

APPARATUS AND METHOD FOR A LOW POWER TRANSMISSION QUASI-CO- LOCATION IN A WIRELESS NETWORK

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more
5 specifically to low power transmission quasi-co-location (QCL) in a wireless network.

BACKGROUND

[0002] A wireless communications system may include one or multiple network
communication devices, such as base stations, which may support wireless
communications for one or multiple user communication devices, which may be
10 otherwise known as user equipment (UE), or other suitable terminology. The wireless
communications system may support wireless communications with one or multiple user
communication devices by utilizing resources of the wireless communication system
(e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency
resources (e.g., subcarriers, carriers, or the like). Additionally, the wireless
15 communications system may support wireless communications across various radio
access technologies including third generation (3G) radio access technology, fourth
generation (4G) radio access technology, fifth generation (5G) radio access technology,
among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

SUMMARY

20 [0003] 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
25 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
30 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.

[0004] Some implementations of the method and apparatuses described herein may further include: receiving configuration information associated with a QCL relationship
5 between a low power transmission and a source reference signal, wherein the low power transmission is configured to be received by a low power processor and the source reference signal is configured to be received by a main radio processor; measuring a signal strength associated with the low power transmission using the low power processor or main radio processor; preparing a low power CSI report based on the measured signal
10 strength; and transmitting the low power CSI report.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0006] Figure 2 illustrates an example of a system having a low power (LP) wake-up
15 radio (WUR) in accordance with aspects of the present disclosure.

[0007] Figure 3 illustrates an example of a user equipment (UE) in accordance with aspects of the present disclosure.

[0008] Figure 4 illustrates an example of a processor in accordance with aspects of the present disclosure.

20 [0009] Figure 5 illustrates an example of a network equipment (NE) in accordance with aspects of the present disclosure.

[0010] Figure 6 illustrates a flowchart of a method performed by a NE in accordance with aspects of the present disclosure.

[0011] Figure 7 illustrates a flowchart of a method performed by a UE in accordance
25 with aspects of the present disclosure.

DETAILED DESCRIPTION

[0012] Various aspects of the present disclosure relate to a system that supports determining QCL between low power transmissions for low power processors and main transmissions for main processors. The low power processors may be power-sensitive

devices, small form-factor devices, internet of things (IoT) devices, wearables, and so forth that may operate with low power.

[0013] Aspects of the present disclosure are described in the context of a wireless communications system.

5 [0014] Figure 1 illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more NE 102, one or more UE 104, and a core network (CN) 106. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be
10 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 new radio (NR) network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network,
15 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, for example, 6G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple
20 access (FDMA), or code division multiple access (CDMA), etc.

[0015] The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a network function, a network entity, a radio access network (RAN), a NodeB,
25 an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE 104 may communicate via a communication link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0016] An NE 102 may provide a geographic coverage area for which the NE 102
30 may support services for one or more UEs 104 within the geographic coverage area. For example, an NE 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, an NE 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). In some implementations, different geographic coverage areas associated with the same or different radio access technologies may overlap, but the different geographic coverage areas may be associated with different NE 102.

[0017] The one or more UE 104 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 remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a transmitter device, a receiver 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.

[0018] A UE 104 may be able to support wireless communication directly with other UEs 104 over a communication link. 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 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a UE-to-UE interface (PC5 interface).

[0019] An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, N2, or network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other or indirectly (e.g., via the CN 106). In some implementations, one or more NE 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).

[0020] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 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 NE 102 associated with the CN 106.

[0021] The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N2, or another network interface). The packet data network may include an application server. In some implementations, one or more UEs 104 may communicate with the application server. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via an NE 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 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 CN 106 (e.g., one or more network functions of the CN 106).

[0022] In the wireless communications system 100, the NEs 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 NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 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 NEs 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0023] 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., $\mu=0$) 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., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu=2$) 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., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0024] 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.

[0025] 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., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) 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., orthogonal frequency division multiplexing (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., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

5 [0026] 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
10 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 NEs 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 NEs 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control
15 information, data). In some implementations, FR2 may be used by the NEs 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0027] 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., $\mu=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu=1$), which
20 includes 30 kHz subcarrier spacing; and a third numerology (e.g., $\mu=2$), 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., $\mu=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu=3$), which includes 120 kHz subcarrier spacing.

25 [0028] Certain examples found herein may be used for a low-power wake up signal (WUS) and/or WUR for power-sensitive devices, small form-factor devices including IoT devices (e.g., industrial sensors, controllers, and so forth), and/or wearables. Other examples of devices are not precluded and may include devices such as extended reality (XR), smart glasses, smart phones, and so forth.

30 [0029] Figure 2 illustrates an example of a system 200 having a LP-WUR in accordance with aspects of the present disclosure. The system 200 includes a gNB 202 and a UE 204. The gNB 202 transmits a new radio (NR) signal 206 to the UE 204. The

UE 204 receives the NR signal 206 at a radio frequency (RF) 208 receiver which provides the NR signal 206 to a NR main receiver 210 that processes the NR signal 206. Further, the gNB 202 transmits a LP-WUS 212 to the UE 204. The UE 204 receives the LP-WUS 212 at a RF 214 receiver which provides the LP-WUS 212 to an LP-WUR 216 that
5 processes the LP-WUS 212.

