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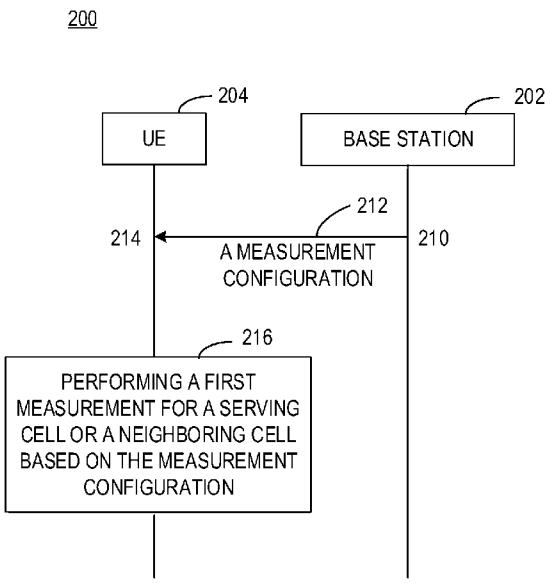


FIG. 2

(57) Abstract: Various aspects of the present disclosure relate to a user equipment, a base station, processors, and methods for measurement based on a main radio (MR) or a low power wake-up receiver (LP-WUR). In an aspect, a user equipment (UE) receives, from a base station (BS), a measurement configuration. The UE performs a first measurement for a serving cell or a neighboring cell based on the measurement configuration. By implementing the embodiments of the present disclosure, RRM measurement based on MR/LP-WUR can be optimized.

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MEASUREMENT BASED ON MR/LP-WUR

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to a user equipment, a base station, processors, and methods for measurement based on a main radio (MR) or a low power wake-up receiver (LP-WUR), such as radio resource management (RRM) measurement based on MR/LP-WUR.

BACKGROUND

[0002] User equipment (UE) may need to periodically wake up once per discontinuous reception (DRX) cycle, which dominates the power consumption in periods with no signaling or data traffic. If UEs are able to wake up only when they are triggered (e.g., triggered by paging), power consumption could be dramatically reduced. This can be achieved by using a wake-up signal to trigger the main radio and a separate receiver which has the ability to monitor wake-up signal with ultra-low power consumption. Main radio works for data transmission and reception, which can be turned off or set to deep sleep unless it is turned on.

[0003] As known, LP-WUR (LR) refers to the receiving (Rx) module operating for receiving/processing signals/channel related to low-power wake-up, while main radio (MR) refers to the transmitting (Tx)/Rx module operating for new radio (NR) signals/channels apart from signals/channel related to low-power wake-up. However, there are still some open problems related to operations of MR/LP-WUR that will be studied in the future.

SUMMARY

[0004] The present disclosure relates to methods, apparatuses, and systems that support RRM measurement based on MR/LP-WUR. In a first aspect of the solution, a user equipment comprising: a processor; and a transceiver coupled to the processor, wherein the processor is configured to: receive, via the transceiver, a measurement configuration; and perform, via the transceiver, a first measurement for a serving cell or a neighboring cell based on the measurement configuration. By performing the first measurement for the serving cell or the neighboring cell based on the measurement configuration, RRM measurement based on MR/LP-WUR can be optimized.

[0005] In some implementations of the user equipment described herein, wherein performing the first measurement for the serving cell or the neighboring cell comprises: performing the first measurement for the serving cell or the neighboring cell based on a first criterion comprised in the measurement configuration.

[0006] In some implementations of the user equipment described herein, wherein performing the first measurement for the serving cell or the neighboring cell based on the first criterion comprises: determining a power level value for the serving cell; and determining a difference between the power level value and a reference power level value, and wherein: in the case that the difference is smaller than a first threshold for a first time duration, performing a first measurement for the neighboring cell; or in the case at least one of (i) the difference is smaller than a sum of the first threshold and a second threshold for a first time duration, or (ii) the difference is smaller than the first threshold for a sum of the first time duration and a second time duration, performing a first measurement for the serving cell.

[0007] In some implementations of the user equipment described herein, wherein the second threshold is configured as a scaling factor of the first threshold in the measurement configuration, and the second time duration is configured as a scaling factor of the first time duration in the measurement configuration.

[0008] In some implementations of the user equipment described herein, wherein performing the first measurement for the serving cell or the neighboring cell based on the first criterion comprises: in the case that a relaxed measurement criterion for neighboring cell is met for more than a first number of times within a second time duration, performing the first measurement for the serving cell.

[0009] In some implementations of the user equipment described herein, wherein performing the first measurement for the serving cell or the neighboring cell based on the first criterion comprises: determining at least one power level value for configured or detected neighboring cell; and in the case that the at least one power level value is lower than a threshold, performing the first measurement for serving cell.

[0010] In some implementations of the user equipment described herein, wherein performing the first measurement for the serving cell or the neighboring cell comprises: performing the first measurement for neighboring cells during a first gap in a low power

radio module of the user equipment, wherein the first gap is configured as a scaling factor of a second gap configured for measurement in a main radio module of the user equipment.

[0011] In some implementations of the user equipment described herein, wherein performing the first measurement for the serving cell or the neighboring cell comprises: performing the first measurement in a low power radio module or a main radio module of the user equipment based on a second criterion.

[0012] In some implementations of the user equipment described herein, wherein performing the first measurement in the low power radio module or the main radio module based on the second criterion comprises: determining a power level value in the low power radio module or the main radio module, and wherein: in the case that the power level value is smaller than a threshold, performing first measurement in the main radio module; or in the case that the power level value is larger than the threshold, performing first measurement in the low power radio module.

[0013] In some implementations of the user equipment described herein, wherein performing the first measurement in the low power radio module or the main radio module based on the second criterion comprises: determining a power level value offset between that in low power radio module and that in main radio module, and wherein: in the case that the power level value offset is smaller than a threshold, performing the first measurement in the low power radio module; or in the case that the power level value offset is larger than the threshold, performing the first measurement in the main radio module.

[0014] In some implementations of the user equipment described herein, wherein the user equipment is configured with a gap duration for the measurement of power level value in the low power radio module and the main radio module simultaneously.

[0015] In some implementations of the user equipment described herein, wherein performing the first measurement in the low power radio module or the main radio module based on the second criterion comprises: determining a power level value offset between the serving cell and a target neighboring cell, and wherein: in the case that the power level value offset is smaller than a threshold, performing the first measurement in the main radio module; or in the case that the power level value offset is larger than the threshold, performing the first measurement in the low power radio module.

[0016] In some implementations of the user equipment described herein, wherein the target neighboring cell is a cell with a highest power level value among a plurality of neighboring cells.

[0017] In some implementations of the user equipment described herein, wherein performing the first measurement for the serving cell or the neighboring cell comprises: performing the first measurement in a low power radio module of the user equipment based on a low power synchronization signal or a low power wake-up signal.

[0018] In some implementations of the user equipment described herein, wherein the first measurement is defined as linear average over power contributions of resource elements that carry one of the following: a low power wake up signal, an ON key part of the low power wake up signal, a low power synchronization signal, an ON key part of the low power synchronization signal, a low power wake up signal and a low power synchronization signal with a first ratio, or an ON key part of the low power wake up signal and an ON key part of the low power synchronization signal with the first ratio.

[0019] In some implementations of the user equipment described herein, wherein the first ratio is determined by a period of low power synchronization signal and a monitoring period of the low power wake up signal.

[0020] In some implementations of the user equipment described herein, wherein the measurement configuration comprises neighboring cell information, and the neighboring cell information comprises one of the following: a cell ID, a low power synchronization period and a time offset to the serving cell, an association low power synchronization ID.

[0021] In some implementations of the user equipment described herein, wherein performing the first measurement for the serving cell or the neighboring cell comprises: performing the first measurement based on normal synchronization or low power synchronization in a lower power radio module or a main radio module of the user equipment for serving cell or neighboring cell determined by the power level value, the first threshold, and the second threshold.

[0022] In a second aspect of the solution, a base station comprising: a processor; and a transceiver coupled to the processor, wherein the processor is configured to: transmit, via the transceiver and to a user equipment, a measurement configuration for performing a first measurement for a serving cell or a neighboring cell, wherein the measurement

configuration comprises neighboring cell information, and wherein the neighboring cell information comprises one of the following: a cell ID, low power synchronization period and time offset to that of the serving cell, association low power synchronization ID.

[0023] In a third aspect of the solution, a processor for wireless communication comprising: at least one memory; and a controller coupled with the at least one memory and configured to cause the controller to: receive, from a base station, a measurement configuration; and perform a first measurement for a serving cell or a neighboring cell based on the measurement configuration.

[0024] In a fourth aspect of the solution, a processor for wireless communication comprising: at least one memory; and a controller coupled with the at least one memory and configured to cause the controller to: transmit, to a user equipment, a measurement configuration for performing a first measurement for a serving cell or a neighboring cell, wherein the measurement configuration comprises neighboring cell information, and wherein the neighboring cell information comprises one of the following: a cell ID, low power synchronization period and time offset to that of the serving cell, association low power synchronization ID.

[0025] In a fifth aspect of the solution, a method performed by a user equipment comprising: receiving, from a base station, a measurement configuration; and performing a first measurement for a serving cell or a neighboring cell based on the measurement configuration.

[0026] In a sixth aspect of the solution, a method performed by a base station comprising: transmitting, to a user equipment, a measurement configuration for performing a first measurement for a serving cell or a neighboring cell, wherein the measurement configuration comprises neighboring cell information, and wherein the neighboring cell information comprises one of the following: a cell ID, low power synchronization period and time offset to that of the serving cell, association low power synchronization ID.

[0027] It is to be understood that the summary section is not intended to identify key or essential features of embodiments of the present disclosure, nor is it intended to be used to limit the scope of the present disclosure. Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] FIG. 1A illustrates an example of a wireless communications system that supports measurement on MR and/or LP-WUR in accordance with aspects of the present disclosure.

[0029] FIG. 1B illustrates an example interaction between a main radio and a separate ultra-low power wake-up receiver within a UE.

[0030] FIG. 1C illustrates an example of transmitting legacy SSB and LP-SS in different frequency band.

[0031] FIG. 1D illustrates an example of three alternative solutions for RRM measurements.

[0032] FIG. 2 illustrates an example signalling procedure for measurement based on MR/LP-WUR in accordance with aspects of the present disclosure.

[0033] FIG. 3 illustrates an example of Solution A for measurements in accordance with aspects of the present disclosure.

[0034] FIG. 4 illustrates another example of three alternative solutions for measurements in accordance with aspects of the present disclosure.

[0035] FIG. 5 illustrates an example of Solution C for measurements in accordance with aspects of the present disclosure.

[0036] FIG. 6 illustrates an example of Solution C-1 for measurements in accordance with aspects of the present disclosure.

[0037] FIG. 7 illustrates another example of Solution C-1 for measurements in accordance with aspects of the present disclosure.

[0038] FIG. 8 illustrates an example of device that support measurement based on MR/LP-WUR in accordance with aspects of the present disclosure.

[0039] FIG. 9 illustrates an example of processor that support measurement based on MR/LP-WUR in accordance with aspects of the present disclosure.

[0040] FIG. 10 illustrates a flowchart of a method that support measurement based on MR/LP-WUR in accordance with aspects of the present disclosure.

[0041] FIG. 11 illustrates a flowchart of a method that support measurement based on MR/LP-WUR in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0042] Principles of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein may be implemented in various manners other than the ones described below.

