

PERFORMANCE MONITORING FOR BEAM PREDICTION

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to user equipments, network entities, methods, and processors for performance monitoring 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 communication devices, such as a base station may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

[0003] The 3rd Generation Partnership Project (3GPP) has approved Release 18 package including 27 diverse study or work items working on embracing artificial intelligence (AI) and/or machine learning (ML) technologies in the evolution of 5G Advanced. Some studies and works are centered on beam management, introducing AI/ML based functionality and/or model for beam prediction based on beam measurement.

SUMMARY

[0004] The present disclosure relates to user equipments, network entities, methods, and processors that support performance monitoring for beam prediction. According to the embodiments of the present disclosure, the accuracy of the beam prediction can be

significantly improved and processing delays can be effectively reduced. This is beneficial to facilitate fast LCM operation, so that the interruption time due to model failure can be significantly reduced.

[0005] In a first aspect, there is provided a user equipment. The user equipment comprises a processor; and a transceiver coupled to the processor. The processor is configured to: receive, via the transceiver, a first resource configuration indicating a first resource set for obtaining measured beams and a second resource configuration indicating a second resource set for obtaining predicated beams; obtain a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and transmit, via the transceiver, a first report including the performance of the beam prediction based on the first reporting configuration.

[0006] In a second aspect, there is provided a network entity. The network entity comprises a processor; and a transceiver coupled to the processor. The processor is configured to: transmit, via the transceiver, a first resource configuration indicating a first resource set for obtaining measured beams and a second resource configuration indicating a second resource set for obtaining predicated beams; transmit, via the transceiver, a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and receive, via the transceiver, a first report including the performance of the beam prediction based on the first reporting configuration.

[0007] In a third aspect, there is provided a method performed by a user equipment. The method comprises the steps of: receiving a first resource configuration including a first resource set for obtaining measured beams and a second resource configuration including a second resource set for obtaining predicated beams; obtaining a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and transmitting a first report including the performance of the beam prediction based on the first reporting configuration.

[0008] In a fourth aspect, there is provided a method performed by a network entity. The method comprises the steps of: transmitting a first resource configuration including a first resource set for obtaining measured beams and a second resource configuration

including a second resource set for obtaining predicated beams; configuring a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and receiving a first report including the performance of the beam prediction based on the first reporting configuration.

[0009] In a fifth aspect, 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 a first resource configuration including a first resource set for obtaining measured beams and a second resource configuration including a second resource set for obtaining predicated beams; obtain a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and transmit a first report including the performance of the beam prediction based on the first reporting configuration.

[0010] In some implementations of the method and apparatuses described herein, the first reporting configuration is associated with the first resource set and a second reporting configuration for the second resource set, and the performance is based on a first measurement of the first resource set and a second report corresponding to the second reporting configuration for the second resource set. In some further implementations of the method and apparatuses described herein, a first gap between a report occasion associated with the second report for the second resource set and a transmission occasion associated with the first measurement of the first resource set is less than or equal to a first threshold; and a second gap between report occasions associated with the second reports is greater than or equal to a second threshold.

[0011] In some implementations of the method and apparatuses described herein, the first reporting configuration is associated with the first resource set and the second resource set, the first resource set and the second resource set belong to different resource sets, and the performance is based on a first measurement of the first resource set and a second measurement of the second resource set.

[0012] In some further implementations of the method and apparatuses described herein, the first resource set and the second resource set are triggered by a downlink signaling, and a configuration for the first resource set and the second resource set

indicates at least one of the following: a first offset between a transmission of the downlink signaling and a transmission of the first resource set; a second offset between a transmission of the downlink signaling and a transmission of the second resource set, wherein the first offset is greater than the second offset; a first time interval between different transmissions of first resource sets; or a second time interval between different transmissions of second resource sets. In some implementations of the method and apparatuses described herein, a first group of the first resource sets and a second group of the second resource sets are triggered by the downlink signaling; and a first transmission occasion of the first resource sets within the first group is based on the first offset and the first time interval between adjacent first resource sets within the first group, and a second transmission occasion of the second resource sets within the second group is based on the second offset and the second time interval between adjacent second resource sets within the second group.

[0013] In some further implementations of the method and apparatuses described herein, the first resource set and the second resource set are triggered by a downlink signaling, and a configuration for the first resource set and the second resource set indicates at least one of the following: a first offset between a transmission of the downlink signaling and a first one of transmissions of a first number of first resource sets, and a second offset between the transmission of the downlink signaling and a first one of transmissions of a second number of second resource sets; or a first offset between a last one of the transmissions of a second number of second resource sets and a first one of transmissions of a first number of first resource sets, and a second offset between a transmission of the downlink signaling and a first one of transmissions of the second number of second resource sets, wherein the first one of the transmissions of the first number of the first resource sets is later than the last one of the transmissions of the second number of the second resource sets.

[0014] In some further implementations of the method and apparatuses described herein, a configuration indicates at least one of the following: a first gap between a transmission of the second resource set and a transmission of the first resource set is less than or equal to a first threshold; a second gap between different transmissions of second resource sets is greater than or equal to a second threshold; or a difference between channel quality associated with a first reference signal based on the first resource set and channel quality associated with a second reference signal based on the second resource

set is less than or equal to a threshold, wherein the second reference signal and the first reference signal have a same resource indicator or are quasi co-located.

[0015] In some implementations of the method and apparatuses described herein, a configuration for the first resource set and the second resource set indicates at least one of the following: a first time interval between different transmissions of a first number of first resource sets; a second time interval between different transmissions of a second number of second resource sets; or a gap between a last one of the transmissions of the second number of the second resource sets and a first one of the transmissions of the first number of the first resource sets.

