

BEAM REPORTING

[0001] The present disclosure relates to wireless communications, and more specifically to beam reporting.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations (BSs), which may be otherwise known as an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. Each network communication devices, such as a base station may support wireless communications for one or multiple user communication devices, which may be 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). Additionally, the wireless 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)).

[0003] In 5G-NR or other communication networks, beam management may be crucial for efficient communication. Beams may be formed dynamically based on the channel conditions, user location, network requirements, or other factors. In general, beam management includes procedures for beamforming, beam tracking, and beam reporting. However, these procedures related to beam management in various communication systems may need to be further improved, so as to provide better communication performance.

SUMMARY

[0004] The present disclosure relates to methods, apparatuses, and systems that support beam reporting.

[0005] Some implementations of the method and devices described herein include, receiving, from a base station, a downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting, wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting; and transmitting, via the transceiver and to the base station, the UCI transmission including a beam report.

[0006] Some implementations of the method and devices described herein may include, receiving, from the base station, a downlink signaling for updating a channel measurement resource (CMR) or at least one resource in the CMR associated with a CSI report configuration among the one or more CSI report configurations.

[0007] In some implementations of the method and devices described herein, the CMR may comprise at least one channel state information reference signal (CSI-RS) resource or at least one synchronization signal block (SSB) resource.

[0008] In some implementations of the method and devices described herein, the indication may comprise at least one CSI request field indicating at least one CSI request codepoint associated with at least one identity (ID) of the at least one CSI report configuration.

[0009] In some implementations of the method and devices described herein, the at least one CSI request field may be included in the DCI with a first DCI format or a second DCI format, and the DCI with the first format or the second DCI format may be scrambled by one of the following: a cell-radio network temporary identifier (C-RNTI); a semi-persistent CSI-RNTI (SP-CSI-RNTI); or a dedicated RNTI configured for the UCI transmission for the event triggered beam reporting.

[0010] In some implementations of the method and devices described herein, the first SR may be transmitted from the UE to the base station, and may have a higher priority than a second SR for regular uplink transmissions and a lower priority than a third SR for a beam failure recovery (BFR).

[0011] In some implementations of the method and devices described herein, a CMR associated with the at least one CSI report configuration may be associated with a serving

cell for the UE, and wherein the event triggered beam reporting may be triggered based on at least one of the following events: qualities of a first number of resources in the CMR are equal to or larger than a first threshold; qualities of a second number of resources in the CMR are larger than a first quality with a first offset, wherein the first quality is a quality of a resource associated with an indicated transmission configuration indication (TCI) state among a plurality of activated TCI states, and the first offset is equal to or larger than a second threshold; or qualities of resources associated with the plurality of activated TCI states are less than a third threshold, and qualities of a third number of resources in the CMR are larger than a fourth threshold.

[0012] In some implementations of the method and devices described herein, a quality of a resource in the CMR may be one of a layer 1 (L1) - reference signal received power (RSRP), a L1-signal to interference noise ratio (SINR), or an average value of the L1-RSRP or the L1-SINR in a measurement window.

[0013] In some implementations of the method and devices described herein, the first threshold or the third threshold may be a block error rate (BLER) based on a plurality of specific hypothetical physical downlink control channel (PDCCH) transmission parameters; and/or the fourth threshold is a L1-RSRP.

[0014] In some implementations of the method and devices described herein, the event triggered beam reporting may be triggered in the case that the at least one event is identified for a plurality of continuous times in at least one time window.

[0015] In some implementations of the method and devices described herein, the beam report may comprise one of the following: resource indicators for a plurality of reported resources among resources in a CMR associated with the at least one CSI report configuration; and qualities of the plurality of reported resources, wherein qualities of the reported resources comprise one of the following qualities corresponding to each of the plurality of reported resources: a L1-RSRP, a L1-SINR, or an average value of the L1-RSRP or the L1-SINR.

[0016] In some implementations of the method and devices described herein, a CMR associated with the at least one CSI report configuration may be associated with one or more candidate cells, and wherein each of the one or more candidate cells may have a physical cell identity (PCI) different from that of a serving cell for the UE, and wherein the event triggered beam reporting may be triggered based on at least one of the following

events: qualities of a fourth number of candidate cells are equal to or larger than a fifth threshold; or a quality of the serving cell is less than a sixth threshold, and qualities of a fifth number of candidate cells are larger than a seventh threshold.

[0017] In some implementations of the method and devices described herein, a CMR associated with the at least one CSI report configuration may be associated with one or more candidate cells, and wherein each of the one or more candidate cells may have a physical cell identity (PCI) different from that of a serving cell for the UE, and wherein the event triggered beam reporting may be triggered based on the following event: qualities of a sixth number of candidate cells are larger than a second quality with a second offset, wherein the second quality is a quality of the serving cell, and the second offset is equal to or larger than an eighth threshold.

[0018] In some implementations of the method and devices described herein, a quality of a candidate cell is an average value of a seventh number of maximum RSRPs of resources in the CMR associated with the candidate cell; and/or a quality of the serving cell is an average value of an eighth number of maximum RSRPs of resources associated with the serving cell.

[0019] In some implementations of the method and devices described herein, may include at least one of the following: in the case that each of a ninth number of maximum RSRPs of resources associated with the candidate cell is equal to or larger than the fifth threshold, the quality of the candidate cell is equal to or larger than the fifth threshold; in the case that each of a tenth number of maximum RSRPs of resources associated with the serving cell is less than the sixth threshold, the quality of the serving cell is less than the sixth threshold; or in the case that each of an eleventh number of maximum RSRPs of resources associated a candidate cell is equal to or larger than the seventh threshold, the quality of the candidate cell is equal to or larger than the seventh threshold.

[0020] In some implementations of the method and devices described herein, the beam report may be an event triggered beam report among a plurality of CSI reports, some implementations may include one of the following: in the case that the plurality of CSI reports are overlapped in a time domain, a priority of the event triggered beam report is higher than a priority of an aperiodic CSI report and a semi-persistent CSI report on the PUSCH among the plurality of CSI reports; or a priority of the event triggered beam report carried on the PUSCH with a first identity is higher than that of a further event

triggered beam report carried on the PUSCH with a second identity, wherein the first identity is smaller than the second identity.

[0021] Some implementations of the method and devices described herein include, transmitting, to a user equipment (UE), a downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting, wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting; and receiving, from the UE, the UCI transmission including a beam report.

[0022] Some implementations of the method and devices described herein may include, transmitting, to the UE, a downlink signaling for updating a channel measurement resource (CMR) or at least one resource in the CMR associated with a CSI report configuration among the one or more CSI report configurations.

[0023] In some implementations of the method and devices described herein, the CMR may comprise at least one channel state information reference signal (CSI-RS) resource or at least one synchronization signal block (SSB) resource.

[0024] In some implementations of the method and devices described herein, the indication may comprise at least one CSI request field indicating at least one CSI request codepoint associated with at least one identity (ID) of the at least one CSI report configuration.

[0025] In some implementations of the method and devices described herein, the at least one CSI request field may be included in the DCI with a first DCI format or a second DCI format, and the DCI with the first format or the second DCI format may be scrambled by one of the following: a cell-radio network temporary identifier (C-RNTI); a semi-persistent CSI-RNTI (SP-CSI-RNTI); or a dedicated RNTI configured for the UCI transmission for the event triggered beam reporting.

[0026] Some implementations of the method and devices described herein may include, receiving, from the UE, the first SR, and wherein the first SR may have a higher priority than a second SR for regular uplink transmissions and a lower priority than a third SR for a beam failure recovery (BFR).

