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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	ILTE_11894US01
		Application Number	
Title of Invention	COVERAGE ENHANCEMENTS OF LOW COST MTC DEVICES IN UL/DL DECOUPLED SCENARIO		
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Attorney Docket Number	ILTE_11894US01	Small Entity Status Claimed	☐
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	3	Suggested Figure for Publication (if any)	

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Title of Invention	COVERAGE ENHANCEMENTS OF LOW COST MTC DEVICES IN UL/DL DECOUPLED SCENARIO		

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Title of Invention	COVERAGE ENHANCEMENTS OF LOW COST MTC DEVICES IN UL/DL DECOUPLED SCENARIO		

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☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

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**COVERAGE ENHANCEMENTS OF LOW COST MTC DEVICES IN UL/DL
DECOUPLED SCENARIO**

BACKGROUND

[0001] Low cost machine type communication (LC-MTC) devices may enable machines to communicate with each other or with humans. Examples of the LC-MTC devices may include smart meters, home automation devices, consumer products, etc. One or more LC-MTC devices may communicate with MTC servers over mobile networks using a 3rd Generation Partnership Project (3GPP) network. Due to various reasons, compared to regular 3GPP devices (e.g., Long Term Evolution (LTE) devices), the LC-MTC devices may suffer higher received Signal to Interference Noise Ratio (SINR) losses. Mechanisms for communicating provided for connecting the regular devices may not be adequate for the LC-MTC devices.

SUMMARY

[0002] Systems, methods, and instrumentalities are disclosed to describe cell selection in low cost machine type communication (LC-MTC) devices. An LTC-MC device may measure a plurality of downlink signals from a plurality of cells. The LTC-MC may detect a channel condition, e.g., by determining a cell with better uplink coverage than a downlink cell. The detection of the channel condition may include measuring an uplink pathloss.

[0003] The LTC-MC may report the channel condition as a decoupled channel condition, e.g., when an uplink cell is identified with uplink coverage better than the downlink cell. The channel condition may be reported, e.g., via a set of Physical Random Access Channel (PRACH)

preambles. The set of PARCH preambles may be predefined. The channel condition may be reported, e.g., via a higher layer signaling (e.g., Radio Resource Control (RRC)).

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. 1A is a system diagram of an example communications system in which one or more disclosed embodiments may be implemented.

[0005] FIG. 1B is a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A.

[0006] FIG. 2 is a diagram illustrating examples of DL/UL coupled and DL/UL cases for low cost machine type communication (LC-MTC).

DETAILED DESCRIPTION

[0007] A detailed description of illustrative embodiments will now be described with reference to the various figures. Although this description provides a detailed example of possible implementations, it should be noted that the details are intended to be exemplary and in no way limit the scope of the application.

[0008] FIG. 1A is a diagram of 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

[0009] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, and/or 102d (which generally or collectively may be referred to as WTRU 102), a radio access network (RAN) 103/104/105, a core network 106/107/109, 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 may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital

assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0010] The communications systems 100 may also include a base station 114a and 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 core network 106/107/109, the Internet 110, and/or the 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 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.

[0011] The base station 114a may be part of the RAN 103/104/105, 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 within a particular geographic region, which may be referred to as a cell (not shown). The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, *e.g.*, one for each sector of the cell. In another embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and, therefore, may utilize multiple transceivers for each sector of the cell.

[0012] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 115/116/117, which may be any suitable wireless communication link (*e.g.*, radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, *etc.*). The air interface 115/116/117 may be established using any suitable radio access technology (RAT).

[0013] 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, 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 (*e.g.*, 802.11ac, 802.11af, and the like) to establish a wireless local area network (WLAN). In another 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 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 core network 106/107/109.

[0014] The RAN 103/104/105 may be in communication with the core network 106/107/109, 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. For example, the core network 106/107/109 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 103/104/105 and/or the core network 106/107/109 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 103/104/105 or a different RAT. For example, in addition to being connected to the RAN 103/104/105, which may be utilizing an E-UTRA radio technology, the core network 106/107/109 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0015] The core network 106/107/109 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or 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 the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 103/104/105 or a different RAT.

[0016] 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.

[0017] FIG. 1B is a system diagram of 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 other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment. Also, embodiments contemplate that the base stations 114a and 114b, and/or the nodes that base stations 114a and 114b may represent, such as but not limited to transceiver station (BTS), a Node-B, a site controller, an access point (AP), a home node-B, an evolved home node-B (eNodeB), a home evolved node-B (HeNB), a home evolved node-B gateway, and proxy nodes, among others, may include some or all of the elements depicted in FIG. 1B and described herein.

[0018] 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 Array (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.

[0019] 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 115/116/117. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In another 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 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.

[0020] In addition, 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 115/116/117.

[0021] 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 UTRA and IEEE 802.11, for example.

[0022] 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).

[0023] 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.

[0024] 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 115/116/117 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 implementation while remaining consistent with an embodiment.

[0025] 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 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, and the like.

[0026] Low cost machine type communication (LC-MTC) device working on LTE network (e.g. smart meter located in a basement of a house) may assume higher received Signal to Interference Noise Ratio (SINR) losses (e.g., up to 15dB) as compared to a regular LTE device. The throughput and/or delay requirements for the LC-MTC may also be relaxed.

[0027] In a heterogeneous network environment, the LC-MTC device may be located nearby a low power node. The LC-MTC device may be downlink/uplink (DL/UL) coupled and/or DL/UL decoupled. FIG. 2 illustrates examples of DL/UL coupled and DL/UL decoupled cases.

[0028] As illustrated in FIG. 2, in DL/UL coupled case, an LC-MTC device may communicate with a Macro cell for uplink and/or downlink. In DL/UL decoupled case, an LC-MTC device may communicate with Macro cell for downlink while transmitting uplink signal to low power node (LPN). The uplink signal may be transmitted to the low power node, e.g., because of transmission power difference between Macro cell and low power node. For example, Macro cell may transmit signals at 46dBm, whereas the low power node may transmit signals at 27dBm thereby resulting in different downlink coverage. The coverage for uplink may be related to the geographical distance between the UE and base station so that low power node may have better uplink coverage.

[0029] In case of decoupled DL/UL for coverage limited LC-MTC devices, for example, one or more of uplink accessibility to Macro cell, downlink signal readability for LPN, backhaul delay between the Macro cell and the LPN, or inter-frequency operation may be considered. The coverage limited LC-MTC device may be assumed to start with a coupled mode and transition into a decoupled mode (e.g., using the uplink of the LPN) for better uplink coverage. In case the coverage LC-MTC device may not have uplink coverage with Macro so that the device may start with LPN.

[0030] For downlink readability for LPN, an LC-MTC device may read each of the downlink signals of LPN, e.g., including PBCH and SIBs. The LC-MTC may measure downlink pathloss and may be synchronized with LPN (e.g., in terms of time and frequency offset). An LC-MTC may synchronize with the LPN (e.g., in terms of time and frequency sync) but may not decode PBCH, e.g., due to its poor received signal quality while it may synchronize with the LPN in terms of time and frequency sync.

[0031] Backhaul delay between Macro and LPN may include delays of ideal backhaul with no delay, 10ms, 20ms, 40ms, 80ms, and/or longer delays. The one or more types of backhaul delay may be taken into consideration to support dual connectivity for the decoupled scenario.

[0032] In an inter-frequency operation in heterogeneous network, the frequency band of Macro and LPN may or may not be the same. Inter-frequency and intra-frequency operation may be taken into account to support decoupled mode. The low cost MTC (LC-MTC) device, low-cost UE, UE, LC-MTC UE, MTC UE, and/or LC-UE, WTRU may be used herein interchangeably to refer to an MTC device that may be low cost.

[0033] Decoupled operation may be desirable, for example, when a UE is unable to communicate in UL and DL to a Macro cell and/or a LPN. Decoupled operation may assume DL transmissions from the Macro cell and UL transmissions to the LPN.

[0034] A UE may receive broadcasting signals from a Macro cell to access the network and acquire the system information for Random Access Channel (RACH). The RACH signal may be transmitted to LPN and the Macro cell may not be able to receive the Physical Random Access Channel (PRACH) preamble from the UE, e.g., due to limited uplink coverage. The preamble reception in network side may be more difficult, e.g., if the backhaul between the Macro cell and the LPN has a delay and the delay gets longer, as the PRACH preamble detection may be forward from LPN to Macro.

[0035] When the LPN uses a different DL-UL frequency pair or is on a different UL TDD frequency from that of DL Macro pair, the FDD UE may experience a frequency duplex separation while using Macro cell DL and LPN UL frequencies. One or more of the LPN UL frequencies may fall into a lower separation values which may cause a receiver self desense, e.g., due to the design of a duplexer that may take the frequency separation between DL and UL into consideration. The design of the duplexer may cause restrictions in the UL frequencies that the UE may use to have a DL-UL separation of at least the nominal band value. For example band V may have 45MHz DL-UL nominal separation. For band V, the UE may operate on UL frequencies that may be at least 45 MHz separated from the Macro cell DL frequency. Separation of lower than, e.g., 45 MHz may deteriorate receiver sensitivity. UE output power limitations may provide a non-nominal duplex separation. The LPN may operate at a different bandwidth than Macro cell, and the UE may have to change the transmitter bandwidth and the baseband sampling frequency.

[0036] For a UE to access a cell, it may first discover the cell. The discovery process may involve detecting PSS/SSS and reading the PBCH and the SIBs. While the coverage of

such signals may be higher than that of data transmissions, a UE may be unable to detect any of the signals from an LPN. It may be possible that such an LPN may be best suited to receive each of the UE's UL transmissions.