[0016] In some implementations of the method and apparatuses described herein, the first reporting configuration is associated with the first resource set and the second resource set that are different subsets of a same resource set, and the performance is based on a first measurement of the first resource set and a second measurement of the second resource set.

[0017] In some further implementations of the method and apparatuses described herein, an association configuration for the first resource set and the second resource set comprises or indicates one of the following: a bitmap indicating the first resource set or the second resource set; the first resources in the resource set configured to be the second resource set or the last resources in the resource set configured to be the first resource set; or a table of a pattern of the first resource set or the second resource set and a code point of the pattern.

[0018] In some implementations of the method and apparatuses described herein, the first reporting configuration is associated with the first resource set and the second resource set that belong to a same resource set, wherein the first resource set includes a first set of transmission occasions, the second resource set includes a second set of transmission occasions, and the performance is based on the first set of transmission occasions and the second set of transmission occasions. In some further implementations of the method and apparatuses described herein, a configuration for the first set of transmission occasions and the second set of transmission occasions indicates at least one of the following: a first time interval between different occasions of the first set of transmission occasions; a second time interval between different occasions of the second set of transmission occasions; or a third time interval between the last one of the second

set of transmission occasions and the first one of the first set of transmission occasions. In some further implementations of the method and apparatuses described herein, the first time interval is based on a first scaler factor and a periodicity of the resource set, the second interval is based on a second scaler factor and the periodicity of the resource set, and the third interval is based on a third scaler factor and the periodicity of the resource set.

[0019] Some implementations of the method and apparatuses described herein further include: transmitting by a user equipment or receiving by a network entity, a request for monitoring the performance of the beam prediction through one of the following: a physical random access channel (PRACH), wherein the user equipment is configured with a dedicated RACH occasion (RO) and dedicated preamble associated with the beam prediction; a dedicated medium access control (MAC) control element (CE) comprising an identifier for the beam prediction; a dedicated scheduling request (SR), wherein the user equipment is configured with a plurality of dedicated SR resources, a dedicated SR resource among the plurality of dedicated SR resources is associated with a beam prediction; or a beam report associated with the beam prediction or beam management.

[0020] In some implementations of the method and apparatuses described herein, the first reporting configuration comprises at least one of the following: an identifier of a functionality or model for the beam prediction; the number of the predicted beams; the number of the measured beams; the number of valid samples for reporting the performance; the number of the first resource sets for a valid sample and the number of the second resource sets for a valid sample; or a performance target for the UE to detect the performance of the beam prediction.

[0021] Some implementations of the method and apparatuses described herein further include: receiving, by a user equipment, a reference signal for beam measurement, to obtain the measured beams by using the first resource set and to obtain the predicted beams by using the second resource set; and determining, by the user equipment, the performance of the beam prediction based on a configured number of valid samples, wherein a valid sample corresponds to a first number of first resource sets and a second number of second resource sets. Accordingly, some implementations of the method and apparatuses described herein further include: transmit, via a network entity, a reference signal for beam measurement, such that the measured beams are obtained by using the

first resource set and the predicated beams are obtained by using the second resource set, wherein the performance of the beam prediction is based on a configured number of valid samples, wherein a valid sample corresponds to a first number of first resource sets and a second number of second resource sets.

[0022] In some implementations of the method and apparatuses described herein, the performance comprises at least one of the following: identifiers of a predetermined number of the best measured beams based on a first measurement of the first resource set; identifiers of a predetermined number of the best predicted beams based on a second measurement of the second resource set; an indicator for a first beam prediction success, indicating that the top one measured beam is one of the predetermined number of the best predicted beams; an indicator for a second beam prediction success, indicating that the top one predicted beam is one of the predetermined number of the best predicted beams; or an indicator for indicating that at least one of the first beam prediction success or the second beam predication success is less than a performance target.

[0023] Some implementations of the method and apparatuses described herein further include: receiving by a user equipment or transmitting by a network entity, an indication of a lifecycle management (LCM) operation based on the first report, wherein the indication of the LCM operation includes at least one of the following: an identifier of a functionality or model for a beam prediction to be switched to and an identifier of candidate beam that is the top one measured beam; an identifier of a functionality or model for a beam prediction to be deactivated and an identifier of candidate beam that is the top one measured beam; or an request for deactivating the beam prediction and an identifier of candidate beam that is the top one measured beam.

[0024] In some further implementations of the method and apparatuses described herein, the indication of the LCM operation is one of the following: an implicit indication, or an indication by dedicated signaling.

[0025] Some further implementations of the method and apparatuses described herein further include: before the indication takes effect, one of the following: beam failure detection and beam failure recovery in the case of detecting a beam failure; or monitoring on a physical downlink control channel (PDCCH) until receiving a radio resource control (RRC) configuration, wherein the used transmit beam is the reported top one measured beam.

[0026] In some implementations of the method and apparatuses described herein, the first report includes a first part with a fixed payload and a second part with a payload based on the first part, wherein the first part indicates the number of monitoring results for the beam prediction, and the second part indicates the monitoring results.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] FIG. 1 illustrates an example of a wireless communications system that supports performance monitoring for beam prediction in accordance with aspects of the present disclosure.

[0028] FIG. 2 illustrates an example of a process flow that supports performance monitoring for beam prediction in accordance with aspects of the present disclosure.

[0029] FIG. 3 illustrates an example of a process flow that supports performance monitoring for beam prediction in accordance with some embodiments of the present disclosure.

[0030] FIG. 4A illustrates an example of a first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure.

[0031] FIG. 4B and FIG. 4C illustrate other examples of a first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure.

[0032] FIG. 5A illustrates an example of a first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure.

[0033] FIG. 5B illustrates another example of a first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure.

[0034] FIG. 6 illustrates an example of another first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure.

