

CONFIGURATION FOR BEAM PREDICTION

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to a user equipment (UE), a base station (BS), methods, apparatuses, and computer readable
5 medium for a configuration for beam prediction.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may be otherwise known as an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. Each network
10 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).
15 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)).
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[0003] In the third generation partnership project (3GPP) release 18, artificial intelligence (AI) enabled beam prediction or AI based beam prediction is studied. AI based beam prediction provided significant gain on reference signal (RS) overhead reduction as well as the latency reduction with negligible performance loss. The AI based beam prediction may
25 be implemented by a UE-side model, details of which should be further studied.

SUMMARY

[0004] The present disclosure relates to a UE, a BS, methods, apparatuses, processors, and computer readable medium for a configuration for beam prediction. According to the proposed solution, a channel state information (CSI) report configuration may be configured
30 to the UE for beam prediction.

[0005] In some implementations, there is provided a UE. The UE comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the UE to: receive, from a base station, a channel state information (CSI) report configuration, wherein the CSI report configuration comprises a first resource set configured as a channel measurement resource (CMR) and a second resource set for beam prediction, wherein the CSI report configuration further comprises a number of measurement instances of the first resource set and a number of prediction instances of the second resource set, wherein the first resource set comprise one or more non-zero power (NZP) CSI reference signal (RS) resource sets or a synchronization signal block (SSB) resource set, and wherein the second resource set for beam prediction comprises a further NZP CSI-RS resource set or a further SSB resource set; determine prediction information for the second resource set for beam prediction based on measurement results of the first resource set configured as the CMR; and transmit, to the base station, a beam report comprising the prediction information for the second resource set for beam prediction.

[0006] In some implementations, there is provided a base station. The base station comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the base station to: transmit, to a UE, a CSI report configuration, wherein the CSI report configuration comprises a first resource set configured as a CMR and a second resource set for beam prediction, wherein the CSI report configuration further comprises a number of measurement instances of the first resource set and a number of prediction instances of the second resource set, wherein the first resource set comprise one or more NZP CSI-RS resource sets or an SSB resource set, and wherein the second resource set for beam prediction comprises a further NZP CSI-RS resource set or a further SSB resource set; and receive, from the UE a beam report comprising prediction information for the second resource set for beam prediction.

[0007] In some implementations, there is provided a method performed by the UE. The method comprises: receiving, from a base station, a CSI report configuration, wherein the CSI report configuration comprises a first resource set configured as a CMR and a second resource set for beam prediction, wherein the CSI report configuration further comprises a number of measurement instances of the first resource set and a number of prediction instances of the second resource set, wherein the first resource set comprise one or more NZP CSI-RS resource sets or an SSB resource set, and wherein the second resource set for beam prediction comprises a further NZP CSI-RS resource set or a further SSB resource set;

determining prediction information for the second resource set for beam prediction based on measurement results of the first resource set configured as the CMR; and transmitting, to the base station, a beam report comprising the prediction information for the second resource set for beam prediction.

5 **[0008]** In some implementations, there is provided a method performed by the base station. The method comprises: transmitting, to a UE, a CSI report configuration, wherein the CSI report configuration comprises a first resource set configured as a CMR and a second resource set for beam prediction, wherein the CSI report configuration further comprises a number of measurement instances of the first resource set and a number of prediction
10 instances of the second resource set, wherein the first resource set comprise one or more NZP CSI-RS resource sets or an SSB resource set, and wherein the second resource set for beam prediction comprises a further NZP CSI-RS resource set or a further SSB resource set; and receiving, from the UE a beam report comprising prediction information for the second resource set for beam prediction.

15 **[0009]** In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a base station, a CSI report configuration, wherein the CSI report configuration comprises a first resource set configured as a CMR and a second resource set for beam prediction, wherein the CSI report configuration further
20 comprises a number of measurement instances of the first resource set and a number of prediction instances of the second resource set, wherein the first resource set comprise one or more NZP CSI-RS resource sets or an SSB resource set, and wherein the second resource set for beam prediction comprises a further NZP CSI-RS resource set or a further SSB resource set; determine prediction information for the second resource set for beam prediction
25 based on measurement results of the first resource set configured as the CMR; and transmit, to the base station, a beam report comprising the prediction information for the second resource set for beam prediction.

[0010] In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and
30 configured to cause the processor to: transmit, to a UE, a CSI report configuration, wherein the CSI report configuration comprises a first resource set configured as a CMR and a second resource set for beam prediction, wherein the CSI report configuration further comprises a number of measurement instances of the first resource set and a number of prediction

instances of the second resource set, wherein the first resource set comprise one or more NZP CSI-RS resource sets or an SSB resource set, and wherein the second resource set for beam prediction comprises a further NZP CSI-RS resource set or a further SSB resource set; and receive, from the UE a beam report comprising prediction information for the second resource set for beam prediction.

[0011] In some implementations of the methods and the UE described herein, further comprising: determining a measurement window for a reception of the first resource set configured as the CMR, wherein a time length of the measurement window is determined based on: the number of measurement instances and a first time duration associated with the first resource set configured as the CMR.

[0012] In some implementations of the methods and the UE described herein, further comprising: determining a prediction window of the second resource set, wherein a time length of the prediction window is determined based on the number of prediction instances and a second time duration associated with the first resource set configured as the CMR.

[0013] In some implementations of the methods and the UE described herein, further comprising: in accordance with a determination that a number of a plurality of received resources in the first resource set exceeds a preconfigured threshold, determining the prediction information for the second resource set.

[0014] In some implementations of the methods and the UE described herein, further comprising: in accordance with a determination that some of resources in the first resource set are not received, performing one of: stopping transmitting the beam report; or transmitting a further beam report comprising measurement results on a plurality of received resources in the first resource set.

[0015] In some implementations of the methods and the UE described herein, further comprising: in accordance with a determination that one of the following, determining that the beam prediction is spatial domain beam prediction: the number of measurement instances equals to 1, the number of prediction instances equals to 0, or an explicit indication comprised in the CSI report configuration indicates the spatial domain beam prediction.

[0016] In some implementations of the methods and the UE described herein, further comprising: in accordance with a determination that one of the following, determining that the beam prediction is temporal beam prediction: the number of measurement instances is larger than 1, the number of prediction instances is larger than 0, an explicit indication

comprised in the CSI report configuration indicates the temporal beam prediction, or the second resource set for beam prediction is the same as the first resource set configured as the CMR.

5 [0017] In some implementations of the methods, the UE, and the BS described herein, each of the one or more NZP CSI-RS resource sets comprises a plurality of NZP CSI-RS resources, further comprising: in accordance with a determination that a number of the plurality of NZP CSI-RS resources is equal to or less than a threshold, determining that the plurality of NZP CSI-RS resources is in a same slot; or in accordance with a determination that the number of the plurality of NZP CSI-RS resources is larger than a threshold, determining that the
10 plurality of NZP CSI-RS resources comprises a plurality of subsets being in a plurality of adjacent slots respectively.