[0037] A UE may have coverage in the DL to the Macro cell and limited coverage in the UL. The UE may be handed off to a nearby LPN for UL transmissions, e.g., to improve the performance. The Macro cell may assist the UE in discovering nearby LPNs. The UE may have no UL coverage to the Macro and may independently connect to a LPN for UL and to a Macro cell for DL. A UE may maintain separate synchronization to Macro and LPN cells for DL and UL transmissions, e.g., if there is no synchronization between the Macro cell and the LPN.

[0038] In decoupled operation arrangement (e.g., assuming DL transmissions from the Macro and UL transmissions to the LPN), upon the reception of the Physical Downlink Shared Channel (PDSCH) by the UE, the UE may send the corresponding Hybrid Automatic reQuest (HARQ) feedback to the LPN. The LPN may communicate the feedback to the serving eNB, which may have sent the corresponding PDSCH. The timing requirement for eNB to receive the PDSCH HARQ feedback may not be sufficient due to the extra LPN processing and further communication and/or communication delay between LPN and eNB. The eNB may not be able to inform the LPN of the transmission of the PDSCH and the LPN may not expect to receive the PDSCH-related feedback when they are sent by the UE. Such an arrangement may make it difficult for the LPN to properly receive and/or decode a feedback. An improved HARQ operation may be provided.

[0039] A UE may be configured for HARQ-less operation for transmission and reception of Physical Uplink Shared Channel (PUSCH) and PDSCH data. The UE may rely on RLC AM and ARQ operation for reliable reception and transmission of data. A UE without HARQ may not have a reliable delivery mechanism for MAC control elements. Improvements to MAC CE reliability may be provided. For a UE with HARQ-less operation, reliability improvements may be provided, e.g., for delivery of msg3 during the RACH procedure, which may operate in RLC transparent mode.

[0040] DL/UL decoupled mode, decoupled mode, dual connected mode, dual connectivity mode, dual connection mode, and/or dual cell mode may be used herein interchangeably. DL/UL coupled mode in which the uplink and the downlink may communicate with the same eNB may be herein interchangeably used with coupled mode, single connected mode, single cell connected mode, single connectivity mode, single connection mode, and/or single cell mode.

[0041] Coupled and/or decouple transmissions for the LC-MTC or LC UE may be

provided. The decoupled transmission mode, decoupled mode, decoupled operation, and/or decoupled mode of operation may be used herein interchangeably. The coupled transmission mode, coupled mode, coupled operation, and/or coupled mode of operation may be used herein interchangeably.

[0042] A cell selection and/or re-selection for the two transmissions (e.g., decoupled and coupled) may be one of coupled or decoupled mode. In a coupled mode, a low-cost UE may measure downlink signals from multiple cells and may select a downlink cell, e.g., based on predefined criteria including but not limited to highest signal strength, Reference Signal Received Power (RSRP), or received SINR. The low-cost UE may assume that the uplink cell is the same as the downlink cell. There may be no separate cell search for uplink cell selection. In a decoupled mode, a low-cost UE may measure downlink signals from multiple cells and may select a downlink cell based on predefined criteria including but not limited to highest signal strength, RSRP, Reference Signal Received Quality (RSRQ), or received SINR. As similar to downlink cell selection, the low-cost UE may perform uplink cell search. The predefined criteria for uplink cell selection may be different from that for downlink cell selection. The uplink cell search may be performed within a list provided by the selected downlink cell. The list of uplink cells associated with the selected downlink cell may be provided in a broadcasting channel (e.g., Master Information Block (MIB), System Information Block (SIB-x)), higher layer signaling (e.g. MAC, RRC), or physical layer signaling (e.g., Enhanced Physical Downlink Control Channel (E)-PDCCH).

[0043] A coupled mode and/or a decoupled mode may be used, e.g., according to the UE category. The coupled and decoupled transmission modes may be defined and used for low-cost UE category. For example, the transmission modes may be used for a UE category. A UE may fall under the UE category and may perform with coupled and decoupled operations. The coupled transmission mode may be assumed to be used for each of the UE categories and the decoupled transmission mode may be used for a UE category (e.g. low-cost UE category). The coupled mode may support a transmission mode (e.g., TM9 mode) with a restricted number of ranks for a specific UE category (e.g., low-cost UE). One or more transmission modes (e.g., TM1~TM10 modes) may be supported in the coupled mode for other UE categories. The capability of the transmission modes that a UE may support may be related to the release of the UE.

[0044] A coupled mode and a decoupled mode may be configured in a semi-static manner. The coupled mode may be defined as a primary mode and the decoupled mode may be defined as a secondary mode. The primary mode may be considered as default mode so that the

low-cost UE may start with coupled mode for the cell access and may be switched to decoupled mode, e.g., according to the channel condition. The decoupled mode may be configured by higher layer during the low-cost UE configured as a coupled mode and/or the configuration signals may include the uplink cell information. If a low-cost UE is configured with a decoupled mode, the low-cost UE may start uplink cell search as described herein while downlink cell search procedure may not be performed. If the configuration signals include the uplink cell information, the uplink cell information may include, e.g., one or more of cell-ID, center frequency, bandwidth, or PRACH resource configuration. The supported downlink and uplink channels may be different, e.g., based on the mode of operation. For example, the coupled mode may support each of the channels defined, and the decoupled mode support a subset of channels used in coupled mode. The coupled mode may support data and control channels while decoupled mode may support data channel, where the data and control channels may include but not limited to PDSCH, PUSCH, PHICH, (E)PDCCH, PUCCH, SR, and SRS. The coupled mode may support broadcasting channels and data/control channels, and decoupled mode may support data and control channel, where the broadcasting channels may include but not limited to PBCH, SIBs, and Paging. For example, a low-cost UE may receive the broadcasting information in a coupled mode and switched to a decoupled mode for data transmission.

[0045] The two transmission modes may be selected during the cell access procedure. The transmission mode may not be changed at least for the connected mode, if a low-cost UE selects or is configured by one transmission mode. A low-cost UE may perform cell selection, e.g., separately for the downlink and uplink. For example, a low-cost UE may perform downlink cell selection and uplink cell selection at the same time, and the cell selection criteria for uplink and downlink may be different. Upon finishing the cell selection, the low-cost UE may select coupled mode or decoupled mode, e.g., according to the outcome of the cell selection for downlink and uplink. The low-cost UE may select decoupled mode, e.g., if the selected uplink cell is different from the downlink cell. Otherwise, coupled mode may be selected. In another example, a low-cost UE may perform downlink cell selection first and if a measured signal during the downlink cell selection procedure satisfies a predefined coverage limited channel condition, the UE may perform uplink cell selection procedure additionally. The UE may not perform uplink cell selection, if the downlink is not coverage limited. Upon finishing the cell selection, the low-cost UE may select coupled mode or decoupled mode, e.g., according to the outcome of the cell selection for downlink and uplink. The low-cost UE may select decoupled mode, if the selected uplink cell is different from the downlink cell. Otherwise, coupled mode may be selected. A low-cost UE may perform downlink cell selection. The low-cost UE may

perform uplink cell selection, if a measured signal during the downlink cell selection satisfies a predefined coverage limited channel condition and a broadcasting signal indicates that the selected downlink cell supports decoupled mode. Upon finishing the cell selection procedure, the low-cost UE may select coupled mode or decoupled mode, e.g., according to the outcome of the cell selection for downlink and uplink. The low-cost UE may select decoupled mode, if the selected uplink cell is different from the downlink cell. Otherwise, coupled mode may be selected. For the cell selection may use, for example, one or more of downlink common reference signal received power (e.g. RSRP), downlink pathloss (e.g. transmitted power – RSRP), downlink received SINR (e.g. RSRQ), or Uplink pathloss.

[0046] Coverage limited mode of operation may be applied on downlink or both downlink and uplink, e.g., according to the channel condition in a decoupled mode. A low-cost UE may be configured with coverage limited mode of operation for downlink while uplink may be non-coverage limited mode of operation. The coverage limited mode of operation may include use of coverage enhancement transmission schemes such as repetitions, TTI bundling, and/or PSD boosting of data and/or control channels. The non-coverage limited mode may include the legacy transmission schemes used for regular LTE device. For non-coverage limited mode, the timing for HARQ procedures may be assumed as coverage limited mode of operation for downlink and/or uplink. The uplink may not be configured as coverage limited mode of operation. The pathloss for uplink power control may be obtained from associated uplink LPN, e.g., if the uplink is configured with non-coverage limited mode of operation while the downlink is configured with coverage limited mode of operation. A low-cost UE may be configured with coverage limited mode of operation for downlink and uplink. The coverage limitation level may be different for downlink and uplink. For different coverage limitation level, the coverage limited mode of operation may be configured, e.g., configured separately for downlink and uplink. For example, the number of repetition for PDSCH for coverage enhancement may be separately configured with the number of repetitions for PUSCH for coverage enhancement. The TTI bundling size may be different between uplink and downlink.

[0047] A low-cost UE may inform a Macro cell whether the low-cost UE satisfies a decoupled channel condition or a coupled channel condition. For example, a PRACH resource may be partitioned to indicate whether a low-cost UE has decoupled channel condition. The decoupled channel condition may include an indication that the selected uplink cell is different from the selected downlink cell after separate cell selection/re-selection for uplink and downlink. The selected downlink cell, best downlink cell, and/or Macro cell may be used interchangeably. A PRACH resource may be partitioned, e.g., in time/frequency. The reserved PRACH resource

may be used, e.g., if a low-cost UE selects decoupled mode as described herein (e.g., if the UE finds a cell that has better uplink coverage as compared to the Macro cell). For example, a low-cost UE may measure downlink signals from the cells. The low-cost UE may be coverage limited low-cost UE and may check whether the cell supports decoupled mode, e.g., if the best measured signal power (or RSRP) is lower than a threshold value. If the cell supports decoupled mode, the low-cost UE may measure uplink pathloss (or downlink pathloss as for uplink pathloss equivalent) to check if there is another cell that may have better uplink coverage. The low-cost UE may use the reserved PRACH resource to indicate the decoupled channel condition for the low-cost UE, e.g., if the low-cost UE finds a better uplink coverage. For decoupled operation mode, the threshold may be predefined and/or configured, and/or the reserved PRACH resource may be informed and/or configured. The threshold may be predefined to differentiate coverage limited low-cost UE from non-coverage limited UE. The threshold may be configured, e.g., via higher layer or broadcasting channels. The reserved PRACH resource may be informed, e.g., via broadcasting channels (e.g., independently) from the PRACH resource for coupled mode or regular LTE UE. The reserved PRACH resource may be predefined and a low-cost UE may be informed whether the network supports decoupled mode. A subset of PRACH preambles may be reserved to indicate the decoupled channel condition.