[0035] FIG. 7 illustrates an example of a further first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure.

[0036] FIG. 8 illustrates an example of a still further first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure.

[0037] FIG. 9 illustrates an example of a device that supports performance monitoring for beam prediction in accordance with aspects of the present disclosure.

[0038] FIG. 10 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure.

[0039] FIG. 11 and FIG. 12 illustrate flowcharts of methods that support performance monitoring for beam prediction in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0040] 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 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.

[0041] References in the present disclosure to “one embodiment,” “an example embodiment,” “an embodiment,” “some embodiments,” and the like indicate that the embodiment(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases do not necessarily refer to the same embodiment(s). Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0042] It shall be understood that although the terms “first” and “second” or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of embodiments. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms. 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 functional alternatives can be made, and such selections need not be better, smaller, higher, or otherwise preferable to other selections.

[0043] 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 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 “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.

[0044] In the beam prediction using the AI/ML based functionality or model, a beam prediction result for a set of beams, which is an output of the AI/ML based functionality or model, is derived based on a beam measurement result of another set of beams, which is an input of the AI/ML based functionality or model. However, due to factors such as frequent changes in channel conditions, distortion of beam measurement data, large variation in prediction results, inaccurate model parameter configuration, etc., it may lead to large deviations between the prediction results and the actual measurement results for beams, resulting in lower performance of the model. For example, limited by model

generalization capability of the deployed AI/ML model, the beam prediction performance may be significantly degraded due to the UE mobility behavior or propagation environment changes. To this end, the performance of beam prediction needs to be monitored to improve the accuracy of the AI/ML based functionalities or models for performance assurance. Therefore, consideration needs to be given to how to design network systems to support performance monitoring for beam prediction for AI/ML based functionalities or models.

[0045] Some embodiments of the present disclosure provide a solution for monitoring performance of beam prediction for an AI/ML based functionality or model. In the embodiments of the present disclosure, the network entity transmits resource configurations to the user equipment, at which the performance of beam prediction for the AI/ML based functionality or model is monitored. The resource configurations include a first resource configuration indicating a first resource set for obtaining measured beams and a second resource configuration indicating a second resource set for obtaining predicated beams. A reporting configuration for the first resource set is obtained at the user equipment, such that the user equipment reports performance of the beam prediction based on the first resource set and the second resource set. The user equipment transmits a report including the performance of the beam prediction associated with the first resource set based on the reporting configuration for the first resource set.

[0046] According to the solution of the present disclosure, the first resource set is configured as a benchmark for obtaining the actually measured beam, and the second resource is configured to provide relevant information for obtaining predicted beams based on the beam prediction using the AI/ML based functionality or model. Thereby, the reference measurement and reporting mechanism will be further enhanced to support a flexible performance monitoring for beam prediction for the AI/ML based functionality or model, thereby improving beam prediction accuracy and reducing processing delays. This is beneficial to facilitate fast lifecycle management (LCM) operation, so that the interruption time due to model failure can be significantly reduced.

[0047] Aspects of the present disclosure are described in the context of a wireless communications system.

[0048] FIG. 1 illustrates an example of a wireless communications system 100 that supports performance monitoring for beam prediction in accordance with aspects of the

present disclosure. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a 5G network, such as an NR network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0049] 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.

[0050] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, messaging, broadcast, etc.) for one or more UEs 104 within the geographic coverage area 112. For example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network. In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities

102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0051] 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.

[0052] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1. A UE 104 may be capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the core network 106, the packet data network 108, a relay device, an integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1. Additionally, or alternatively, a UE 104 may support communication with other network entities 102 or UEs 104, which may act as relays in the wireless communications system 100.

[0053] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0054] A network entity 102 may support communications with the core network 106, or with another network entity 102, or both. For example, a network entity 102 may

interface with the core network 106 through one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the core network 106). In some implementations, one or more network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0055] 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 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.

[0056] An RU may also be referred to as a radio head, a smart radio head, a remote radio head (RRH), a remote radio unit (RRU), or a transmission reception point (TRP). One or more components of the network entities 102 in a disaggregated RAN architecture may be co-located, or one or more components of the network entities 102 may be located in distributed locations (e.g., separate physical locations). In some implementations, one or more network entities 102 of a disaggregated RAN architecture may be implemented as virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0057] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a

functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaptation protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU 160.

[0058] 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).

[0059] 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.

[0060] The core network 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The core network 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW),

a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the core network 106.

[0061] The core network 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the core network 106 via a network entity 102. The core network 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the core network 106 (e.g., one or more network functions of the core network 106).

[0062] 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.

[0063] 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.

[0064] 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.

[0065] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0066] 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.

[0067] 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.

[0068] FIG. 2 illustrates an example of a process flow 200 that supports performance monitoring for beam prediction in accordance with aspects of the present disclosure. The process flow 200 may involve the network entity 102 and the UE 104 in the communication network 100 with reference to FIG. 1. It would be appreciated that the process flow 200 may be applied to other communication scenarios, which will not be described in detail.

[0069] In some embodiments of the present disclosure, the network entity 102 transmits 210 to the UE 104 a first resource configuration 211 indicating a first resource set for obtaining measured beams and a second resource configuration 212 indicating a second resource set for obtaining predicated beams. The UE 104 receives 215 the first resource configuration 211 and the second resource configuration 212. It is to be

understood that the first resource configuration 211 and the second resource configuration 212 may be a single configuration or a plurality of configurations, which may be transmitted collectively or separately through a single message or a plurality of messages, without suggesting any limitations.