[0027] In some implementations of the method and devices described herein, a CMR associated with the at least one CSI report configuration may be associated with a serving cell for the UE, and some implementations may include receiving, from the UE, the first SR based on at least one of the following events: qualities of a first number of resources in the CMR are equal to or larger than a first threshold; qualities of a second number of resources in the CMR are larger than a first quality with a first offset, wherein the first quality is a quality of a resource associated with an indicated transmission configuration indication (TCI) state among a plurality of activated TCI states, and the first offset is equal to or larger than a second threshold; or qualities of resources associated with the plurality of activated TCI states are less than a third threshold, and qualities of a third number of resources in the CMR are larger than a fourth threshold.

[0028] In some implementations of the method and devices described herein, a quality of a resource in the CMR may be one of a layer 1 (L1) - reference signal received power (RSRP), a L1-signal to interference noise ratio (SINR), or an average value of the L1-RSRP or the L1-SINR in a measurement window.

[0029] In some implementations of the method and devices described herein, may include at least one of the following: the first threshold or the third threshold is a block error rate (BLER) based on a plurality of specific hypothetical physical downlink control channel (PDCCH) transmission parameters; or the fourth threshold is a L1-RSRP.

[0030] Some implementations of the method and devices described herein may include, receiving, from the UE, the first SR in the case that the at least one event may be identified for a plurality of continuous times in at least one time window.

[0031] In some implementations of the method and devices described herein, the beam report may comprise one of the following: resource indicators for a plurality of reported resources among resources in a CMR associated with the at least one CSI report configuration; and qualities of the plurality of reported resources, wherein qualities of the reported resources comprise one of the following qualities corresponding to each of the plurality of reported resources: a L1-RSRP, a L1-SINR, or an average value of the L1-RSRP or the L1-SINR.

[0032] In some implementations of the method and devices described herein, a CMR associated with the at least one CSI report configuration may be associated with one or more candidate cells, and wherein each of the one or more candidate cells may have a

physical cell identity (PCI) different from that of a serving cell for the UE, and some implementations may include receiving, from the UE, the first SR based on at least one of the following events: qualities of a fourth number of candidate cells are equal to or larger than a fifth threshold; or a quality of the serving cell is less than a sixth threshold, and qualities of a fifth number of candidate cells are larger than a seventh threshold.

[0033] In some implementations of the method and devices described herein, a CMR associated with the at least one CSI report configuration may be associated with one or more candidate cells, and wherein each of the one or more candidate cells has a physical cell identity (PCI) different from that of a serving cell for the UE, and some implementations may include receiving, from the UE, the first SR based on the following event: qualities of a sixth number of candidate cells are larger than a second quality with a second offset, wherein the second quality is a quality of the serving cell, and the second offset is equal to or larger than an eighth threshold.

[0034] Some implementations of the method and devices described herein, may include one of the following: a quality of a candidate cell is an average value of a seventh number of maximum RSRPs of resources in the CMR associated with the candidate cell; or a quality of the serving cell is an average value of an eighth number of maximum RSRPs of resources associated with the serving cell.

[0035] Some implementations of the method and devices described herein, may include at least one of the following: in the case that each of a ninth number of maximum RSRPs of resources associated with the candidate cell is equal to or larger than the fifth threshold, the quality of the candidate cell is equal to or larger than the fifth threshold; in the case that each of a tenth number of maximum RSRPs of resources associated with the serving cell is less than the sixth threshold, the quality of the serving cell is less than the sixth threshold; or in the case that each of an eleventh number of maximum RSRPs of resources associated a candidate cell is equal to or larger than the seventh threshold, the quality of the candidate cell is equal to or larger than the seventh threshold.

[0036] In some implementations of the method and devices described herein, the beam report is an event triggered beam report among a plurality of CSI reports, wherein one of the following: in the case that the plurality of CSI reports are overlapped in a time domain, a priority of the event triggered beam report is higher than a priority of an aperiodic CSI report and a semi-persistent CSI report on the PUSCH among the plurality

of CSI reports; or a priority of the event triggered beam report carried on the PUSCH with a first identity is higher than that of a further event triggered beam report carried on the PUSCH with a second identity, wherein the first identity is smaller than the second identity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] FIG. 1 illustrates an example of a wireless communications system that supports beam reporting in accordance with aspects of the present disclosure.

[0038] FIG. 2 illustrates an example signaling diagram illustrating an example process that supports beam reporting in accordance with aspects of the present disclosure.

[0039] FIG. 3 illustrates an example of a device that support beam reporting in accordance with aspects of the present disclosure.

[0040] FIG. 4 illustrates an example of a processor that support beam reporting in accordance with aspects of the present disclosure.

[0041] FIG. 5 illustrates a flowchart of a method that supports beam reporting in accordance with aspects of the present disclosure.

[0042] FIG. 6 illustrates a flowchart of a method that supports beam reporting in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0043] Principles of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described 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.

[0044] 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.

[0045] 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.

[0046] 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 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.

[0047] The terminology used herein is for the purpose of describing particular embodiments 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.

[0048] As used herein, the term “communication network” refers to a network following any suitable communication standards, such as, 5G new radio (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 user equipment 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.

[0049] As used herein, the term “network device” generally refers to a node in a communication network via which a user equipment 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 a base station (BS), a pico BS, and so forth, depending on the applied terminology and technology. The network device may further refer to a network function (NF) in the core network, for example, a SMF, an AMF, a PCF, a UPF or devices with same function in future network architectures, and so forth.

[0050] As used herein, the term “user equipment (UE)” generally refers to any end device that may be capable of wireless communications. By way of example rather than a limitation, a user equipment may also be referred to as a communication device, a terminal device, 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 user equipment 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 user equipment, a personal digital assistant (PDA), a portable computer, a desktop computer, an image capture user equipment such as a digital camera, a gaming user equipment, a music storage and playback appliance, a vehicle-mounted wireless user equipment, 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: “user equipment,” “communication device,” “terminal,” “user equipment” and “UE,” may be used interchangeably.

[0051] Aspects of the present disclosure are described in the context of a wireless communications system.

[0052] FIG. 1 illustrates an example of a wireless communications system (or referred to as communication network) 100 that supports beam reporting 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), 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.

[0053] 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 signalling, transmit signalling) over a communication interface.

[0054] 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.

[0055] The one or more UEs 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 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.

[0056] 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. 1. 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. 1. 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.

[0057] 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 communication interface.

[0058] 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).

[0059] 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 central unit (CU), a distributed unit (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.

[0060] 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)).

[0061] 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 signalling (e.g., RRC, service data adaptation 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, MAC layer) functionality and signalling, and may each be at least partially controlled by the CU.

[0062] 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).

[0063] 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.

[0064] 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.

[0065] 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, N3, 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).

[0066] 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.

[0067] 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.

[0068] 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.

[0069] 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., 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.

[0070] 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.

[0071] 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 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.

[0072] Network (NW) controlled beam measurement and beam reporting for beam management was specified in the first version of new radio (NR) and has been enhanced

from Rel-16 to Rel-18 for performance improvement or for signaling overhead reduction. In order to timely acquire the quality of interested beams, e.g., the qualities of the activated transmission configuration indication (TCI) state for a bandwidth part (BWP) of a serving cell, the network needs to configure/activate frequent periodic or semi-persistent beam reporting (e.g., N best beams and corresponding layer 1 reference signal received powers (L1-RSRPs)) or triggers frequent aperiodic beam reporting. However, such operation clearly results in larger uplink (UL) report overhead.