[0048] A higher layer signaling (e.g. RRC signaling) may be used to indicate the decoupled channel condition after RRC connection setup. The configuration information of decoupled mode may be provided, e.g., via higher layer and the low-cost UE may switch from coupled mode to decoupled mode.

[0049] A UE may attempt random access to the cell with an RSRP (e.g., best RSRP), e.g., the Macro cell. The UE may determine that it may attempt decoupled (or simultaneous) random access to both Macro and LPN, e.g., when the UE fails random access x times, where x may be pre-configured or may be stated in a SIB. A UE may determine that it may attempt decoupled (or simultaneous) random access to both Macro and LPN, e.g., when the UE fails random access after using max PRACH transmission power. The trigger that a UE may use to switch to decoupled operation (e.g., the value of x or the threshold) may be included in a SIB transmitted by the Macro cell.

[0050] A UE may, e.g., in one of the SIBs of the Macro cell, receive information related to cell selection and reselection for UL access to the Macro cell. For example, the UE may receive a minimum pathloss threshold and an offset. The UE may determine if the cell is suitable for UL access, based on the received information. The UE may perform UL cell selection and suitability check upon meeting the RSRP or RSRQ based (e.g., as specified in

3GPP Rel-11) cell suitability criteria or the cell selection and UL cell selection. If the UL cell suitability criteria are not met, the UE may, e.g., based on the Macro cell SIB information, attempt to search a more suitable cell, e.g., another Macro cell or an LPN cell, for UL access. The UE may continue to use the Macro cell for DL connectivity, e.g., if the legacy cell selection criteria have been met. For cell re-selection, a UE may monitor UL conditions (e.g., current UL conditions) with neighboring Macro and LPN cells and may perform UL cell re-selection, e.g., if another cell provides better UL conditions than the current cell. For example, the cell selection criteria may be based on pathloss measurements. The UE may perform cell reselection, e.g., if a neighbor LPN cell pathloss is an offset better than the current cell pathloss. The UE may perform cell re-selection monitoring, e.g., based on information provided by the Macro cell SIBs.

[0051] Inter-frequency operation for decoupled mode may be provided. The decoupled mode may be supported for the case where the frequency bands are different for LPN and Macro cell in FDD and/or TDD. For example, if decoupled mode is used with different frequency bands for LPN and Macro in TDD, it may be an FDD operation since the frequency band for the uplink may be distinct from the downlink. A low-cost UE for TDD may provide a duplexer, which may increase the cost of device. In another example, A frequency restriction may apply for the uplink band (e.g., from LPN) such that the uplink frequency band may be separated from downlink frequency band, e.g., if the duplexer is designed for a certain FDD carrier with a specific band separation. The specific band separation may be assumed in a coupled case. The following solutions may be used for decoupled mode, e.g., if the frequency band is different for LPN and Macro cells.

[0052] A duplex capability of a low-cost UE, e.g., supporting decoupled mode, may be reported or informed to a Macro cell. The Macro cell may indicate and/or configure a certain range of EARFCN (E-UTRA Absolute Radio Frequency Channel Number), e.g., on receiving the duplex capability of the low-cost UE. The EARFCN may be used as uplink cell search for the low-cost UE in decoupled mode. A range of EARFCN may not be used for uplink cell search in decoupled mode. This range of EARFCN may be configured and/or informed to the low-cost UE. The EARFCN range may be replaced with LPN list for decoupled mode in which the LPN list and its associated information for uplink cell search may be included. The associated information may include, e.g., frequency band (e.g. EARFCN), duplex mode (e.g. FDD or TDD), bandwidth, base station transmission power, etc. The Macro may configure the UE with fallback operation, e.g., if the EARFCN is not available with the duplex capability for the low-cost UE. The UE may select (e.g., autonomously select) a fallback operation. The fallback operation may include, e.g., one or more of scenarios where a UE may assume that an

uplink cell may be the same as the selected downlink cell, a UE may try to reselect downlink cell, or a radio link failure may restart a cell search. A coupled mode operation may be considered as a fallback operation so that a UE may assume that the uplink cell is the same as the selected downlink cell. A low-cost UE may try to reselect downlink cell which may have an LPN with adequate frequency separation (e.g., at least of nominal band value). The unavailability of the EARFCN may be considered as radio link failure so that the low-cost UE may restart the cell search. The duplex capability may be informed as reference EARFCN which may have minimum band separation supported in the low-cost UE. The duplex capability may be informed as actual value of band separation number.

[0053] A Macro cell may broadcast a list of LPNs, which may be used for uplink cell selection with frequency band information. A low-cost UE may autonomously remove the LPNs for which the uplink band separation is smaller than for the coupled mode. If there is no LPN available in the list provides a duplex capability of the low-cost UE, the UE may assume that decoupled mode is not supported in the cell. A low-cost UE may reselect downlink cell until the UE finds a pair of downlink and uplink cells with adequate frequency separation (e.g., at least of nominal band value). The low-cost UE may report to the Macro cell information about the selected uplink LPN cell.

[0054] Transmission power limitation may be used, e.g., if the band separation of decoupled mode is less than the minimum band separation of coupled mode. For example, if a low-cost UE detects an inappropriate frequency separation which may be resolved through limitation of its output power, the UE may report its maximum allowed power for the UL frequency (e.g., if the nominal separation is 45MHz and the LPN uses an UL frequency that is 40MHz apart, a low-cost UE output power limitation to 20 or 17dBm may compensate for the lack of separation). The UE may report power headroom (PHR) based on its own maximum allowed power, e.g. if the UE reports maximum power limitation that is lower than the one supported through deployment by the LPN (e.g., $P_{c,max}$). A UE may report a negative power headroom, e.g., when the UE's allowed power is exceeded but under the maximum LPN allowed power ($P_{c,max}$).

[0055] The UE may use the Power Management Reduction (P-MPR) bit that may be associated with a half FDD operation to signal the power limitation for half duplex FDD case. A Macro may select LPN as an uplink cell for a low-cost UE configured with decoupled mode based on PRACH preamble detection and/or the duplex capability information reported from the low-cost UE. A low-cost UE may report capability of duplex capability. The low-cost UE may be configured with an uplink cell from the selected downlink cell.

[0056] Half duplex FDD (HD-FDD) mode may be used for low-cost UE in TDD network with decoupled operation, e.g., if the frequency band for LPN and Macro is different. For this decoupled operation, a low-cost UE may report HD-FDD, select duplex mode of operation between TDD and HD-FDD.

[0057] A TDD low-cost UE may report or indicate HD-FDD capability. The UE may perform cell selection procedure separately for uplink and downlink, e.g., if the low-cost UE has HD-FDD capability and use decoupled mode. For the TDD subframe configuration for Macro and LPN. The low-cost UE may assume that Macro and LPN may have the same TDD subframe configuration and the subframe configuration may be acquired from broadcasting channel from the Macro cell. The low-cost UE may assume that the uplink subframe configuration of LPN may be at least the same with that for Macro or a subset of the uplink subframes of Macro. The low-cost UE may receive broadcasting channels for both Macro and LPN. If TDD subframe configuration is different between Macro and LPN, predefined priority rules may be applied. In an example, the downlink subframes in the Macro cell may have higher priority than the uplink subframes in LPN. In another example, the uplink subframes in LPN may have higher priority than downlink subframes in the Macro cell. A low-cost UE may select duplex mode of operation between TDD and HD-FDD, e.g., on selecting a downlink cell. For example, a low-cost UE may select a downlink cell based on a predefined criterion. The UE may perform uplink cell selection, if a measured signal satisfies a predefined coverage limited condition. The UE, e.g., upon selecting an uplink cell, may select TDD, e.g., if the selected uplink cell is the same as selected downlink cell. The UE may otherwise select an HD-FDD. A low-cost UE selected HD-FDD may indicate the UE's duplex capability as HD-FDD. A low-cost UE selected TDD may indicate the UE's duplex capability as TDD and HD-FDD.

[0058] For the HD-FDD operation for the TDD low-cost UE with decoupled mode, a guard subframe may be introduced for switching between uplink and downlink. For example, N_{guard} subframes may be used between uplink and downlink subframes. The N_{guard} may be a positive integer number. The N_{guard} may be predefined and/or configured, e.g., via a higher layer, or implicitly configured according to the downlink and uplink subframe configuration. The guard subframe may be introduced, e.g., while switching from downlink to uplink. Further, the uplink and downlink subframe switching may be based on radio frame number (e.g., an SFN frame). For example, even numbered radio frame may be used for downlink and odd numbered radio frame may be used for uplink. The guard subframe may be introduced in the N_{guard} last subframes in the downlink radio frames. The TDD operation may be considered as default mode and HD-FDD mode may be configured. In an example, a low-cost UE may operate with TDD

mode, e.g., until the RRC connection. The low-cost UE, e.g., using the RRC connection may be configured to HD-FDD mode.