[0030] The LP-WUS 212 residing in the LP-WUR 216 which may be used to wake up the main radio (NR main receiver 210). For waveform generation, the following observations may be made: 1) a flat spectrum in a frequency domain may provide robustness against frequency selective fading compared to concentrated energy in the
10 frequency domain; and 2) for OOK-4, a sequence before a discrete Fourier transform (DFT)/least-square (LS) with a variation in phase, such as with a Zadoff-Chu (ZC) sequence, an M-sequence, or quadrature amplitude modulation (QAM) sequence, may achieve a more flattened spectrum.

[0031] Knowledge of sequences used in LP-WUS waveform generation may improve
15 performance for a receiver with in-phase (I) and/or quadrature (Q) (IQ) branches. For example, for a waveform-option-3, there may be a harmonized design that accommodates OOK-1/OOK-4 and an orthogonal frequency division multiplexing (OFDM) waveform, e.g., specified overlaid OFDM sequences over OOK symbols. As another example, for radio resource control (RRC) IDLE/INACTIVE, in addition to existing primary
20 synchronization signal (PSS)/secondary synchronization signal (SSS), low power (LP)-synchronization signal (SS) (e.g., OOK-1 and/or OOK-4 waveform with/without overlaid OFDM sequences with potential further down selection in a certain phase) for LP-WUR that cannot receive existing PSS/SSS, synchronization and/or radio resource management (RRM) may be supported for a serving cell.

25 [0032] In some systems, a receiver based on an envelope detector receiving an OOK waveform maximizes a power saving gain compared to an IQ correlator; however, coverage of a receiver based on an envelope detector may be limited as compared with coverage of an IQ correlator receiver type.

[0033] In a connected mode, a LP-WUS receiver may need to align a reception beam
30 based on mobility of a UE having the LP-WUS receiver or a transmission beam from a gNB, and channel state information (CSI) feedback from the LP-WUS receiver may be

helpful. Since the LP-WUS doesn't have may not have transmission capability, then CSI reporting may be done using the main radio (e.g., main radio processor).

[0034] To measure LP-WUS and/or LP-SS beam information for LP radio (LR)-CSI reporting, there may be a configuration of a spatial filter relationship used for the transmission and/or reception of LP-WUS and LP-SS between a target transmission and a reference and/or source reference signal (RS). With such a spatial filter configuration, a BS may transmit a target RS transmission with a same spatial domain filter used for transmission of a reference and/or source RS.

[0035] The spatial filter configuration may be provided using a transmission configuration indication (TCI)-state associated with a target RS transmission and may be indicated as a parameter for configuring a QCL relationship between the target RS transmission (e.g., LP-SS and LP-WUS) and source reference signals (e.g., SS block (SSB) and/or CSI-RS) with respect to QCL type parameters indicated in the corresponding TCI state. The TCI state of the LP-WUS and the LP-SS may describe which reference signals are used as a QCL source, and what QCL properties may be derived from each reference signal.

[0036] In certain configurations, it may be determined how a low power processor works with a multi-beam environment such that an update of a transmission and/or a reception beam from a gNB and a LP-WUR depend on mobility of a UE during a discontinuous reception (DRX) on-duration period which may include how: 1) configuration of a spatial filter relationship of a RS is related to the low power processor, such as LP-SS and/or LP-WUS with respect to a reference and/or source RS of a main radio (MR); and/or 2) transmission of LP-CSI measurement results from the LP- WUR (e.g., LR-CSI reports from the measurement of LP-SS and LP-WUS).

[0037] In some systems, for CSI reporting in DRX if a UE is configured with a WUS and higher layer signaling to enable periodic CSI reporting, if the UE is configured with DRX: 1) if the UE is configured to monitor downlink control information (DCI) format 2_6 and configured by higher layer parameter ps-TransmitOtherPeriodicCSI to report CSI with the higher layer parameter reportConfigType set to 'periodic' and reportQuantity set to quantities other than 'cri-reference signal received power (RSRP)' and 'ssb-Index-RSRP' when drx-onDurationTimer is not started, the most recent CSI measurement occasion occurs in DRX active time or during the time duration indicated by drx-

onDurationTimer also outside DRX active time for CSI to be reported; 2) if the UE is configured to monitor DCI format 2_6 and configured by higher layer parameter ps-TransmitPeriodicL1-RSRP to report L1-RSRP with the higher layer parameter reportConfigType set to 'periodic' and reportQuantity set to cri-RSRP when drx-onDurationTimer is not started, the most recent CSI measurement occasion occurs in DRX active time or during the time duration indicated by drx-onDurationTimer also outside DRX active time for CSI to be reported; and 3) otherwise, the most recent CSI measurement occasion occurs in DRX active time for CSI to be reported.