[0070] The UE 104 obtains 225 a first reporting configuration 221 for the first resource set to report performance of a beam prediction. The performance is based on the first resource set and the second resource set. In some embodiments, the network entity 102 may transmit 220 the first reporting configuration 221 to the UE 104, such that the UE 104 obtains 225 the first reporting configuration 221. It is to be understood that the configuration of the resource (for example, the first resource configuration 211 and the second resource configuration 212) and the reporting configuration (for example, the first reporting configuration 221) can be transmitted collectively or separately through a single message or a plurality of messages, without suggesting any limitations.

[0071] In some further embodiments, the first reporting configuration 221 may be prescribed in the specification, such that the UE 104 may obtain 225 the first reporting configuration 221 in accordance with the specification. It is to be understood that the specific manners for obtaining 225 the first reporting configuration 221 is not limited to herein, and the UE 104 may apply any manners to obtain 225 the first reporting configuration 221. In response, the UE 104 transmits 230 to the network entity 102 a first report 231 including the performance of the beam prediction based on the first reporting configuration 221. Accordingly, the network entity 102 receives 235 the first report 231, such that the network entity 102 can obtain the performance of the beam prediction of the AI/ML functionality or model monitored by the UE 104.

[0072] According to the embodiments of the present disclosure, the UE is configured with the resource configurations and reporting configuration by the network to obtain the measured beams from the first resource set and the predicated beams from a second resource set, for monitoring and reporting the performance of the beam prediction of the UE's AI/ML functionality or model. Benefiting from the enhanced reference measurement and reporting mechanism proposed by the present disclosure, beam prediction accuracy can be significantly improved and processing delays can be effectively reduced. This is beneficial to facilitate fast LCM operation, so that the interruption time due to model failure can be significantly reduced.

[0073] In some embodiments, the resource and reporting configuration of the present disclosure may be applied to the measurement mechanism of channel state information reference signal (CSI-RS) or synchronization signal/physical broadcast channel (SS/PBCH) block, by which CSI report mechanism in legacy NR communication system can be adopted with the enhancements provided by the present disclosure to support Layer1-based reporting of performance monitoring. It is to be understood that the present disclosure may also be applied to other downlink reference signals for measurement in the LTE and NR system, such as demodulation reference signal (DM-RS), positioning reference signal (PRS), phase tracking reference signal (PT-RS), cell-specific reference signal (CRS), etc. In some further embodiments, some examples of the present disclosure may also be applied to the measurement of uplink reference signals, such as sounding reference signal (SRS), uplink synchronization signal (USS), etc. In other words, although the present disclosure is described in accordance with the embodiments applied to downlink beam measurement for prediction, it can be also applied to uplink beam measurement for prediction in a similar manner. In general, those skilled in the art can apply or amend the present disclosure to arrive at any other solutions according to their common technical knowledge in the art in combination with the existing communication system or the communication system to be developed in the future.

[0074] FIG. 3 illustrates an example of a process flow 300 that supports performance monitoring for beam prediction in accordance with some embodiments of the present disclosure. The process flow 300 may involve the network entity 102 and the UE 104 in the communication network 100 with reference to FIG. 1 and FIG 2. It would be appreciated that the process flow 300 may be applied to other communication scenarios, which will not be described in detail.

[0075] In some embodiments of the present disclosure, the UE 104 may transmit 310 to the network entity 102 a request 311 for monitoring the performance of the beam prediction. Accordingly, the network entity 102 may receive 315 the request 311, such that the network entity 102 triggers and/or configures the performance monitoring of the beam prediction corresponding to a certain AI/ML based functionality or model. As non-limiting examples, the UE 104 may transmit the request 311 through a signaling to request information on performance monitoring of the beam prediction functionality or model.

[0076] As a non-limiting example, the request 311 may be transmitted through a physical random access channel (PRACH). The UE 104 is configured with a dedicated RACH occasion (RO) and dedicated preamble associated with the beam prediction, such that if a PRACH with the dedicated preamble is received by the network entity 102 at the dedicated RO, the network entity 102 triggers or configures the performance monitoring of the corresponding functionality/model. For example, the dedicated RO and dedicated preamble may be configured for a contention free random access (CFRA) configuration. As a non-limiting example, the request 311 may be transmitted through a dedicated medium access control (MAC) control element (CE) comprising an identifier for the beam prediction.

[0077] As a non-limiting example, the request 311 may be transmitted through a dedicated scheduling request (SR), wherein the UE 104 is configured with a plurality of dedicated SR resources, and a dedicated SR resource among the plurality of dedicated SR resources is associated with a beam prediction. As a non-limiting example, the request 311 may be transmitted through a beam report associated with the beam prediction or beam management.

[0078] As a non-limiting example in the CSI reporting, the beam report may be shown in Table 1, in which a certain CSI report includes one or more fields to indicate a CSI-RS resource indicator (CRI) or SSB Resource Indicator (SSB-RI) corresponding predicted beam among the top-K predicted beams with a bit width of $\text{Log2}[S1]$ and one field to indicate the requesting of performance monitoring with a bit width of 1. In some embodiments, S1 is the number of total predicted beams of the beam prediction functionality or model.

Table 1

CSI Report	CSI Field	Bit Width
CSI report #n	CRI or SSB-RI associated with 1st predicted beam	$\text{Log2}[S1]$
	CRI or SSB-RI associated with 2nd predicted beam	$\text{Log2}[S1]$
	...	$\text{Log2}[S1]$
	CRI or SSB-RI associated with K-th predicted beam	$\text{Log2}[S1]$
	Requesting performance monitoring	1

[0079] In some embodiments of the present disclosure, the network entity 102 may transmit 320 to the UE 104 a first resource configuration 321 indicating a first resource set (denoted as set 1 in the figures) for obtaining measured beams and a second resource configuration 322 indicating a second resource set (denoted as set 2 in the figures) for

obtaining predicated beams. In some embodiments of the present disclosure, the first resource set may be configured as a benchmark for obtaining the actually measured beam, and the second resource may be configured to provide relevant information for obtaining predicted beams based on the beam prediction using the AI/ML based functionality or model. The UE 104 may receive 325 the first resource configuration 321 and the second resource configuration 322 accordingly. It is to be understood that the first resource configuration 321 and the second resource configuration 322 may be a single configuration or a plurality of configurations, which may be transmitted collectively or separately through a single message or a plurality of messages, without suggesting any limitations.