[0073] For example, when a unified TCI framework is configured for a serving cell, the NW may first configure up to 128 joint/downlink (DL) TCI state for a BWP of a serving cell by a radio resource control (RRC) signaling. Based on the beam report corresponding to periodic/semi-persistent/aperiodic beam measurement and beam reporting, the NW may activate up to 8 joint or DL TCI states for one or two transmission reception points (TRP)s and any one of them may be indicated for DL channel/reference signal (RS) reception. To ensure the system performance with the indicated TCI state, which is selected among the activated TCI states, the NW should carefully select the TCI states for activation. For this purpose, frequent beam reporting on the some beams is required, which usually corresponds to heavy uplink control information (UCI) report overhead. Given that UE has better and more-timely knowledge of beam quality changes for each of the activated TCI state, UE-initiated beam reporting procedure with specified event can lead to more timely beam reports yet with reduced reporting overhead.

[0074] With such justification, the following objective is approved for Rel-19 MIMO evolution: (i) Specify enhancement to facilitate UE-initiated/event-driven beam management for reducing overhead and/or latency, assuming the unified TCI while leveraging (as much as possible) legacy CSI measurement and reporting configuration frameworks, targeting FR2 and TRPs with intra- and inter-cell beam management; (ii) UL signaling content(s) (and procedure(s) as required) for UE-initiated/event-driven beam reporting facilitating fast beam switching; and (iii) UL signaling medium/container considering the UE-initiated/event-driven nature of the UL transmission, designed primarily for the purpose of beam reporting.

[0075] Some embodiments in the present disclosure involve a UE initiated beam reporting procedure to help the NW select proper TCI states for activation for a BWP of a serving cell.

[0076] Principles and implementations of embodiments of the present disclosure will be described in detail below with reference to FIGS. 2-6.

[0077] FIG. 2 illustrates an example signaling diagram illustrating an example process that supports beam reporting in accordance with aspects of the present disclosure. As shown in FIG. 2, the process 200 may involve a UE 201 and a base station 202. The UE 201 may be an example of the UE 104. The base station 202 may be an example of the network entity 102. It would be appreciated that although the process 200 is applied in the communication environment 100 of FIG. 1, this process may be likewise applied to other communication scenarios with similar issues.

[0078] In the process 200, the base station 202 may transmit (210), for example via its transceiver, to the UE 201, a downlink control information (DCI) 205 for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting. The DCI 205 may be based on a first scheduling request (SR) for requesting the UCI transmission 215 and may include an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting. On the UE 201 side, the UE 201 may receive (212), for example via its transceiver, from the base station 202, the DCI 205 above. The UE 201 may transmit (214), for example via its transceiver, to the base station 202, the UCI transmission 215 including a beam report. The base station 202 may receive (216), for example via its transceiver, from the UE 201, the UCI transmission 215 above.

[0079] In some examples, the UE 201 may be configured with one or more CSI report configurations, for example, higher layer information element *CSI-ReportConfig*, which can be used for the CSI report for intra-cell measurement, or *LTM-CSI-ReportConfig*, which can be used for CSI report for L1/L2 triggered mobility, dedicated for UE initiated beam reporting. In some examples, one or more CSI report configurations may be configured for the event triggered beam reporting. For example, the *CSI-ReportConfig* or the *LTM-CSI-ReportConfig* may be configured with a higher layer parameter *reportType* set to 'eventTriggered'. UE initiated beam report is triggered by specified event, so UE initiated beam report is also called event driven or event triggered beam report.

[0080] In some embodiments, resources for measurement (e.g. channel measurement resource (CMR) associated with the CSI report configuration) may be configured for the UE 201 and may be updated by a downlink (DL) signaling. In some examples, firstly, the

UE 201 may monitor a quality of the periodic QCL-TypeD RS, which can be a CSI-RS for beam management or a CSI-RS for tracking (TRS), configured in all the activated joint/DL TCI states to monitor the radio link quality. In unified TCI framework, a UE can be configured with multiple TCI states for a BWP of a serving cell and one or more of the configured TCI states can be activated for a BWP of serving cell. In additional, a UE can be configured with a joint TCI state in a BWP of a serving cell for the UE to determine the spatial receive (Rx) filter, i.e., Rx beam, for the DL reception as well as the spatial transmit (Tx) filter, i.e., Tx beam, for the UL transmission in joint TCI mode; or be indicated with a DL TCI state which is used for the UE to determine the Rx beam and a UL TCI state which is used for the UE to determine the Tx beam in a BWP of a serving cell. A beam is represented by a reference signal, e.g., a CSI-RS resource or an SSB. Additionally, a NZP CSI-RS resource set containing K periodic or semi-persistent NZP CSI-RS resources are configured as the channel measurement resource (CMR) of the *CSI-ReportConfig* or *LTM-CSI-ReportConfig* for the UE 201 to identify new candidate beams for TCI state activation. The configured NZP CSI-RS resource set is called as the candidate beam identification set hereinafter. Since all the K NZP CSI-RS resources in the CMR will be measured by the UE 201, the number K should be configured according to capability of the UE 201. In some examples, considering that the potential candidate beams may be different for the UE 201 in different areas, the measurement resources associated with the *CSI-ReportConfig* or the *LTM-CSI-ReportConfig* may be semi-statically updated. For example, if the activated TCI states are updated by the unified TCI state activation/deactivation MAC CE, the candidate beam identification set may need to be updated as well, e.g., by a MAC CE.

[0081] In some examples, the base station 202 may transmit, and the UE 201 may receive, a downlink signaling for updating a channel measurement resource (CMR) or at least one resource in the CMR associated with a CSI report configuration among the one or more CSI report configurations. In some examples, the downlink signaling may be a DCI, a MAC CE or a RRC signaling. An example of the CSI report configuration may be *CSI-ReportConfig* or the *LTM-CSI-ReportConfig*. In some examples, the CMR may comprise at least one channel state information reference signal (CSI-RS) resource or at least one synchronization signal block (SSB) resource. In some examples, the base station 202 may transmit the downlink signaling to the UE 201 via the transceiver of the base station 202, and the UE 201 may receive the downlink signaling from the base station 202

via the transceiver of the UE 201. The transceivers of the UE 201 and the base station 202 may be used for other receiving or transmitting operations as mentioned below between the UE 201 and the base station 202.

[0082] In some examples, multiple *CSI-ReportConfigs* or *LTM-CSI-ReportConfigs* may be configured for the event triggered beam reporting, the network (NW, e.g. the base station 202) may dynamically activate any one of them when the activated joint/DL TCI state is updated. For example, any one of the *CSI-ReportConfig* or *LTM-CSI-ReportConfig* configured for the event triggered beam reporting may be activated by the DL signaling, such as a DCI, a MAC CE or a RRC signaling. One example is that the *CSI-ReportConfig* or the *LTM-CSI-ReportConfig* may be activated by the Unified TCI States Activation/Deactivation MAC CE, which is used for the TCI state activation for a BWP of a serving cell for the UE 201. In some other examples, one *CSI-ReportConfig* or *LTM-CSI-ReportConfig* is configured for the event triggered beam reporting, while the CMR associated with the *CSI-ReportConfig* or *LTM-CSI-ReportConfig*, or the NZP CSI-RS resources or SSB resources within the CSI resource set for the CMR may be updated by a MAC CE.