[0018] In some implementations of the methods and the BS described herein, further comprising: receiving, from the UE, a further beam report comprising measurement results on a plurality of received resources in the first resource set.

15 [0019] In some implementations of the methods and the BS described herein, further comprising: determining that a number of the plurality of received resources is less than a preconfigured threshold.

[0020] In some implementations of the methods, the UE, and the BS described herein, the first resource set configured as the CMR are transmitted in a measurement window, wherein
20 a time length of the measurement window is determined based on: the number of measurement instances and a first time duration associated with the first resource set configured as the CMR.

[0021] In some implementations of the methods, the UE, and the BS described herein, the second resource set for beam prediction is in a prediction window, wherein a time length of
25 the prediction window is determined based on the number of prediction instances and a second time duration associated with the first resource set configured as the CMR.

[0022] In some implementations of the methods, the UE, and the BS described herein, the second time duration associated with the first resource set configured as the CMR is determined based on a first time duration associated with the first resource set configured as
30 the CMR and a preconfigured scaling factor.

[0023] In some implementations of the methods, the UE, and the BS described herein, a start time of the prediction window is before a transmission time for the beam report or after

the transmission time for the beam report.

[0024] In some implementations of the methods, the UE, and the BS described herein, the first time duration associated with the first resource set configured as the CMR is a periodicity of NZP CSI-RS resources or a periodicity of SSB resources, or the first time duration
5 associated with the first resource set configured as the CMR is a separation between two consecutive transmissions of aperiodic NZP CSI-RS resource sets.

[0025] In some implementations of the methods, the UE, and the BS described herein, a number of NZP CSI-RS resources in a first subset of the plurality of subsets is determined based on one of: the threshold, a largest number not larger than a ratio of the number of the
10 plurality of NZP CSI-RS resources and a number of the plurality of subsets, or an indication transmitted to the UE.

[0026] In some implementations of the methods, the UE, and the BS described herein, each resource in the first resource set configured as the CMR is associated with a further NZP CSI-RS resource or a further SSB resource for beam prediction.

15 [0027] In some implementations of the methods, the UE, and the BS described herein, the second resource set for beam prediction comprises part or all of NZP CSI-RS resources or part or all of SSB resources in a serving cell of the UE, wherein the CSI report configuration comprises a plurality of resource identifiers (IDs) of a plurality of resources in the second resource set for beam prediction, and wherein each resource ID in the plurality of resource
20 IDs is used to identify a NZP CSI-RS resource or an SSB resource in the serving cell.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] FIG. 1 illustrates an example of a wireless communications system in which some embodiments of the present disclosure can be implemented;

25 [0029] FIG. 2 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

[0030] FIG. 3A illustrates an example schematic of multiple subsets of CSI-RS resources in accordance with some example embodiments of the present disclosure;

[0031] FIG. 3B illustrates an example schematic of multiple subsets of CSI-RS resources in accordance with some example embodiments of the present disclosure;

30 [0032] FIG. 3C illustrates an example schematic of multiple subsets of CSI-RS resources

in accordance with some example embodiments of the present disclosure;

[0033] FIG. 4 illustrates an example schematic of measurement instances and prediction instances in accordance with some example embodiments of the present disclosure;

5 **[0034]** FIG. 5 illustrates an example of a device that is suitable for implementing embodiments of the present disclosure;

[0035] FIG. 6 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure;

[0036] FIG. 7 illustrates a flowchart of an example method implemented at a UE in accordance with aspects of the present disclosure; and

10 **[0037]** FIG. 8 illustrates a flowchart of an example method implemented at a BS in accordance with aspects of the present disclosure.

[0038] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

15 **[0039]** Principles of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones
20 described below. 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.

[0040] References in the present disclosure to “one embodiment,” “an example embodiment,” “an embodiment,” “some embodiments,” and the like indicate that the
25 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
30 affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0041] It shall be understood that although the terms “first” and “second” or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of
5 embodiments. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms. In some examples, values, procedures, or apparatuses are referred to as “best,” “lowest,” “highest,” “minimum,” “maximum,” or the like. It will be appreciated that such descriptions are intended to indicate that a selection among many used
10 functional alternatives can be made, and such selections need not be better, smaller, higher, or otherwise preferable to other selections.

[0042] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of embodiments. As used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly
15 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, components and/or the like, but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof. For example, the term “includes” and its variants are to be read as open terms that mean
20 “includes, but is not limited to.” The term “based on” is to be read as “based at least in part on.” The term “one embodiment” and “an embodiment” are to be read as “at least one embodiment.” The term “another embodiment” is to be read as “at least one other embodiment.” The use of an expression such as “A and/or B” can mean either “only A” or “only B” or “both A and B.” Other definitions, explicit and implicit, may be included below.

[0043] FIG. 1 illustrates an example of a wireless communications system 100 in which some embodiments of the present disclosure can be implemented. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network (CN) 106, and a packet data network 108. The wireless communications system 100 may support various radio
30 access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as a long term evolution (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 a new radio (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.

[0044] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. A network entity 102 and a UE 104 may communicate via a communication link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0045] 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, message, 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.

[0046] 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.

[0047] 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 CN 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.

[0048] 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 (SL). For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0049] A network entity 102 may support communications with the CN 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the CN 106 through one or more backhaul links 116 (e.g., via an S1, N2, N3, 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 CN 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).

5 [0050] 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 RAN (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
10 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.

[0051] 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
15 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)).

20 [0052] 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
25 support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaption protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or
30 more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU.

[0053] 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).

[0054] 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.

[0055] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the CN 106.

[0056] The CN 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 CN 106 via a network entity 102. The CN 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 CN 106 (e.g., one or more network functions of the CN 106).

[0057] 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.

[0058] 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.

[0059] 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.

[0060] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., orthogonal frequency-division multiplexing (OFDM) symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0061] 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.

[0062] 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.

5 **[0063]** 3GPP has studied the benefits of augmenting the air-interface with features that enable improved support of artificial intelligence (AI) or machine learning (ML). Typical features include AI based CSI feedback, AI enabled beam prediction, and AI enabled positioning. AI based beam prediction provided significant gain on the RS overhead reduction as well as the latency reduction with negligible performance loss. The AI/ML
10 based beam prediction is proposed to be supported with the following objective in NR release 19:

- Beam management - DL Tx beam prediction for both UE-sided model and NW-sided model, encompassing:
 - Spatial-domain DL Tx beam prediction for Set A of beams based on measurement
15 results of Set B of beams (“BM-Case1”).
 - Temporal DL Tx beam prediction for Set A of beams based on the historic measurement results of Set B of beams (“BM-Case2”).
 - Specify necessary signalling/mechanism(s) to facilitate LCM operations specific to the Beam Management use cases, if any.
 - 20 ○ Enabling method(s) to ensure consistency between training and inference regarding NW-side additional conditions (if identified) for inference at UE.

[0064] In this event, a common framework design to support both BM-Case 1 and BM-Case 2 with UE-side AI/ML model should be studied.