[0080] In some embodiments of the present disclosure, the UE 104 may obtain 335 a first reporting configuration 331 for the first resource set to report performance of a beam prediction. The performance is based on the first resource set and the second resource set. In some embodiments, the network entity 102 may transmit 330 the first reporting configuration 331 to the UE 104, such that the UE 104 obtains 335 the first reporting configuration 331. It is to be understood that the configuration of the resource (for example, the first resource configuration 321 and the second resource configuration 322) and the reporting configuration (for example, the first reporting configuration 331) can be transmitted collectively or separately through a single message or a plurality of messages, without suggesting any limitations. In some further embodiments, the first reporting configuration 331 may be prescribed in the specification, such that the UE 104 may obtain 335 the first reporting configuration 331 in accordance with the specification. It is to be understood that the specific manners for obtaining 335 the first reporting configuration 331 is not limited to herein, and the UE 104 may apply any manners to obtain 335 the first reporting configuration 331.

[0081] As non-limiting examples, for the performance monitoring on an AI/ML functionality or model, the first reporting configuration 331 may comprise an identifier of a functionality or model for the beam prediction; the number M of the predicted beams, wherein M may be a positive integer; the number K of the measured beams, wherein K may be a positive integer; the number X of valid samples for reporting the performance, wherein X may be a positive integer; the number Z of the first resource sets for a valid sample and the number Y of the second resource sets for a valid sample; a performance target P_{target} for the UE to detect the performance of the beam prediction; or any

combination thereof. In some embodiments, the first reporting configuration may be associated with the at least one first resource set and/or the at least one second resource set as configured above. In some embodiments, the first reporting configuration may be associated with another reporting configuration used to report model inference result during usage of the functionality or model. The detailed embodiments will be described below.

[0082] In some embodiments of the present disclosure, for the reporting configuration of performance monitoring, two beam measurement cases are provided for spatial domain beam prediction and temporal domain beam prediction, respectively.

[0083] FIG. 4A illustrates an example 410 of a first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure, and especially shows an example use case of aperiodic report with aperiodic resource sets for spatial beam prediction.

[0084] As shown in FIG. 4A, the first reporting configuration is associated with the first resource set 41 and the second resource set 42, the first resource set 41 and the second resource set 42 belong to different resource sets, and the performance is based on a first measurement of the first resource set 41 and a second measurement of the second resource set 42. It is to be understood that depending on the number X of valid samples for performance monitoring, the first resource set 41 may be one or more resource sets 41 (for example, including sets 41-1, 41-2, ..., 41-N, wherein N is a positive integer) and the second resource set 42 may also be one or more resource sets (for example, including sets 42-1, 42-2, ..., 42-N, wherein N is a positive integer).

[0085] In some embodiments, the first resource set 41 and the second resource set 42 are triggered by a downlink signaling 43, and a configuration for the first resource set 41 and the second resource set 42 indicates: a first offset (for example, offset 1) between a transmission of the downlink signaling 43 and a transmission of the first resource set 41 (for example, set 41-1); a second offset (for example, offset 2) between a transmission of the downlink signaling 43 and a transmission of the second resource set (for example, set 42-1). The first offset is greater than the second offset; a first time interval (for example, TI 1) between different transmissions of first resource sets (for example, adjacent set 41-1 and set 41-2); a second time interval (for example, TI 2) between different transmissions

of second resource sets (for example, adjacent set 41-1 and set 41-2); or any combination thereof.

[0086] In another embodiment, a first group of the first resource sets 41-1 to 41-N and a second group of the second resource sets 42-1 to 42-N are triggered by the downlink signaling 43. A first transmission occasion of the first resource sets 41-1 to 41-N within the first group is based on the first offset (for example, offset 1) and the first time interval (for example, TI 1) between adjacent first resource sets (for example, adjacent set 41-1 and set 41-2) within the first group, and a second transmission occasion of the second resource sets 42-1 to 42-N within the second group is based on the second offset (for example, offset 2) and the second time interval (for example, TI 2) between adjacent second resource sets (for example, adjacent set 42-1 and set 42-2) within the second group. The UE 104 may transmit the first report 44 to the network entity.

[0087] As a specific non-limiting example of CSI-RS measurement and reporting, in the case where the number X of valid samples is taken as 1 (i.e., $X = 1$), two aperiodic CSI-RS resource sets are triggered by a single DCI for triggering a CSI report for performance monitoring of beam prediction, i.e., a first resource set and a second resource set. In some examples, the time offsets of the two sets and the triggering DCI may be indicated by the network entity 102 through the triggering DCI or other higher layer signaling. In the case where the number X of valid samples is taken as being above 1 (i.e., $X > 1$), two groups of aperiodic CSI-RS resource sets may be triggered by a single DCI, i.e., a group of first resource sets and a group of second resource sets. In some examples, the respective time offsets, offset 1 and offset 2, between the first ones of the two groups and the triggering DCI may be indicated by the network entity 102 through the triggering DCI or higher layer signaling. In some examples, time intervals (TIs) of two adjacent resource sets in the same group may be indicated by the network entity 102 through the triggering DCI or other higher layer signaling, for example, TI 1 for the group of first resource sets and TI 2 for the group of second resource sets. In some embodiments, the UE 104 may report results of monitoring for the functionality/model based on measurements associated with the first group and the second group. The measurement associated with the first group is used to perform beam measurement for obtaining measured beams as benchmark or reference, and the measurement associated with the second group is used to perform beam prediction for obtaining predicted beams to be compared with the benchmark or reference in the performance determination. The UE104

reports performance of beam prediction in the CSI report based on the measured beams and the predicted beams.