[0059] Half duplex FDD mode may be used for low-cost UE in FDD network with decoupled operation if the frequency band for LPN and Macro is different. The UE may perform cell selection separately for uplink and downlink, e.g., if the low-cost UE has HD-FDD capability and uses decoupled mode. For the subframe configuration for uplink and downlink, a predefined rule may be applied to defined uplink and downlink subframes. For example, one or more of the subframes (e.g., subframe number 0, 4, 5, or 9) may be designated as downlink subframes. The subframes other than the downlink subframes may be designated as uplink subframes. The MBSFN subframe configuration may be used so that the subframes configured as MBSFN subframe may be considered as uplink subframe and the other subframes may be considered as downlink subframe. The uplink and downlink subframes may be configured, e.g., via higher layer signaling. One or more downlink subframes may be designated as default downlink subframes. For the data channels, uplink and/or downlink subframes may be dynamically configured based on HARQ process. For example, if a UE receives downlink assignment in subframe n the $n+4$ subframe may be assigned as an uplink subframe.

[0060] UE measurements and channel feedback may be provided. If a low-cost UE is configured and/or selects the half duplex FDD mode as decoupled mode may be used to compensate the self desensing of low-cost UE receiver. For example, the UE may avoid taking samples from DL subframes that may overlap with UL transmissions, e.g., for the RSRP/RSRQ, CQI, CSI RLM (Radio Link Monitoring) measurements. For example, the UE may avoid transmitting feedback measurements or delay transmission while monitoring DL control channels or being scheduled for reception. The UE may store feedback measurements in case the feedback scheduling time overlap with a DL reception. The UE may drop the measurements that may be considered obsolete and may restart the process until the next feedback occasion. The eNB may request an aperiodic measurement, e.g., if UE skips the period occasion(s). For example, the UE may drop an SR transmission, e.g., if the SR transmission overlaps with scheduled DL data. The UE may scale SR power and transmit the SR, if the UE uses power limitation alternative for half duplex FDD.

[0061] Low Power Node (LPN) discovery for an LC-MTC device may be provided. A Low-cost UE may discover an LPN, e.g., for UL transmissions. Such a Low-cost UE may determine that it may be better served in a decoupled manner and may thus trigger discovery of such LPN cells. The LC-MTC may be configured to discover, e.g., via one or more LPNs that may enable the LC-MTC to enable decoupled operation. The LC-MTC may perform discovery

of small cells with or without the Macro cell assistance.

[0062] LPN discovery with Macro cell assistance may be provided. A UE may be provided with the configuration of one or more LPNs. Such configurations may enable a UE to take relevant measurements. Such configurations may enable the UE to perform random access on the LPN. The random access may indicate (e.g., explicitly and/or implicitly) to the LPN that the random access is for UL transmissions and that DL may be continued from the Macro cell.

[0063] The Macro cell may provide a list of LPN configurations to the UE. The list of LPN configuration may include one or more of an identity (or index) for each LPN, e.g., along with reference signal (RS) configuration, time and/or frequency offset (e.g., with respect to the time and/or frequency of the Macro cell), RACH parameters, UE identity (e.g., C-RNTI, RA-RNTI, SI-RNTI, P-RNTI) to use with each LPN, UL bandwidth, frame timing (possibly as an offset), system frame number (possibly as an offset), or cell identity. The UE may be configured to maintain an identity (e.g., an C-RNTI) for the LPN independent of the C-RNTI used by the Macro cell for DL transmissions. The UE may determine the C-RNTI to be used by the LPN as a function or an offset value of the C-RNTI used by the Macro cell.

[0064] The configuration of LPN cells may be used for UL transmission. The configuration may be UE-specific and may be provided, e.g., via higher layer signaling to UEs that have Macro cell access. A UE may be triggered to obtain measurements on a subset of the LPNs in the pre-configured list. Such triggering may be dynamic, e.g., via physical layer signaling and/or higher layer signaling. The list of LPN cells along with their parameters may be provided by a System Information Block (SIB) and/or PBCH transmission from the Macro cell. This may enable UL access to LPN cells by UEs that may be unable to obtain UL access to the Macro cell. One of the SIBs of the Macro cell may indicate a set of triggers and measurement states that a UE may use to determine that it should attempt decoupled operation.

[0065] Configuration of LPN reference signal by the Macro cell may be provided. A UE may be configured by a Macro to take measurements, e.g., on one or more LPNs. The measurements may be enabled by the configuration of reference signals (RS). For example, a Macro cell may indicate to a UE a CRS configuration. The CRS configuration may include one or more of a cell ID, a time and a frequency location, a subframe periodicity and an offset, an RS sequence, an RS sequence initialization, or a v-shift, transmission power. A Macro cell may indicate to a UE a CSI-RS configuration that may be used for measurements. The CSI-RS configuration may include one or more of a cell ID, an RE mapping, a subframe periodicity, a subframe offset, an RS sequence, an RS sequence initialization, or a transmission power. A UE may be configured to make measurements on a RS transmitted by LPNs to enable measurements

by UEs that may be unable to use one or more cell discovery mechanisms (e.g., legacy cell discovery mechanisms). Such a configuration may include one or more of a coarse (or fine) RE mapping, a subframe periodicity and an offset (e.g., based on the subframe timing of the Macro cell), an RS sequence, an RS sequence initialization (e.g., based on a cell ID), or a transmission power. The Macro cell may provide a timing and frequency offset value to enable appropriate measurements by the UE, e.g., for the RS configurations.

[0066] A UE may begin taking measurements on the RS, e.g., when the UE is provided with RS configurations. The UE may measure RSRP/RSRQ type measurements. The UE may determine the pathloss of the appropriate LPN. The UE may attempt to determine the time and frequency offset (e.g., relative to the Macro cell transmission). A UE may determine the state of the LPN (for example, if it allows decoupled operation), e.g., based on the measurements taken. The UE may feed one or more measurements (e.g., as described herein) back to its Macro cell. For example, a UE may be configured to take measurements on a plurality of LPNs. The UE may feed a subset of the measurements back as described herein, to the Macro cell. The UE may be configured with an identity for each LPN in the measurement configurations, e.g., when the UE feeds back measurements for a plurality of LPNs. The UE may feed measurements for a subset of the configured LPNs back. The UE may have triggers and thresholds configured to determine the appropriate subset of LPNs for which the UE may feed measurements back. For example, a UE may report measurements for LPNs whose frequency and/or time offset may be within an allowable value, and/or a UE may report feedback for the LPN with the smallest pathloss.

[0067] A UE may begin random access to an LPN, e.g., in determining that an LPN is appropriate for UL transmissions. The random access may be a modified random access to indicate to the LPN that the UE may be attempting access for the purpose of UL transmissions. The random access may indicate to the LPN the Macro cell, the UE may use for DL transmissions (or, e.g., is expected to use for DL transmissions). The UE may obtain the RACH configuration from the LPN or the Macro cell.

[0068] A UE may be configured by a Macro cell to enable LPN discovery for possible UL transmissions. In one method, the Macro cell may provide a set of PRACH resources on which the UE may attempt random access to the LPN. For example, the random access may be a legacy type random access or may be a modified random access for UL transmissions only. The Macro cell may indicate a subset of PRACH preambles to be used by the UE when attempting random access on the LPN. Such a subset of preambles may be interpreted by the LPN as an indication that the UE may wish to have access for UL transmissions. The physical PRACH

resources (e.g., the time and frequency resources, as well as a set of subframes) may be configured by the Macro cell for the UE. Reception of a PRACH preamble in any pre-configured subset of resources by the LPN may indicate to the LPN that the UE may wish to have UL access while maintaining DL access to the Macro cell.

[0069] The RACH configuration provided by the Macro cell may indicate guard time (e.g., required guard time) to the UE. The guard time may be adjusted for decoupled random access, e.g., to mitigate possible timing errors caused by a UE that may be unable to synchronize to the LPN. The RACH configuration provided by the Macro may include a frequency offset, e.g., for reasons as that stated for the increased guard time. The Macro cell may include a pathloss offset value. The pathloss offset value may be used by the UE to determine an appropriate initial transmission power of the PRACH preamble. The Macro cell may include an absolute power level to be used by the UE for its initial PRACH preamble transmission. Such a configured UE transmission power may be provided to the LPN or may be used at the Macro cell (or any other controlling entity) to determine the pathloss between the UE and the LPN, e.g., based on the received power of the PRACH preamble at the LPN.

[0070] LPN discovery without Macro cell assistance may be provided. A UE may determine that it may not have UL transmissions to a Macro cell and/or that it may be better served by having UL transmissions to an LPN. The UE may attempt to discover LPN that may provide better UL coverage. A UE may detect (e.g., autonomously detect) LPNs that may be adequate for UL transmissions. Such detection may be based on legacy detection mechanisms and/or on measurements taken on a discovery signal.

[0071] The UE may attempt random access to that LPN, e.g., on discovering an adequate LPN. The UE may attempt a modified random access to that LPN. The modified random access may indicate to the LPN that the UE may wish to connect for UL and that DL may be handled by a Macro cell. The UE may report to the Macro cell one or more LPNs the UE may use for UL transmissions. The UE may report to the LPN or the Macro cell, the timing and/or frequency and/or pathloss offsets of the LPN with respect to the Macro cell.

[0072] Simultaneous random access to LPN and Macro cell may be provided. A UE may be unable to have an UL coverage to the Macro cell or a DL coverage from the LPN. The UE may perform random access (e.g., simultaneously perform random access) to LPN and Macro cell. For example, a UE may transmit an appropriate PRACH preamble to a nearby LPN, upon obtaining the PRACH preamble transmission parameters. The PRACH preamble may implicitly (e.g., by use of a pre-configured subset of preambles and/or time/frequency resources) or explicitly indicate to the LPN the Macro cell from which the UE may like to have DL

connectivity.