[0038] The terms antenna, panel, and antenna panel may be used interchangeably. An antenna panel may be a hardware that is used for transmitting and/or receiving radio signals at frequencies lower than 6GHz, e.g., FR1, or higher than 6GHz, e.g., FR2 or millimeter wave (mmWave). Moreover, an antenna panel may include an array of antenna elements, wherein each antenna element is connected to hardware such as a phase shifter that allows a control module to apply spatial parameters for transmission and/or reception of signals. The resulting radiation pattern may be called a beam, which may or may not be unimodal and may allow the device to amplify signals that are transmitted or received from spatial directions.

[0039] Further, an antenna panel may or may not be virtualized as an antenna port in the specifications. An antenna panel may be connected to a baseband processing module through a radio frequency (RF) chain for each of transmission (egress) and reception (ingress) directions. A capability of a device in terms of the number of antenna panels, their duplexing capabilities, their beamforming capabilities, and so on, may or may not be transparent to other devices. Capability information may be communicated via signaling or capability information may be provided to devices without a need for signaling. In the case that such information is available to other devices, it may be used for signaling or local decision making.

[0040] A device (e.g., UE, node) antenna panel may be a physical or logical antenna array including a set of antenna elements or antenna ports that share a common or a significant portion of an RF chain (e.g., IQ modulator, analog to digital (A/D) converter, local oscillator, phase shift network). The device antenna panel or "device panel" may be a logical entity with physical device antennas mapped to the logical entity. The mapping of physical device antennas to the logical entity may be up to device implementation.

Communicating (receiving or transmitting) on at least a subset of antenna elements or antenna ports active for radiating energy (also referred to herein as active elements) of an antenna panel requires biasing or powering on of the RF chain which results in current drain or power consumption in the device associated with the antenna panel (including power amplifier/low noise amplifier (LNA) power consumption associated with the antenna elements or antenna ports). The phrase "active for radiating energy," as used herein, is not meant to be limited to a transmit function but also encompasses a receive function. Accordingly, an antenna element that is active for radiating energy may be coupled to a transmitter to transmit radio frequency energy or to a receiver to receive radio frequency energy, either simultaneously or sequentially, or may be coupled to a transceiver in general, for performing its intended functionality. Communicating on the active elements of an antenna panel enables generation of radiation patterns or beams.

[0041] Depending on a device's own implementation, a "device panel" may have at least one of the following functionalities as an operational role of a unit of an antenna group to control its transmit (TX) beam independently, a unit of an antenna group to control its transmission power independently, and/or a unit of an antenna group to control its transmission timing independently. The "device panel" may be transparent to a gNB. For certain conditions, the gNB or network may assume a mapping between the device's physical antennas and a logical entity "device panel" may not be changed. For example, the condition may be included until the next update or report from the device or may include a duration of time over which the gNB assumes there will be no change to the mapping. A device may report its capability with respect to the "device panel" to the gNB or network. The device capability may include at least a number of "device panels". In one implementation, the device may support UL transmission from one beam within a panel; however, with multiple panels, more than one beam (one beam per panel) may be used for UL transmission. In another implementation, more than one beam per panel may be supported and/or used for UL transmission.

[0042] An antenna port may be defined such that a channel over which a symbol on the antenna port is conveyed may be inferred from the channel over which another symbol on the same antenna port is conveyed.

[0043] Two antenna ports may be QCL if large-scale properties of a channel over which a symbol on one antenna port is conveyed can be inferred from the channel over

which a symbol on the other antenna port is conveyed. The large-scale properties may include one or more of: delay spread, Doppler spread, Doppler shift, average gain, average delay, and/or spatial receive (RX) parameters. Two antenna ports may be QCL with respect to a subset of the large-scale properties and a different subset of large-scale properties may be indicated by a QCL Type. The QCL Type may indicate which channel properties are the same between the two reference signals (e.g., on the two antenna ports). Thus, the reference signals may be linked to each other with respect to what the UE can assume about their channel statistics or QCL properties. For example, a qcl-Type may take one of the following values: 1) 'QCL-TypeA': {Doppler shift, Doppler spread, average delay, delay spread}; 2) 'QCL-TypeB': {Doppler shift, Doppler spread}; 3) 'QCL-TypeC': {Doppler shift, average delay}; and 4) 'QCL-TypeD': {Spatial RX parameter}.

[0044] Spatial RX parameters may include one or more of: angle of arrival (AoA), Dominant AoA, average AoA, angular spread, Power Angular Spectrum (PAS) of AoA, average AoD (angle of departure), PAS of AoD, transmit and/or receive channel correlation, transmit and/or receive beamforming, spatial channel correlation, and so forth.

[0045] The QCL-TypeA, QCL-TypeB, and QCL-TypeC may be applicable for all carrier frequencies, but the QCL-TypeD may be applicable only in higher carrier frequencies (e.g., mmWave, FR2, and beyond), where essentially a UE may not be able to perform omni-directional transmission (e.g., the UE would need to form beams for directional transmission). For a QCL-TypeD between two reference signals A and B, the reference signal A may be considered to be spatially co-located with reference signal B and the UE may assume that the reference signals A and B may be received with the same spatial filter (e.g., with the same RX beamforming weights).