[0043] In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0044] References in the present disclosure to "one embodiment," "an example embodiment," "an embodiment," "some embodiments," and the like indicate that the embodiment(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases do not necessarily refer to the same embodiment(s). Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0045] It shall be understood that although the terms "first" and "second" or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of embodiments. As used herein, the term "and/or" includes any and all combinations of one or more of the listed terms.

[0046] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as

well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "has", "having", "includes" and/or "including", when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/ or combinations thereof.

[0047] As used herein, the term "communication network" refers to a network following any suitable communication standards, such as, 5G NR, long term evolution (LTE), LTE-advanced (LTE-A), wideband code division multiple access (WCDMA), high-speed packet access (HSPA), narrow band internet of things (NB-IoT), and so on. Further, the communications between a terminal device and a network device in the communication network may be performed according to any suitable generation communication protocols, including but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the fifth generation (5G) communication protocols, and/or any other protocols either currently known or to be developed in the future. Embodiments of the present disclosure may be applied in various communication systems. Given the rapid development in communications, there will also be future type communication technologies and systems in which the present disclosure may be embodied. It should not be seen as limiting the scope of the present disclosure to only the aforementioned systems.

[0048] As used herein, the term "network device" generally refers to a node in a communication network via which a terminal device can access the communication network and receive services therefrom. The network device may refer to a base station (BS) or an access point (AP), for example, a node B (NodeB or NB), a radio access network (RAN) node, an evolved NodeB (eNodeB or eNB), a NR NB (also referred to as a gNB), a remote radio unit (RRU), a radio header (RH), an infrastructure device for a V2X (vehicle-to-everything) communication, a transmission and reception point (TRP), a reception point (RP), a remote radio head (RRH), a relay, an integrated access and backhaul (IAB) node, a low power node such as a femto BS, a pico BS, and so forth, depending on the applied terminology and technology.

[0049] As used herein, the term "terminal device" generally refers to any end device that may be capable of wireless communications. By way of example rather than a limitation, a terminal device may also be referred to as a communication device, a user

equipment (UE), an end user device, a subscriber station (SS), an unmanned aerial vehicle (UAV), a portable subscriber station, a mobile station (MS), or an access terminal (AT). The terminal device may include, but is not limited to, a mobile phone, a cellular phone, a smart phone, a voice over IP (VoIP) phone, a wireless local loop phone, a tablet, a wearable terminal device, a personal digital assistant (PDA), a portable computer, a desktop computer, an image capture terminal device such as a digital camera, a gaming terminal device, a music storage and playback appliance, a vehicle-mounted wireless terminal device, a wireless endpoint, a mobile station, laptop-embedded equipment (LEE), laptop-mounted equipment (LME), a USB dongle, a smart device, wireless customer-premises equipment (CPE), an internet of things (IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device (for example, a remote surgery device), an industrial device (for example, a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. In the following description, the terms: "terminal device," "communication device," "terminal," "user equipment" and "UE," may be used interchangeably.

[0050] Aspects of the present disclosure are described in the context of a wireless communications system.

[0051] FIG. 1A illustrates an example of a wireless communications system 100 that supports measurement on MR and/or LP-WUR in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a 5G network, such as an NR network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G. Additionally, the wireless communications system 100 may

support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0052] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. A network entity 102 and a UE 104 may communicate via a communication link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0053] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, messaging, broadcast, etc.) for one or more UEs 104 within the geographic coverage area 112. For example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network. In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities 102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0054] The one or more UEs 104 (such as UE 104-1 or UE 104-2) may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a mobile device, a wireless device, a remote device, a remote unit, a handheld device, or a subscriber device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104

may be referred to as an internet-of-things (IoT) device, an internet-of-everything (IoE) device, or machine-type communication (MTC) device, among other examples. In some implementations, a UE 104 may be stationary in the wireless communications system 100. In some other implementations, a UE 104 may be mobile in the wireless communications system 100.

[0055] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1A. A UE 104 may be capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the core network 106, the packet data network 108, a relay device, an integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1A. Additionally, or alternatively, a UE 104 may support communication with other network entities 102 or UEs 104, which may act as relays in the wireless communications system 100.

[0056] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0057] A network entity 102 may support communications with the core network 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the core network 106 through one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the core network 106). In some implementations, one or more network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which

may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0058] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access backhaul (IAB) network, an open radio access network (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity 102 may include one or more of a CU, a DU, a radio unit (RU), a RAN intelligent controller (RIC) (e.g., a near-real time RIC (Near-RT RIC), a non-real time RIC (Non-RT RIC)), a service management and orchestration (SMO) system, or any combination thereof.

[0059] An RU may also be referred to as a radio head, a smart radio head, a remote radio head (RRH), a remote radio unit (RRU), or a transmission reception point (TRP). One or more components of the network entities 102 in a disaggregated RAN architecture may be co-located, or one or more components of the network entities 102 may be located in distributed locations (e.g., separate physical locations). In some implementations, one or more network entities 102 of a disaggregated RAN architecture may be implemented as virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0060] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., radio resource control (RRC), service data adaption protocol (SDAP), packet data convergence protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU 160.

[0061] Additionally, or alternatively, a functional split of the protocol stack may be employed between a DU and an RU such that the DU may support one or more layers of the protocol stack and the RU may support one or more different layers of the protocol stack. The DU may support one or multiple different cells (e.g., via one or more RUs). In some implementations, a functional split between a CU and a DU, or between a DU and an RU may be within a protocol layer (e.g., some functions for a protocol layer may be performed by one of a CU, a DU, or an RU, while other functions of the protocol layer are performed by a different one of the CU, the DU, or the RU).

[0062] A CU may be functionally split further into CU control plane (CU-CP) and CU user plane (CU-UP) functions. A CU may be connected to one or more DUs via a midhaul communication link (e.g., F1, F1-c, F1-u), and a DU may be connected to one or more RUs via a fronthaul communication link (e.g., open fronthaul (FH) interface). In some implementations, a midhaul communication link or a fronthaul communication link may be implemented in accordance with an interface (e.g., a channel) between layers of a protocol stack supported by respective network entities 102 that are in communication via such communication links.

[0063] The core network 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The core network 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a packet data network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the core network 106.

[0064] The core network 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like)

with the core network 106 via a network entity 102. The core network 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the core network 106 (e.g., one or more network functions of the core network 106).

[0065] In the wireless communications system 100, the network entities 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the network entities 102 and the UEs 104 may support different resource structures. For example, the network entities 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the network entities 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the network entities 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The network entities 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0066] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., μ=0) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., μ=0) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., μ=1) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., μ=2) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., μ=3) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., μ=4) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0067] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each

frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0068] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., μ=0, μ=1, μ=2, μ=3, μ=4) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., μ=0) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0069] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the network entities 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the network entities 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the

network entities 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0070] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., μ=0), which includes 15 kHz subcarrier spacing; a second numerology (e.g., μ=1), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., μ=3), which includes 120 kHz subcarrier spacing.

[0071] FIG. 1B illustrates an example interaction 100B between a main radio 130 and a separate ultra-low power wake-up receiver 140 within a UE 104.

[0072] As discussed above, the UE 104 needs to periodically wake up once per DRX cycle, which dominates the power consumption in periods with no signaling or data traffic. If the UE 104 are able to wake up only when they are triggered (e.g., triggered by paging), power consumption could be dramatically reduced. This can be achieved by using a wake-up signal to trigger the main radio 130 and a separate receiver 140 which has the ability to monitor wake-up signal with ultra-low power consumption. Main radio 130 works for data transmission and reception, which can be turned off or set to deep sleep unless it is turned on.

[0073] UE is further configured with transmission bits or segments for each OFDM symbol. The transmission bits for each OFDM symbol implicitly determine the waveform of WUS. For example, if the transmission bits (i.e., transmission segments) for each OFDM are 1, the waveform of WUS may be a first waveform that transmits a single bit in one OFDM symbol. An example of the first waveform is OOK-1. If the transmission bits for each OFDM symbol are larger than 1, the waveform of WUS may be a second waveform that transmits M (M>1) bits in one OFDM symbol. An example of the second waveform is OOK-4. OOK stands for On-Off Keying.

[0074] With regard to WUS generation and structure, WUS can be generated by various methods, e.g., MC-OOK. For example, a first waveform (e.g., OOK-1) can be used to generate WUS, where each OFDM symbol carries one bit information of WUS.

For another example, a second waveform (e.g., OOK-4) can be used to generate WUS, where each OFDM symbol carries multiple bits information of WUS. For example, the OOK-4 may need DFT precoder before mapping the signal to frequency domain.

[0075] The sequence of WUS (e.g., OOK-1 or OOK-4) can be generated with random QPSK sequence or ZC sequence. For OOK-1, one bit is transmitted in each OFDM symbol. It means that two different states, one of which modulates 'on' chip and the other of which modulates 'off' chip, are mapped to REs. For example, the random QPSK sequence or ZC sequence is mapped to REs to modulate 'on' chip in time domain, and zeros are mapped to the REs to modulate 'off' chip. OOK=1 means all subcarriers are modulated (can be modulated as random QPSK, ZC sequence). OOK=0 means all SCs are zero power (from base-band point of view).

[0076] For OOK-4, M-bits on/off chip is mapped to one OFDM symbol. WUS needs to carry information to distinguish UEs. In a first way, WUS carries at least one of the following information to distinguish UEs (e.g., distinguish UEs from different POs, UEs from different BWPs, UEs from different cells): start slot number, start symbol number, and start frequency subcarrier number of the corresponding DRX or PO. The above-mentioned information can be carried by the random QPSK sequence or ZC sequence in the generation of the WUS waveform. For example, the random QPSK sequence or ZC sequence (e.g. for each sequence, or for all sequence with chip on OOK=1 concatenation) is initialized with at least one of the start slot number, the start symbol number, and the start frequency subcarrier number of the corresponding DRX or PO.

[0077] The slot number, the symbol number, and the frequency subcarrier number of the corresponding DRX or PO in the second BWP (or the second carrier) are scaled to the subcarrier spacing in the first BWP (or the first carrier) if the subcarrier spacing of the first BWP and the subcarrier spacing of the second BWP are different. When the WUS is initialized, the slot number according to the subcarrier spacing of the BWP where WUS is transmitted (i.e., first BWP) is used. So, the slot number of the DRX or PO according to the subcarrier spacing of the second BWP needs to be scaled to the slot number according to the subcarrier spacing of the first BWP, e.g., by an equation of ceil {slot number / $(= 2^{\mu 2}/2^{\mu 1})$}, where $\mu 2$ and $\mu 1$ are numerologies of the subcarrier spacings of the second BWP and the first BWP, where the numerologies of subcarrier spacings 15kHz, 30kHz, 60kHz, 120kHz and 240kHz are 0, 1, 2, 3 and 4, respectively.

[0078] For example, pseudo-random sequences are defined by a length-31 Gold sequence. The output sequence c(n) is defined by:

$$\begin{aligned} c(n) &= \left(x_1(n+N_C) + x_2(n+N_C)\right) \bmod 2 \\ x_1(n+31) &= \left(x_1(n+3) + x_1(n)\right) \bmod 2 \\ x_2(n+31) &= \left(x_2(n+3) + x_2(n+2) + x_2(n+1) + x_2(n)\right) \bmod 2 \end{aligned}$$

[0079] The initialization of the second m-sequence x_2 is denoted by $c_{init} = \sum_{i=0}^{30} x_2(i) \cdot 2^i$.

