating a handover to the second cell;
 - determining, based on the SSB, a subset of the CSI-RSs of the second cell that are associated with the SSB;
 - determining to measure the subset of the CSI-RSs of the second cell based on one or more of a measurement of the SSB being greater than a first threshold associated with the SSB, the measurement of the SSB being greater than a second threshold associated with the SSB, or the handover;
 - measuring a reference signal received power (RSRP) of the subset of the CSI-RSs of the second cell;
 - transmitting an indication of a selected CSI-RS of the subset of the CSI-RSs to the second cell, wherein the indication of the selected CSI-RS is sent using uplink resources associated with the SSB;

and

receiving a scheduling grant from the second cell.

12. The method of claim 11, wherein the selected CSI-RS is a best CSI-RS of the subset of CSI-RSs.

13. The method of claim 12, further comprising selecting the best CSI-RS based on the measured RSRP of the subset of the CSI-RSs of the second cell, wherein the selected CSI-RS has the highest measured RSRP of the subset of CSI-RSs.

14. The method of claim 13, wherein the best CSI-RS is selected autonomously by the processor.

15. The method of claim 13, wherein the best CSI-RS is selected based on network instructions received based on RSRP measurements sent to the network.

16. The method of claim 11, wherein the configuration information comprises an indication of the uplink resources associated with the SSB.

17. The method of claim 11, wherein the determination to measure the CSI-RSs of the second cell is based on the RSRP of the SSB being greater than the first threshold associated with the SSB.

18. The method of claim 11, wherein the configuration information comprises one or more configured grants associated with the SSB of the second cell.

19. The method of claim 11, wherein handover to the second cell is initiated in response to receipt of a physical downlink control channel (PDCCH) order from the first cell.

20. The method of claim 11, further comprising:
measure the SSB of the second cell; and
transmit a channel state information (CSI) report to the first cell, the CSI report comprising measurements of the SSB.