[0088] FIG. 4B illustrates an example 420 of a first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure, and especially shows an example use case of aperiodic report with aperiodic resource sets for temporal beam prediction.

[0089] As shown in FIG. 4B, the first reporting configuration is associated with the first resource set 41 and the second resource set 42, the first resource set 41 and the second resource set 42 belong to different resource sets, and the performance is based on a first measurement of the first resource set 41 and a second measurement of the second resource set 42. It is to be understood that the first resource set 41 may be one or more resource sets 41 (for example, including sets 41-1, 41-2, ..., 41-N, wherein N is a positive integer) and the second resource set 42 may also be one or more resource sets (for example, including sets 42-1, 42-2, ..., 42-N, wherein N is a positive integer). The UE 104 may transmit the first report 44 to the network entity.

[0090] In some embodiments, the first resource set 41 and the second resource set 42 are triggered by a downlink signaling 43, and a configuration for the first resource set 41 and the second resource set 42 indicates at least one of the following: a first offset (for example, offset 1) between a transmission of the downlink signaling 43 and a first one of transmissions of a first number of first resource sets (for example, transmission occasion corresponding to set 41-1), and a second offset (for example, offset 2) between the transmission of the downlink signaling 43 and a first one of transmissions of a second number of second resource sets 42 (for example, transmission occasion corresponding to set 42-1). In some embodiments, the first one of the transmissions of the first number of the first resource sets (for example, transmission occasion corresponding to set 41-1) is later than the last one of the transmissions of the second number of the second resource sets (for example, transmission occasion corresponding to set 42-N).

[0091] As a specific non-limiting example of CSI-RS measurement and reporting, in the case where the number X of valid samples is taken as 1 (i.e., $X = 1$), two groups of CSI-RS resource sets may be triggered by a single DCI, where a first group may comprises Z CSI-RS resource sets or Z transmissions of one CSI-RS resource set for beam measurement of the first resource set (for example, a group of set 1) and a second group

comprises Y CSI-RS resource sets or Y transmission of one CSI-RS resource set for beam measurement of the first resource set (for example, a group of set 2). Time offset between a first CSI-RS resource set of the first group and the triggering DCI and time offset between a first CSI-RS resource set of the second group and the triggering DCI may be indicated by the network entity 102 through the triggering DCI or other higher layer signaling. The time offset between the triggered CSI report and associated triggering DCI is determined according to legacy aperiodic CSI report method, for example, the offset may be indicated by the triggering DCI. In some embodiments, the UE 104 may report results of monitoring for the functionality/model based on measurements associated with the first group and the second group. The measurement associated with the first group is used to perform beam measurement for obtaining measured beams as benchmark or reference, and the measurement associated with the second group is used to perform beam prediction for obtaining predicted beams to be compared with the benchmark or reference in the performance determination.

[0092] FIG. 4C illustrates an example 430 of a first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure, and especially shows an another example use case of aperiodic report with aperiodic resource sets for temporal beam prediction.

[0093] As shown in FIG. 4C, the first reporting configuration is associated with the first resource set 41 and the second resource set 42, the first resource set 41 and the second resource set 42 belong to different resource sets, and the performance is based on a first measurement of the first resource set 41 and a second measurement of the second resource set 42. It is to be understood that the first resource set 41 may be one or more resource sets 41 (for example, including sets 41-1, 41-2, ..., 41-N, wherein N is a positive integer) and the second resource set 42 may also be one or more resource sets (for example, including sets 42-1, 42-2, ..., 42-N, wherein N is a positive integer).

[0094] In some embodiments, the first resource set 41 and the second resource set 42 are triggered by a downlink signaling 43, and a configuration for the first resource set 41 and the second resource set 42 indicates at least one of the following: a first offset (for example, offset 1) between a last one of the transmissions of a second number of second resource sets (for example, transmission occasion corresponding to set 42-N) and a first one of transmissions of a first number of first resource sets (for example, transmission

occasion corresponding to set 41-1), and a second offset (for example, offset 2) between a transmission of the downlink signaling 43 and a first one of transmissions of the second number of second resource sets (for example, transmission occasion corresponding to set 42-1). In some embodiments, the first one of the transmissions of the first number of the first resource sets (for example, transmission occasion corresponding to set 41-1) is later than the last one of the transmissions of the second number of the second resource sets (for example, transmission occasion corresponding to set 42-N).

[0095] As a specific non-limiting example of CSI-RS measurement and reporting, in the case where the number X of valid samples is taken as 1 (i.e., $X = 1$), two groups of CSI-RS resource sets may be triggered by a single DCI, where a first group may comprises Z CSI-RS resource sets or Z transmissions of one CSI-RS resource set for beam measurement of the first resource set (for example, a group of set 1) and a second group comprises Y CSI-RS resource sets or Y transmissions of one CSI-RS resource for beam measurement of the first resource set (for example, a group of set 2). Time offset between a first CSI-RS resource set of the first group and the triggering DCI and time offset between a last CSI-RS resource set of the second group and a first CSI-RS resource set of the first group may be indicated by the network entity 102 through the triggering DCI or other higher layer signaling. The time offset between the triggered CSI report and associated triggering DCI is determined according to legacy aperiodic CSI report method, for example, the offset may be indicated by the triggering DCI. In some embodiments, the UE 104 may report results of monitoring for the functionality/model based on measurements associated with the first group and the second group. The measurement associated with the first group is used to perform beam measurement for obtaining measured beams as benchmark or reference, and the measurement associated with the second group is used to perform beam prediction for obtaining predicted beams to be compared with the benchmark or reference in the performance determination.