[0080] The initialization of the sequence is determined by $c_{WUS} = \left(\left(10n_{f_start_PO} + \left\lfloor \frac{n_{s_start_PO}}{2} \right\rfloor\right) \bmod 2048 + 1\right) 2^9 + n_{k_start_PO}$. And nf_start_PO is the first frame of the first PO to which the NWUS is associated, ns_start_PO is the first slot of the first PO to which the NWUS is associated, and $n_{k_start_PO}$ is the lowest subcarrier of the first PO to which the NWUS is associated.

[0081] In a second way, in order to support fallback mechanism of WUS and PEI in NR Releases 16 and 17, WUS may alternatively carry UE specific information, e.g., the RNTI information configured to UE, such as ps-rnti or pei-rnti, and/or a position indication corresponding to a control signal configured by higher layer, such as ps-positioning, to distinguish UEs. For example, UE is configured with ps-rnti or pei-rnti, and ps-positioning. The random QPSK sequence or ZC sequence is initialized with at least one of ps-rnti or pei-rnti and ps-positioning.

[0082] In a third way, the WUS can be generated with encoded bit with CRC. The encoded bit is scrambled by scramble sequence. The scramble sequence is determined by at least one of the start slot number, start symbol number, and start frequency subcarrier number of the corresponding DRX or PO. The slot number, the symbol number and frequency subcarrier number are scaled to the subcarrier spacing in the first BWP (or the first carrier). Alternatively, the scramble sequence is determined by the RNTI information configured to UE (e.g., ps-rnti or pei-rnti), and/or a position indication corresponding to a control signal configured by higher layer (e.g., ps-positioning).

[0083] Optionally, the first waveform (e.g., OOK-1) or the second waveform (e.g., OOK-4) is determined by the payload size (configured subgroup number, or associated

PO number) and a threshold. For example, if the payload size (configured subgroup number, or associated PO number) is smaller than the threshold, the waveform of OOK-1 is adopted; and if the payload size is equal to or larger than the threshold, the waveform of OOK-4 is adopted.

[0084] Further optionally, the waveform of OOK-1 or OOK-4 is determined by the UE connection mode (e.g., connected mode or idle or inactive mode). For example, if the UE is in idle or inactive mode, the waveform of OOK-4 is adopted; and if the UE is in connected mode, the waveform of OOK-1 is adopted.

[0085] The MR needs to monitor SSB (SS/PBCH block, i.e., synchronization signal / Physical Broadcast Channel). The WUR needs to monitor lower power synchronization signal (LP-SS). LP-WUS in WUR and SSB in MR can be within same frequency band (e.g., FR1 band or even in the same BWP) or different frequency bands. Since LP-SS and LP-WUS are in the same frequency band, LP-SS and SSB can be configured in the same frequency band or different frequency bands.

[0086] The RRM measurement includes serving cell measurement and neighboring cell measurement. When UE operates in idle states (RRC-IDLE and RRC-INACTIVE), UE might need to perform RRM measurement, cell re-selection if triggered and paging monitoring every I-DRX. The need for neighboring cell measurement is determined by the serving cell status, e.g., neighboring cell RRM starts only when serving cell quality does not fill certain conditions. For the serving cell measurement, the following is specified in TS 38.133.

[0087] The UE shall measure the SS-RSRP and SS-RSRQ level of the serving cell and evaluate the cell selection criterion S defined in TS 38.304 for the serving cell at least once every M1*N1 DRX cycle; where: M1=2 if SMTC periodicity (TSMTC) > 20 ms and DRX cycle $\leqslant$ 0.64 second, otherwise M1=1.

[0088] The value of N1 is different for FR1 and FR2. For FR1, N1 is equal to 1. It means that NR UE should perform serving cell measurement every 1 or 2 paging DRX cycles. Therefore, RRM measurement is a significant contributor to the overall power consumption in RRC idle or inactive state.

[0089] For neighboring cell measurement in Rel-16, in order to reduce the UE power saving, the relaxed RRM measurement for intra-frequency or inter-frequency/inter-RAT frequency is allowed for UEs not at cell edge and/or with low mobility.

[0090] If the relaxed measurement criterion in clause 5.2.4.9.1 of TS38.133 is fulfilled for a period of $T_{SearchDeltaP}$: the UE may choose to perform relaxed measurements for intra-frequency cells, NR inter-frequency cells or inter-RAT frequency cells according to relaxation methods in clauses 4.2.2.9, 4.2.2.10, 4.2.2.11, 4.2C.2.7 and 4.2C.2.8 in TS 38.133 as an example; that is, maximal 3x relaxed measurement period/frequency compared to that of measurement without relaxation.

[0091] TS38.304 for relaxed measurement criterion with low mobility / not at cell edge. The relaxed measurement criterion for UE with low mobility is fulfilled when:

[0092] $(Srxlev_{Ref} - Srxlev) < S_{SearchDeltaP}$, for a period of $T_{SearchDeltaP}$

[0093] Where:

[0094] Srxlev = current Srxlev value of the serving cell (dB).

[0095] $Srxlev_{Ref}$ = reference Srxlev value of the serving cell (dB), set as follows:

[0096] After selecting or reselecting a new cell, or if $(Srxlev - Srxlev_{Ref}) > 0$, or if the relaxed measurement criterion has not been met for $T_{SearchDeltaP}$: the UE shall set the value of $Srxlev_{Ref}$ to the current Srxlev value of the serving cell.

[0097] FIG. 1C illustrates an example 100C of transmitting legacy SSB and LP-SS in different frequency bands, and FIG. 1D illustrates an example 100D of three alternative solutions for RRM measurements.

[0098] For UE capable of MR and LP-WUR, it may perform measurement for serving cell and neighboring cell with MR and/or LP-WUR since the two radio modules separately work. If both RRM measurements (serving cell measurement and neighboring cell measurement) are performed only by MR, MR would need to wake-up and perform the RRM measurements every one or two DRX cycles even in ultra-deep sleep state, and it may be a bottleneck for power saving gain. In this case, RRM measurement enhancement can be considered, e.g., RRM measurement relaxation, and/or measurement on new reference signal in LP-WUR.

[0099] It should be noted that, LP-WUS in WUR and SSB in MR can be within same FR1 band or different bands, and SSB and LP-SS can be configured in the same or different bands.

[0100] There are three alternative solutions for RRM measurements with MR and LP-WUR operation. For Solution A, MR measurement may be performed on legacy SSB (no measurement by WUR); for Solution B, LP-WUR measurement may be performed on legacy SSB (no measurements by MR); and for Solution C, LP-WUR measurement may be performed on a new WUR-specific reference signal (LP-SS).

[0101] It should be noted that, the above solutions are associated with serving cell measurement and neighboring cell measurement. In the following description, the terms of "MR" and "main radio" may be used interchangeably, and the terms of "LP-WUR" and "low power wake-up receiver" may be used interchangeably.

[0102] Furthermore, MR measurement and LP-WUR measurement could also be implemented or described as measurement based on a first frequency band (i.e., measurement in the first frequency band) and measurement based on a second frequency band (i.e., measurement in the second frequency band) respectively, because in specific network deployment scenario, operation on MR may be implemented in the first frequency band and/or in a first time duration, and operation on LP-WUR may be implemented in the second frequency band and/or in a second time duration. In other words, the descriptions of "MR measurement", "measurement based on MR", "measurement based on a first frequency band", and "measurement in a first frequency band" may be construed as being equivalent in nature and may be used interchangeably; and the descriptions of "LP-WUR measurement", "measurement based on LP-WUR", "measurement based on a second frequency band", and "measurement in a second frequency band" may be construed as being equivalent in nature and may be used interchangeably.

[0103] For example, the PEI and the paging message in PO can be transmitted by base station (e.g., gNB) and monitored and received by UE on a first frequency band, e.g., on a first BWP of a first carrier; and LP-WUS can be transmitted by base station (e.g., gNB) and monitored and received by UE on a second frequency band, e.g., on a second BWP of a second carrier.

[0104] FIG. 2 illustrates an example signalling procedure 200 for RRM measurement based on MR/LP-WUR in accordance with aspects of the present disclosure. At 210, the base station 202 may transmit, to the UE 204, a measurement configuration 212, where the base station 202 may be an example of network entity 102 in FIG. 1, and the UE 204 may be an example of UE 104 in FIG. 1. In some embodiments, the measurement configuration 212 is used for performing a first measurement for a serving cell or a neighboring cell, wherein the measurement configuration comprises neighboring cell information, and wherein the neighboring cell information comprises one of the following: a cell ID, low power synchronization period and time offset to that of the serving cell, association low power synchronization ID.

[0105] Accordingly, at 214, the UE 204 may receive the measurement configuration 212. Thereafter, at 216, the UE 204 may perform a first measurement for a serving cell or a neighboring cell based on the measurement configuration 212.

[0106] In some embodiments, when performing the first measurement for the serving cell or the neighboring cell, the UE 204 may perform the first measurement for the serving cell or the neighboring cell based on a first criterion comprised in the measurement configuration. For example, such embodiments may correspond to Solution A for RRM measurements mentioned above.

[0107] FIG. 3 illustrates an example 300 of Solution A for RRM measurements in accordance with aspects of the present disclosure, where stricter criterion is imposed to UE if UE needs to relax the requirement for serving cell measurement, and FIG. 4 illustrates another example 400 of three alternative solutions for RRM measurements in accordance with aspects of the present disclosure.

[0108] For Solution A, MR measurement may be performed on legacy SSB (no measurement by WUR), where relaxed measurement criterion for neighboring cell was introduced in Rel.16. If there is no relaxed measurement for serving cell with regard to serving cell RRM, the MR needs to frequently wake up for the serving cell measurement; as a result, power saving gain would not be high and it can be the bottleneck.

[0109] For LP-WUS deployment scenarios, most of the UE types are with low mobility or stationary feature, similar for NB-IoT and LTE-M serving, cell measurements of up to every 8th DRX cycle was introduced for more stationary UEs. As such, with

regard to UE especially with low mobility or/and not at cell edge, relaxed measurement criterion for NR serving cell aims to further power saving for MR is introduced.

[0110] Referring back to FIG. 2, in some embodiments, when performing the first measurement for the serving cell or the neighboring cell based on the first criterion, the UE 204 may determine a power level value for the serving cell; and determining a difference between the power level value and a reference power level value, and wherein: in the case that the difference is smaller than a first threshold for a first time duration, performing a first measurement for the neighboring cell; or in the case at least one of (i) the difference is smaller than a sum of the first threshold and a second threshold for a first time duration, or (ii) the difference is smaller than the first threshold for a sum of the first time duration and a second time duration, performing a first measurement for the serving cell.

[0111] In some embodiments, the second threshold is configured as a scaling factor of the first threshold in the measurement configuration, and the second time duration is configured as a scaling factor of the first time duration in the measurement configuration.

[0112] For example, Solution A-1 proposes enhancing the relaxed measurement criterion for neighboring cell to relaxed measurement criterion for serving cell and set strict requirement with additional offset of received power and additional offset of time duration. For example, UE determines a receiver RX power level value (e.g., RSRP) for serving cell by MR, and determines the difference between the determined receiver RX power level value and a reference receiver RX power level value, where the reference receiver RX power level value described herein may be determined based on the relaxed measurement criterion for neighboring cell as mentioned above.