[0083] In some examples, the UE 201 may directly report the beam report (including beam measurement results) in layer 1 (L1) as an uplink control information (UCI) to reduce the latency. For example, as shown in FIG. 2, the UE 201 may transmit the UCI transmission 215 including the beam report to the base station 202. In some examples, a dedicated scheduling request (SR) is configured for the UE 201 to request a physical uplink shared channel (PUSCH) transmission for the beam report corresponding a *CSI-ReportConfig* for the event triggered beam reporting. The dedicated SR may be an example of the first SR transmitted from the UE 201 to the base station 202. The first SR may have a higher priority than a SR (referred to as a second SR) for regular uplink transmissions and a lower priority than a SR (referred to as a third SR) for a beam failure recovery (BFR) request, that is the dedicated SR above should have a higher priority than a regular SR and have a lower priority than the SR for beam failure recovery (BFR) request. After receiving this dedicated SR, the NW (e.g. the base station 202) may transmit a downlink control information (DCI) 205 scheduling a PUSCH for the UCI transmission 215. In order to tell the UE 201 that the scheduled PUSCH is dedicated for the UCI reporting (i.e. the beam reporting in a way of the UCI transmission), the indication included in the DCI 205 may comprise at least one CSI request field indicating

at least one CSI request codepoint associated with at least one identity (ID) of the at least one CSI report configuration. For example, the DCI 205 can use the CSI request field to indicate the CSI request codepoint associated with a *CSI-ReportConfigId* or a *LTM-CSI-ReportConfigId*. The *CSI-ReportConfigId* or the *LTM-CSI-ReportConfigId* may be an example of the ID of the at least one CSI report configuration.

[0084] In some examples, the at least one CSI request field may be included in the DCI 205 with a first DCI format or a second DCI format. An example of the first DCI format may be DCI format 0_1. An example of the second DCI format may be DCI format 0_2. The DCI 205 with the first format or the second DCI format may be scrambled by a cell-radio network temporary identifier (C-RNTI), or a semi-persistent CSI-RNTI (SP-CSI-RNTI), or a dedicated RNTI configured for the UCI transmission for the event triggered beam reporting. Specifically, the CSI request for aperiodic CSI triggering or CSI request for semi-persistent CSI triggering may be used for the following examples 1-3.

[0085] In an example 1, one of the *CSI-AssociatedTriggerState* that is mapped with a non-zero CSI request field codepoint is associated with a *CSI-ReportConfigId* or *LTM-CSI-ReportConfigId* for the event triggered beam reporting, or to configure a *CSI-AssociatedTriggerStateId* for the *CSI-ReportConfigId* or the *LTM-CSI-ReportConfigId* for the event triggered beam reporting. In this case, the PUSCH for the beam reporting may be scheduled by the DCI 205 with the DCI format 0_1 or the DCI format 0_2 scrambled by the C-RNTI containing a non-zero CSI request field which is associated with the *CSI-ReportConfigId* or the *LTM-CSI-ReportConfigId* for the event triggered beam reporting.

[0086] In an example 2, one of the *CSI-SemiPersistentOnPUSCH-TriggerState* that is mapped with a CSI request field codepoint is associated with the *CSI-ReportConfigId* or the *LTM-CSI-ReportConfigId* for the event triggered beam reporting, or to configure a *CSI-SemiPersistentOnPUSCH-TriggerStateId* for the *CSI-ReportConfigId* or the *LTM-CSI-ReportConfigId* for the event triggered beam reporting. In this case, the PUSCH for the beam reporting is scheduled by the DCI 205 with the DCI format 0_1 or the DCI format 0_2 scrambled by the SP-CSI-RNTI containing a CSI request field which is associated with the *CSI-ReportConfigId* for the event triggered beam reporting. Similar with semi-persistent CSI triggering, some of the DCI field shall be set as special values.

For example, the HARQ process number field and the redundancy version field may be set to all '0's. Different from the semi-persistent CSI triggering, this CSI and the corresponding PUSCH only transmitted in one time.

[0087] In an example 3, a dedicated RNTI is configured for the PUSCH scheduling for the UCI reporting for the event trigger beam reporting. For example, the DCI 205 with the DCI format 0_1 or the DCI format 0_2 scrambled by EVENT-CSI-RNTI is used for the PUSCH scheduling for the CSI report for the *CSI-ReportConfigId* or the *LTM-CSI-ReportConfigId* for the event triggered beam reporting. In this case, one or more *CSI-Event-TriggerState* may be configured by RRC, where each *CSI-Event-TriggerState* may be associated with one or more *CSI-ReportConfigIds* or *LTM-CSI-ReportConfigIds* for the event triggered beam reporting. Each *CSI-Event-TriggerState* is mapped to a CSI request field codepoint value for the UE 201 to identify that the scheduled PUSCH is dedicated for the UCI reporting for the *CSI-ReportConfigId* or the *LTM-CSI-ReportConfigId* for the event triggered beam reporting. The DCI 205 with a DCI format 0_0 scrambled with a dedicated RNTI may also be used to schedule the PUSCH resource for the beam reporting. This method of the process 200 may be at least applied to the case that a dedicated CSI report configuration is configured for the event triggered beam reporting.

[0088] In above examples, the UE 201 may directly report the beam report in an UCI transmission. In some other examples, the CSI report carrying the triggered beam report should be carried by a PUSCH to save the UL signal resources. For example, the beam measurement results corresponding to a specified event are carried by MAC CE. For this case, the UE 201 needs to transmit a SR to request UL resources for the MAC CE transmission when the beam reporting is triggered. The MAC CE format for the measurement results reporting corresponding to different event should be specified. In some further examples, the UE 201 may transmit the beam report with a configured grant PUSCH by associating a CG-PUSCH with the *CSI-ReportConfig* for the event triggered beam reporting. When the UE 201 determine to trigger/send a beam report, the beam report is carried by the earliest CG PUSCH transmission corresponding to the associated CG PUSCH configuration satisfying the timing requirement.

[0089] The essential of UE initiated beam report is how to specify the event for the beam report triggering. Different events correspond to different UE behavior and different

content for beam reporting. For example, each *CSI-ReportConfig* for the event triggered beam reporting may be configured with one or more events to trigger the beam report.

[0090] In some examples, the CMR associated with the at least one CSI report configuration is associated with a serving cell for the UE 201. In such examples, the event triggered beam reporting is triggered based on one or more of the following events: event (i) qualities of a first number of resources in the CMR are equal to or larger than a first threshold. Additionally, or alternatively, event (ii) qualities of a second number of resources in the CMR are larger than a first quality with a first offset, in which the first quality is a quality of a resource associated with an indicated transmission configuration indication (TCI) state among a plurality of activated TCI states, and the first offset is equal to or larger than a second threshold. Additionally, or alternatively, event (iii) qualities of resources associated with the plurality of activated TCI states are less than a third threshold, and qualities of a third number of resources in the CMR are larger than a fourth threshold.

[0091] In some examples, a quality of a resource in the CMR is one of a layer 1 (L1) - reference signal received power (RSRP), a L1-signal to interference noise ratio (SINR), or an average value of the L1-RSRP or the L1-SINR in a measurement window. In some examples, the first threshold above (e.g. Q_1 below) may be a block error rate (BLER) based on a plurality of specific hypothetical physical downlink control channel (PDCCH) transmission parameters. In some examples, the third threshold above (e.g. Q_3^{out} below) may be a block error rate (BLER) based on a plurality of specific hypothetical physical downlink control channel (PDCCH) transmission parameters. In some examples, the fourth threshold (e.g. Q_3^{in} below) may be a L1-RSRP. In some examples, the event triggered beam reporting may be triggered in the case that the at least one event is identified for a plurality of continuous times in at least one time window. The details will be further described below.