[0046] An “antenna port” according may be a logical port that may correspond to a beam (resulting from beamforming) or may correspond to a physical antenna on a device. A physical antenna may map directly to a single antenna port in which an antenna port corresponds to an actual physical antenna. Alternately, a set or subset of physical antennas, antenna set, antenna array, or antenna sub-array may be mapped to one or more antenna ports after applying complex weights, a cyclic delay, or both to the signal on each physical antenna. The physical antenna set may have antennas from a single module or panel or from multiple modules or panels. The weights may be fixed as in an antenna

virtualization scheme, such as cyclic delay diversity (CDD). The procedure used to derive antenna ports from physical antennas may be specific to a device implementation and transparent to other devices.

[0047] A TCI-state associated with a target transmission may indicate parameters for configuring a QCL relationship between a target transmission (e.g., target RS of demodulation RS (DMRS) ports of the target transmission during a transmission occasion) and source reference signals (e.g., SSB, CSI-RS, and/or sounding reference signal (SRS)) with respect to QCL type parameters indicated in the TCI state. The TCI may describe which reference signals are used as a QCL source, and what QCL properties can be derived from each reference signal. A device may receive a configuration of a plurality of TCI states for a serving cell for transmissions on the serving cell.

[0048] Spatial relation information associated with a target transmission may indicate parameters for configuring a spatial setting between a target transmission and a reference RS (e.g., SSB, CSI-RS, and/or SRS). For example, the device may transmit the target transmission with the same spatial domain filter used for reception of a reference RS (e.g., downlink (DL) RS such as SSB and/or CSI-RS). In another example, the device may transmit the target transmission with the same spatial domain transmission filter used for the transmission of the reference RS (e.g., UL RS such as SRS). A device may receive a configuration of a plurality of spatial relation information configurations for a serving cell for transmissions on the serving cell.

[0049] A reference signal, control information, and/or data transmitted to a low power processor by a BS may have a spatial relationship associated with a source reference signal transmitted by the BS to a MR (e.g., main radio processor). The spatial relationship configuration may be needed to measure and report a CSI report (e.g., LR-CSI) from the low power processor. Signaling the spatial relationship information to the MR or to the LR and differentiating LR-CSI reports from MR CSI reports may enable efficient reception of beams at the LR.

[0050] Various different architectures may be used with a low power processor, such as: 1) a LP-WUR may have a separate broadband (BB), RF chain, and antenna than a MR; 2) the LP-WUR may have a separate BB, but a shared RF chain and antenna with the MR; 3) the LP-WUR may have a shared BB, RF, and antenna with the MR; 4) the

LP-WUR may have a separate BB, RF chain, and/or antenna with the MR; and/or 5) the LP-WUR may have separate BB, RF chain, and/or antenna than the MR.

[0051] Further, various receiver types may be used with a low power processor, such as: 1) a LP-WUR may have a heterodyne envelope detector implemented at an inter-radio
5 frequency (IF) level; 2) the LP-WUR may have a homodyne and/or zero-IF envelope detector at a BB; and 3) the LP-WUR may have an OFDM based sequence and/or signal with a time domain and/or a frequency domain correlation.

[0052] In a harmonized waveform implementation, an ON-OFF keying (OOK) signal may contain a sequence or randomly modulated symbols like quadrature phase shift
10 keying (QPSK) transmitted within an ON-duration of the OOK transmission to produce a flattened spectrum to improve against frequency selective fading. The sequence may be Zadoff chu sequence, an M-ary or Gold sequence, and/or a golay sequence. In the OFF duration of the OOK transmission, no signal transmission may happen.

[0053] A low power processor described herein may contain any use case described
15 herein, any architecture described herein, and/or any receiver type implementation described herein. The low power processor may be related to: 1) a standalone TX and/or RX IoT device; or 2) an auxiliary chip to wake-up a main processor.

[0054] Examples of measurement metrics may include a signal quality, a signal power, and/or a detection rate of LP-WUS and/or LP-SS. For example, there may be: 1)
20 LP-reference signal strength indicator (RSSI) or energy detection (e.g., linear average of total received power over an RSSI resource); 2) LP-RSRP (e.g., a linear average of a received power of a resource of reference signals or signal parts); 3) LP-signal-to-interference and noise ratio (SINR) = LP-RSRP/(power of interference and noise); and 4) LP-reference signal received quality (RSRQ) = $[N \times] \text{LP-RSRP} / \text{LP-RSSI}$, where N is the
25 factor of resource size difference for evaluation LP-RSRP and LP-RSSI. A reference signal for performing measurements may be SSB (e.g., PSS, SSS, and/or physical broadcast channel (PBCH) DMRS), a LP-WUS-waveform sequence, and/or a LP-SS.

[0055] In one embodiment, a BS may be configured to transmit a low power RS and/or a data signal to at least one low power processors such as with a low power SS, a
30 low power broadcast signal, a low power reference signal, a low power wake-up signal, a low power control signal, and/or a low power data signal. The low power RS and/or data signal transmitted by the BS to the low power processor may be associated with a

spatial relationship configuration with source reference signal such as SSB and/or CSI-RS transmitted to a MR. Further, the low power data signal transmitted by the BS to the low power processor may be associated with a spatial relation configuration with a source low power reference signal such as a low power reference (e.g., low power SS and low power preamble transmitted to the low power processor).