[0113] When the difference is determined to be smaller than (or no larger than) a sum of legacy threshold and additional offset for legacy time duration plus additional time duration, UE may perform serving cell measurement. It should be noted that, the receiver RX power level value can be replaced with RX power quality value or other measurement metric values (e.g., RSRQ). And the determination can be implemented as follows:

- $(Srxlev_{Ref} - Srxlev) < S_{SearchDeltaP} - \Delta S_{SearchDeltaP}$, for a period of $T_{SearchDeltaP} + \Delta T_{SearchDeltaP}$,

- where $\Delta S_{SearchDeltaP}$ can be configured as absolute value of {1dB, 2dB...} or configured as scaling factor of $S_{SearchDeltaP}$ (i.e., $\Delta S_{SearchDeltaP} = \beta * S_{SearchDeltaP}$, where $\beta = 0.125, 0.25, 0.75, 1, 2,$ or 4),
- $\Delta T_{SearchDeltaP}$ can be configured as absolute value of {5s, 10s, 15s....} or configured as scaling factor of $T_{SearchDeltaP}$ (i.e., $\Delta T_{SearchDeltaP} = \alpha * T_{SearchDeltaP}$, where $\alpha = 0.125, 0.25, 0.75, 1, 2,$ or 4).
- It should be noted that, the above mentioned scaling factors of α and β can be configured/determined as the same, or configured/determined separately.

[0114] In some embodiments, when performing the first measurement for the serving cell or the neighboring cell based on the first criterion, the UE 204 may, in the case that a relaxed measurement criterion for neighboring cell is met for more than a first number of times within a second time duration, perform the first measurement for the serving cell.

[0115] For example, Solution A-2 proposes: when the relaxed measurement criterion for neighboring cell for UE with low mobility or/and not at cell edge is met for more than N consecutive times, UE may perform relaxed measurement for serving cell.

[0116] In some embodiments, when performing the first measurement for the serving cell or the neighboring cell based on the first criterion, the UE 204 may determine at least one power level value for configured or detected neighboring cell, and in the case that the at least one power level value is lower than a threshold, perform the first measurement for serving cell.

[0117] It should be noted that, the first measurement for serving cell described herewith may correspond to the relaxed measurement for serving cell mentioned above, which has maximal 3x relaxed measurement period/frequency compared to that of measurement without relaxation. As a result, the UE may not need to switch to MR for RRM measurement frequently.

[0118] For example, Solution A-3 proposes introducing neighboring cell receive power level value for relaxed measurement criterion, for example. For any detected or configured neighboring cell, when $N_{rxlev} < N_{threshold}$ for a period of $T_{neighboring}$, UE may perform serving cell measurement, where N_{rxlev} is neighbouring cell RX power level value or quality value, and $T_{neighboring}$ is configured by higher layer. It should be noted that, this criterion can be combined with legacy criterion (e.g., the relaxed measurement criterion

for neighboring cell as mentioned above). That is, for example, when the relaxed measurement criterion for neighboring cell and the criterion described above are met at the same time, UE may perform the relaxed measurement for serving cell.

[0119] It should be noted that, the above criterion method can also be adopted to LP-WUR measurement on legacy SSB and LP-SS/LP-WUS (that is, be adopted to Solution B and Solution C).

[0120] For Solution B, LP-WUR measurement may be performed on legacy SSB (no measurements by MR). Compared to the MR measurement on legacy SSB, LP-WUR may have limited measurement capability (e.g., due to the simple receiver architecture), and LP-WUR measurement may not have the same accuracy as MR measurement.

[0121] In some embodiments, when performing the first measurement for the serving cell or the neighboring cell, the UE 204 may perform the first measurement for neighboring cells during a first gap in a low power radio module of the user equipment, wherein the first gap is configured as a scaling factor of a second gap configured for measurement in a main radio module of the user equipment.

[0122] For example, Solution B-1 proposes that a measurement gap is configured in LP-WUR for inter-frequency measurement (e.g., for neighboring cell measurement), and the gap duration can be configured as multiple of legacy gap duration configured for MR (e.g., 40ms).

[0123] In some embodiments, when performing the first measurement for the serving cell or the neighboring cell, the UE 204 may perform the first measurement in a low power radio module or a main radio module of the user equipment based on a second criterion.

[0124] Furthermore, in some embodiments, when performing the first measurement in the low power radio module or the main radio module based on the second criterion, the UE 204 may determine a power level value in the low power radio module or the main radio module, and wherein: in the case that the power level value is smaller than a threshold, performing first measurement in the main radio module (e.g., in the first frequency band); or in the case that the power level value is larger than the threshold, performing first measurement in the low power radio module (e.g., in the second frequency band).

[0125] Additionally or alternatively, in some embodiments, when performing the first measurement in the low power radio module or the main radio module based on the second criterion , the UE 204 may determine a power level value offset between that in low power radio module and that in main radio module, and wherein: in the case that the power level value offset is smaller than a threshold, performing the first measurement in the low power radio module; or in the case that the power level value offset is larger than the threshold, performing the first measurement in the main radio module. Moreover, the UE 204 may be configured with a gap duration for the measurement of power level value in the low power radio module and the main radio module simultaneously.

[0126] Additionally or alternatively, in some embodiments, when performing the first measurement in the low power radio module or the main radio module based on the second criterion, the UE 204 may determine a power level value offset between the serving cell and a target neighboring cell, and wherein: in the case that the power level value offset is smaller than a threshold, performing the first measurement in the main radio module; or in the case that the power level value offset is larger than the threshold, performing the first measurement in the low power radio module. Moreover, the target neighboring cell is a cell with a highest power level value among a plurality of neighboring cells.

[0127] For example, Solution B-2 proposes switching between LP-WUR measurement on legacy SSB and MR measurement on legacy SSB. If measurement result of LP-WUS (e.g., the receiver RX power level value for serving cell, RSRP, RSRQ, SINR) is smaller than a threshold, then the UE may switch from LP-WUR to MR for measurement. Alternatively, if measurement result of LP-WUS (e.g., the receiver RX power level value for serving cell, RSRP, RSRQ, SINR) is larger than a threshold, then the UE may switch from MR to LP-WUR for measurement.

[0128] Considering the measurement accuracy of LP-WUR is lower than that of MR, and the measurement accuracy of LP-WUR is determined by the channel condition, a gap duration for measurement of LP-WUS and MR operation simultaneously on legacy SSB is optionally configured. For example, if differential measurement value of LP-WUS and MR (e.g., the receiver RX power level value for serving cell or RSRP for a time duration) is larger than a configured threshold, then the UE may switch from LP-WUR to MR. Alternatively, if differential measurement value of LP-WUS and MR (e.g., the receiver

RX power level value for serving cell or RSRP for a time duration) is smaller than a configured threshold, then the UE may switch from MR to LP-WUR.

[0129] Optionally, if differential measurement value of serving cell and configured neighboring cells / or some neighboring cell (for example, highest measurement value of neighboring cells) in MR or in LP-WUS is smaller than a configured threshold, then the UE may switch from LP-WUS to MR, otherwise the UE may switch from MR to LP-WUS.

[0130] It should be noted that, a combination of the above solutions to determine the switch between MR and LP-WUR is also possible.

[0131] For Solution C, LP-WUR measurement may be performed on a new WUR-specific reference signal (LP-SS).

[0132] In some embodiments, when performing the first measurement for the serving cell or the neighboring cell, the UE 204 may perform the first measurement in a low power radio module of the user equipment based on a low power synchronization signal or a low power wake-up signal.

[0133] Furthermore, in some embodiments, the first measurement is defined as linear average over power contributions of resource elements that carry one of the following: a low power wake up signal, an ON key part of the low power wake up signal, a low power synchronization signal, an ON key part of the low power synchronization signal, a low power wake up signal and a low power synchronization signal with a first ratio, or an ON key part of the low power wake up signal and an ON key part of the low power synchronization signal with the first ratio.

[0134] FIG. 5 illustrates an example of Solution C for RRM measurements in accordance with aspects of the present disclosure. For example, in legacy measurement, only RSRP and RSRQ is supported as measurement metric for RRC idle/inactive state for Uu interface as specified in TS38.215, while RSSI and SINR is defined only for RRC connected mode. Meanwhile, the metrics for RRM measurement by LP-WUR can reuse same or similar metrics, i.e., LP-RSRP and LP-RSRQ.

[0135] For example, the LP-SS can be used for LP-WUR synchronization to address the timing drift due to the clock inaccuracy. Moreover, for example, LP-SS can be transmitted with much longer periodicity than SSB (and/or LP-WUS) as long as the

timing uncertainty arising from the timing drift between two LP-SS occasions is not too much. On the other hand, to meet certain measurement accuracy, LP-SS may need to transmit with a short periodicity to allow combining more measurement results for cell selection criteria evaluation, which increase the network overload for the always-on signal. And the transmission of LP-WUS may be on demand, e.g., triggered by paging, and thus it may not always be available for measurement.

[0136] In order to balance the measurement accuracy and network overhead, combining the potential LP-WUS and always-on LP-SS for measurement is considered.

[0137] FIG. 6 illustrates an example of Solution C-1 for RRM measurements in accordance with aspects of the present disclosure, and FIG. 7 illustrates another example of Solution C-1 for RRM measurements in accordance with aspects of the present disclosure.

[0138] For example, Solution C-1 proposes a new definition of LP-SS/LP-WUS measurement metric. Specifically, for example, Solution C-1-1 proposes that LP-WUS reference signal received power (WUS-RSRP) may be defined as the linear average over the power contributions (in [W]) of the resource elements that carry wake up signal.

[0139] Optionally, since LP-WUS is a kind of OOK signal, including ON key and OFF key of the wake up signal, LP-WUS reference signal received power (WUS-RSRP) may be defined as the linear average over the power contributions (in [W]) of the resource elements that carry ON key of wake up signal (see FIG. 6).

[0140] Solution C-1-2 proposes that LP-SS reference signal received power (LPSS-RSRP) may be defined as the linear average over the power contributions (in [W]) of the resource elements that carry low power synchronization signal or ON key of low power synchronization signal (see FIG. 6). It should be noted that LP-SS is a kind of OOK signal.

[0141] Moreover, Solution C-1-3 proposes that LP-RS reference signal received power (LPRS-RSRP) may be defined as the linear average over the power contributions (in [W]) of the resource elements that carry low power synchronization signal or ON key of low power synchronization signal and wake up signal with ratio of a, where a may be configured as [0.125, 0.25, 0.75, 1, 2, or 4] or implicitly determined by the period of LP-SS and LP-WUS monitoring period. For example, LP-SS period is 320ms, and LP-WUS monitoring occasion period is 80ms, then a=0.25 (see FIG. 7).

[0142] Since the power of LP-SS and LP-WUS may be different, the target value of LPSS-RSRP depends on the ratio of LP-SS and LP-WUS. Optionally, normalize power can be considered (e.g., the power of LP-WUS is normalized to the power of LP-SS when determining the final measurement value).

[0143] In some embodiments, the first ratio is determined by a period of low power synchronization signal and a monitoring period of the low power wake up signal.

[0144] For example, as proposed by Solution C-1-4, the measurement time resource(s) for LP-SS/LP-WUS are confined within LP-SS/LP-WUS Measurement Time Configuration (SMTC) window duration, and the window period and corresponding window length may be defined as a scaling factor of that of legacy SMTC window defined for SSB based measurement time resource. Optionally, the scaling factor is implicitly determined by the period of SSB and period of LP-SS/LP-WUS.

[0145] In some embodiments, the measurement configuration comprises neighboring cell information, and the neighboring cell information comprises one of the following: a cell ID, a low power synchronization period and a time offset to the serving cell, an association low power synchronization ID.