[0092] With reference to event (i) above, in some examples, if $L \geq 1$ beams, i.e., resources, in the candidate beam identification set become better than (e.g. larger than or equal to) a threshold (Q_1), then the beam reporting is triggered. In these examples, L is an example of the first number, and L is an integer. Q_1 is an example of the first threshold $L \geq 1$ beams in the candidate beam identification set become better than the threshold (Q_1), that is, qualities of L resources in the CMR are equal to or larger than the threshold (Q_1).

In such examples, the UE 201 only needs to monitor the qualities of the beams configured in the CMR of the dedicated *CSI-ReportConfig*. In some examples, the quality may be a L1-RSRP or a L1-SINR, and the Q_1 may be a block error rate (BLER) which is derived based on the specific hypothetical PDCCH transmission parameters. When L1-SINR is adopted, a resource set for interference measurement should be configured for the *CSI-ReportConfig* as well. In some other examples, the quality may be the average value within a slide window (or referred to as a measurement window), e.g., $W_{Meas} = Nd$, where d is the periodicity of the NZP CSI-RS resource in CMR and $N \geq 1$ is a integer configured by RRC. When L is not configured, it is assumed as $L=1$. For example, when the UE finds L beams of the CMR with its average L1-RSRP over the slide window equals to or larger than Q_1 , it will send a SR (a first SR) on the dedicated SR resource to request UL resource for the beam reporting. In some examples, when the measurement window is not configured, the L1-RSRP for the event triggering may be a measured RSRP corresponding to a measurement instance.

[0093] As mentioned above, the event triggered beam reporting may be triggered in the case that the at least one event is identified for a plurality of continuous times in at least one time window. Specifically, with continuous reference to event (i) above, for example, for the case that the MAC CE based beam reporting, the UE 201 may send the MAC CE when the UE 201 has detected that the quality equals to or be larger than Q_1 for N_1 continuous times (which may be controlled by a counter in MAC) within a time window W_1 (which can be controlled by a timer in the MAC), then the UE 201 may send a SR to trigger the beam reporting procedure.

[0094] With reference to event (ii) above, in some examples, $L \geq 1$ beams in the candidate beam identification set become offset ($\geq Q_2$) better than the indicated beam, then the beam reporting is triggered. In other words, the qualities of L resources in the CMR are larger than the first quality with the first offset. In these examples, L is an example of the second number, and L is an integer. Q_2 may be an example of the second threshold. Qualities of $L \geq 1$ beams in the candidate beam identification set refer to the qualities of the second number of resources in the CMR. The quality of the indicated beam refers to the first quality, i.e. the quality of a resource associated with an indicated TCI state among a plurality of activated TCI states for a BWP of a serving cell.

[0095] For this event, the UE 201 needs to monitor the qualities of the beams configured in CMR and the beam associated with the indicated joint and/or DL transmission configuration indication (TCI) states. In some examples, L1-RSRP as the quality is preferred. In some examples, the UE may compare the qualities of the beams in CMR (i.e. the qualities of the resources in the CMR) against Q_0 to find $L \geq 1$ beams satisfy the condition whose quality is better than Q_0 with an offset (an example of the first offset). Q_0 is the quality of the indicated joint/DL TCI state, i.e., the first quality. In some examples, if the UE 201 detects that L beams in the CMR with qualities are better than Q_0 , and the quality offset (i.e. the first offset) equals to or larger than Q_2 , then the UE will send a SR (i.e. the first SR) to trigger the beam report procedure.

[0096] As mentioned above, the event triggered beam reporting may be triggered in the case that the at least one event is identified for a plurality of continuous times in at least one time window. Specifically, with continuous reference to event (ii) above, for example, if the UE 201 detects that L beams in the CMR with qualities are better than Q_0 , and the quality offset (i.e. the first offset) equals to or larger than Q_2 for N_1 continuous times within a time window W_1 , then the UE will send a SR (i.e. the first SR) to trigger the beam report procedure.

[0097] With reference to event (iii) above, in some examples, if all the activated TCI states become worse than a threshold (Q_3^{out}) and $L \geq 1$ beams become better than a threshold (Q_3^{in}), then the beam reporting is triggered. All the activated TCI states become worse than a threshold (Q_3^{out}), in other words, the qualities of resources associated with the plurality of activated TCI states of a BWP of a serving cell are less than a third threshold. The threshold (Q_3^{out}) is an example of the third threshold. $L \geq 1$ beams become better than a threshold (Q_3^{in}), in other words, the qualities of a third number of resources in the CMR are larger than a fourth threshold. In these examples, L is an example of the third number, an L is an integer. The threshold (Q_3^{in}) is an example of the fourth threshold. In some examples, Q_3^{out} may be a block error rate (BLER) which is derived based on the specific hypothetical PDCCH transmission parameters and Q_3^{in} may be a L1-RSRP.

[0098] For this event, the UE 201 may firstly monitor the quality of all the activated TCI states, when the qualities of all the activated TCI state is below Q_3^{out} , then the UE may further monitor the qualities of the beams in the CMR against Q_3^{in} , when L out of all

the beams in CMR are identified with qualities better than Q_3^{in} , the UE may trigger the beam reporting.

[0099] As mentioned above, the event triggered beam reporting may be triggered in the case that the at least one event is identified for a plurality of continuous times in at least one time window. Specifically, with continuous reference to event (iii) above, for example, if the UE 201 has detected that qualities of all the activated TCI states are less than Q_4^{out} for N_1 continuous times (which can be controlled by a counter in MAC layer) within a time window W_1 (which can be controlled by a timer in MAC layer), and identify L beams in CMR with the radio link quality better than the threshold Q_4^{in} within another time window, the UE will send a SR (i.e. the first SR) to trigger the beam report procedure. On the base station 202 side, the base station 202 may receive the first SR in the case that the at least one event is identified for the plurality of continuous times in the at least one time window. When the counter and the time window are not configured, the UE may send the SR when the event is detected for a measurement time instance.

[0100] In some examples, the beam report may comprise resource indicators for a plurality of reported resources among resources in the CMR associated with the at least one CSI report configuration. The plurality of reported resource may be one of the first number of resources, the second number of resources or third number of resources above. For example, the beam report may comprise L CSI-RS resource indicators (CRIs) for the identified NZP CSI-RS resources with the quality better than Q_1 above. Additionally or alternatively, the beam report may further comprise qualities of the plurality of reported resources. The qualities of the reported resources may comprise qualities corresponding to each of the plurality of reported resources, for example, the L1-RSRP, the L1-SINR, or the average value of the L1-RSRP or the L1-SINR. For example, the beam report may comprise the L1-RSRP or the L1-SINR correspond to each of the reported NZP CSI-RS resources.

[0101] In some embodiments above, the CMR associated with the at least one CSI report configuration may be associated with a serving cell for the UE 201. In some other embodiments below, the CMR associated with the at least one CSI report configuration may be associated with one or more candidate cells. Each of the one or more candidate cells may have a physical cell identity (PCI) different from that of the serving cell for the UE 201. For example, the *CSI-ReportConfig* or the *LTM-CSI-ReportConfig* is configured

for event triggered beam measurement/report for inter-cell operation, e.g., by setting reportType as 'eventTriggered'. A UE initiated beam reporting for the inter-cell operation will be described below.