[0056] A TCI state table may signal a QCL relationship configuration of a reference signal, such as SSB and/or CSI-RS transmitted by a BS to a MR, which uses the same spatial filter to transmit a low power RS and a data signal to the low power processor. The TCI state table may signal the QCL relationship configuration of the low power RS such as LP-SS and LP-data signal transmission or LP-WUS transmission to the low power processor.

[0057] The low power reference signal transmitted to the low power processor may be transmitted in an antenna port that may have followed a QCL type relationship configured to an antenna port that transmits a RS to a MR may mean that the low power reference signal may have similar propagation radio channel conditions and hence may share similar radio channel sharing properties.

[0058] For example, the low power synchronization signal is QCL-ed with an SSB via QCL type-C indicating that these two signals went through similar radio condition sharing similar properties in terms of average delay and doppler shift. Moreover, a qcl-Type may take one of the following values: 1) 'QCL-TypeA': {Doppler shift, Doppler spread, average delay, delay spread}; 2) 'QCL-TypeB': {Doppler shift, Doppler spread}; 3) 'QCL-TypeC': {Doppler shift, average delay}; and 4) 'QCL-TypeD': {Spatial RX parameter}.

[0059] One implementation of QCL for LP-SS may be configured as shown in Table 1.

Table 1

LP-SS configuration	QCL type that TCI state indicates	
	QCL type	QCL-ed reference signal
LP-SS resource type = periodic	QCL type C Ex 1 > { Tci-stateId n, Qci-Type1 { Bwp-id b, Reference signal ssb : k Qcl-Type type C } }	SSB block, k indicates SSB bit position

[0060] The LP-SS may be used to achieve coarse time and frequency synchronization of LP-WUR; hence, a preamble preceding or part of LP-WUS may be used for a finer time and frequency synchronization. The preamble may have a QCL relationship with LP-SS or with any of the reference signal transmission from the MR. Further, The LP-WUS may have a QCL-D relationship with any of the reference signals transmitted to the LP-WUR or to the MR which implies that the LP-WUR may use the same beam that is used to receive the reference signal to receive the LP-WUS.

[0061] In one example, a TCI state of LP-WUS = a TCI state of LP-SS. In another example, a TCI state of LP-WUS = a TCI state of SSB. In a further example, a TCI state of LP-WUS = a TCI state of CSI-RS.

[0062] A TCI state indicator may be transmitted as: 1) a TCI state indicator transmitted using LP-WUS or any other LP- configuration signaling; and/or 2) a TCI state indicator for RS for LR transmitted to a MR using dynamic, semi-static signaling, or another signaling, which is then transferred to the LR using inter processor communication.

[0063] The LR-CSI report may contain an L1 signal strength measurement (e.g., LP-RSSI, LP-RSRP, etc.) at a low power processor using a low power RS transmission from a BS and may be transmitted by a MR to help adjust a beam between the BS and the LR. The low power processor may have different processing capabilities to generate the LR-

CSI report than compared to the CSI report generated by the MR and the LR-CSI report may need to be transferred to the MR using inter-processor communication which may incur additional latency. In other way, the L1 signal strength measurement may be transferred to the MR using the inter processor communication and then the LR-CSI report is prepared at the MR.

[0064] Although a report type may be requested or configured for a LR, the MR could perform measurement and prepare a CSI report based on an existing reference signal transmitted to the MR QCL-ed with a reference signal of LR. The accuracy of the measurement may not be the same between the LR and the MR and hence the difference in the accuracy of measurement arising due to a noise figure and measurement inaccuracies due to different receiver architecture between LR and MR may be reported as part of capability information due to a difference in RF hardware of the LR and the MR as compared to the BS.

[0065] A LR-CSI report processing capability including a preparation time may be indicated to a BS as part of UE capability information. The UE capability information may include aspects related to a low power processor which may include an ability to measure and report CSI. The LR-CSI may be configured using a separate report type to perform L1-RSRP measurement on a LP-SS or any preamble and/or RS preceding or part of LP-WUS.

[0066] Periodic LR-CSI reporting occasions of a physical uplink control channel (PUCCH) may be separately configured compared to MR CSI reporting occasions. In another implementation, when CSI reporting for DCI WUS is disabled or set to false and when LR-CSI reporting is set to true, LR CSI may be reported using existing PUCCH occasions.

[0067] One way to limit and/or restrict wake-up of a MR when LP-WUS is being monitored in an RRC_CONNECTED mode is by offloading some CSI measurements onto a LR to allow for prolonged sleep of the MR when a CSI report is triggered. To trigger an 'LR-CSI Report' -- that is based on the LP-SS, LP-WUS, and/or LP_preamble measured by the low power processor and SSB, CSI-RS, and/or DMRS measurements made by the MR. Taking into consideration a noise figure accuracy and measurement accuracy of LR such MR measurement may be used as a LR CSI report . The network

first sends a CSI request to a UE, the UE then formulates the report based on measurements made by the LR, and finally the UE transmits this report.