[0065] Embodiments of the present disclosure provide a solution for a configuration of
25 beam prediction. In the solution, a UE may receive a CSI report configuration which indicates resources configured as CMR and resources for beam prediction. Each beam is represented by a reference resource, e.g. a NZP CSI-RS resource or an SSB resource, and a beam ID can be represented by a reference resource ID, e.g., a NZP CSI-RS resource ID or an SSB resource ID. The CSI report configuration may further indicate a measurement
30 window and a prediction window for BM-Case 2 (i.e. temporal beam prediction). Accordingly, the UE may perform the beam prediction based on the CSI report configuration.

The CSI report configuration may be used for spatial domain beam prediction, i.e. BM-Case 1, and/or temporal beam prediction, i.e., BM-Case 2, thus can be regarded as a common framework for both the spatial domain beam prediction and temporal beam prediction.

[0066] In the present disclosure, a beam report is carried by a CSI report corresponding to a CSI report configuration, and the beam report may also be called as a beam prediction report, a report of beam prediction, etc. the present disclosure does not limit.

[0067] FIG. 2 illustrates a signalling chart illustrating communication process 200 in accordance with some example embodiments of the present disclosure. The process 200 may involve a UE 201 and a base station 202. With reference to FIG. 1, the UE 201 may be implemented as the UE 104 and the base station 202 may be implemented as the network entity 102. It would be appreciated that the process 200 may be applied to other communication scenarios, which will not be described in detail.

[0068] In the process 200, the BS 202 transmits a CSI report configuration to the UE 201 at 210. In some implementations, the CSI report configuration may be a CSI report configuration for beam report (such as *CSI-ReportConfig*). The UE 201 may be provided or configured with *CSI-ReportConfig*, which is used to configure a beam report by including the resource setting for channel and interference measurement (channel measurement resource (CMR) and interference measurement resource (IMR)), number of reported beams, report quality (L1-RSRP or L1-SINR), and report type in time domain which can be periodic, semi-persistent, or aperiodic. In some implementations, the CSI report configuration may be a configuration dedicated for beam report associated with a UE-side AI/ML model (such as *AI-CSI-ReportConfig*). For example, the CSI report configuration is configured for UE-side AI/ML based beam prediction, which may be a spatial domain beam prediction or a temporal beam prediction.

[0069] In the present disclosure, the UE 201 may have one or more deployed AI/ML models for beam prediction, that is a UE-side AI/ML model. In some examples, "BM-Case 1" mentioned above may be applied, for example, the UE 201 may need to input the measurement results of Set B of beams (i.e. measurement beam Set B) in one measurement instance to the AI/ML model, and output the predicted beams for Set A (i.e. prediction beam Set A), i.e., the model output. In some examples, "BM-Case 2" mentioned above may be applied, for example, the UE 201 may input the measurement results of Set B of beams in multiple measurement instances to the AI/ML model, and the AI/ML model outputs the

predicted beam(s) for Set A for multiple future time instances. Measurement beam Set B is different from the prediction beam Set A for BM-Case 1, for example beam Set B may be a subset of beam Set A, while measurement beam Set B maybe the same as prediction beam Set A for BM-Case 2. In some cases, BM-Case 1 can be seen as a specific case of BM-Case 2 with single measurement instance and single prediction instance.

[0070] Specifically, for temporal beam prediction, i.e. “BM-Case 2”, the multiple measurement instances are historical measurement instances before a time slot, e.g. the time slot taken as the CSI reference resource. The historical measurement results may be used as the AI/ML model input for predicting the beams for future time instance(s) after a time slot, e.g., after the time slot taken as the CSI reference resource. It is to be understood that the further time instance(s) is/are after the multiple measurement instances.

[0071] In some implementations, the configuration may include an indication indicating that the beam prediction is the spatial domain beam prediction or the temporal beam prediction. In some examples, the indication may be implemented as a dedicated RRC parameter, e.g. beam prediction type which can be set to ‘spatial domain beam prediction’ or ‘temporal domain beam prediction’. In some examples, the indication may be omitted, for example the spatial domain beam prediction or the temporal beam prediction may be implicated indicated.

[0072] In some implementations, the CSI report configuration may include what resources are configured for CMR, i.e. measurement beam Set B. For example, the resource configuration of the measurement beam Set B may be included in the CSI report configuration.

[0073] In some implementations, the configuration may include a resource configuration for CMR, in some example embodiments, the configuration includes a first resource set which are configured as CMR. In some examples, the configuration may include one or more sets of CSI-RS and/or SSB resources configuration for CMR, for example, measurement beam Set B. For example, each resource set for CMR may include multiple NZP CSI-RS resources or SSB resources. In the present disclosure, the first resource set may be replaced by measurement beam Set B in some examples.

[0074] In some example embodiments, the resources for CMR may include multiple NZP CSI-RS resources. The multiple NZP CSI-RS resources may be configured as periodic, semi-persistent, or aperiodic.

[0075] For periodic and semi-persistent NZP CSI-RS resources, one NZP CSI-RS resource set may include multiple NZP CSI-RS resources which are configured as CMR. For example, a NZP CSI-RS resource set may include K NZP CSI-RS resources, where K is an integer larger than 1. In some examples, K NZP CSI-RS resources in a NZP CSI-RS resource set may be transmitted in a single slot if K is less than or equal to a threshold, for example, the threshold may be 14 or another value. In some other examples, K NZP CSI-RS resources in a NZP CSI-RS resource set may be transmitted in multiple adjacent slots if K is larger than the threshold. For example, the BS 202 may configure, via an RRC message or RRC signalling, a resource mapping for a number of NZP CSI-RS resources not exceeding the threshold within a slot. For example, the threshold may be predefined, preconfigured, or specified in the specification.

[0076] In some examples, if K is larger than the threshold, K NZP CSI-RS resources may include multiple subsets in multiple adjacent slots respectively. For example, the number of subsets (the number of slots) may be represented as N, which is an integer larger than 1.

[0077] In some examples, each subset of (N-1) subsets among the N subsets may include K1 NZP CSI-RS resources, and one subset among the N subsets may include the remaining NZP CSI-RS resources. For example, K1 may equal to the threshold (e.g. 14 or another value), or may equal to a largest number not larger than a ratio of the number of the multiple of NZP CSI-RS resources in a set and a number of the multiple of subsets (i.e. $\left\lfloor \frac{K}{N} \right\rfloor$). For example, K1 may be determined by the BS 202, and the BS 202 may transmit an indication of the value of K1 to the UE 201.

[0078] For example, if the threshold is 14, then the first 14 NZP CSI-RS resources are in the first subset, the second 14 NZP CSI-RS resources are in the second subset, ..., and the remaining NZP CSI-RS resources are in the N-th subset. For examples, the first $\left\lfloor \frac{K}{N} \right\rfloor$ NZP CSI-RS resources are in the first subset, the second $\left\lfloor \frac{K}{N} \right\rfloor$ NZP CSI-RS resources are in the second subset, ..., and the remaining resources are in the N-th subset. For example, the configuration or an indication from the BS 202 may explicitly indicate one or more NZP CSI-RS resources for each of the N subsets.