[0073] The UE may expect a Random Access Response (RAR) message from a Macro cell for which it may have DL coverage. The window frame within which a UE may expect a RAR from the Macro cell may be increased, e.g., to allow for backhaul communication between the LPN and the Macro cell. Such a RAR message may include a configuration for the transmission of a random access message (e.g., a random access message 3) by the UE to the LPN. The configuration may include one or more of an UL grant, a cell ID, a C-RNTI, a timing advance command, or an UL DM-RS configuration. The UE may transmit message 3 to the LPN and may expect any contention resolution message to be transmitted by the Macro cell. The UE may consider itself connected to the Macro for DL and to the LPN for UL.

[0074] LC-MTC device discovery by an LPN may be provided. A UE may be configured by a Macro cell with one or more PRACH resources to use, e.g., in case the LC-MTC may be unable to have UL transmission to the Macro cell. The PRACH resources may include one or more of a subset of preambles, a set of time and/or frequency resources, one or more subframes, or a transmission power setting. A UE may broadcast a PRACH preamble from the configured subset, e.g., when the UE determines that it requires LPN for UL transmissions. The PRACH preamble transmission may be designated as a broadcast, e.g., if the UE may not be aware of what LPN may be capable of receiving the transmission.

[0075] A broadcasted PRACH preamble transmission may use a power level (e.g., a pre-determined and fixed transmission power level). For example, a UE may be configured to transmit the PRACH preamble one or more times. Each PRACH preamble transmission may have a pre-configured power level, and the power levels may be constant over each of the PRACH preamble transmissions. The transmission power used for PRACH preamble transmission may be explicitly configured by a Macro cell. The PRACH preamble transmission power may be configured to be the max UE transmission power. The PRACH preamble transmission power may be a function (or equivalently, an offset) of the transmission power used for any UL transmission to the Macro. The PRACH preamble transmission power may be selected (e.g., jointly selected) with the PRACH preamble and/or the PRACH time/frequency used. The LPNs may be enabled to receive the PRACH preamble transmission to determine the transmission power used by the UE.

[0076] A Macro cell may configure one or many LPNs with the one or more parameters to receive a broadcasted PRACH preamble by a UE that may experience poor UL coverage to the Macro cell. The configuration may be provided over X2 interface. The contents of the configuration may include one or more of a set of preambles, one or more time/frequency

resources, or transmission power characteristics. The LPNs may indicate to the Macro cell the PRACH configuration that may be used by UEs for broadcasted PRACH preamble transmission.

[0077] The Macro cell may configure one or more LPNs with information relating to the UEs that may use broadcasted PRACH preamble transmission. For example, the Macro cell may inform the LPNs of the identity of UE(s) that may transmit a PRACH preamble in case of decoupled operation. The Macro may indicate to the LPNs one or more of an C-RNTI used by the Macro, a pathloss to the Macro, a timing and frequency offset of the Macro, or security keys used by the UE at the Macro cell.

[0078] Upon reception of a broadcasted PRACH preamble, an LPN may transmit an acknowledgement to the Macro or to some other centralized entity. For the case where multiple LPNs have received the PRACH preamble transmission, the Macro and/or the centralized entity may determine, based on the contents of the acknowledgement, the appropriate LPN. The Macro and/or centralized entity may then indicate to the LPN whether it has been selected or not for the decoupled operation of the UE.

[0079] An acknowledgement may be transmitted by the LPNs that may receive the PRACH preamble transmission. The acknowledgment may be sent over the X2 interface. The acknowledgement may include parameters associated with the received PRACH preamble transmission. For example, the acknowledgement may include one or more of the received preamble IDs, a UE ID, the resources on which the PRACH preamble was received, the received power, the pathloss (e.g., which may be determined based on the received power as well as explicit or implicit determination of the transmission power used), or a time and/or frequency offset value. The acknowledgement may include an allowed UL grant, a timing advance command and a frequency offset command that the Macro cell may provide to the UE. Such a grant may be used for a random access message 3 type communication or for other UL transmissions for the UE.

[0080] Time and frequency synchronization for UL transmissions may be provided. LPNs may synchronize (e.g., synchronize regularly) with the Macro cell to enable UEs to decoupled operation. Such synchronization may be performed via X2 interface. A Macro cell may indicate a time and/or frequency offset value the LPN may use to better align with the Macro cell. For example, such tuning may be performed in a periodic manner. Such tuning may be done aperiodically and/or based on a request from the LPN and/or a recommendation from the Macro cell.

[0081] The LPN may attempt to synchronize using over-the air methods. For example, a LPN may determine the timing and frequency of the Macro cell, e.g., by detecting the PSS/SSS

and/or CRS of the Macro cell. The LPN may assume that the timing and frequency of the Macro cell may be experienced by UEs under its coverage, if the LPN has limited coverage and the UEs served by the LPN are located near to the LPN. An LPN may perform a random access to the Macro cell and may be provided with a timing advance command. Such a random access may be used by LPN and Macro cells for synchronization purposes. The random access may not lead to the LPN being granted UL resources to the Macro cell. An LPN may determine the timing advance command to be provided to a UE, e.g., with UL connectivity to the LPN.

[0082] A UE may determine the time and frequency offset of a LPN with respect to the Macro cell. The UE may report to the LPN the offset values, e.g., if the offsets are greater than a threshold value. The UE may request synchronization (e.g., tighter synchronization) of the LPN to the Macro cell. UE synchronization to one or more points may be provided. A UE may maintain synchronization with one or more (e.g., two) non-synchronized points. The UE may segregate the UL synchronization from the DL synchronization. A UE may maintain separate timing and/or frequency offsets for UL and/or DL transmissions. The DL synchronization may be obtained from the PSS/SSS and/or CRS/CSI-RS transmissions of the Macro cell. The UL synchronization may be obtained from the PSS/SSS and/or CRS/CSI-RS of the LPN. The UL synchronization may be obtained as an offset value of the DL synchronization values. The offsets to use may be provided by the Macro cell, e.g., via higher layer signaling. The appropriate offsets to use may be broadcasted by the Macro cell (e.g., using an SIB). A UE may understand a timing advance command transmitted by the Macro cell. The timing advance may be used as an offset value on its UL transmissions and/or based on current UL synchronization.

[0083] The UE and/or eNB may use one or more mechanisms for HARQ operation including, for example, SR-based PDSCH HARQ (e.g., using bundling, constellation points, and/or resource sets), legacy PUCCH-based HARQ, PUSCH-based HARQ, modified PDSCH HARQ timing, etc.

[0084] The UE may not transmit an ACK/NACK signal, e.g., upon to the reception of a PDSCH using the PDSCH HARQ ACK/NACK timing. Following the transmission of a PDSCH by the eNB, e.g., the eNB may not expect to receive an ACK/NACK from the UE using the PDSCH HARQ ACK/NACK timing of the R11 and/or prior releases.

[0085] SR-based PDSCH HARQ ACK/NACK may be provided. The UE on the reception of one or more PDSCHs may transmit the related PDSCH HARQ ACK/NACK using Scheduling Request (SR) resources and/or signal. The eNB, e.g., on the transmission of one or more PDSCH by the eNB, may receive the related PDSCH HARQ ACK/NACK by receiving a signal on an SR resource and/or an SR signal.

[0086] SR-based PDSCH HARQ ACK/NACK (e.g., using bundling) may be provided. A UE may bundle the HARQ ACK/NACK bits corresponding to one or more PDSCH, received in a time window, into one or more ACK/NACK bits. The UE may receive a configuration of the HARQ bundling time window through higher layer signaling, possibly from eNB. The HARQ bundling window may be represented with one or more parameters including, for example, a window size (e.g., represented in number of subframes, e.g., n frames), a window offset (e.g., represented in number of subframe, e.g., m subframes), etc. The window size, for example, may be set to the same value as the number of subframes between two consecutive configured SR resources. The window offset, for example, may be defined and/or configured as a number of subframes (e.g., $m=4$) before the subframe containing the next SR resource (e.g., the SR resource to be used to carry the corresponding PDSCH HARQ ACK/NACK bits). For example, for a UE with $n=10$ and $m=4$, the UE may receive each of the potential PDSCHs in a window with the size of 10 subframe which may end 4 subframes before the next SR resource. The UE may determine the PDSCH HARQ ACK/NACK bits for each of the received PDSCHs within the window. The UE may bundle each of those bits into a single ACK/NACK bit, and may send the bundled ACK/NACK bit using the next SR resource. An eNB may receive of a bounded PDSCH HARQ feedback. The eNB may apply the received HARQ feedback for each of the PDSCHs transmitted to the UE during the corresponding PDSCH transmission window.

[0087] SR-based PDSCH HARQ ACK/NACK (e.g., using constellation points) may be provided. A UE may not send PDSCH negative acknowledgement to the eNB. The UE may send PDSCH positive acknowledgement to the eNB. The UE may send an actual transmission request to the eNB, e.g., using a PUCCH in the SR resources, which may include the same constellation point as for a negative HARQ PUCCH acknowledgement. The UE may send a PUCCH in the SR resources, which may include the same constellation point as for a positive HARQ PUCCH acknowledgement as a positive PDSCH HARQ acknowledgement for the corresponding PDSCH(s). The negative and positive acknowledgments may be presented by different constellation points. The eNB may expect to receive a PDSCH HARQ ACK/NACK with a predefined time frame. If the eNB does not receive a positive acknowledgement during the predefined time frame, it may assume that a negative acknowledgment for the corresponding PDSCH(s).

[0088] A UE may not send PDSCH positive acknowledgement to the eNB. The UE may send PDSCH negative acknowledgement to the eNB. The UE may send a transmission request to the eNB, e.g., using a PUCCH in the SR resources, which may include the same constellation point as for a negative HARQ PUCCH acknowledgement. The UE may send a PUCCH in the

SR resources, which may include the same constellation point as for a positive HARQ PUCCH acknowledgement as a negative PDSCH HARQ acknowledgement for the corresponding PDSCH(s). The negative and positive acknowledgments may be presented by different constellation points. The eNB may expect to receive a PDSCH HARQ ACK/NACK with a predefined time frame. The eNB may assume a positive acknowledgment for the corresponding PDSCH(s), e.g., if the eNB does not receive a negative acknowledgment during a time frame (e.g., a predefined time frame).