[0068] In one implementation, a network may send a CSI request on a DCI signal to the MR, and the MR may transfer this request to a LR using inter-processor communication. In another implementation, a network may have a new CSI request that is LR specific, wherein the request is directly received by the LR (e.g., it may be a LP-WUS that is QCL-D with CSI-RS). Once the LR obtains this request and conducts the required measurements, the LR may either transfer these values to the MR using the inter-processor communication after which the MR formulates the LR-CSI report, or the LR may formulate the LR-CSI report directly. When the report is ready, the MR may wake-up to transmit this report on an appropriate reporting occasion.

[0069] In a further implementation, a reporting occasion may be based on a reporting restriction and/or limitation, wherein the LR-CSI report is differentiated by means of a tag within the report. The tag may be a one-bit indication that denotes a current report to be LR measured. In yet another implementation, reporting occasions for LR-CSI reports may be different than reporting occasions of other CSI reports such that a network may be implicitly aware of a report type based on an occasion it receives the report on.

[0070] Figure 3 illustrates an example of a UE 300 in accordance with aspects of the present disclosure. The UE 300 may include a processor 302, a memory 304, a controller 306, and a transceiver 308. The processor 302, the memory 304, the controller 306, or the transceiver 308, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0071] The processor 302, the memory 304, the controller 306, or the transceiver 308, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0072] The processor 302 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, a field programmable gate array (FPGA), or

any combination thereof). In some implementations, the processor 302 may be configured to operate the memory 304. In some other implementations, the memory 304 may be integrated into the processor 302. The processor 302 may be configured to execute computer-readable instructions stored in the memory 304 to cause the UE 300 to perform various functions of the present disclosure.

[0073] The memory 304 may include volatile or non-volatile memory. The memory 304 may store computer-readable, computer-executable code including instructions when executed by the processor 302 cause the UE 300 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 304 or another type of memory. 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.

[0074] In some implementations, the processor 302 and the memory 304 coupled with the processor 302 may be configured to cause the UE 300 to perform one or more of the functions described herein (e.g., executing, by the processor 302, instructions stored in the memory 304). For example, the processor 302 may support wireless communication at the UE 300 in accordance with examples as disclosed herein.

[0075] The controller 306 may manage input and output signals for the UE 300. The controller 306 may also manage peripherals not integrated into the UE 300. In some implementations, the controller 306 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 306 may be implemented as part of the processor 302.

[0076] In some implementations, the UE 300 may include at least one transceiver 308. In some other implementations, the UE 300 may have more than one transceiver 308. The transceiver 308 may represent a wireless transceiver. The transceiver 308 may include one or more receiver chains 310, one or more transmitter chains 312, or a combination thereof.

[0077] A receiver chain 310 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 310 may include one or more antennas for receive the signal over the air or wireless medium.

The receiver chain 310 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 310 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 receiver chain 310 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0078] A transmitter chain 312 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 312 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 transmitter chain 312 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 transmitter chain 312 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0079] Figure 4 illustrates an example of a processor 400 in accordance with aspects of the present disclosure. The processor 400 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 400 may include a controller 402 configured to perform various operations in accordance with examples as described herein. The processor 400 may optionally include at least one memory 404, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 400 may optionally include one or more arithmetic-logic units (ALUs) 406. 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).

[0080] The processor 400 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

5 caches (e.g., memory local to or included in the processor chipset (e.g., the processor 400) 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).

[0081] The controller 402 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 400 to cause the processor 400 to support various operations in accordance with
10 examples as described herein. For example, the controller 402 may operate as a control unit of the processor 400, generating control signals that manage the operation of various components of the processor 400. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

15 [0082] The controller 402 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 404 and determine subsequent instruction(s) to be executed to cause the processor 400 to support various operations in accordance with examples as described herein. The controller 402 may be configured to track memory address of instructions associated with the memory 404. The controller 402 may be configured to
20 decode instructions to determine the operation to be performed and the operands involved. For example, the controller 402 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 400 to cause the processor 400 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 402 may be configured to manage
25 flow of data within the processor 400. The controller 402 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 400.

[0083] The memory 404 may include one or more caches (e.g., memory local to or included in the processor 400 or other memory, such RAM, ROM, DRAM, SDRAM,
30 SRAM, MRAM, flash memory, etc. In some implementations, the memory 404 may reside within or on a processor chipset (e.g., local to the processor 400). In some other

implementations, the memory 404 may reside external to the processor chipset (e.g., remote to the processor 400).

[0084] The memory 404 may store computer-readable, computer-executable code including instructions that, when executed by the processor 400, cause the processor 400 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 402 and/or the processor 400 may be configured to execute computer-readable instructions stored in the memory 404 to cause the processor 400 to perform various functions. For example, the processor 400 and/or the controller 402 may be coupled with or to the memory 404, the processor 400, the controller 402, and the memory 404 may be configured to perform various functions described herein. In some examples, the processor 400 may include multiple processors and the memory 404 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.