[0102] In some examples, a CMR including CSI-RS or SSB associated with serving cell PCI, and/or one of an additional PCI, which is different from the serving cell PCI or candidate cell PCI may be configured for beam measurement. For example, CSI Resource Set including multiple SSBs is configured for the *CSI-ReportConfig* or the *LTM-CSI-ReportConfig* for channel measurement as that in NR release 18. Each of the SSBs may be associated with a PCI. This can be used for the case that the UE 201 only need to monitor the performance for one or more candidate cells and the serving cells are monitored by another set of CSI report configuration, e.g., for inter-cell beam management scenario without L1/L2 triggered mobility. In some other examples, the UE 201 may be configured with a set of PCIs or candidate cell indices and the SSB indices associated with each PCI or candidate cell. For example, the CMR is configured by a list of PCI/candidate cell index and each PCI/candidate cell index is associated with a set of SSBs for measurement. In such examples, explicit CSI resource set is not needed. This can be used for the case that the UE 201 is required to compare the quality of serving cell and the candidate cells for potential cell switch in L1 and/or L2, e.g., for L1/L2 triggered mobility scenario.

[0103] In some examples, the event triggered beam reporting may be triggered based on events (a), (b) and (c) below. Event (a): qualities of a fourth number of candidate cells equal to or be larger than a fifth threshold. Event (b): a quality of the serving cell is less than a sixth threshold, and qualities of a fifth number of candidate cells are larger than a seventh threshold. Event (c): qualities of a sixth number of candidate cells are larger than a second quality with a second offset, in which the second quality is a quality of the serving cell, and the second offset is equal to or larger than an eighth threshold. For the event (a) above, in some examples, if CSI-RSs and/or SSBs associated with a serving PCI (i.e. the PCI of the serving cell) are not configured in the CMR, then the UE 201 only needs to measure the beams configured for candidate cell. For the event (b) and the event (c) above, if CSI-RSs/SSBs associated with serving PCI are configured in the CMR, then the UE may measure the beams configured for the serving cell as well as the beams configured for multiple candidate cells.

[0104] With reference to the event (a) above, an example of the event (a) may be defined as ‘E(a): $L \geq 1$ candidate cells become better than a threshold’. In such example, the threshold is the fifth threshold, and L is an integer representing the fourth number. With reference to the event (b) above, an example of the event (b) may be defined as ‘E(b): The serving cell is worse than a threshold and $L \geq 1$ candidate cells become better than a further threshold’. In such example, L is an integer representing the fifth number, the threshold may be the sixth threshold, and the further threshold may be the seventh threshold. With reference to the event (c) above, an example of the event (c) may be defined as ‘E(c): $L \geq 1$ candidate cells become offset (equal to or larger than a threshold) better than the serving cell’. In such example, L is an integer representing the sixth number, and offset may be the second offset, and the threshold may be the eighth threshold.

[0105] In some examples, a quality of a candidate cell may be an average value of a seventh number of maximum RSRPs of resources in the CMR associated with the candidate cell. In some examples, a quality of the serving cell may be an average value of an eighth number of maximum RSRPs of resources associated with the serving cell. In some examples, the quality of a cell (a candidate cell or a serving cell) may be referred to as performance of the cell. In some examples, L1-RSRP is basically used as a metric for cell quality evaluation. In some examples, layer 3 (L3)-RSRP which is filtered over measured L1-RSRP of adjacent occasions can be used (as the metric) based on UE capability when the candidate cell is one of the neighbor cells configured for L3 mobility. For example, the cell level quality may be the average L1/L3-RSRP of the top-K beams of the cell, in which K is an integer representing the seventh number for the candidate cell or the eighth number for the serving cell.

[0106] For the event (a) (i.e. E(a)), a candidate cell is identified when the average L1-RSRP/L3-RSRP of the top-K beams equals to or larger than a configured threshold. As shown in the following formula, the configured threshold is the fifth threshold and represented as Q_1 .

$$\frac{1}{K} \sum_{k,l}^K RSRP_{k,l} \geq Q_1$$

[0107] For the event (b) (i.e. E(b)), the average L1/L3-RSRP of the top-K beams of each candidate cell and the serving cell is used for the cell quality monitoring. As shown

in the following formula, a candidate cell or a serving cell may be identified when the average L1-RSRP/L3-RSRP of the top-K beams equals to or larger than a configured threshold. As an example, the sixth threshold is represented as Q_{2b}^{out} , and the seventh threshold is represented as Q_{2b}^{in} .

$$\frac{1}{K} \sum_{k, serving=1}^K RSRP_{k, serving} < Q_{2b}^{out} \ \& \ \frac{1}{K} \sum_{k, l=1}^K RSRP_{k, s} \geq Q_{2b}^{in}$$

[0108] $RSRP_{k, l}$ is the L1-RSRP or the L3-RSRP of resource k in a candidate cell l . $RSRP_{k, serving}$ is the L1-RSRP or the L3-RSRP of resource k in the serving cell. For event (c) (i.e. E(c)), the average L1-RSRP/L3-RSRP of the top-K beams of each candidate cell and the serving cell is used for the cell quality monitoring. As shown in the following formula, $\frac{1}{K} \sum_{k, l=1}^K RSRP_{k, l}$ represents a quality of the candidate cell l , and $\frac{1}{K} \sum_{k, serving=1}^K RSRP_{k, serving}$ represents a quality of the serving cell. If the offset (i.e. the second offset between the quality of the candidate cell and the quality of the serving cell is equal to or larger than a threshold (i.e. the eighth threshold, represented as Q_{2a} as shown in the following formula), then the candidate cell is identified.

$$\frac{1}{K} \sum_{k, l=1}^K RSRP_{k, l} - \frac{1}{K} \sum_{k, serving=1}^K RSRP_{k, serving} \geq Q_{2a}$$

[0109] In some examples, the cell level quality may be associated with each of a number of maximum RSRPs of resources associated with the cell. For example, the cell level quality is associated with the L1-RSRP or L3-RSRP of the top-K beams of a same cell.

[0110] In some examples, in the case that each of a ninth number of maximum RSRPs of resources associated with the candidate cell is equal to or larger than the fifth threshold, the quality of the candidate cell is equal to or larger than the fifth threshold. For example, with continuous reference to event (a), a candidate cell is identified when the L1-RSRP /L3-RSRP of each of the top-K beams equals to or larger than a configured threshold (e.g. the fifth threshold and represented as Q_1 in the following formula.

$$\{RSRP_{k, l}\}_{k=1, \dots, K} \geq Q_1$$

[0111] In some examples, in the case that each of a tenth number of maximum RSRPs of resources associated with the serving cell is less than the sixth threshold, the quality of

the serving cell is less than the sixth threshold. Additionally or alternatively, in the case that each of an eleventh number of maximum RSRPs of resources associated a candidate cell is equal to or larger than the seventh threshold, the quality of the candidate cell is equal to or larger than the seventh threshold. For example, with continuous reference to event (b), the L1/L3-RSRP of the top-K beams of each candidate cell and all the resources for serving cell is used for the cell quality monitoring. As shown in the following formula, Q_{2b}^{out} in the following formula represents the sixth threshold, and Q_{2b}^{in} in the following formula represents the seventh threshold.

$$\{RSRP_{k,serving}\}_{k=1,...,K_{all}} < Q_{2b}^{out} \ \& \ \{RSRP_{k,l}\}_{k=1,...,K} \geq Q_{2b}^{in}$$

[0112] In some examples, if L3-RSRP is used for quality monitoring, the UE 201 may trigger the beam report procedure when the condition is satisfied for one beam measurement instance. In some other examples, if L1-RSRP is used for quality monitoring, the UE 201 may trigger the beam report procedure when event has been detected for N_1 continuous times (which can be controlled by a counter in MAC layer) within a time window W_1 (which can be controlled by a timer in MAC layer).