[0089] SR-based PDSCH HARQ ACK/NACK (e.g., transmitted on SR resource sets) may be provided. A signal transmitted on SR resources may not include a UL transmission request from the UE. The eNB may not interpret each PUCCH received in a SR resource as the one including an actual UL data transmission request from that specific UE. The UE may send PUCCH to inform the network of its UL transmission request in a subset of the SR resources. The UE may receive indications on the SR resources to use for this purpose. For example, the UE may receive a second configuration for the SR resources. The second configuration may indicate a subset of PUCCH resources provided by the first (main) configured SR resources. As an example, the UE may receive a configuration parameter, e.g., a parameter r which may indicate that each r -th SR resource (e.g., each r -th subframe including SR resources for that UE) may carry an actual UL transmission request and/or possibly not the potential PDSCH HARQ ACK/NACK bit(s).

[0090] The UE may send PUCCH to inform the network of its PDSCH HARQ ACK/NACK in a subset of the SR resources. The UE may receive indications on which SR resources to use for this purpose. For example, the UE may receive a second configuration for the SR resources. This second configuration may indicate a subset of PUCCH resources provided by the first (main) configured SR resources. As an example, the UE may receive a configuration parameter r which may indicate that each r -th SR resource (e.g., each r -th subframe containing SR resources for that UE) may carry PDSCH HARQ ACK/NACK bits and/or possibly not the potential UL transmission request.

[0091] Legacy PUCCH-based HARQ ACK/NACK may be provided. The UE may not send PDSCH HARQ ACK/NACK bits (e.g., via PUCCH) in each UL subframe. The UE may receive a configuration parameter indicating the subframes the UE may use to send PDSCH HARQ ACK/NACK bits (e.g., via PUCCH). The UE may receive a configuration parameter, e.g., a parameter r which may indicate that each r -th subframe may include PUCCH resources allocated to the UE and/or the UE may transmit PDSCH HARQ ACK/NACK bits (e.g., via PUCCH) in those subframes. One or more UEs may be configured by the same PUCCH

resources and/or the same PUCCH indexes. One or more UEs may be configured to send PDSCH HARQ ACK/NACK bits (e.g., via PUCCH) in different subframes.

[0092] PUSCH-based HARQ ACK/NACK may be provided. A UE may transmit a PUSCH carrying the corresponding PDSCH HARQ ACK/NACK bit(s), e.g., when the UE receives one or more PDSCH. The UE may not transmit a PUCCH including the corresponding PDSCH HARQ ACK/NACK bits, when the UE receives one or more PDSCHs. The UE may transmit the PDSCH HARQ ACK/NACK bit(s) of one or more PDSCHs in the same PUSCH. For example, the UE may transmit the HARQ ACK/NACK bit(s) of each PDSCH received in a certain period of time, e.g., a time window, in the same PUSCH. This window may be referred to as HARQ bundling window. A PUSCH may carry PDSCH HARQ ACK/NACK bit(s) and/or information regarding the corresponding PDSCH(s). For example, the PUSCH may carry indications of the DL HARQ processes of the corresponding PDSCH(s). The PUSCH may carry indications of the frequency and/or time locations the corresponding PDSCH(s) may be received. The UE may receive one or more configuration parameters defining the HARQ bundling window, e.g., window size. The size of the bundling window may be a value equal or greater than one. The UE may receive one or more UL grants for each window to carry the PDSCH HARQ ACK/NACK bits of the corresponding window. The UE may derive the frequency, time location and/or other transmission parameters of the PUSCH carrying the PDSCH HARQ ACK/NACK bits based on one or more DL grants of the PDSCH and/or PDSCH in the corresponding HARQ bundling window. For example, the transmission parameters of the PUSCH carrying the PDSCH HARQ ACK/NACK bits may be derived based on the characteristics of the first (or last) PDSCH grant in the corresponding bundling window. The UE may derive the frequency, time location and/or other parameters of the PUSCH carrying the PDSCH HARQ ACK/NACK bits, e.g., based on the boundaries of the bundling window. For example, the related PUSCH may be transmitted in n subframes after the end of the bundling window.

[0093] Modified PDSCH HARQ ACK/NACK timing may be provided. The eNB may be configured to expect to receive the PDSCH HARQ ACK/NACK, from the UE and/or another network entity, within a predefined and/or configured time window (possibly in terms of subframes), e.g., following the transmission of the corresponding PDSCH. The eNB may be configured to expect to receive the PDSCH HARQ ACK/NACK, from the UE and/or another network entity, e.g., after a predefined and/or configured number of subframes following the transmission of the corresponding PDSCH.

[0094] A UE may be configured to operate without HARQ processes for transmission

and/or reception of PUSCH and PDSCH data, e.g. HARQ-less operation. A UE may receive PDSCH data and in response may transmit ACK/NACK in the allocated PUCCH or, if available, in PUSCH. A UE may be configured not to transmit any HARQ-ACK response. In HARQ-less operation, a UE may not receive a re-transmission of PDSCH data corresponding to NACK response as part of the HARQ process. From the UL perspective, a UE may not expect to receive HARQ feedback in response to PUSCH transmission on PHICH from the eNB. For example, a UE may receive HARQ response on the PHICH, but may not re-transmit the PUSCH data in response to a received NACK. For example, a UE may not be allocated with PHICH resource for HARQ-less operation. For UL and DL, the UE, on receiving or transmitting the first transmission of data, may consider the HARQ process completed. In an HARQ-less operation, a UE may use RLC acknowledged mode and ARQ process for retransmissions for reliable data transfers. The ARQ process of AM RLC ARQ may allow for a less stringent feedback time between the transmitter and the receiver, and may allow for additional delays between UL receiving and DL transmitting eNBs, e.g., in the decoupled UL/DL scenario.

[0095] Delivery of MAC CEs between eNB and UE rely on the HARQ processes for feedback and any retransmissions. A UE in HARQ-less operation may be configured with RLC AM with ARQ process for data retransmissions and in-sequence delivery of packets. A UE may not use HARQ processes as a reliable delivery method for delivery of MAC CEs in HARQ-less operation. The UE may be configured with one or more of the RLC S/N to MAC CE mapping, Individual MAC CE delivery, MAC CE based on HARQ feedback, Information included in MAC CE delivered by other layers, or MAC CE including UL grant for reliable delivery of MAC CEs.

[0096] A UE may associate a MAC CE with the sequence number of RLC PDU to which the UE may include the MAC CE to construct the MAC PDU for transmission. The UE may allocate a one-to-one mapping between the MAC CE and the RLC PDU. When the RLC, e.g., based on ARQ feedback needs to retransmit the RLC PDU, the UE may determine the mapping between the re-transmitted RLC PDU sequence number and MAC CE, and may include the MAC CE in the retransmission of the RLC PDU. For example, the UE may transmit a RLC PDU with the MAC CE in the MAC PDU for the first and retransmission for the ARQ process.

[0097] A UE, e.g., for PDSCH transmissions, may receive a single data packet in PDCP that may be segmented into one or more RLC SDUs (e.g., 8 RLC SDUs). Each SDU may be assigned a sequence number (e.g., SN 0 ~ 7) to construct RLC PDUs. Each RLC PDU may be assigned to separate HARQ process. The MAC may include a MAC CE to RLC PDU with SN (e.g., SN 7, which for example the UE may transmit with errors). The error may be indicated by

the receiver RLC entity (e.g., on the network side) with an RLC STATUS PDU, or may be indicated by lower layers, e.g., by an HARQ NACK feedback response from the corresponding HARQ process. In the RLC ARQ retransmission, the UE transmitting RLC entity may again provide MAC with RLC PDU with SN7, and the MAC entity, receiving the SN7 may be re-transmitted and based on the mapping between SN and MAC CE may include the MAC CE into the MAC PDU for transmission by a HARQ process.

[0098] A UE may provide an empty RLC PDU to the MAC layer with headers such that the MAC layer may include MAC CE with the RLC PDU, e.g., to construct the MAC PDU. A UE may use the RLC ARQ process to determine whether the MAC CE has been properly received by the receiver MAC entity, e.g., based on the positive ARQ or negative feedback received. The UE MAC entity may determine whether the MAC CE is properly received based on the single HARQ feedback received by HARQ process which sent the MAC CE. If a negative ARQ feedback and/or HARQ feedback is received for the RLC PDU sequence number which included the MAC CE, the UE may re-transmit the header RLC PDU and the MAC layer may include the same MAC CE for retransmission. On the receiver RLC entity side, an empty RLC PDU may be included into the receiver buffer for the purpose of in-sequence delivery and proper reconstruction of the RLC SDU and for purpose of ARQ process feedback, but otherwise is discarded once the receiver window is moved beyond the RLC PDU, and may not be delivered to high layers.

[0099] To indicate to RLC its intention for delivery of a MAC CE, the MAC layer may provide an indication to the RLC layer to provide an empty RLC PDU, e.g., with RLC PDUs to be transmitted in an upcoming grant. For example, the MAC layer may request the empty RLC PDU from any RLC entity associated with the MAC layer, or possibly may request the empty PDU from the RLC entity associated with the lowest logical channel identifier.

[0100] In HARQ-less operation, a UE may receive a HARQ feedback for any UL transmission and may transmit HARQ feedback for DL reception but may not transmit or receive any retransmissions for a HARQ process. A UE may then determine the reliable transmission and reception of a MAC CE, based on the acknowledgement of the HARQ. For reception of MAC CE in DL, in case a MAC CE reception resulted in NACK, a UE may expect the retransmission of MAC CE in another HARQ transmission. In case of decoupled UL/DL, the DL transmission of MAC CE and the resulting feedback may allow for sufficient tolerance of delay between the eNB which receives the HARQ feedback from the UE to the eNB which transmits and then retransmits the MAC CE in the next DL opportunity.