[0085] The one or more ALUs 406 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 406 may reside within or on a processor chipset (e.g., the processor 400). In some other implementations, the one or more ALUs 406 may reside external to the processor chipset (e.g., the processor 400). One or more ALUs 406 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 406 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 406 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 406 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 406 to handle conditional operations, comparisons, and bitwise operations.

[0086] The processor 400 may support wireless communication in accordance with examples as disclosed herein. The processor 400 may be configured to or operable to support a means for: receiving configuration information associated with a QCL relationship between a low power transmission and a source reference signal, wherein the

low power transmission is configured to be received by a low power processor and the source reference signal is configured to be received by a main radio processor; measuring a signal strength associated with the low power transmission using the low power processor or main radio processor; preparing a low power CSI report based on the measured signal strength; and transmitting the low power CSI report.

[0087] Figure 5 illustrates an example of a NE 500 in accordance with aspects of the present disclosure. The NE 500 may include a processor 502, a memory 504, a controller 506, and a transceiver 508. The processor 502, the memory 504, the controller 506, or the transceiver 508, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0088] The processor 502, the memory 504, the controller 506, or the transceiver 508, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0089] The processor 502 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 502 may be configured to operate the memory 504. In some other implementations, the memory 504 may be integrated into the processor 502. The processor 502 may be configured to execute computer-readable instructions stored in the memory 504 to cause the NE 500 to perform various functions of the present disclosure.

[0090] The memory 504 may include volatile or non-volatile memory. The memory 504 may store computer-readable, computer-executable code including instructions when executed by the processor 502 cause the NE 500 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 504 or another type of memory. 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.

[0091] In some implementations, the processor 502 and the memory 504 coupled with the processor 502 may be configured to cause the NE 500 to perform one or more of the functions described herein (e.g., executing, by the processor 502, instructions stored in the memory 504). For example, the processor 502 may support wireless communication at the NE 500 in accordance with examples as disclosed herein. The NE 500 may be configured to support a means for: receiving configuration information associated with a QCL relationship between a low power transmission and a source reference signal, wherein the low power transmission is configured to be received by a low power processor and the source reference signal is configured to be received by a main radio processor; measuring a signal strength associated with the low power transmission using the low power processor or main radio processor; preparing a low power CSI report based on the measured signal strength; and transmitting the low power CSI report.

[0092] The controller 506 may manage input and output signals for the NE 500. The controller 506 may also manage peripherals not integrated into the NE 500. In some implementations, the controller 506 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 506 may be implemented as part of the processor 502.

[0093] In some implementations, the NE 500 may include at least one transceiver 508. In some other implementations, the NE 500 may have more than one transceiver 508. The transceiver 508 may represent a wireless transceiver. The transceiver 508 may include one or more receiver chains 510, one or more transmitter chains 512, or a combination thereof.

[0094] A receiver chain 510 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 510 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 510 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 510 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 receiver chain 510 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0095] A transmitter chain 512 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 512 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 transmitter chain 512 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 transmitter chain 512 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0096] Figure 6 illustrates a flowchart of a method 600 in accordance with aspects of the present disclosure. The operations of the method 600 may be implemented by a NE as described herein. In some implementations, a NE may execute a set of instructions to control the function elements of a processor to perform the described functions.

[0097] At 602, the method may include receiving configuration information associated with a QCL relationship between a low power transmission and a source reference signal, wherein the low power transmission is configured to be received by a low power processor and the source reference signal is configured to be received by a main radio processor. The operations of 602 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 602 may be performed by a NE as described with reference to Figure 5.

[0098] At 604, the method may include measuring a signal strength associated with the low power transmission using the low power processor or main radio processor. The operations of 604 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 604 may be performed by a NE as described with reference to Figure 5.

[0099] At 606, the method may include preparing a low power CSI report based on the measured signal strength. The operations of 606 may be performed in accordance with

examples as described herein. In some implementations, aspects of the operations of 606 may be performed a NE as described with reference to Figure 5.

[0100] At 608, the method may include transmitting the low power CSI report. The operations of 608 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 608 may be performed a NE as described with reference to Figure 5.

[0101] Figure 7 illustrates a flowchart of a method 700 in accordance with aspects of the present disclosure. The operations of the method 700 may be implemented by a UE as described herein. In some implementations, a UE 300 may execute a set of instructions to control the function elements of a processor to perform the described functions.

[0102] At 702, the method may include receiving configuration information associated with a QCL relationship between a low power transmission and a source reference signal, wherein the low power transmission is configured to be received by a low power processor and the source reference signal is configured to be received by a main radio processor. The operations of 702 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 702 may be performed by a UE as described with reference to Figure 3.

[0103] At 704, the method may include measuring a signal strength associated with the low power transmission using the low power processor or main radio processor. The operations of 704 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 704 may be performed by a UE as described with reference to Figure 3.

[0104] At 706, the method may include preparing a low power CSI report based on the measured signal strength. The operations of 706 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 706 may be performed a UE as described with reference to Figure 3.

[0105] At 708, the method may include transmitting the low power CSI report. The operations of 708 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 708 may be performed a UE as described with reference to Figure 3.