[0096] In some aspects of the present disclosure, legacy resource configuration is considered to be reused for performance monitoring of AI/ML beam management functionality or model by enhancing the report mechanism to facilitate the UE to report performance monitoring results.

[0097] FIG. 5A illustrates an example 510 of a first reporting configuration for performance monitoring in accordance with some example embodiments of the present

disclosure, and especially shows an example use case of periodic or semi-persistent resource sets for spatial beam prediction.

[0098] As shown in FIG. 5A, the first reporting configuration is associated with the first resource set 51 and a second reporting configuration for the second resource set, and the performance is based on a first measurement of the first resource set 51 and a second report 52 corresponding to the second reporting configuration for the second resource set. It is to be understood that depending on the number X of valid samples for performance monitoring, the first resource set 51 may be one or more resource sets 51 (for example, including sets 51-1, 51-2, ..., 51- N , wherein N is a positive integer) and the second report 52 may also be one or more reports for one or more second resource sets (for example, including report 52-1, 52-2, ..., 52- N , wherein N is a positive integer). In some embodiments, a first resource set 51 and a second report 52 may be included in a sample 50 (for example, the set 51-1 and the report 52-1 are included in the sample 50-1, and so on).

[0099] In some further embodiments of the example 510, a first gap (for example, gap 1) between a report occasion associated with the second report (for example, report 52- N) for the second resource set and a transmission occasion associated with the first measurement of the first resource set (for example, set 51- N) is less than or equal to a first threshold, and a second gap (for example, gap 2) between report occasions associated with the second reports (for example, adjacent report 52-1 and report 52-2) is greater than or equal to a second threshold.

[0100] As a specific non-limiting example of CSI-RS measurement and reporting, a CSI report (for example, CSI report 1) is configured for the UE 104 and associated with an SSB/CSI-RS resource set for benchmark or reference (for example, denoted as set 1 in FIG. 5A). The CSI report 1 is further associated with other one CSI report (for example, CSI report 2) which is used to report model inference result of the functionality/model. The UE 104 may report the monitoring results in the CSI report 1 based on the measurement associated with the set 1 and the content reported in the CSI report 2. In some examples, the UE 104 may determine a number X of valid samples based on the measurement associated with a number X of occasions of the first resource set and the content reported in a number X of CSI report 2. For any of the X samples, the corresponding occasion of the set 1 is no later than the CSI reference resource (for

example, denoted as 53 in FIG. 5A) corresponding to the CSI report 1 (for example, denoted as 54 in FIG. 5A).

[0101] In some embodiments, the third gap (for example, denoted as gap 3 in FIG. 5B) may be configured by the network entity 102 or specified in the specification. For any of the X samples, the gap between the CSI report 2 and the corresponding transmission of the first resource set is no larger than a threshold1 that is configured by the network entity 102 or specified in the specification. In the case where the number of valid samples is taken as being above 1, (i.e., $X > 1$), the gap between the CSI report 2 in two consecutive samples shall be larger than a threshold2 that may be configured by the network entity 102 or specified in the specification. In some embodiments, an example of the two thresholds may be specified in the specification as follows:

u1	Threshold1 [symbols]	u2	Threshold2[symbols]
0	A1	0	B1
1	A2	1	B2

In this example, the parameter u1 may correspond to the maximum value of (uUL, uCSI-RS) and the parameter u2 may correspond to the minimum value of (uUL, uCSI-RS). The uUL may correspond to the subcarrier spacing of the CSI report 2 and the uCSI-RS may correspond to the subcarrier spacing of CSI-RS of the set 1.

[0102] In some further embodiments, in the case where the number of CSI report 2 satisfies the timeline requirement, for example, each of threshold1 and threshold2 is less than X , then the UE 104 may drop the CSI report 1 or report the beam(s) based on measurement associated with the set 1 only, no later than the CSI-RS resource.

[0103] FIG. 5B illustrates an example 520 of a first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure, and especially shows an another example use case of periodic or semi-persistent resource sets for spatial beam prediction.

[0104] As shown in FIG. 5B, the first reporting configuration is associated with the first resource set 51 and the second resource set 52, the first resource set 51 and the second resource set 52 belong to different resource sets, and the performance is based on a first measurement of the first resource set 51 and a second measurement of the second resource set 52. It is to be understood that depending on the number X of valid samples for performance monitoring, the first resource set 51 may be one or more resource sets 51

(for example, including sets 51-1, 51-2, ..., 51-N, wherein N is a positive integer) and the second resource set 52 may also be one or more resource sets (for example, including sets 52-1, 52-2, ..., 52-N, wherein N is a positive integer).

[0105] In some embodiments of the example 520, a configuration indicates: a first gap (for example, gap 1) between a transmission of the second resource set (for example, set 52-N) and a transmission of the first resource set (for example, set 51-N) is less than or equal to a first threshold; a second gap (for example, gap 2) between different transmissions of second resource sets (for example, adjacent set 52-1 and set 52-2) is greater than or equal to a second threshold; a difference between channel quality associated with a first reference signal based on the first resource set and channel quality associated with a second reference signal based on the second resource set is less than or equal to a threshold; or any combination thereof. The second reference signal and the first reference signal have a same resource indicator or are quasi co-located.