[0101] For transmission of MAC CE in UL by a UE, the UE may, based on received

NACK feedback for a previous transmission, include the same MAC CE for transmission on a HARQ feedback based on normal procedures for MAC CE inclusion into the MAC PDU for UL transmission. In the transmission, the UE may transmit the MAC CE, or may include it into the MAC PDU with data from higher layers. For example, a UE may transmit ad/or receive MAC CE in multiple HARQ transmissions, repeated in different HARQ processes. A UE may receive and/or transmit multiple repeated MAC CEs regardless of HARQ feedback. A UE may include and/or receive a MAC procedure identifier in the MAC subheader along with LCID, which may indicate the MAC CE type, e.g., in order to distinguish between repeated MAC CEs and a different MAC CE. The number of repetitions may be a function of the coverage enhancement mode for which the UE may be configured, and may be indicated by higher layer signaling from the eNB.

[0102] A UE may provide or receive information indicated in a MAC CE by signaling from a layer; for example, by RRC signaling or PDCCH in physical layer. For example, a UE may use information related to RACH procedure, e.g. RAR, and timing alignment command for decoupled UL/DL and/or coverage enhancement scenario. For example, the UE may receive the one or more of a timing advance command, an UL grant, or an C-RNTI from RRC or PDCCH. The timing advance command may be one or more bits (e.g., 6 or 11 bits) and may indicate timing adjustment amount. For example, in response to preamble transmission, UE may receive this information in PDCCH, e.g., masked with C-RNTI for the UE. The UL grant may be one or more bits long (e.g., 20 bits) and may indicate UL resources to be used for transmission by the UE. For example, this information may be received by the UE in PDCCH masked with C-RNTI. The C-RNTI may be one or more bits long (e.g., 16 bits) and may indicate the UE identifier allocated the cell. For example, a UE may include C-RNTI as part of a RRC message as part of the scheduling request procedure using RACH for UL transmission of data.

[0103] A UE, for example, using decoupled UL/DL for reception and transmission, and in coverage enhancements mode may not use certain MAC CEs for the purpose of assisting the eNB scheduler with information for providing UL grants to the UE. For example, a UE may not be configured to transmit PHR, BSR MAC CEs. For example, a UE may expect not to receive commands such as for DRX, MBMS or carrier activation/deactivation, which a UE in coverage enhancement mode and decoupled UL/DL may not support.

[0104] A UE may be indicated with UL grant information which may be included in a MAC CE received from the network. A UE may use the included UL grant to transmit the corresponding HARQ feedback of received MAC CE information on the allocated PUSCH. The UE may be allocated with PUSCH for the purpose of HARQ feedback rather than using PUCCH

in the decoupled UL/DL scenario. For example, a UE may receive MAC CE with UL grant information for each scheduled PDSCH reception of data, which may be used by the UE to transmit the corresponding HARQ feedback for reception of PDSCH data on PUSCH. The UE may receive reduced UL grant information in the MAC CE. The MAC CE UL grant may include RB assignment and/or modulation and coding scheme. The UE may receive the UL resources for HARQ A/N transmission, or may include resources for UL data and/or for other UL control information.

[0105] As part of RACH related message transmissions, e.g. msg3, UE may rely on HARQ process for feedback and retransmissions for increased reliability of signaling. A UE, by default may have a radio bearer configuration with RLC in transparent mode. For a UE configured for HARQ-less operation, there may be no feedback and retransmission mechanism to ensure reliable signaling for msg3 and possibly RRC connection request for initial connection establishment. For purpose of reliable msg3 transmission in HARQ-less operation, a UE may be configured with one or more of the following.

[0106] A UE may configure a default signaling radio bearer (SRB), e.g., as specified in RRC for UL transmission of msg3 as part of random access procedure. A UE may configure the default SRB with RLC acknowledged mode. The UE may be configured for SRB with RLC AM, e.g., without explicit configuration signaling from the network with default parameter values as defined in RRC. The UE may configure the RLC AM related parameters such as reordering timer (e.g., t-Reordering) with the maximum allowable duration, e.g. 200ms, to allow for the longest delay for coverage enhancement mode operation in the ARQ process. For example, the UE may configure the default SRB with t-Reordering for longer than 200ms, e.g., depending on the coverage enhancement amount that is specified for the UE.

[0107] In a HARQ-less operation, if the msg3 transmission fails, e.g., a UE does not receive *RRC connection setup* message, the UE may re-attempt the msg3 transmission. The UE may be provided with an UL grant, e.g., via PDCCH with the UE C-RNTI which may be pre-allocated by the network, or via the TC-RNTI, which may be allocated to the UE by the previous reception of RAR from the network. The UE may re-use the same resources from the UL grant that was allocated in the initial msg3 transmission attempt. For example, in the UL grant, the UE may receive a semi-persistent scheduling of msg3 in case of unsuccessful transmissions. The UE may be configured with a re-transmission timer and maximum number of msg3 transmission attempts. For example, the UE may use the T300 timer and *maxHARQ-Msg3Tx* IE values, e.g., as specified in SIB of the cell for the purpose in HARQ-less operation. For example, on expiry of the retransmission timer, the UE may attempt a re-transmission of the same msg3 contents in

the same UL resource in the next available UL subframe. The UE may, on reaching maximum number of msg3 retransmissions, reset MAC and indicate to the higher layers of failure of RRC connection establishment. As part of the re-attempt of msg3 transmission, the UE may perform the random access procedure from preamble transmission to the same cell. For example, the UE may receive in the UL grant for initial msg3 transmission configuration for dedicated RACH resources for msg3 re-transmission. The UE may re-use the same dedicated RACH resources on each re-attempt, e.g., until the number of maximum msg3 transmission re-attempt has been reached.

[0108] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element may be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, WTRU, terminal, base station, RNC, or any host computer.

CLAIMS

What Is Claimed:

1. A cell selection method comprising:
measuring a plurality of downlink signals from a plurality of cells;
detecting a channel condition, wherein detecting the channel condition comprises
determining a cell with better uplink coverage than a downlink cell; and
reporting the channel condition as a decoupled channel condition when an uplink cell is
identified with uplink coverage better than the downlink cell.
2. The method of claim 1, wherein the channel condition is reported via a set of Physical
Random Access Channel (PRACH) preambles.
3. The method of claim 2, wherein the set of Physical Random Access Channel (PRACH)
preambles are predefined.
4. The method of claim 1, wherein the channel condition is reported via a higher layer
signaling.
5. The method of claim 1, wherein detecting the channel condition further comprises
measuring an uplink pathloss.

ABSTRACT

Systems, methods, and instrumentalities are disclosed to describe cell selection in low cost machine type communication (LC-MTC) devices. An LTC-MC device may measure a plurality of downlink signals from a plurality of cells. The LTC-MC may detect a channel condition, e.g., by determining a cell with better uplink coverage than a downlink cell. The detection of the channel condition may include measuring an uplink pathloss. The LTC-MC may report the channel condition as a decoupled channel condition, e.g., when an uplink cell is identified with uplink coverage better than the downlink cell. The channel condition may be reported, e.g., via a set of Physical Random Access Channel (PRACH) preambles. The set of PARCH preambles may be predefined. The channel condition may be reported via a higher layer signaling.