[0146] For example, as in Solution C, LP-WUS/LP-SS based serving cell RRM measurement should be considered as the baseline, such that the serving cell quality can be maintained to be on track even when the MR is in the sleep mode. If LP-WUS/LP-SS based neighbor cell measurement can't be performed by LP-WUR, UE should switch to MR for neighboring cell measurement even with maximal allowed 3x relaxation, and thus the power saving gain is very limited.

[0147] So LP-WUS/LP-SS based neighboring cell RRM measurement by LP-WUR can also be supported, such that cell reselection or handover without turning on the MR, especially for UE with stationary or low mobility. And an exemplary set of neighboring cell information is listed in Table 1.

Table 1. An exemplary set of neighboring cell information

Cell ID	LP-SS ID	LP-SS period	Time offset
100	0	320ms	1ms

121	1	640ms	2ms
135	6	640ms	4ms

[0148] For example, as proposed by Solution D, in order to support neighboring cell RRM by LP-WUR, LP-SS/LP-WUS should include Cell ID information to differentiate the cells. If all Cell ID information is included in LP-SS/LP-WUS, the coverage of LP-SS/LP-WUS would further degraded, so partial cell ID information or association between cell ID and LP-SS ID can be considered in LP-SS/LP-WUS (e.g., in case that association is not configured, LP-SS ID = cell ID mod N, N is the maximal number of LP-SS ID).

[0149] UE is configured with neighboring cell information, especially for UE with stationary or low mobility feature, the neighboring cell information includes cell ID and related LP-SS ID association, and LP-SS transmission period and corresponding time offset to serving cell, which facilitates UE neighboring cell measurement.

[0150] Referring back to FIG. 2, in some embodiments, when performing the first measurement for the serving cell or the neighboring cell, the UE 204 may perform the first measurement based on normal synchronization or low power synchronization in a lower power radio module or a main radio module of the user equipment for serving cell or neighboring cell determined by the power level value, the first threshold, and the second threshold.

[0151] For example, as described above, there are three alternative solutions for RRM measurements with LP-WUR operation: for Solution A, MR measurement may be performed on legacy SSB (no measurement by WUR); for Solution B, LP-WUR measurement may be performed on legacy SSB (no measurements by MR); and for Solution C, LP-WUR measurement may be performed on a new WUR-specific reference signal (LP-SS). It should be noted that the above solutions are associated with serving cell measurement and neighboring cell measurement.

[0152] As proposed by Solution E, UE may be configured with measurement thresholds (TH1>TH2) to determine the measurement scheme. For example, in case of measurement value (e.g., RSRP for serving cell) by MR or by LP-WUR is larger than

TH1, then LP-WUR measurement on SSB or WUR-specific reference signal may be adopted.

[0153] In case of measurement value (e.g., RSRP for serving cell) by MR or by LP-WUR is larger than TH2, then LP-WUR measurement on SSB or WUR-specific reference signal is adopted and MR measurement on SSB with relaxing requirement is adopted. In case of measurement value (e.g., RSRP for serving cell) is smaller than TH2, then MR measurement on SSB is adopted.

[0154] FIG. 8 illustrates an example of a device 800 that support measurement based on MR/LP-WUR in accordance with aspects of the present disclosure. The device 800 may be an example of a UE 104-1 as described herein. The device 800 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 800 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 802, a memory 804, a transceiver 806, and, optionally, an I/O controller 808. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0155] The processor 802, the memory 804, the transceiver 806, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. For example, the processor 802, the memory 804, the transceiver 806, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0156] In some implementations, the processor 802, the memory 804, the transceiver 806, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some implementations, the processor 802 and the memory 804 coupled with

the processor 802 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 802, instructions stored in the memory 804).

[0157] For example, the processor 802 may support wireless communication at the device 800 in accordance with examples as disclosed herein. The processor 802 may be configured to operable to support means for receiving, from a base station, a measurement configuration; and means for performing a first measurement for a serving cell or a neighboring cell based on the measurement configuration.

[0158] The processor 802 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor 802 may be configured to operate a memory array using a memory controller. In some other implementations, a memory controller may be integrated into the processor 802. The processor 802 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 804) to cause the device 800 to perform various functions of the present disclosure.

[0159] The memory 804 may include random access memory (RAM) and read-only memory (ROM). The memory 804 may store computer-readable, computer-executable code including instructions that, when executed by the processor 802 cause the device 800 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 802 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 804 may include, among other things, a basic I/O system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[0160] The I/O controller 808 may manage input and output signals for the device 800. The I/O controller 808 may also manage peripherals not integrated into the device M02. In some implementations, the I/O controller 808 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 808 may utilize an operating system such as iOS®, ANDROID®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In some

implementations, the I/O controller 808 may be implemented as part of a processor, such as the processor 806. In some implementations, a user may interact with the device 800 via the I/O controller 808 or via hardware components controlled by the I/O controller 808.

[0161] In some implementations, the device 800 may include a single antenna 810. However, in some other implementations, the device 800 may have more than one antenna 810 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 806 may communicate bi-directionally, via the one or more antennas 810, wired, or wireless links as described herein. For example, the transceiver 806 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 806 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 810 for transmission, and to demodulate packets received from the one or more antennas 810. The transceiver 806 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0162] A transmit chain may be configured to generate and transmit signals (e.g., control information, data, packets). The transmit chain may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmit chain may also include one or more antennas 810 for transmitting the amplified signal into the air or wireless medium.

[0163] A receive chain may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receive chain may include one or more antennas 810 for receive the signal over the air or wireless medium. The receive chain may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receive chain may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing

the modulation technique applied during transmission of the signal. The receive chain may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0164] FIG. 9 illustrates an example of a processor 900 that supports measurement based on MR/LP-WUR in accordance with aspects of the present disclosure. The processor 900 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 900 may include a controller 902 configured to perform various operations in accordance with examples as described herein. The processor 900 may optionally include at least one memory 904, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 900 may optionally include one or more arithmetic-logic units (ALUs) 900. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0165] The processor 900 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 900) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[0166] The controller 902 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 900 to cause the processor 900 to support various operations of a base station in accordance with examples as described herein. For example, the controller 902 may operate as a control unit of the processor 900, generating control signals that manage the operation of various components of the processor 900. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0167] The controller 902 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 904 and determine subsequent instruction(s) to be executed to cause the processor 900 to support various operations in accordance with examples as described herein. The controller 902 may be configured to track memory address of instructions associated with the memory 904. The controller 902 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 902 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 900 to cause the processor 900 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 902 may be configured to manage flow of data within the processor 900. The controller 902 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 900.

[0168] The memory 904 may include one or more caches (e.g., memory local to or included in the processor 900 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 904 may reside within or on a processor chipset (e.g., local to the processor 900). In some other implementations, the memory 904 may reside external to the processor chipset (e.g., remote to the processor 900).

[0169] The memory 904 may store computer-readable, computer-executable code including instructions that, when executed by the processor 900, cause the processor 900 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 902 and/or the processor 900 may be configured to execute computer-readable instructions stored in the memory 904 to cause the processor 900 to perform various functions. For example, the processor 900 and/or the controller 902 may be coupled with or to the memory 904, and the processor 900, the controller 902, and the memory 904 may be configured to perform various functions described herein. In some examples, the processor 900 may include multiple processors and the memory 904 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[0170] The one or more ALUs 900 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 900 may reside within or on a processor **chipset** (e.g., the processor 900). In some other implementations, the one or more ALUs 900 may reside external to the processor chipset (e.g., the processor 900). One or more ALUs 900 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 900 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 900 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 900 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 900 to handle conditional operations, comparisons, and bitwise operations.

[0171] The processor 900 may support wireless communication in accordance with examples as disclosed herein. The processor 900 may be configured to or operable to support means for receiving, via the transceiver, a measurement configuration; and means for perform, via the transceiver, a first measurement for a serving cell or a neighboring cell based on the measurement configuration.

[0172] FIG. 10 illustrates a flowchart of a method 1000 that supports RRM measurement based on MR/LP-WUR in accordance with aspects of the present disclosure. The operations of the method 1000 may be implemented by a device or its components as described herein. For example, the operations of the method 1000 may be performed by a UE 104 as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0173] At 1010, the method may include receiving, from a base station, a measurement configuration. The operations of 1010 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1010 may be performed by a device as described with reference to FIG. 1A.

[0174] At 1020, the method may include performing a first measurement for a serving cell or a neighboring cell based on the measurement configuration. The operations of

1020 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1020 may be performed by a device as described with reference to FIG. 1A.

[0175] FIG. 11 illustrates a flowchart of a method 1100 that supports RRM measurement based on MR/LP-WUR in accordance with aspects of the present disclosure. The operations of the method 1100 may be implemented by a device or its components as described herein. For example, the operations of the method 1100 may be performed by a base station as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0176] At 1110, the method may include transmitting, to a user equipment, a measurement configuration for performing a first measurement for a serving cell or a neighboring cell, wherein the measurement configuration comprises neighboring cell information, and wherein the neighboring cell information comprises one of the following: a cell ID, low power synchronization period and time offset to that of the serving cell, association low power synchronization ID. The operations of 1110 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1510 may be performed by a device as described with reference to FIG. 1A.

[0177] It should be noted that the methods described herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible. Further, aspects from two or more of the methods may be combined.

[0178] The various illustrative blocks and components described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a DSP, an ASIC, a CPU, an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, multiple

microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0179] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described herein may be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations.

[0180] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer. By way of example, non-transitory computer-readable media may include RAM, ROM, electrically erasable programmable ROM (EEPROM), flash memory, compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that may be used to carry or store desired program code means in the form of instructions or data structures and that may be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor.

[0181] As used herein, including in the claims, an article "a" before an element is unrestricted and understood to refer to "at least one" of those elements or "one or more" of those elements. The terms "a," "at least one," "one or more," and "at least one of one or more" may be interchangeable. As used herein, including in the claims, "or" as used in a list of items (e.g., a list of items prefaced by a phrase such as "at least one of" or "one or more of" or "one or both of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase "based on" shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as "based on

condition A" may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase "based on" shall be construed in the same manner as the phrase "based at least in part on. Further, as used herein, including in the claims, a "set" may include one or more elements.

[0182] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A user equipment, comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

receive, via the transceiver, a measurement configuration; and

perform, via the transceiver, a first measurement for a serving cell or a neighboring cell based on the measurement configuration.

2. The user equipment of claim 1, wherein performing the first measurement for the serving cell or the neighboring cell comprises:

performing the first measurement for the serving cell or the neighboring cell based on a first criterion comprised in the measurement configuration.

3. The user equipment of claim 2, wherein performing the first measurement for the serving cell or the neighboring cell based on the first criterion comprises:

determining a power level value for the serving cell; and

determining a difference between the power level value and a reference power level value, and wherein:

in the case that the difference is smaller than a first threshold for a first time duration, performing a first measurement for the neighboring cell; or

in the case at least one of (i) the difference is smaller than a sum of the first threshold and a second threshold for a first time duration, or (ii) the difference is smaller than the first threshold for a sum of the first time duration and a second time duration, performing a first measurement for the serving cell.

4. The user equipment of claim 3, wherein the second threshold is configured as a scaling factor of the first threshold in the measurement configuration, and the second time duration is configured as a scaling factor of the first time duration in the measurement configuration.

5. The user equipment of any of claims 2-4, wherein performing the first measurement for the serving cell or the neighboring cell based on the first criterion comprises:

in the case that a relaxed measurement criterion for neighboring cell is met for more than a first number of times within a second time duration, performing the first measurement for the serving cell.