[0079] In some examples, all the NZP CSI-RS resources within one CSI-RS resource subset are transmitted in a same slot. In some examples, all the N NZP CSI-RS resource subsets are transmitted in N adjacent available slots, where a slot containing sufficient DL symbols

for the CSI-RS transmission corresponding to a CSI-RS resource subset is regarded as an available slot. In some examples, all the K CSI-RS resources may be configured with the same bandwidth and the same RE locations, powerControlOffset, and powerControlOffsetSS values.

5 **[0080]** Assuming the threshold is 14, FIG. 3A illustrates an example schematic of multiple subsets 310 of CSI-RS resources in accordance with some example embodiments of the present disclosure. As shown in FIG. 3A, the CSI-RS resources may be configured as periodic with a periodicity. A CSI-RS resource set may include $K=16$ resources, where the first 14 resources 312 belong to a CSI-RS resource subset#1 and the last 2 resources 314
10 belong to a CSI-RS resource subset#2. FIG. 3B illustrates another example schematic of multiple subsets 320 of CSI-RS resources in accordance with some example embodiments of the present disclosure. As shown in FIG. 3B, the CSI-RS resources may be configured as periodic with a periodicity. A CSI-RS resource set may include $K=16$ resources, where the first 8 resources 322 belong to a CSI-RS resource subset#1 and the last 8 resources 324
15 belong to a CSI-RS resource subset#2.

[0081] For aperiodic NZP CSI-RS resources, multiple NZP CSI-RS resource sets (such as M NZP CSI-RS resource sets) may be configured as CMR. For example, M is an integer, $M=1$ for spatial domain beam prediction, and $M>1$ for temporal beam prediction. Each of the multiple NZP CSI-RS resource sets may include multiple NZP CSI-RS resources (such
20 as K_m NZP CSI-RS resources). For example, a separation between two consecutive transmissions of the aperiodic NZP CSI-RS resource sets may be configured as m slots.

[0082] For a NZP CSI-RS resource set including K_m NZP CSI-RS resources, if K_m does not exceed the threshold, the K_m NZP CSI-RS resources are in a same slot; if K_m is larger than the threshold, the K_m NZP CSI-RS resources may include multiple subsets corresponding to
25 multiple adjacent slots. Details of the multiple subsets/slots are similar with that described with reference to N subsets/slots for periodic and semi-persistent NZP CSI-RS resources above, and thus will not be repeated herein.

[0083] Assuming the threshold is 14, FIG. 3C illustrates an example schematic of multiple subsets 330 of CSI-RS resources in accordance with some example embodiments of the present disclosure. As shown in FIG. 3C, the CSI-RS resources may be configured as
30 aperiodic, and a separation between two consecutive transmission of aperiodic CSI-RS resource sets is $m = 3$ slots. A CSI-RS resource set#1 may include $K=16$ resources,

where the first 8 resources 332 belong to a CSI-RS resource subset#1 and the last 8 resources 334 belong to a CSI-RS resource subset#2.

[0084] In some implementations, the configuration may include a number of measurement instances. The number of measurement instances may be represented as H_{meas} , which is an integer. In some examples, the measurement results on measurement beam Set B corresponding to H_{meas} measurement instances may be used as the model input. For example, the number of measurement instances may be any of 1, 2, 3, ...

[0085] In some examples, a measurement instances may be associated with a measurement resource set, e.g. a NZP CSI-RS resource set or an SSB resource set. For example, a measurement resource set is transmitted in a resource transmission occasion. For example, H_{meas} measurement instances may correspond H_{meas} continuous NZP CSI-RS transmission occasions for associated NZP CSI-RS resource set(s) configured as CMR. Each transmission occasion contains all the NZP CSI-RS resource transmissions which are configured as CMR.

[0086] In some examples, the number of measurement instances is 1, that is $H_{meas} = 1$, which indicates that the beam prediction is the spatial domain beam prediction. In some other examples, the number of measurement instances is an integer larger than 1, that is $H_{meas} > 1$, which may indicate that the beam prediction is the temporal beam prediction.

[0087] In some example embodiments, the number of measurement instances (H_{meas}) may be used for determining a measurement window. In some examples, the configuration may implicitly indicate the measurement window by including the number of measurement instances.

[0088] In some examples, the measurement window may be represented as W_{meas} . In some examples, a time length of the measurement window may be determined based on: the number of measurement instances (H_{meas}) and a first time duration associated with the first resource set configured for CMR. For example, the first time duration may be represented as d , and the time length of the measurement window may be $H_{meas} \times d$. For example, the first time duration may be a periodicity of NZP CSI-RS resources or a periodicity of SSB resources configured as CMR, e.g. for periodic and semi-persistent resources. For another example, the first time duration may be a separation (e.g. m slots) between two consecutive transmissions of the aperiodic NZP CSI-RS resource sets configured as CMR, e.g. for aperiodic resources.

[0089] In some examples, an end time of the measurement window may be associated with a slot configured for the beam report. For example, if slot n is configured or determined for beam report corresponding to the CSI report configuration, then a slot before slot n shall be determined as the CSI reference resource which may be the end time of the measurement window. For example, the end time of the measurement window may be or be before the slot $n - n_{CSI_ref}$, where n_{CSI_ref} may be determined based on a known manner for a CSI report. In some examples, the measurement window may be represented as $[k, k + H_{meas} \times d - 1]$ corresponding H_{meas} continuous NZP CSI-RS transmission occasions before the slot $n - n_{CSI_ref}$.

10 [0090] In some implementations, the CSI report configuration may indicate what beams are to be predicted, i.e. prediction beam Set A. For example, the prediction beam Set A may be explicitly or implicated indicated by the CSI report configuration.

[0091] In some implementations, the configuration may further indicate a resource configuration for beam prediction, in some example embodiments, the configuration may include a second resource set for beam prediction. In the present disclosure, the second resource set may be replaced by prediction beam Set A in some examples.

[0092] In some example embodiments, the second resource set for beam prediction may include one NZP CSI-RS resource set, such as prediction beam Set A, which may include multiple CSI-RS resources (such as K_{SetA}^{CSI-RS} CSI-RS resources). In some example embodiments, the resource set for beam prediction may include one SSB resource set which may include K_{SetA}^{SSB} SSB resources. As such, the resource set for beam prediction may be explicitly configured for the CSI-ReportConfig or AI-CSI-ReportConfig.

[0093] In some example embodiments, a resource set configured as CMR (such as each NZP CSI-RS resource set or SSB resource set which is configured as CMR) may be associated with a resource set for beam prediction (such as a NZP CSI-RS resource set or SSB resource set for beam prediction). As such, the resource set for beam prediction may be determined (e.g. implicitly indicated) by the first resource set configured for CMR and the association. A same resource set for beam prediction is expected to be associated with all the resource sets configured as CMR for a CSI report configuration.