[0106] It should be noted that the method described herein describes A possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0107] The description herein is provided to enable a person having ordinary skill in
5 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
10 features disclosed herein.

CLAIMS

What is claimed is:

1. A user equipment (UE), comprising:
at least one memory; and
5 at least one processor coupled with the at least one memory and configured to cause the UE to:
receive configuration information associated with a quasi-co-
location (QCL) relationship between a low power
transmission and a source reference signal, wherein the low
10 power transmission is configured to be received by a low
power processor and the source reference signal is
configured to be received by a main radio processor;
measure a signal strength associated with the low power
transmission using the low power processor or main radio
15 processor;
prepare a low power channel state information (CSI) report based
on the measured signal strength; and
transmit the low power CSI report.
2. The UE of claim 1, wherein the low power transmission comprises a low power
20 reference signal, low power control information, low power data, a low power
broadcast signal, or a low power synchronization signal, or a combination
thereof.
3. The UE of claim 1, wherein the low power processor receives the configuration
information, and the configuration information comprises a transmission
25 configuration indicator (TCI) indicating the QCL relationship and a low power
CSI report configuration.
4. The UE of claim 1, wherein the main radio processor receives the configuration
information, and the configuration information comprises a transmission

configuration indicator (TCI) indicating the QCL relationship and a low power CSI report configuration.

5. The UE of claim 1, wherein:
 - the low power transmission uses a different broadband (BB) than the source reference signal;
 - the low power transmission uses a different radio frequency (RF) chain than the source reference signal; or
 - the low power transmission uses a different antenna than the source reference signal;
 - or a combination thereof.
6. The UE of claim 1, wherein:
 - the low power transmission uses a same broadband (BB) as the source reference signal;
 - the low power transmission uses a same radio frequency (RF) chain as the source reference signal; or
 - the low power transmission uses a same antenna as the source reference signal;
 - or a combination thereof.
7. The UE of claim 1, wherein the at least one processor is configured to cause the UE to receive report configuration information indicating to transmit the low power CSI report using the main radio processor.
8. The UE of claim 1, wherein the low power CSI report is transmitted on a physical uplink control channel (PUCCH) occasion.
9. The UE of claim 8, wherein a separate PUCCH occasion is configured to transmit the low power CSI report.
10. The UE of claim 8, wherein a trigger or a reporting type configuration is associated with transmitting the low power CSI report.

11. The UE of claim 1, wherein the at least one processor is configured to cause the UE to receive a transmission configuration indicator (TCI) state indication signaling indicating the QCL relationship between the low power transmission and the source reference signal.
- 5 12. The UE of claim 11, wherein the at least one processor is configured to cause the UE to signal the TCI state directly to the low power processor using the low power transmission.
13. The UE of claim 11, wherein the at least one processor is configured to cause the UE to signal the TCI state to the low power processor indirectly using the main
10 radio processor.
14. A processor for wireless communication, comprising:
at least one controller coupled with at least one memory and configured to cause the processor to:
receive configuration information associated with a quasi-co-
15 location (QCL) relationship between a low power transmission and a source reference signal, wherein the low power transmission is configured to be received by the processor and the source reference signal is configured to be received by a main radio processor;
20 measure a signal strength associated with the low power transmission using;
prepare a low power channel state information (CSI) report based on the measured signal strength; and
transmit the low power CSI report.
- 25 15. A method performed by a user equipment (UE), the method comprising:
receiving configuration information associated with a quasi-co-location (QCL) relationship between a low power transmission and a source reference signal, wherein the low power transmission is configured

- to be received by a low power processor and the source reference signal is configured to be received by a main radio processor;
measuring a signal strength associated with the low power transmission using the low power processor or main radio processor;
5 preparing a low power channel state information (CSI) report based on the measured signal strength; and
transmitting the low power CSI report.
16. A base station, comprising:
at least one memory; and
10 at least one processor coupled with the at least one memory and configured to cause the base station to:
receive configuration information associated with a quasi-co-location (QCL) relationship between a low power transmission and a source reference signal, wherein the low
15 power transmission is configured to be received by a low power processor and the source reference signal is configured to be received by a main radio processor;
measure a signal strength associated with the low power transmission using the low power processor or main radio
20 processor;
prepare a low power channel state information (CSI) report based on the measured signal strength; and
transmit the low power CSI report.
17. The base station of claim 16, wherein the low power transmission comprises a
25 low power reference signal, low power control information, low power data, a low power broadcast signal, or a low power synchronization signal, or a combination thereof.
18. The base station of claim 16, wherein the low power processor receives the configuration information, and the configuration information comprises a

transmission configuration indicator (TCI) indicating the QCL relationship and a low power CSI report configuration.

19. The base station of claim 16, wherein the main radio processor receives the configuration information, and the configuration information comprises a transmission configuration indicator (TCI) indicating the QCL relationship and a low power CSI report configuration.
20. The base station of claim 16, wherein:
- the low power transmission uses a different broadband (BB) than the source reference signal;
 - the low power transmission uses a different radio frequency (RF) chain than the source reference signal; or
 - the low power transmission uses a different antenna than the source reference signal;
 - or a combination thereof.