6. The user equipment of any of claims 2-5, wherein performing the first measurement for the serving cell or the neighboring cell based on the first criterion comprises:

determining at least one power level value for configured or detected neighboring cell; and

in the case that the at least one power level value is lower than a threshold, performing the first measurement for serving cell.

7. The user equipment of claim 1, wherein performing the first measurement for the serving cell or the neighboring cell comprises:

performing the first measurement for neighboring cells during a first gap in a low power radio module of the user equipment, wherein the first gap is configured as a scaling factor of a second gap configured for measurement in a main radio module of the user equipment.

8. The user equipment of claim 1, wherein performing the first measurement for the serving cell or the neighboring cell comprises:

performing the first measurement in a low power radio module or a main radio module of the user equipment based on a second criterion.

9. The user equipment of claim 8, wherein performing the first measurement in the low power radio module or the main radio module based on the second criterion comprises:

determining a power level value in the low power radio module or the main radio module, and wherein:

in the case that the power level value is smaller than a threshold, performing first

measurement in the main radio module; or

in the case that the power level value is larger than the threshold, performing first measurement in the low power radio module.

10. The user equipment of claim 8, wherein performing the first measurement in the low power radio module or the main radio module based on the second criterion comprises:

determining a power level value offset between that in low power radio module and that in main radio module, and wherein:

in the case that the power level value offset is smaller than a threshold, performing the first measurement in the low power radio module; or

in the case that the power level value offset is larger than the threshold, performing the first measurement in the main radio module.

11. The user equipment of claim 10, wherein the user equipment is configured with a gap duration for the measurement of power level value in the low power radio module and the main radio module simultaneously.

12. The user equipment of claim 8, wherein performing the first measurement in the low power radio module or the main radio module based on the second criterion comprises:

determining a power level value offset between the serving cell and a target neighboring cell, and wherein:

in the case that the power level value offset is smaller than a threshold, performing the first measurement in the main radio module; or

in the case that the power level value offset is larger than the threshold, performing the first measurement in the low power radio module.

13. The user equipment of claim 12, wherein the target neighboring cell is a cell with a highest power level value among a plurality of neighboring cells.

14. The user equipment of claim 1, wherein performing the first measurement for the serving cell or the neighboring cell comprises:

performing the first measurement in a low power radio module of the user equipment based on a low power synchronization signal or a low power wake-up signal.

15. The user equipment of claim 14, wherein the first measurement is defined as linear average over power contributions of resource elements that carry one of the following:

a low power wake up signal,

an ON key part of the low power wake up signal,

a low power synchronization signal,

an ON key part of the low power synchronization signal,

a low power wake up signal and a low power synchronization signal with a first ratio, or

an ON key part of the low power wake up signal and an ON key part of the low power synchronization signal with the first ratio.

16. The user equipment of claim 15, wherein the first ratio is determined by a period of low power synchronization signal and a monitoring period of the low power wake up signal.

17. The user equipment of claim 1, wherein the measurement configuration comprises neighboring cell information, and the neighboring cell information comprises one of the following:

a cell ID,

a low power synchronization period and a time offset to the serving cell,

an association low power synchronization ID.

18. The user equipment of claim 3, wherein performing the first measurement for the serving cell or the neighboring cell comprises:

performing the first measurement based on normal synchronization or low power synchronization in a lower power radio module or a main radio module of the user equipment for serving cell or neighboring cell determined by the power level value, the first threshold, and the second threshold.

19. A base station, comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

transmit, via the transceiver and to a user equipment, a measurement configuration for performing a first measurement for a serving cell or a neighboring cell, wherein the measurement configuration comprises neighboring cell information, and wherein the neighboring cell information comprises one of the following:

a cell ID,

low power synchronization period and time offset to that of the serving cell,

association low power synchronization ID.

20. A processor for wireless communication, comprising:

at least one memory; and

a controller coupled with the at least one memory and configured to cause the controller to:

receive, from a base station, a measurement configuration; and

perform a first measurement for a serving cell or a neighboring cell based on the measurement configuration.

21. A processor for wireless communication, comprising:

at least one memory; and

a controller coupled with the at least one memory and configured to cause the controller to:

transmit, to a user equipment, a measurement configuration for performing a first measurement for a serving cell or a neighboring cell, wherein the measurement configuration comprises neighboring cell information, and wherein the neighboring cell information comprises one of the following:

a cell ID,

low power synchronization period and time offset to that of the serving cell,

association low power synchronization ID.

22. A method performed by a user equipment, the method comprising:

receiving, from a base station, a measurement configuration; and

performing a first measurement for a serving cell or a neighboring cell based on the measurement configuration.

23. A method performed by a base station, the method comprising:

transmitting, to a user equipment, a measurement configuration for performing a first measurement for a serving cell or a neighboring cell, wherein the measurement configuration comprises neighboring cell information, and wherein the neighboring cell information comprises one of the following:

a cell ID,

low power synchronization period and time offset to that of the serving cell,

association low power synchronization ID.

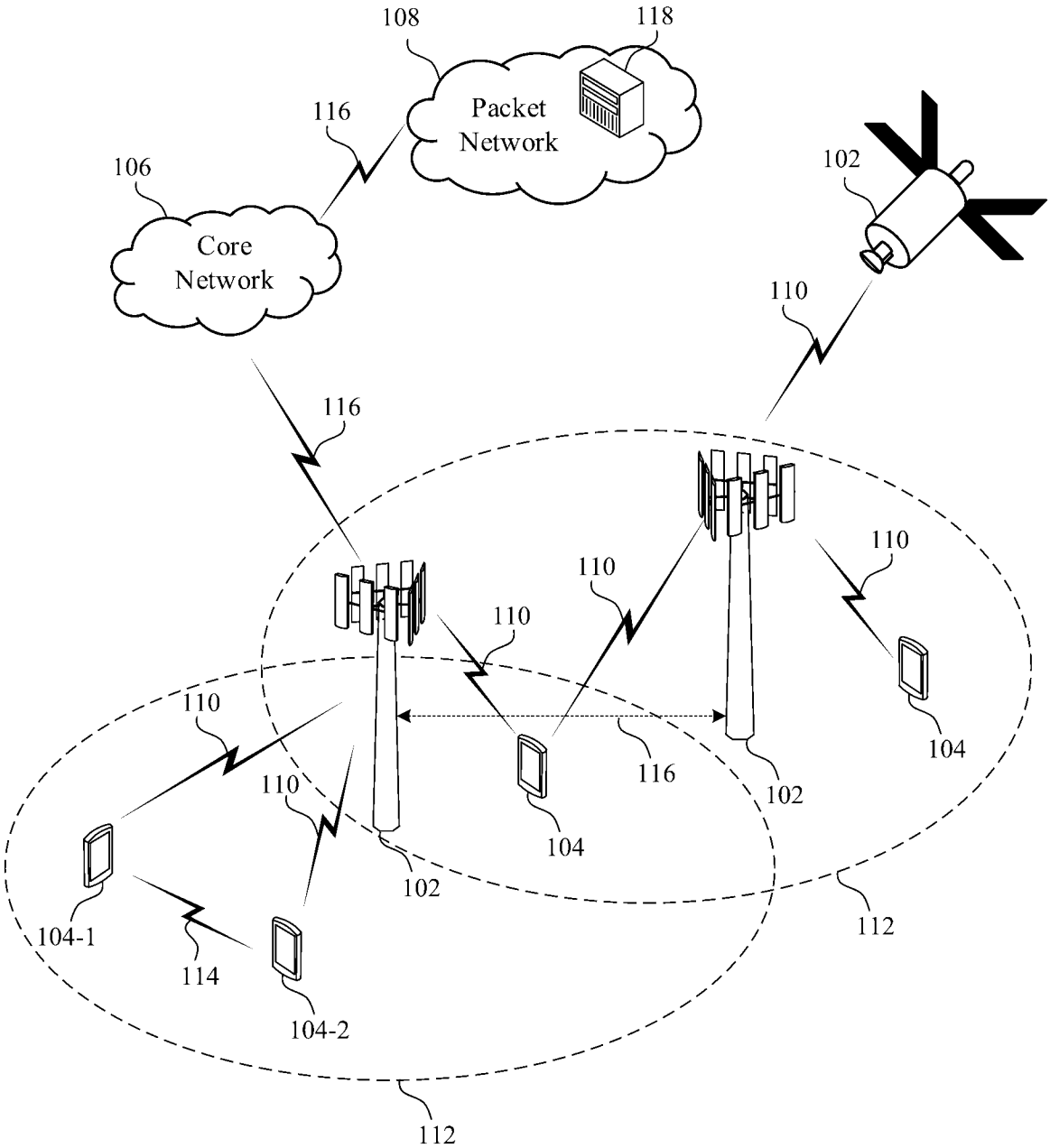

100
108
118
Packet Network
116
106
Core Network
102
110
116
110
110
110
110
104
116
102
110
104
102
104-1
114
104-2
112
112

FIG. 1A

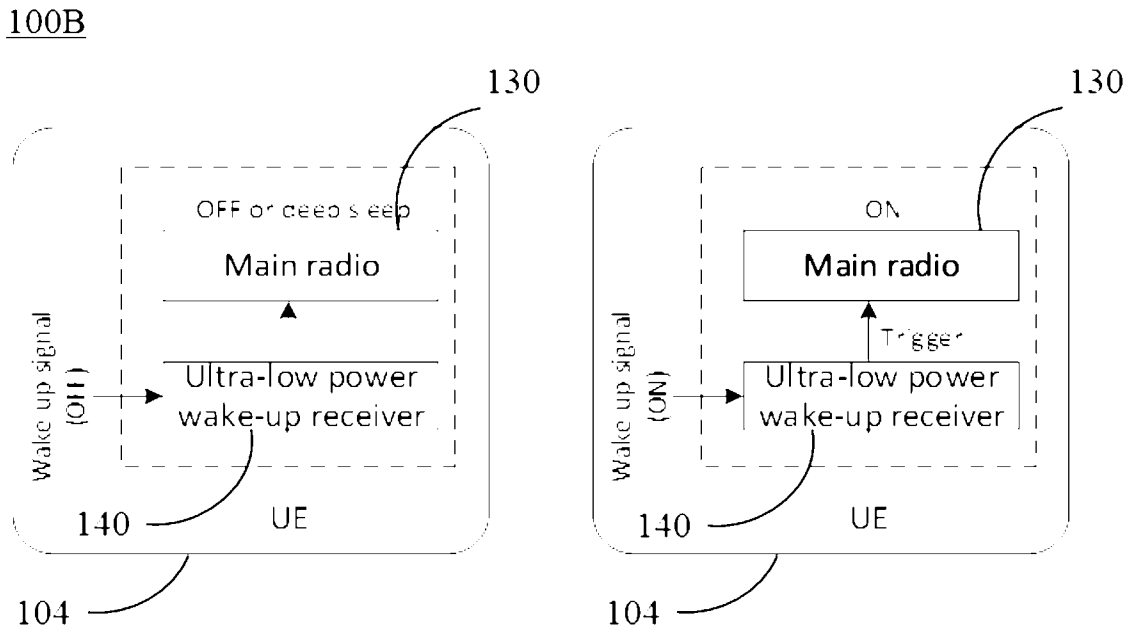

100B
130
OFF or deep sleep
Main radio
Ultra-low power wake-up receiver
Wake up signal (OFF)
140
UE
104
130
ON
Main radio
Trigger
Ultra-low power wake-up receiver
Wake up signal (ON)
140
UE
104