30 [0094] In some example embodiments, a global prediction beam Set A can be specified. For example, an SSB resource set includes all the SSB resources in the serving cell, or a NZP CSI-RS resource set includes all the NZP CSI-RS resources for beam management in a

bandwidth part (BWP) of a serving cell. For example, all NZP CSI-RS resources in a BWP of a serving cell are indexed according to NZP CSI-RS resource IDs in an increasing order. For example, CSI-RS resource indicator (CRI) 0 corresponding to the NZP CSI-RS resource for beam management with lowest NZP CSI-RS resource ID, ..., CRI k corresponding to the
 5 NZP CSI-RS resource for beam management with k -th lowest NZP CSI-RS resource ID. In some example embodiments, the configuration may include at least one resource ID for indicating at least resource for beam prediction, where a resource ID may identify a NZP CSI-RS resource in a BWP of a serving cell or an SSB resource in a serving cell.

[0095] In some example embodiments, the resource configuration for beam prediction may
 10 be omitted, then the second resource set for beam prediction may be regarded as the same as the first resource set configured for CMR (e.g. beam Set B) if the beam prediction is temporal beam prediction.

[0096] In some implementations, the configuration may include a number of prediction instances. The number of prediction instances may be represented as F_{pred} , which is a
 15 integer. For example, the number of prediction instances may be any of 0, 1, 2, 3, ...

[0097] In some examples, the number of prediction instances is 0, that is $F_{pred} = 0$, which indicates that the beam prediction is the spatial domain beam prediction. In some other examples, the number of prediction instances is an integer larger than 0, that is $F_{pred} > 1$ such as 1, 2, 3, 4, ..., which may indicate that the beam prediction is the temporal beam
 20 prediction.

[0098] In some example embodiments, the number of prediction instances (F_{pred}) may be used for determining a prediction window for temporal beam prediction. In some examples, the configuration may implicitly indicate the prediction window by including the number of prediction instances.

[0099] In some examples, the prediction window may be represented as W_{pred} . In some examples, a time length of the prediction window may be determined based on: the number of prediction instances (F_{pred}), a first time duration associated with the first resource set configured for CMR, and a preconfigured scaling factor. For example, the first time duration may be represented as d , the preconfigured scaling factor may be represented as W ,
 30 and the time length of the prediction window may be $F_{pred} \times d \times W$. A time length for one prediction instance is $d \times W$. For example, the first time duration may be a periodicity of NZP CSI-RS resources or a periodicity of SSB resources configured as CMR, e.g. for

periodic and semi-persistent resources. For another example, the first time duration may be a separation (e.g. m slots) between two consecutive transmissions of the aperiodic NZP CSI-RS resource sets configured as CMR, e.g. for aperiodic resources. For example, the preconfigured scaling factor (W) may be preconfigured by an RRC message or RRC signaling, which may be a value larger than 0, such as one of $\{1/4, 1/2, 1, 2, 3, 4, \dots\}$.

[00100] In some examples, a start time (beginning) of the prediction window may be before a transmission time of the beam report or after the transmission time of the beam report. For example, the transmission time of the beam report may be a slot configured for the beam report, such as slot n . In some examples, the start time of the prediction window may be represented as l , which is determined based on: (1) mode 1: $l = n - n_{CSI_ref}$, i.e., l is the slot taken as the CSI reference resource; or (2) mode 2: $l = n + \delta$. For example, the BS 202 may configure to the UE 201 to use mode 1 or mode 2. For example, the value of δ may be also configured to the UE 201 e.g. based on a capability of the UE 201.

[00101] FIG. 4 illustrates an example schematic of measurement instances and prediction instances 400 in accordance with some example embodiments of the present disclosure. As shown in FIG. 4, a number of measurement instances is 4 and accordingly a measurement window 410 is determined. A number of prediction instances is 2 and accordingly a prediction window 420 or 430 is determined. Exemplarily, the prediction window 420 is before the slot n for CSI report, while the prediction window 430 is after the slot n for CSI report. For example, there is an offset δ between the slot n for CSI report and a start time of the prediction window 430.

[00102] In some implementations, the configuration may further indicate a number of beams for beam report, which may be represented as X . In some examples, for spatial domain beam prediction (such as $F_{pred} = 0$), X CRIs or SSB resource indicators (SSBRIs) (i.e., predicted top- X beams from prediction beam Set A) in a same CSI report in slot n corresponding to CSI reference resource $n - n_{CSI_ref}$ should be reported. In some other examples, for temporal beam prediction (such as $F_{pred} \geq 1$), $F_{pred} \cdot X$ CRIs or SSBRIs (i.e., predicted beams from prediction beam Set A) in a same CSI report in slot n corresponding to F_{pred} beam groups should be reported. For example, each beam group may include X beams corresponding to a predicted beams corresponding to a future time instance.

[00103] Reference is back made to FIG. 2, in the process 200, the UE 201 determines, at 220, prediction information based on measurement results of the first resource set configured as CMR.

[00104] In addition or alternatively, the UE 201 should perform a channel measurement of first resource set configured for CMR within the measurement window, to obtain the measurement results, which may be used as input of an AI/ML model deployed at the UE 201.

[00105] In the process 200, the UE 201 transmits a beam report to the BS 202 at 230. In some implementations, the beam report may be transmitted based on the CSI report configuration (*CSI-ReportConfig* or *AI-CSI-ReportConfig*), for example, the beam report is included in the CSI report in slot n .

[00106] In some implementations, the beam report may include X CRIs or SSBRI (i.e., predicted beams from prediction beam Set A) in a same CSI report transmitted in slot n corresponding to CSI reference resource $n - n_{CSI_ref}$ for spatial domain beam prediction (such as $F_{pred} = 0$). In some implementations, the beam report may include $F_{pred} \cdot X$ CRIs or SSBRI (i.e., predicted beams from prediction beam Set A) in a same CSI report transmitted in slot n corresponding to F_{pred} beam groups for temporal beam prediction (such as $F_{pred} \geq 1$).

[00107] In some examples, the prediction information in the beam report may indicate a predicted reference signal received power (RSRP) for each beam. Table 1 shows an example of the report.

Table 1 Mapping order of CSI fields of predicted CRI/RSRP or SSBRI/RSRP reporting

CSI report number	CSI fields	Bitwidth
CSI report# n	Instance indicator for CRI has largest predicted RSRP	$\lceil \log_2(F_{pred}) \rceil$
	CRI or SSBRI #1 for the first future instance	$\lceil \log_2(K_{SetA}^{CSI-RS}) \rceil$ or $\lceil \log_2(K_{SetB}^{CSI-RS}) \rceil$
	...	
	CRI or SSBRI # X for the first future instance	$\lceil \log_2(K_{SetA}^{CSI-RS}) \rceil$ or $\lceil \log_2(K_{SetB}^{CSI-RS}) \rceil$
	...	
	CRI or SSBRI #1 for the F_{pred} future instance	$\lceil \log_2(K_{SetA}^{CSI-RS}) \rceil$ or $\lceil \log_2(K_{SetB}^{CSI-RS}) \rceil$
	...	