[0113] For the examples above, for example, the CMR associated with the at least one CSI report configuration is associated with one or more candidate cells, in such examples, the beam report may comprise the identified candidate cell and the beams in the candidate cell. For the event (b) and the event (c), the NW (e.g. the base station 202) may indicate the UE 201 to always report the top-K beams and the corresponding L1-RSRPs of the identified candidate cells in the beam report.

[0114] In some examples, the beam report for a certain event is reported by a MAC CE, it's carried by a PUSCH as a data transmission and no collision handling principle is needed. In some other examples, the event is report as a type of UCI in L1, when two PUSCHs carrying UCI are overlapped in a time domain and only one of them can be transmitted, priority may be needed for the UE 201 when only one UCI can be transmitted by one PUSCH. Prioritization is also needed when UCI carrying PUSCH collides with PUCCH. Because the event triggered beam report is carried by PUSCH, it should have higher priority than the CSI carried by PUCCH. In some examples, the beam report is an event triggered beam report among a plurality of CSI reports. In some examples, in the case that the plurality of CSI reports are overlapped in a time domain, a priority of the event triggered beam report is higher than a priority of an aperiodic CSI report and a semi-

persistent CSI report on the PUSCH among the plurality of CSI reports. For example, considering that the beam report corresponding to an event may be more important than the regular beam report because the regular beam report may be the same as the last report, it should have higher priority than the aperiodic beam report and the semi-persistent beam report on PUSCH.

[0115] In some examples, a priority of the event triggered beam report carried on the PUSCH with a first identity may be higher than that of a further event triggered beam report carried on the PUSCH with a second identity, in which the first identity is smaller than the second identity. For example, when multiple beam reports for the event beam reporting overlapped in a time domain, the *CSI-ReportConfigId* associated with the beam report will be used to determine its priority. As an example, the *CSI-ReportConfigId* smaller, the corresponding priority higher. The example below may be used for describe the priority.

[0116] CSI reports are associated with a priority value:

$$\text{PriiCSI}(y, k, c, s) = 2 \cdot N_{\text{cells}} \cdot M_s \cdot y + N_{\text{cells}} \cdot M_s \cdot k + M_s \cdot c + s$$

where $y = -1$ is for event triggered CSI reports to be carried on PUSCH, $y = 0$ is for aperiodic CSI reports to be carried on PUSCH, $y = 1$ is for semi-persistent CSI reports to be carried on PUSCH, $y = 2$ is for semi-persistent CSI reports to be carried on PUCCH and $y = 3$ is for periodic CSI reports to be carried on PUCCH; $k = 0$ for CSI reports carrying L1-RSRP or L1-SINR and $k = 1$ for CSI reports not carrying L1-RSRP or L1-SINR; c is the serving cell index and N_{cells} is the value of the higher layer parameter *maxNrofServingCells*; s is the *reportConfigID* and M_s is the value of the higher layer parameter *maxNrofCSI-ReportConfigurations*. A first CSI report is said to have priority over second CSI report if the associated *PriiCSI*(y, k, c, s) value is lower for the first CSI report than for the second CSI report.

[0117] In some embodiments of the present disclosure, a UE initiated beam report mechanism is proposed. One or two activated TCI states may be indicated as a common beam for all the DL reception and/or UL transmission. Dedicated *CSI-ReportConfig* is configured for event triggered beam report and several events are proposed. Different from event beam reporting by the MAC CE, e.g., beam report for BFR (Beam Failure Recovery), UCI based event triggered beam report in L1 is proposed: a dedicated SR is

configured for event triggered beam report and DCI format 0_1/0_2 with CSI request field is used to schedule the PUSCH resources for the UCI reporting. In some embodiments, an event triggered beam report for LTM (lower layer triggered mobility) is proposed, where the UE only need to send the beam report when one or more good cells are identified based on the proposed events. Based on solutions of some embodiments of the present disclosure, more timely beam reporting may be implemented, and beam reporting overhead may be reduced, in addition, it is helpful for the network to select proper TCI states to be activated for a BWP of a serving cell for the UE.

[0118] FIG. 3 illustrates an example of a device 300 that supports beam reporting in accordance with aspects of the present disclosure. The device 300 may be an example of a UE 104 as described herein. The device 300 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 300 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 302, a memory 304, a transceiver 306, and, optionally, an I/O controller 308. 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).

[0119] The processor 302, the memory 304, the transceiver 306, 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 302, the memory 304, the transceiver 306, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0120] In some implementations, the processor 302, the memory 304, the transceiver 306, 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 302 and the memory 304 coupled with

the processor 302 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 302, instructions stored in the memory 304).

[0121] For example, the processor 302 may support wireless communication at the device 300 in accordance with examples as disclosed herein. In some examples, the processor 302 may be configured to operable to support a means for receiving, from a base station, a downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting, wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting; and a means for, transmitting, to the base station, the UCI transmission including a beam report. The processor 302 may be configured to operable to support other means for other implementations of method 500. In some other examples, the processor 302 may be configured to operable to support a means for transmitting, to a user equipment (UE), a downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting, wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting; and a means for receiving, from the UE, the UCI transmission including a beam report. The processor 302 may be configured to operable to support other means for other implementations of method 600.

[0122] The processor 302 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 302 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 302. The processor 302 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 304) to cause the device 300 to perform various functions of the present disclosure.

[0123] The memory 304 may include random access memory (RAM) and read-only memory (ROM). The memory 304 may store computer-readable, computer-executable code including instructions that, when executed by the processor 302 cause the device 300 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 302 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 304 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.

[0124] The I/O controller 308 may manage input and output signals for the device 300. The I/O controller 308 may also manage peripherals not integrated into the device 300. In some implementations, the I/O controller 308 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 308 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 308 may be implemented as part of a processor, such as the processor 302. In some implementations, a user may interact with the device 300 via the I/O controller 308 or via hardware components controlled by the I/O controller 308.

[0125] In some implementations, the device 300 may include a single antenna 310. However, in some other implementations, the device 300 may have more than one antenna 310 (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 306 may communicate bi-directionally, via the one or more antennas 310, wired, or wireless links as described herein. For example, the transceiver 306 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 306 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 310 for transmission, and to demodulate packets received from the one or more antennas 310. The transceiver 306 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0126] 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 310 for transmitting the amplified signal into the air or wireless medium.

[0127] 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 310 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.

[0128] FIG. 4 illustrates an example of a processor 400 that supports beam reporting 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. 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).

[0129] 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 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).

[0130] 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 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.

[0131] 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 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 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.

[0132] 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, SRAM, MRAM, flash memory, etc. In some implementation, 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).

[0133] 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 (e.g., functions or tasks supporting transmit power prioritization). 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.

[0134] The one or more ALUs 406 may be configured to support various operations in accordance with examples as described herein. In some implementation, 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.

[0135] The processor 400 may support wireless communication in accordance with examples as disclosed herein. In some examples the processor 402 may be configured to

or operable to support a means for receiving, from a base station, a downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting, wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting; and a means for, transmitting, to the base station, the UCI transmission including a beam report. The processor 400 may be configured to or operable to support other means for other implementations of method 500. In some other examples, the processor 402 may be configured to or operable to support a means for transmitting, to a user equipment (UE), a downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting, wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting; and a means for receiving, from the UE, the UCI transmission including a beam report. The processor 400 may be configured to or operable to support other means for other implementations of method 600.