FIG. 1B

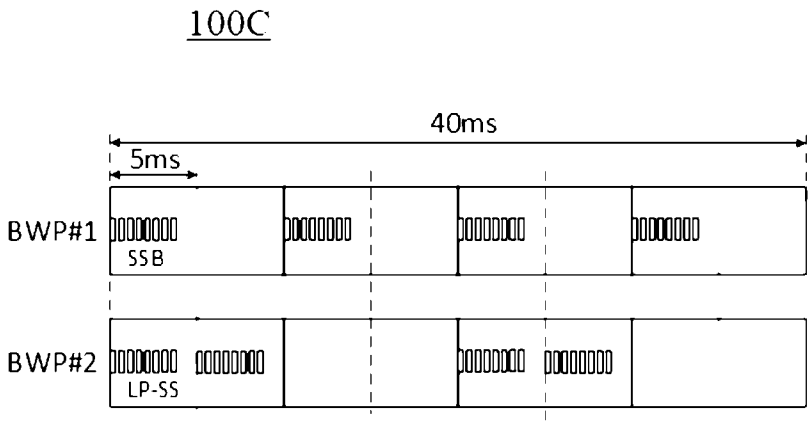

100C
40ms
5ms
BWP#1
SSB
BWP#2
LP-SS

FIG. 1C

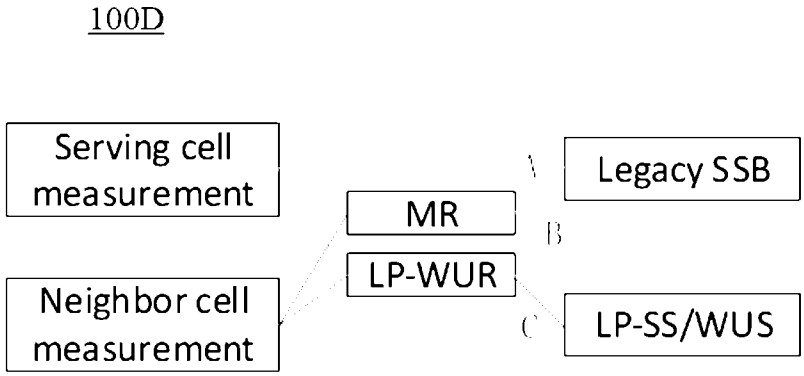

100D
Serving cell measurement
Neighbor cell measurement
MR
LP-WUR
A
B
C
Legacy SSB
LP-SS/WUS

FIG. 1D

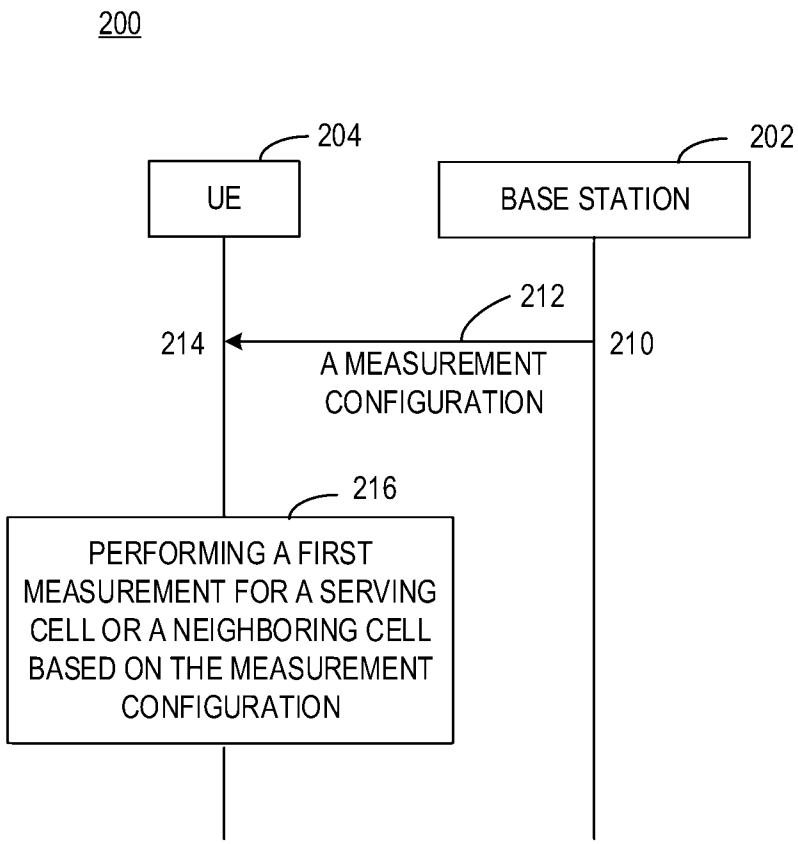

200
204
UE
202
BASE STATION
212
214
210
A MEASUREMENT CONFIGURATION
216
PERFORMING A FIRST MEASUREMENT FOR A SERVING CELL OR A NEIGHBORING CELL BASED ON THE MEASUREMENT CONFIGURATION

FIG. 2

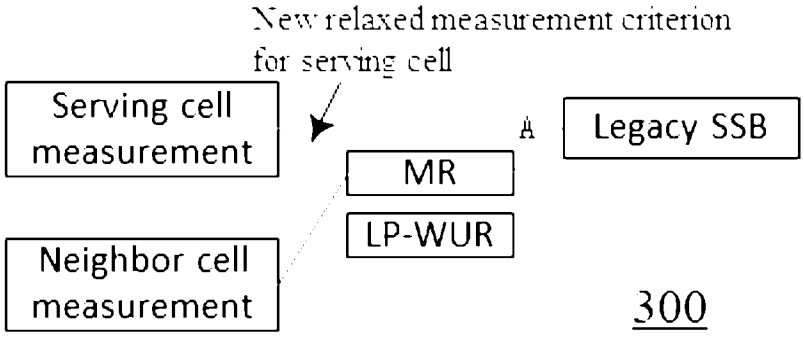

New relaxed measurement criterion for serving cell
Serving cell measurement
A
Legacy SSB
MR
LP-WUR
Neighbor cell measurement
300

FIG. 3

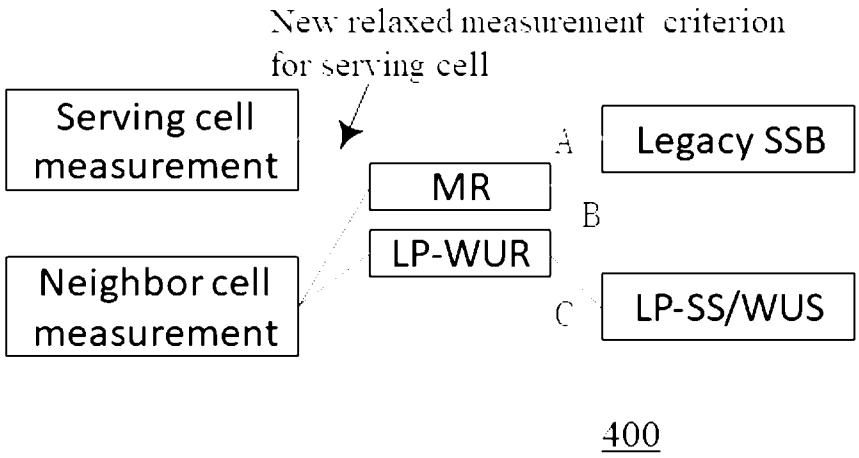

New relaxed measurement criterion for serving cell
Serving cell measurement
A
Legacy SSB
MR
B
LP-WUR
Neighbor cell measurement
C
LP-SS/WUS
400