	CRI or SSBRI #X for the F_{pred} future instance	$\lceil \log_2(K_{SetA}^{CSI-RS}) \rceil$ or $\lceil \log_2(K_{SetB}^{CSI-RS}) \rceil$
	RSRP of CRI or SSBRI #1 for the first future instance	7
	Differential RSRP of CRI or SSBRI #2 for the first future instance	4
	...	
	Differential RSRP of CRI or SSBRI #X for the first future instance	4
	...	
	Differential RSRP of CRI or SSBRI #1 for the F_{pred} future instance	4
	...	
	Differential RSRP of CRI or SSBRI #X for the F_{pred} future instance	4

[00108] K_{SetB}^{CSI-RS} is the number of resources configured in the resource set as CMR for this CSI report configuration, K_{SetA}^{CSI-RS} is the number of resources determined as the resource set for beam prediction for this CSI report configuration.

- 5 **[00109]** In some implementations, the beam report may further include a confidence value or a probability level of the predicted RSRP for each beam. Table 2 shows an example of the report.

Table 2 Mapping order of CSI fields of predicted CRI/RSRP or SSBRI/RSRP reporting

CSI report number	CSI fields	Bitwidth
CSI report#n	CRI or SSBRI #1 for the first future instance	$\lceil \log_2(K_{SetA}^{CSI-RS}) \rceil$ or $\lceil \log_2(K_{SetB}^{CSI-RS}) \rceil$
	...	
	CRI or SSBRI #X for the first future instance	$\lceil \log_2(K_{SetA}^{CSI-RS}) \rceil$ or $\lceil \log_2(K_{SetB}^{CSI-RS}) \rceil$
	...	
	CRI or SSBRI #1 for the F_{pred} future instance	$\lceil \log_2(K_{SetA}^{CSI-RS}) \rceil$ or $\lceil \log_2(K_{SetB}^{CSI-RS}) \rceil$
	...	
	CRI or SSBRI #X for the F_{pred} future instance	$\lceil \log_2(K_{SetA}^{CSI-RS}) \rceil$ or $\lceil \log_2(K_{SetB}^{CSI-RS}) \rceil$
	Confidence/probability level of CRI or SSBRI #1 for the first future instance	3
	Confidence/probability level of CRI or	3

	SSBRI #2 for the first future instance	
	...	
	Confidence/probability level of CRI or SSBRI #X for the first future instance	3
	...	
	Confidence/probability level of CRI or SSBRI #1 for the F_{pred} future instance	3
	...	
	Confidence/probability level of CRI or SSBRI #X for the F_{pred} future instance	3

[00110] In some examples, a corresponding relation between a range of confidence/probability values and a confidence/probability level may be predefined, in this case, the confidence/probability level may be included in the beam report, thus the overhead may be reduced. Table 3 shows an example of the definition of confidence/probability level.

Table 3

Reported value	Confidence/probability range
Confidence/probability level 0	$Th_{low}^0 < \text{Confidence/probability}$ (e.g., $95\% < \text{Conf/Prob}$)
Confidence/probability level 1	$Th_{low}^1 \leq \text{Confidence/probability} < Th_{up}^1$ (e.g., $90\% \leq \text{Conf/Prob} < 95\%$)
Confidence/probability level 2	$Th_{low}^2 \leq \text{Confidence/probability} < Th_{up}^2$ (e.g., $85\% \leq \text{Conf/Prob} < 90\%$)
Confidence/probability level 3	$Th_{low}^3 \leq \text{Confidence/probability} < Th_{up}^3$ (e.g., $80\% \leq \text{Conf/Prob} < 85\%$)
Confidence/probability level 4	$Th_{low}^4 \leq \text{Confidence/probability} < Th_{up}^4$ (e.g., $75\% \leq \text{Conf/Prob} < 80\%$)
Confidence/probability level 5	$Th_{low}^5 \leq \text{Confidence/probability} < Th_{up}^5$ (e.g., $70\% \leq \text{Conf/Prob} < 75\%$)
Confidence/probability level 6	$Th_{low}^6 \leq \text{Confidence/probability} < Th_{up}^6$ (e.g., $60\% \leq \text{Conf/Prob} < 70\%$)
Confidence/probability level 7	$\text{Confidence/probability} < Th_{up}^7$ (e.g., $\text{Conf/Prob} < 60\%$)

[00111] It is to be understood that the uplink control information (UCI) format for the CSI report shown in Table 1 or 2 is only for illustration without any limitation. For example, a reference beam for determining the differential value of the RSRP may be selected in a different way. It is to be understood that differential RSRP is adopted for UCI overhead reduction. For example, the beam report has a single part.

[00112] In some implementations, some resources configured for CMR may not be successfully received by the UE 201. In some example embodiments, if a number of resources that are received equals to or is larger than a further threshold (e.g. a smallest number for prediction), then the UE 201 may continue generate the beam report and transmit
5 the beam report based on measurement results of received resources. In some example embodiments, if the number of resources that are received is smaller than the further threshold, then the beam prediction may not be performed.

[00113] For spatial domain beam prediction, if some beams in the CMR are not received by the UE 201, e.g., some of CSI-RS resources are dropped due to collision, the UE side AI/ML
10 model may not perform AI inference to obtain accurate model output. In some examples, the UE 201 may drop the corresponding CSI report. In some other examples, the UE 201 may report X beams selected from the NZP CSI-RS resource set for CMR, i.e., the beams in measurement beam Set B. In this case, the UE 201 may need to indicate that the reported beams are measured beams other than predicted beams in the beam report.

[00114] In some other examples, the further threshold may be configured for the UE 201 to determine whether the UE 201 can provide the predicted beams. The further threshold can be a number of beams, e.g., the smallest number of beams for AI/ML model input. If the received number of CSI-RS resources is more than the configured threshold and the corresponding measured L1-RSRP is larger than another threshold, the UE 201 may provide
20 the predicted beams. Otherwise, the CSI report may be dropped or beam measurement results of the received CSI-RS resources may be reported.

[00115] For temporal domain beam prediction, if some beams in the measurement window are not received by the UE 201, the UE side AI/ML model may not perform AI inference to obtain accurate model output. In some examples, the UE 201 may drop the corresponding
25 CSI report. In some other examples, the UE 201 may report X beams selected from the NZP CSI-RS resource set for CMR corresponding to the latest CSI-RS resource transmission occasion(s) before CSI reference resource, i.e., the beams in measurement beam Set B. In this case, the UE 201 may need to indicate that the reported beams are measured beams other than predicted beams in the beam report.

[00116] In some other examples, for each measurement instance, the UE 201 may determine
30 whether a number of beams with the corresponding measured L1-RSRP larger than another threshold is larger than the further threshold, so as to determine whether available historical

measurement result can be obtained corresponding to each measurement instance. If a number of beams of available measurement results is more than the further threshold, the UE 201 may provide the predicted beams. Otherwise, the CSI report may be dropped or beam measurement results of the received CSI-RS resources may be reported.