[0136] FIG. 5 illustrates a flowchart of a method 500 that supports beam reporting in accordance with aspects of the present disclosure. The operations of the method 500 may be implemented by a device or its components as described herein. For example, the operations of the method 500 may be performed by the UE 201 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.

[0137] At 505, the method includes receiving, from a base station, a downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting, wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting. The operations of 505 may be performed in accordance with examples as described herein. In

some implementations, aspects of the operations of 505 may be performed by a device as described with reference to FIG. 1.

[0138] At 510, the method may include transmitting, to the base station, the UCI transmission including a beam report. The operations of 510 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 510 may be performed by a device as described with reference to FIG. 1.

[0139] FIG. 6 illustrates a flowchart of a method 600 that supports beam reporting in accordance with aspects of the present disclosure. The operations of the method 600 may be implemented by a device or its components as described herein. For example, the operations of the method 600 may be performed by the base station 202 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.

[0140] At 605, the method includes transmitting, to a user equipment (UE), a downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting, wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting. The operations of 605 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 605 may be performed by a device as described with reference to FIG. 1.

[0141] At 610, the method may include receiving, from the UE, the UCI transmission including a beam report. The operations of 610 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 610 may be performed by a device as described with reference to FIG. 1.

[0142] 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.

[0143] 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).

[0144] 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.

[0145] 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.

[0146] 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.

[0147] 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 (UE) comprising:
a processor; and
a transceiver coupled to the processor,
wherein the processor is configured to:
receive, via the transceiver and from a base station, a downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting, wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting; and
transmit, via the transceiver and to the base station, the UCI transmission including a beam report.
2. The UE of claim 1, wherein the processor is further configured to:
receive, via the transceiver and from the base station, a downlink signaling for updating a channel measurement resource (CMR) or at least one resource in the CMR associated with a CSI report configuration among the one or more CSI report configurations.
3. The UE of claim 2, wherein the CMR comprises at least one channel state information reference signal (CSI-RS) resource or at least one synchronization signal block (SSB) resource.
4. The UE of claim 1, wherein the indication comprises at least one CSI request field indicating at least one CSI request codepoint associated with at least one identity (ID) of the at least one CSI report configuration.
5. The UE of claim 4, wherein the at least one CSI request field is included in the DCI with a first DCI format or a second DCI format, and the DCI with the first format or the second DCI format is scrambled by one of the following:

a cell-radio network temporary identifier (C-RNTI);
a semi-persistent CSI-RNTI (SP-CSI-RNTI); or
a dedicated RNTI configured for the UCI transmission for the event triggered beam reporting.

6. The UE of claim 1, wherein the first SR is transmitted from the UE to the base station, and has a higher priority than a second SR for regular uplink transmissions and a lower priority than a third SR for a beam failure recovery (BFR).

7. The UE of claim 1, wherein a CMR associated with the at least one CSI report configuration is associated with a serving cell for the UE, and wherein the event triggered beam reporting is triggered based on at least one of the following events:

qualities of a first number of resources in the CMR are equal to or larger than a first threshold;

qualities of a second number of resources in the CMR are larger than a first quality with a first offset, wherein the first quality is a quality of a resource associated with an indicated transmission configuration indication (TCI) state among a plurality of activated TCI states, and the first offset is equal to or larger than a second threshold; or

qualities of resources associated with the plurality of activated TCI states are less than a third threshold, and qualities of a third number of resources in the CMR are larger than a fourth threshold.

8. The UE of claim 7, wherein:

a quality of a resource in the CMR is one of a layer 1 (L1) - reference signal received power (RSRP), a L1-signal to interference noise ratio (SINR), or an average value of the L1-RSRP or the L1-SINR in a measurement window.

9. The UE of claim 7, wherein at least one of the following:

the first threshold or the third threshold is a block error rate (BLER) based on a plurality of specific hypothetical physical downlink control channel (PDCCH) transmission parameters; or

the fourth threshold is a L1-RSRP.

10. The UE of any of claims 7-9, wherein the event triggered beam reporting is triggered in the case that the at least one event is identified for a plurality of continuous times in at least one time window.

11. The UE of claim 1, wherein the beam report comprises one of the following:

resource indicators for a plurality of reported resources among resources in a CMR associated with the at least one CSI report configuration; and

qualities of the plurality of reported resources, wherein qualities of the reported resources comprise one of the following qualities corresponding to each of the plurality of reported resources: a L1-RSRP, a L1-SINR, or an average value of the L1-RSRP or the L1-SINR.

12. The UE of claim 1, wherein a CMR associated with the at least one CSI report configuration is associated with one or more candidate cells, and wherein each of the one or more candidate cells has a physical cell identity (PCI) different from that of a serving cell for the UE, and wherein the event triggered beam reporting is triggered based on at least one of the following events:

qualities of a fourth number of candidate cells are equal to or larger than a fifth threshold; or

a quality of the serving cell is less than a sixth threshold, and qualities of a fifth number of candidate cells are larger than a seventh threshold.

13. The UE of claim 1, wherein a CMR associated with the at least one CSI report configuration is associated with one or more candidate cells, and wherein each of the one or more candidate cells has a physical cell identity (PCI) different from that of a serving cell for the UE, and wherein the event triggered beam reporting is triggered based on the following event:

qualities of a sixth number of candidate cells are larger than a second quality with a second offset, wherein the second quality is a quality of the serving cell, and the second offset is equal to or larger than an eighth threshold.

14. The UE of claim 12 or 13, wherein one of the following:

a quality of a candidate cell is an average value of a seventh number of maximum RSRPs of resources in the CMR associated with the candidate cell; or

a quality of the serving cell is an average value of an eighth number of maximum RSRPs of resources associated with the serving cell.

15. The UE of claim 12, wherein at least one of the following:

in the case that each of a ninth number of maximum RSRPs of resources associated with the candidate cell is equal to or larger than the fifth threshold, the quality of the candidate cell is equal to or larger than the fifth threshold;

in the case that each of a tenth number of maximum RSRPs of resources associated with the serving cell is less than the sixth threshold, the quality of the serving cell is less than the sixth threshold; or

in the case that each of an eleventh number of maximum RSRPs of resources associated a candidate cell is equal to or larger than the seventh threshold, the quality of the candidate cell is equal to or larger than the seventh threshold.

16. The UE of claim 1, wherein the beam report is an event triggered beam report among a plurality of CSI reports, wherein one of the following:

in the case that the plurality of CSI reports are overlapped in a time domain, a priority of the event triggered beam report is higher than a priority of an aperiodic CSI report and a semi-persistent CSI report on the PUSCH among the plurality of CSI reports; or

a priority of the event triggered beam report carried on the PUSCH with a first identity is higher than that of a further event triggered beam report carried on the PUSCH with a second identity, wherein the first identity is smaller than the second identity.

17. 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 (UE), a downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting,

wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting; and

receive, via the transceiver and from the UE, the UCI transmission including a beam report.

18. 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 downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting, wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting; and

transmit, to the base station, the UCI transmission including a beam report.

19. 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 (UE), a downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information (UCI) transmission for event triggered beam reporting, wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting; and

receive, from the UE, the UCI transmission including a beam report.

20. A method performed by a user equipment (UE), the method comprising:

receiving, from a base station, a downlink control information (DCI) for scheduling a physical uplink shared channel (PUSCH) for an uplink control information

(UCI) transmission for event triggered beam reporting, wherein the DCI is based on a first scheduling request (SR) for requesting the UCI transmission and includes an indication associated with at least one channel state information (CSI) report configuration for the event triggered beam reporting; and

transmitting, to the base station, the UCI transmission including a beam report.