100

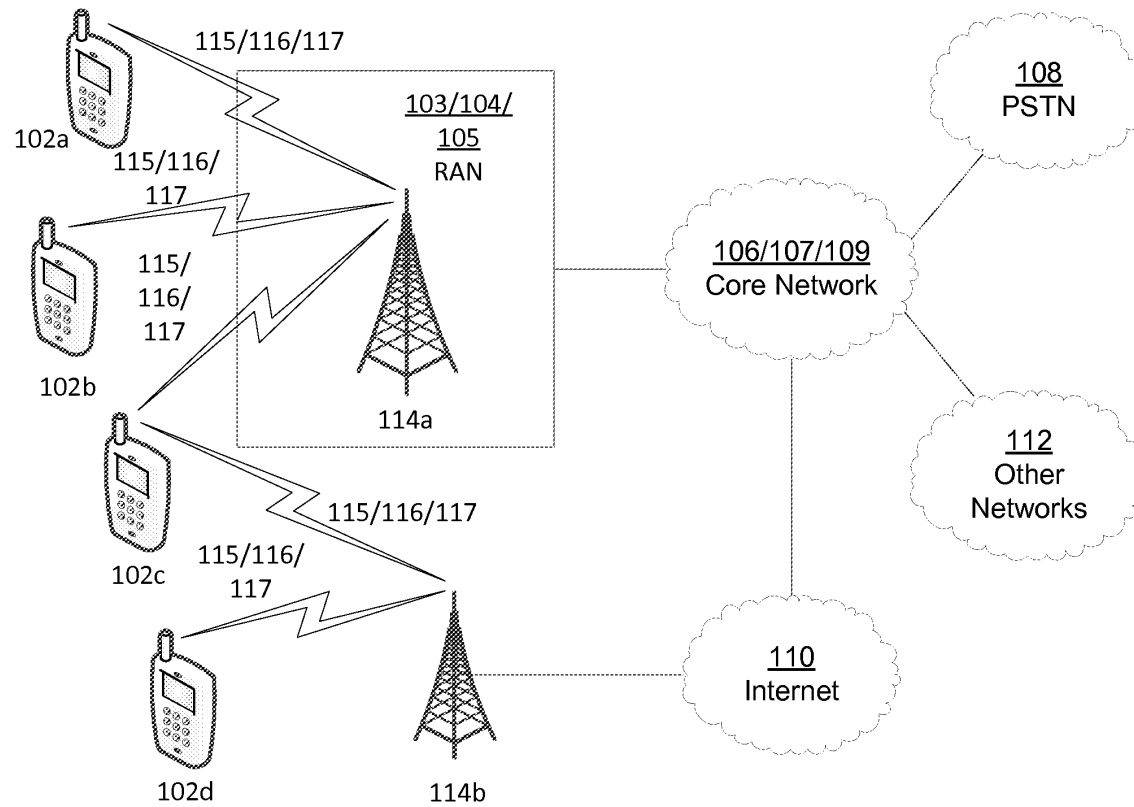


FIG. 1A

1/3

2/3

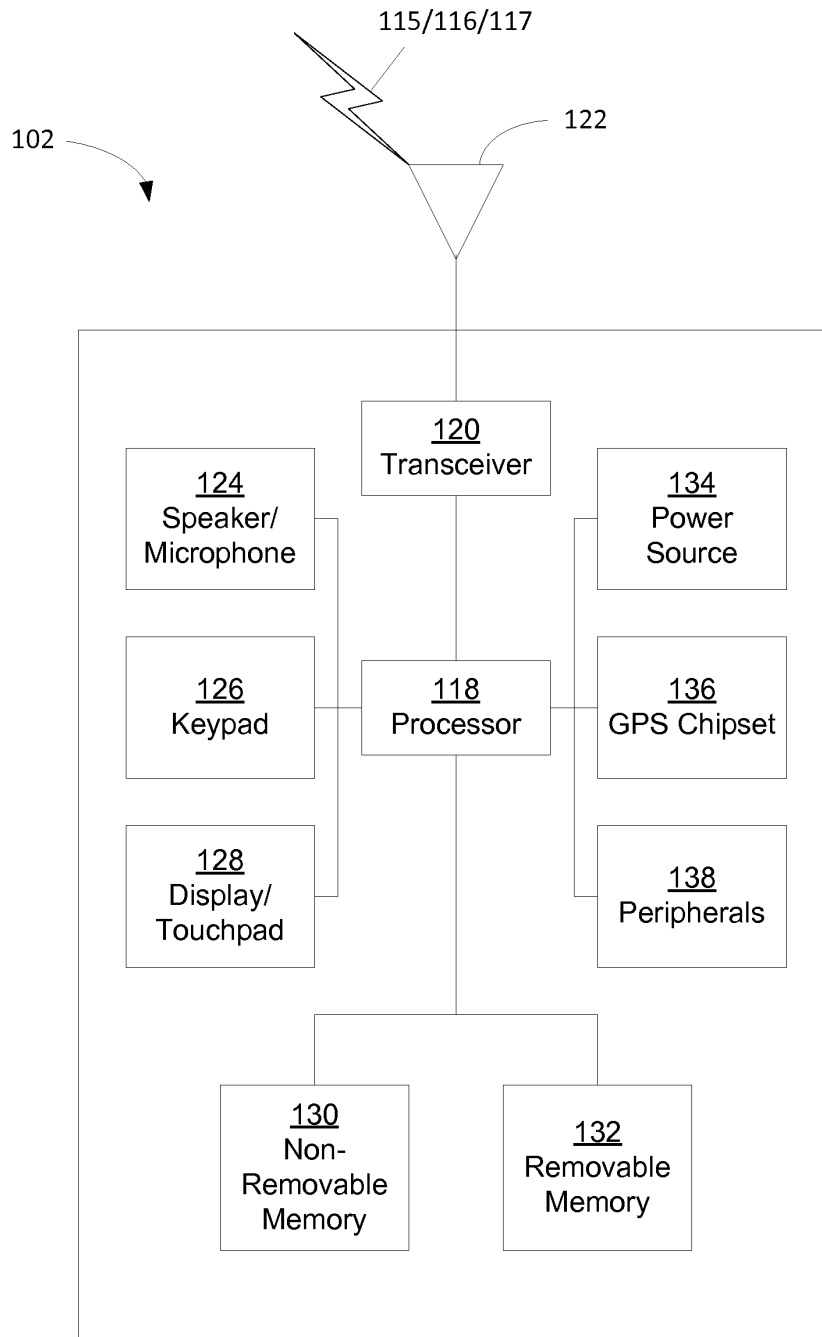


FIG. 1B

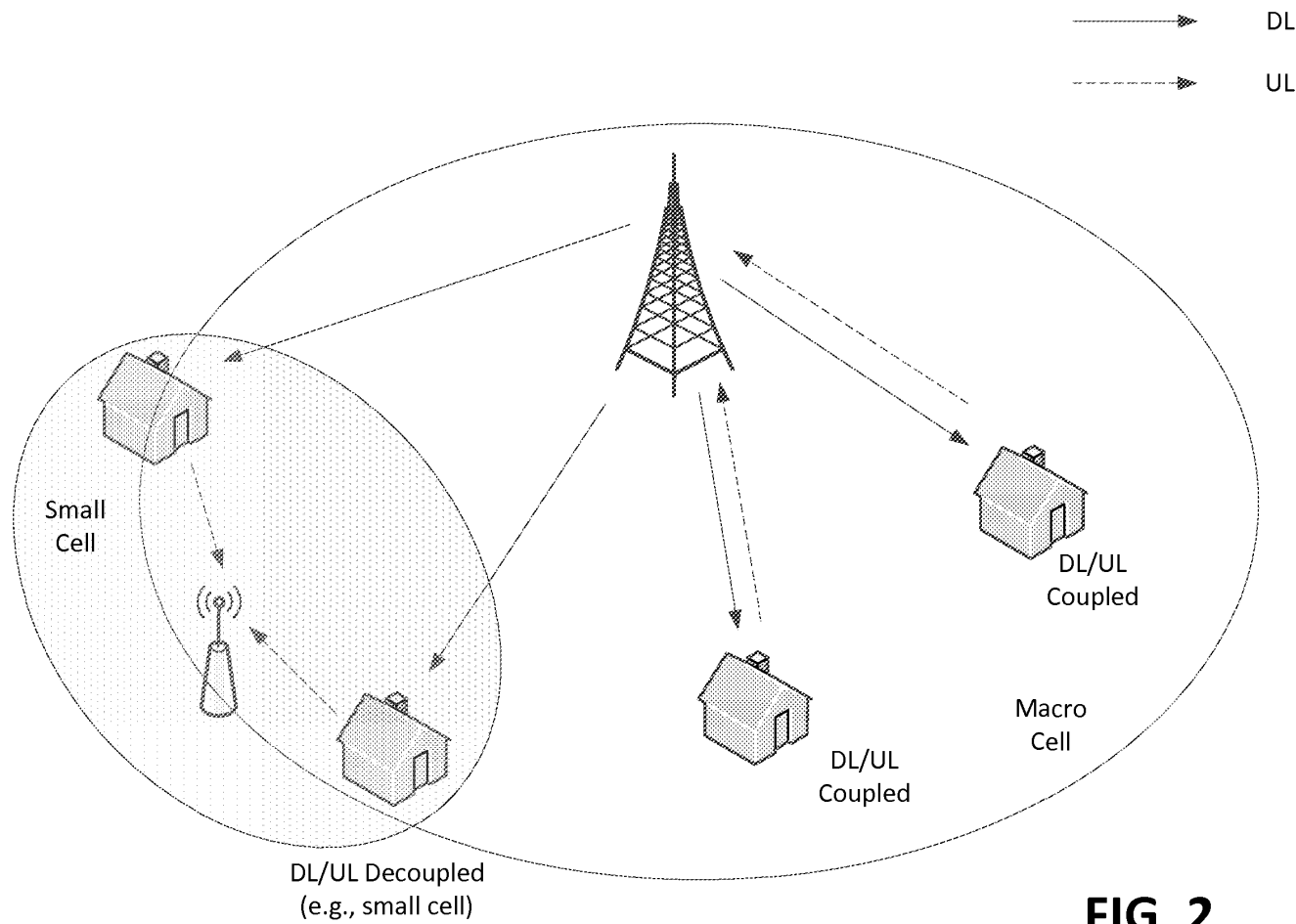


FIG. 2

Electronic Patent Application Fee Transmittal				
Application Number:				
Filing Date:				
Title of Invention:		COVERAGE ENHANCEMENTS OF LOW COST MTC DEVICES IN UL/DL DECOUPLED SCENARIO		
First Named Inventor/Applicant Name:		Moon-il Lee		
Filer:		Arshid A. Sheikh/Cassandra Katz		
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Provisional Filing Fees				
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Provisional Application Filing	1005	1	260	260
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Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Miscellaneous:				
Total in USD (\$)				260

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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	ILTE_11894US01_ProvADS.pdf	1503956	no	8
			d93786e27265f42a2a44c10f7b101ac578a6dd0c		
Warnings:					
Information:					
2		ILTE_11894US01_Specification.pdf	239575	yes	33
			038d32cd58e59a7ca549b335a75adcdaf5ba9c040		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Specification		1	31	
	Claims		32	32	
	Abstract		33	33	
Warnings:					
Information:					
3	Drawings-only black and white line drawings	ILTE_11894US01_Drawings.pdf	193994	no	3
			54ddf0bea1515e0eaf241ecb70a017ffc0b5ed4d		
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4	Fee Worksheet (SB06)	fee-info.pdf	29894	no	2
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO.	TOT CLAIMS	IND CLAIMS
61/863,328	08/07/2013		260	ILTE_11894US01		

CONFIRMATION NO. 8136

15800
Condo Roccia LLP
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Suite 2200
Philadelphia, PA 19103

FILING RECEIPT



OC000000063353528

Date Mailed: 08/21/2013

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Title

COVERAGE ENHANCEMENTS OF LOW COST MTC DEVICES IN UL/DL DECOUPLED
SCENARIO

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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