5 [00117] According to some embodiments in the present disclosure, the CSI report configuration may be used for both spatial domain beam prediction and the temporal beam prediction, thus a common CSI framework is provided. In some embodiments, one or more resource set may be configured for CMR, and a resource set may include multiple resource subsets transmitted in multiple consecutive available slots in some cases. In some
10 embodiments, the resource set for beam prediction, i.e. a prediction beam set may be explicitly or implicitly indicated by the CSI report configuration, for example each measurement beam Set B which is configured for CMR may be associated with a prediction beam Set A. In some embodiments, multiple measurement instances may be used for model input for temporal beam prediction, for example a measurement window associated with the
15 multiple measurement instances may be determined. In some embodiments, the UE behavior is defined for beam report, e.g. when some beams in the CMR are not received by the UE 201.

[00118] FIG. 5 illustrates an example of a device 500 that is suitable for implementing embodiments of the present disclosure. The device 500 may be an example of a base station
20 or a UE as described herein. The device 500 may support wireless communication with a UE 201, a BS 202, or any combination thereof. The device 500 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 502, a memory 504, a transceiver 506, and, optionally, an I/O controller 508. These components may be in electronic communication or otherwise
25 coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[00119] The processor 502, the memory 504, the transceiver 506, 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 502, the
30 memory 504, the transceiver 506, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[00120] In some implementations, the processor 502, the memory 504, the transceiver 506,

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 502 and the memory 504 coupled with the processor 502 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 502, instructions stored in the memory 504).

10 [00121] For example, the processor 502 may support wireless communication at the device 500 in accordance with examples as disclosed herein. The processor 502 may be configured to operable to support a means for operations discussed above.

[00122] The processor 502 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 502 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 502. The processor 502 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 504) to cause the device 500 to perform various functions of the present disclosure.

[00123] The memory 504 may include random access memory (RAM) and read-only memory (ROM). The memory 504 may store computer-readable, computer-executable code including instructions that, when executed by the processor 502 cause the device 500 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 502 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 504 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.

[00124] The I/O controller 508 may manage input and output signals for the device 500.

The I/O controller 508 may also manage peripherals not integrated into the device 500. In some implementations, the I/O controller 508 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 508 may utilize an operating system such as iOS®, ANDROID®, MS-WINDOWS®, OS/2®, UNIX®,
5 LINUX®, or another known operating system. In some implementations, the I/O controller 508 may be implemented as part of a processor, such as the processor 502. In some implementations, a user may interact with the device 500 via the I/O controller 508 or via hardware components controlled by the I/O controller 508.

[00125] In some implementations, the device 500 may include a single antenna 510.
10 However, in some other implementations, the device 500 may have more than one antenna 510 (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 506 may communicate bi-directionally, via the one or more antennas 510, wired, or wireless links as described herein. For example, the transceiver 506 may represent a
15 wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 506 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 510 for transmission, and to demodulate packets received from the one or more antennas 510. The transceiver 506 may include one or more transmit chains, one or more receive chains, or a combination thereof.

20 [00126] 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
25 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 510 for transmitting the amplified signal into the air or wireless medium.

30 [00127] 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 510 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.

[00128] FIG. 6 illustrates an example of a processor 600 that is suitable for implementing some embodiments of the present disclosure. The processor 600 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 600 may include a controller 602 configured to perform various operations in accordance with examples as described herein. The processor 600 may optionally include at least one memory 604, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 600 may optionally include one or more arithmetic-logic units (ALUs) 606. 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).

[00129] The processor 600 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 600) 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).

[00130] The controller 602 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 600 to cause the processor 600 to support various operations in accordance with examples as described herein. For example, the controller 602 may operate as a control unit of the processor 600, generating control signals that manage the operation of various components of the processor 600. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[00131] The controller 602 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 604 and determine subsequent instruction(s) to be executed to cause the processor 600 to support various operations in accordance with examples as described herein. The controller 602 may be configured to track memory address of instructions associated with the memory 604. The controller 602 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 602 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 602 may be configured to manage flow of data within the processor 600. The controller 602 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 600.

[00132] The memory 604 may include one or more caches (e.g., memory local to or included in the processor 600 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 604 may reside within or on a processor chipset (e.g., local to the processor 600). In some other implementations, the memory 604 may reside external to the processor chipset (e.g., remote to the processor 600).

[00133] The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 600, cause the processor 600 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 602 and/or the processor 600 may be configured to execute computer-readable instructions stored in the memory 604 to cause the processor 600 to perform various functions. For example, the processor 600 and/or the controller 602 may be coupled with or to the memory 604, the processor 600, the controller 602, and the memory 604 may be configured to perform various functions described herein. In some examples, the processor 600 may include multiple processors and the memory 604 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.

[00134] The one or more ALUs 606 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 606 may reside within or on a processor chipset (e.g., the processor 600). In some

other implementations, the one or more ALUs 606 may reside external to the processor chipset (e.g., the processor 600). One or more ALUs 606 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 606 may receive input operands and an operation code, which
5 determines an operation to be executed. One or more ALUs 606 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 606 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more
10 ALUs 606 to handle conditional operations, comparisons, and bitwise operations.

[00135] The processor 600 may support wireless communication in accordance with examples as disclosed herein. The processor 600 may be configured to or operable to support a means for operations described in some embodiments of the present disclosure.

[00136] FIG. 7 illustrates a flowchart of a method 700 performed by a UE in accordance with aspects of the present disclosure. The operations of the method 700 may be implemented
15 by a device or its components as described herein. For example, the operations of the method 700 may be performed by the UE 201 in FIG. 2. 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
20 aspects of the described functions using special-purpose hardware.

[00137] At 710, the method may include receiving, from a base station, a CSI report configuration, wherein the CSI report configuration comprises a first resource set configured as a CMR and a second resource set for beam prediction, wherein the CSI report configuration further comprises a number of measurement instances of the first resource set
25 and a number of prediction instances of the second resource set, wherein the first resource set comprise one or more NZP CSI-RS resource sets or an SSB resource set, and wherein the second resource set for beam prediction comprises a further NZP CSI-RS resource set or a further SSB resource set. The operations of 710 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 710
30 may be performed by the UE 201 as described with reference to FIG. 2.

[00138] At 720, the method may include determining prediction information for the second resource set for beam prediction based on measurement results of the first resource set

configured as the CMR. The operations of 720 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 720 may be performed by the UE 201 as described with reference to FIG. 2.

5 [00139] At 730, the method may include transmitting, to the base station, a beam report comprising the prediction information for the second resource set for beam prediction. The operations of 730 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 730 may be performed by the UE 201 as described with reference to FIG. 2.

10 [00140] FIG. 8 illustrates a flowchart of a method 800 performed by a base station in accordance with aspects of the present disclosure. The operations of the method 800 may be implemented by a device or its components as described herein. For example, the operations of the method 800 may be performed by the BS 202 in FIG. 2. 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
15 may perform aspects of the described functions using special-purpose hardware.

[00141] At 810, the method may include transmitting, to a UE, a CSI report configuration, wherein the CSI report configuration comprises a first resource set configured as a CMR and a second resource set for beam prediction, wherein the CSI report configuration further comprises a number of measurement instances of the first resource set and a number of
20 prediction instances of the second resource set, wherein the first resource set comprise one or more NZP CSI-RS resource sets or an SSB resource set, and wherein the second resource set for beam prediction comprises a further NZP CSI-RS resource set or a further SSB resource set. The operations of 810 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 810 may be
25 performed by the BS 202 as described with reference to FIG. 2.