FIG. 4

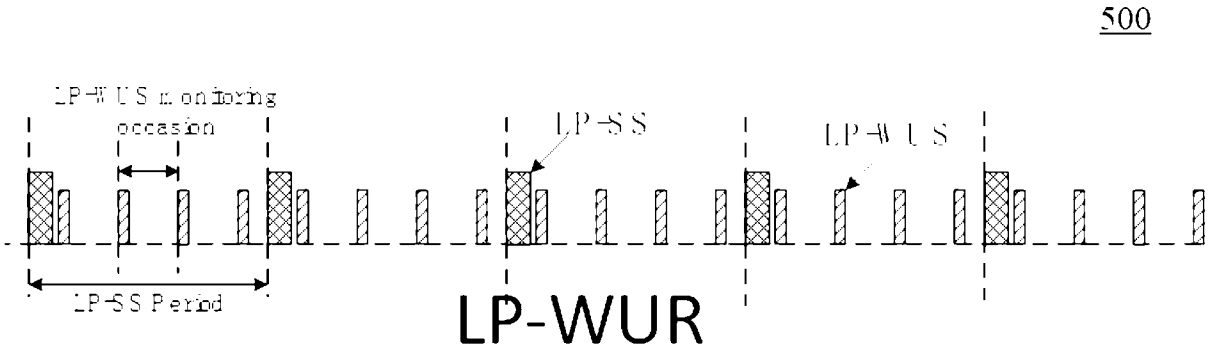


FIG. 5

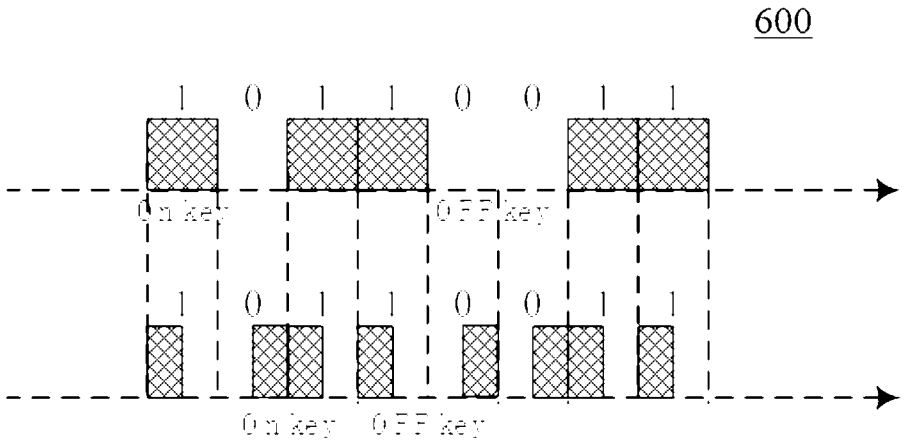


FIG. 6



FIG. 7

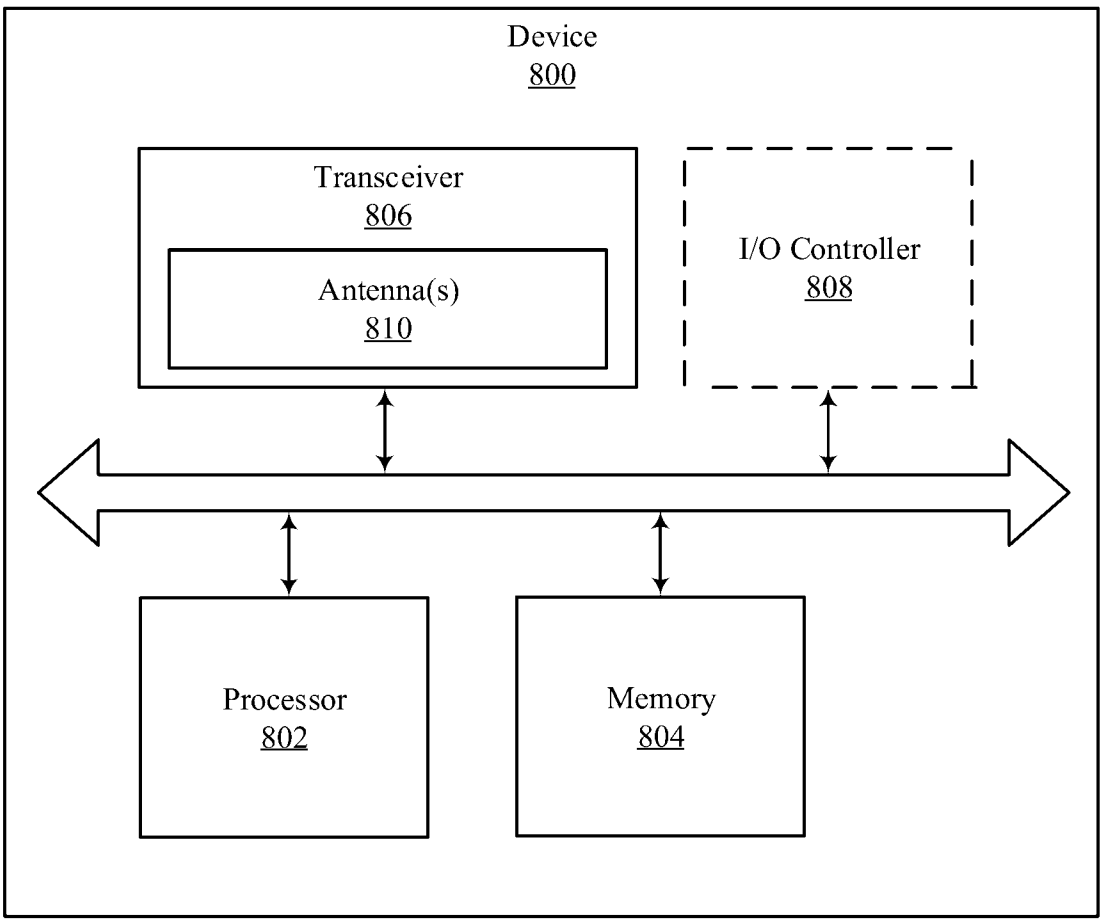

Device
800
Transceiver
806
Antenna(s)
810
I/O Controller
808
Processor
802
Memory
804

FIG. 8

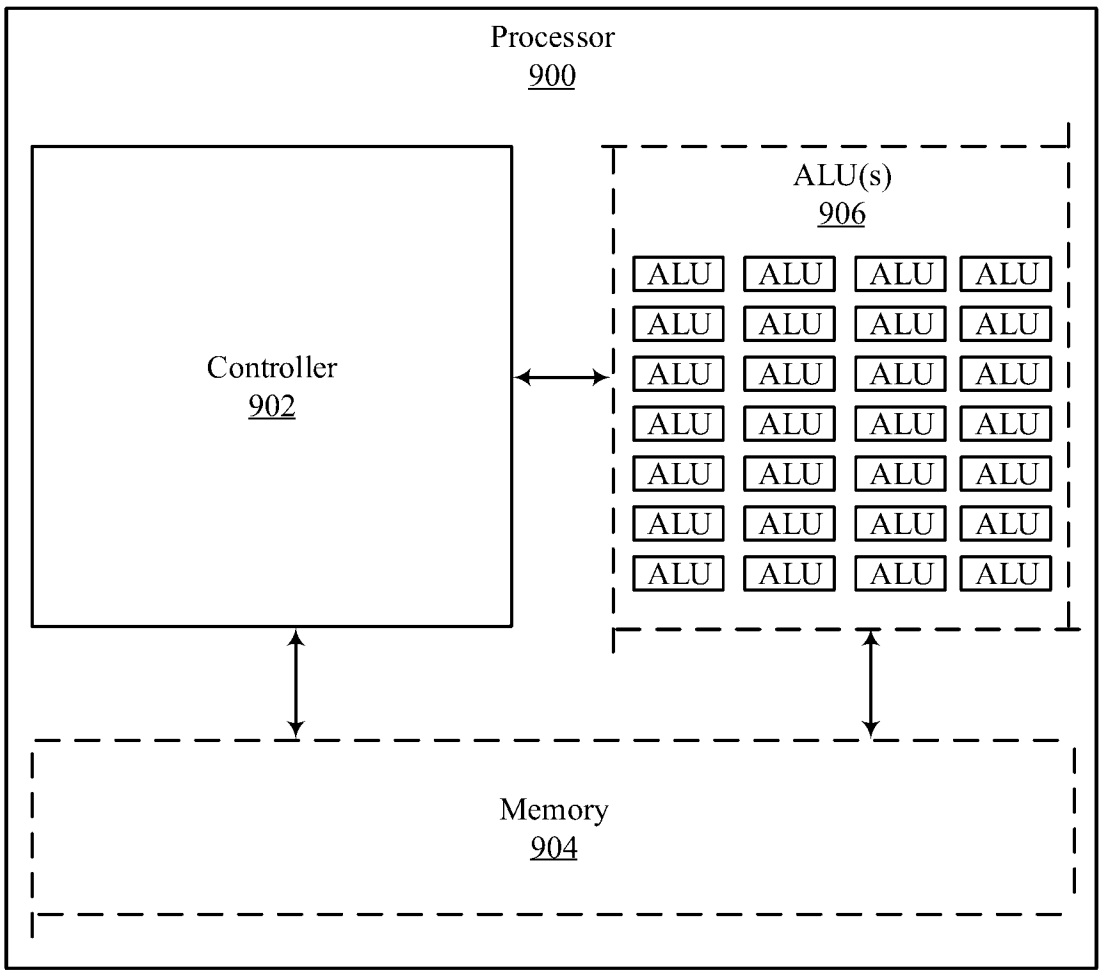


FIG. 9

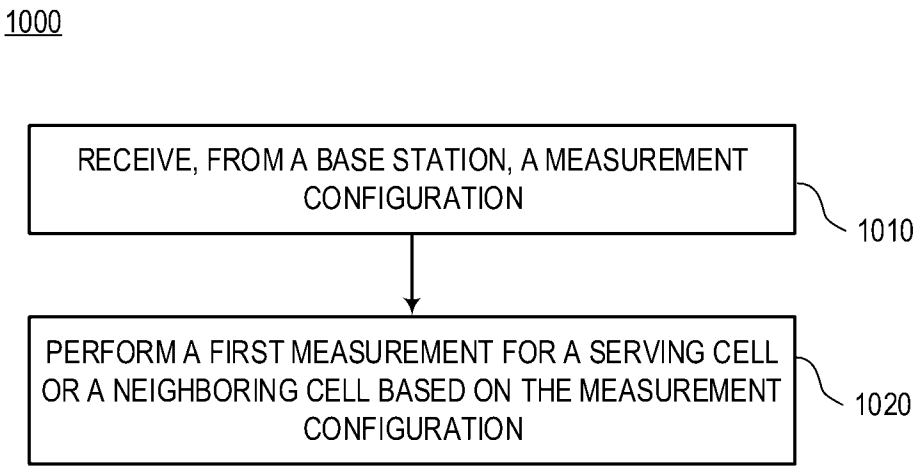

1000
RECEIVE, FROM A BASE STATION, A MEASUREMENT CONFIGURATION
1010
PERFORM A FIRST MEASUREMENT FOR A SERVING CELL OR A NEIGHBORING CELL BASED ON THE MEASUREMENT CONFIGURATION
1020

FIG. 10

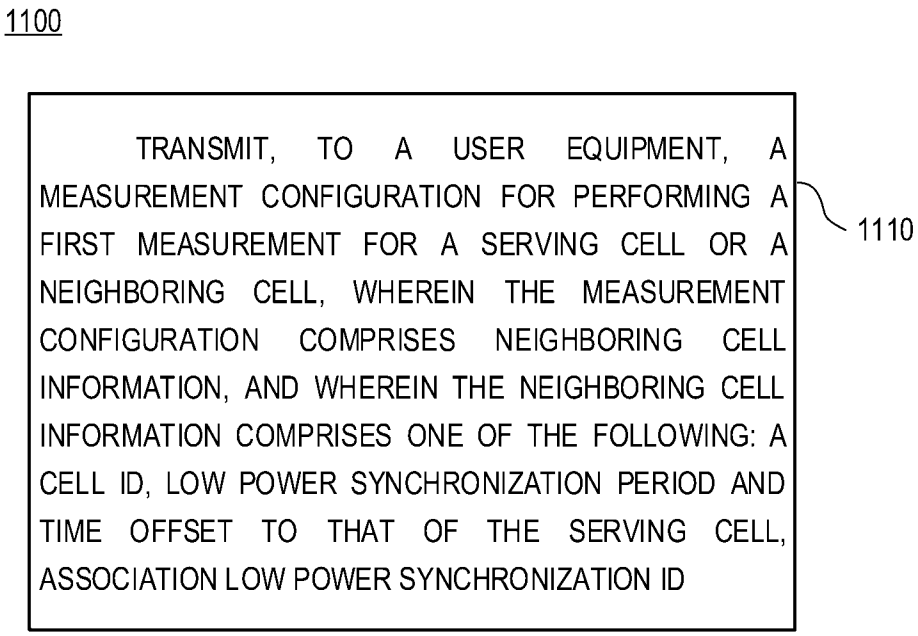

1100
TRANSMIT, TO A USER EQUIPMENT, A MEASUREMENT CONFIGURATION FOR PERFORMING A FIRST MEASUREMENT FOR A SERVING CELL OR A NEIGHBORING CELL, WHEREIN THE MEASUREMENT CONFIGURATION COMPRISES NEIGHBORING CELL INFORMATION, AND WHEREIN THE NEIGHBORING CELL INFORMATION COMPRISES ONE OF THE FOLLOWING: A CELL ID, LOW POWER SYNCHRONIZATION PERIOD AND TIME OFFSET TO THAT OF THE SERVING CELL, ASSOCIATION LOW POWER SYNCHRONIZATION ID
1110

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/122874

A. CLASSIFICATION OF SUBJECT MATTER

H04W 52/02(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT,ENTXTC,VEN: RRM, DRX, WUR, referrence, measurement, configuration, low, power, synchronization, period, signal, neighboring, cell, wake-up, transmit, time offset.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2023055700 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 06 April 2023 (2023-04-06) claims 1-10 and description, paragraphs 102-142	1-23
X	US 2023156637 A1 (QUALCOMM INC.) 18 May 2023 (2023-05-18) claims 1-22 and description, paragraphs 6-20	1-23
A	WO 2023152253 A1 (TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)) 17 August 2023 (2023-08-17) the whole document	1-23
A	CN 109314891 A (TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)) 05 February 2019 (2019-02-05) the whole document	1-23

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
18 June 2024	**21 June 2024**

Name and mailing address of the ISA/CN	Authorized officer
CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	**GUO,Jing** Telephone No. **(+86) 010-53961671**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/122874

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2023055700	A1	06 April 2023	KR	2024071411	A	22 May 2024
US	2023156637	A1	18 May 2023	JP	2023501880	A	20 January 2023
				TW	202131724	A	16 August 2021
				EP	4042754	A1	17 August 2022
				BR	112022006244	A2	21 June 2022
				KR	20220083686	A	20 June 2022
				WO	2021068181	A1	15 April 2021
WO	2023152253	A1	17 August 2023		None		
CN	109314891	A	05 February 2019	WO	2017220135	A1	28 December 2017
				EP	3476153	A1	01 May 2019
				US	2018213470	A1	26 July 2018
				KR	20190020124	A	27 February 2019