[00142] At 820, the method may include receiving, from the UE a beam report comprising prediction information for the second resource set for beam prediction. The operations of 820 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 820 may be performed by the BS 202 as
30 described with reference to FIG. 2.

[00143] 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.

[00144] 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.

[00145] 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.

[00146] 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.

[00147] 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
5 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
10 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.

[00148] 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
15 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:
at least one memory; and
5 at least one processor coupled with the at least one memory and configured to cause the UE to:
receive, from a base station, a channel state information (CSI) report configuration, wherein the CSI report configuration comprises a first resource set configured as a channel measurement resource (CMR) and a second resource set for beam prediction,
10 wherein the CSI report configuration further comprises a number of measurement instances of the first resource set and a number of prediction instances of the second resource set, wherein the first resource set comprise one or more non-zero power (NZP) CSI reference signal (RS) resource sets or a synchronization signal block (SSB) resource set, and wherein the second resource set for beam prediction comprises a further NZP CSI-RS resource set or
15 a further SSB resource set;
determine prediction information for the second resource set for beam prediction based on measurement results of the first resource set configured as the CMR; and
transmit, to the base station, a beam report comprising the prediction information for the second resource set for beam prediction.
20
2. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:
determine a measurement window for a reception of the first resource set configured as the CMR, wherein a time length of the measurement window is determined based on: the
25 number of measurement instances and a first time duration associated with the first resource set configured as the CMR.
3. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:
30 determine a prediction window of the second resource set, wherein a time length of the prediction window is determined based on the number of prediction instances and a second time duration associated with the first resource set configured as the CMR.

4. The UE of claim 3, wherein the second time duration associated with the first resource set configured as the CMR is determined based on a first time duration associated with the first resource set configured as the CMR and a preconfigured scaling factor.

5. The UE of claim 3, wherein a start time of the prediction window is before a transmission time for the beam report or after the transmission time for the beam report.

6. The UE of claim 2 or 4, wherein,
the first time duration associated with the first resource set configured as the CMR is
a periodicity of NZP CSI-RS resources or a periodicity of SSB resources, or
the first time duration associated with the first resource set configured as the CMR is
a separation between two consecutive transmissions of aperiodic NZP CSI-RS resource sets.

7. The UE of claim 1, wherein each of the one or more NZP CSI-RS resource sets
comprises a plurality of NZP CSI-RS resources, and wherein the at least one processor is
further configured to cause the UE to:

in accordance with a determination that a number of the plurality of NZP CSI-RS
resources is equal to or less than a threshold, determine that the plurality of NZP CSI-RS
resources is in a same slot; or

in accordance with a determination that the number of the plurality of NZP CSI-RS
resources is larger than a threshold, determine that the plurality of NZP CSI-RS resources
comprises a plurality of subsets being in a plurality of adjacent slots respectively.

8. The UE of claim 7, wherein a number of NZP CSI-RS resources in a first subset
of the plurality of subsets is determined based on one of:

the threshold,

a largest number not larger than a ratio of the number of the plurality of NZP CSI-RS
resources and a number of the plurality of subsets, or

an indication from the base station.

30

9. The UE of claim 1, wherein each resource in the first resource set configured as
the CMR is associated with a further NZP CSI-RS resource or a further SSB resource for
beam prediction.

10. The UE of claim 1, wherein the second resource set for beam prediction comprises part or all of NZP CSI-RS resources or part or all of SSB resources in a serving cell of the UE, wherein the CSI report configuration comprises a plurality of resource identifiers (IDs) of a plurality of resources in the second resource set for beam prediction,
5 and wherein each resource ID in the plurality of resource IDs is used to identify a NZP CSI-RS resource or an SSB resource in the serving cell.

11. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:
10 in accordance with a determination that a number of a plurality of received resources in the first resource set exceeds a preconfigured threshold, determine the prediction information for the second resource set.

12. The UE of claim 1, wherein the at least one processor is further configured to
15 cause the UE to:
in accordance with a determination that some of resources in the first resource set are not received, perform one of:
stopping transmitting the beam report; or
transmitting a further beam report comprising measurement results on a
20 plurality of received resources in the first resource set.

13. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:
in accordance with a determination that one of the following, determine that the beam
25 prediction is spatial domain beam prediction:
the number of measurement instances equals to 1,
the number of prediction instances equals to 0, or
an explicit indication comprised in the CSI report configuration indicates the
spatial domain beam prediction.

30
14. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:
in accordance with a determination that one of the following, determine that the beam prediction is temporal beam prediction:

the number of measurement instances is larger than 1,
the number of prediction instances is larger than 0,
an explicit indication comprised in the CSI report configuration indicates the
temporal beam prediction, or

5 the second resource set for beam prediction is the same as the first resource set
configured as the CMR.

15. A base station comprising:
at least one memory; and
10 at least one processor coupled with the at least one memory and configured to cause
the base station to:
transmit, to a user equipment (UE), a channel state information (CSI) report
configuration, wherein the CSI report configuration comprises first resource set configured
as a channel measurement resource (CMR) and a second resource set for beam prediction,
15 wherein the CSI report configuration further comprises a number of measurement instances
of the first resource set and a number of prediction instances of the second resource set,
wherein the first resource set comprise one or more non-zero power (NZP) CSI reference
signal (RS) resource sets or a synchronization signal block (SSB) resource set, and wherein
the second resource set for beam prediction comprises a further NZP CSI-RS resource set or
20 a further SSB resource set; and
receive, from the UE a beam report comprising prediction information for the
second resource set for beam prediction.

16. The base station of claim 15, wherein each resource in the first resource set
25 configured as the CMR is associated with a further NZP CSI-RS resource or a further SSB
resource for beam prediction.

17. The base station of claim 15, wherein the second resource set for beam
prediction comprises part or all of NZP CSI-RS resources or part or all of SSB resources in
30 a serving cell of the UE, wherein the CSI report configuration comprises a plurality of
resource identifiers (IDs) of a plurality of resources in the second resource set for beam
prediction, and wherein each resource ID in the plurality of resource IDs is used to identify
a NZP CSI-RS resource or an SSB resource in the serving cell.

18. The base station of claim 15, wherein the at least one processor is further configured to cause the base station to:

receive, from the UE, a further beam report comprising measurement results on a plurality of received resources in the first resource set.

5

19. The base station of claim 15, wherein the CSI report configuration indicates that the beam prediction is spatial domain beam prediction by one of:

the number of measurement instances equals to 1,

the number of prediction instances equals to 0, or

10 an explicit indication comprised in the CSI report configuration indicates the spatial domain beam prediction.

20. The base station of claim 15, wherein the CSI report configuration indicates that the beam prediction is temporal beam prediction by one of:

15 the number of measurement instances is larger than 1,

the number of prediction instances is larger than 0,

an explicit indication comprised in the CSI report configuration indicates the temporal beam prediction, or

20 the second resource set for beam prediction is the same as the first resource set configured as the CMR.