[0106] As a specific non-limiting example of CSI-RS measurement and reporting, a CSI report may be configured for the UE 104 and associated with two SSB/CSI-RS resource sets (for example, denoted as set 1 and set 2 in FIG. 5B) for obtaining measured beams and predicted beams, respectively. The UE 104 may report monitoring results in the CSI report based on beam measurement associated with the set 1 and set 2. In some further embodiments, the UE 104 may determine a number X of valid samples, each of which comprises measurement associated with an occasion of the set 2 and measurement associated with an occasion of the set 1. For any of the X samples, both the corresponding occasion of set 1 and the corresponding occasion of set 2 are no later than CSI reference resource (for example, denoted as 53 in FIG. 5B) corresponding to the CSI report (for example, denoted as 54 in FIG. 5B). In some embodiments, the third gap (for example, denoted as gap 3 in FIG. 5B) may be configured by the network entity 102 or specified in the specification.

[0107] In some aspects of the embodiment, due to the time-varying channel condition, beam measurement of a same beam will vary with time as well as the best beam at certain time instance. For a monitoring sample, the measurement for the predicted beams and the measurement for the measured beams may be bounded. For example, for each of the X samples, at least one of the following conditions may be satisfied: the gap between the occasion of the set 2 and the occasion of the set 1 is no larger than a threshold1, for

example, a value T_{time1} ; or the difference between measured Layer 1 reference signal received power (L1-RSRP) associated with CSI-RS of set 2 and measured L1-RSRP associated with CSI-RS with the same CRI or SSB-RI of set 1 is no larger than a L1-RSRP threshold $DL1\text{-RSRP}$. In the case where the number of valid samples is taken as being above 1, (i.e., $X > 1$), the time gap of occasions of the set 2 corresponding to two samples may be larger than a threshold2, for example, T_{time2} , which may be configured by the network entity 102 or specified in the specification. In some further embodiments, in the case where the number of samples satisfies the timeline requirement, for example, each of threshold1 and threshold2 is less than X, then the UE 104 may drop the CSI report 1 or report the beam(s) based on measurement associated with the set 1 only or the set 1 and the set 2.

[0108] FIG. 6 illustrates an example 600 of a first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure, and especially shows a further example use case of periodic or semi-persistent resource sets for spatial beam prediction.

[0109] As shown in FIG. 6, the first reporting configuration is associated with the first resource set 61 and the second resource set 62 that are different subsets of a same resource set, and the performance is based on a first measurement of the first resource set 61 and a second measurement of the second resource set 62. It is to be understood that depending on the number X of valid samples for performance monitoring, the first resource set 61 may be one or more resource sets 61 (for example, including subsets 61-1, 61-2, ..., 61-N, wherein N is a positive integer) and the second resource set 62 may also be one or more resource sets (for example, including subsets 62-1, 62-2, ..., 62-N, wherein N is a positive integer). A first resource set 61 and a corresponding second resource set 62 are different subsets of a same resource set corresponding to a sample (for example, the subset 61-1 and the corresponding subset 62-1 are different subsets of a resource set corresponding to the sample 60-1, and so on).

[0110] In some embodiments of the example 600, an association configuration for the first resource set 61 and the second resource set 62 comprises or indicates: a bitmap indicating the first resource set or the second resource set; the first resources in the resource set configured to be the second resource set or the last resources in the resource

set configured to be the first resource set; a table of a pattern of the first resource set or the second resource set and a code point of the pattern; or any combination thereof.

[0111] As a specific non-limiting example of CSI-RS measurement and reporting, a CSI report may be configured for UE and associated with an SSB/CSI-RS resource set for obtaining measured beams and predicted beams, respectively. The UE 104 may report monitoring results in the CSI report based on beam measurement associated with the SSB/CSI-RS resource set. In some embodiments, a number X of samples may be determined by the UE 104 based on measurement associated with a number of X occasions of the SSB/CSI-RS resource set. To make UE obtain the predicted beams for model input, a CSI-RS resource subset of the set may be indicated by the network entity 102 to the UE 104. For example, a bitmap may be used to indicate the subset from the set. An IE is introduced in radio resource control (RRC) parameters of CSI-RS resource set for the bitmap. As another example, first m CSI-RS resources of the set may be specified as measurement resource for the predicted beams. For a further example, a table of a pattern of predicted beams may be configured by the network entity 102 and a codepoint associated with a pattern of predicted beams of the table may be indicated to the UE 104. For any of the X samples, the corresponding occasion of the subset 1 and the corresponding occasion of the subset 2 is no later than the CSI reference resource (for example, denoted as 63 in FIG. 6) corresponding to the CSI report 1 (for example, denoted as 64 in FIG. 6). In some embodiments, a third gap (for example, denoted as gap 3 in FIG. 6) may be configured by the network entity 102 or specified in the specification.

[0112] FIG. 7 illustrates an example 700 of a first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure, and especially shows an example use case of periodic or semi-persistent resource sets for temporal beam prediction.

[0113] As shown in FIG. 7, the first reporting configuration is associated with the first resource set and the second resource set that belong to a same resource set. The first resource set includes a first set of transmission occasions 71 (for example, TO 71-1, 71-2, ..., 71- Z , wherein Z is a positive integer), the second resource set includes a second set of transmission occasions 72 (for example, TO 72-1, 72-2, ..., 72- Z , wherein Y is a positive integer), and the performance is based on the first set of transmission occasions 71 and the second set of transmission occasions 72.

[0114] In some embodiments of the example 700, a configuration for the first set of transmission occasions and the second set of transmission occasions indicates: a first time interval (for example, TI 1) between different occasions of the first set of transmission occasions (for example, adjacent TO 71-1 and TO 71-2); a second time interval (for example, TI 2) between different occasions of the second set of transmission occasions (for example, adjacent TO 72-1 and TO 72-2); a third time interval (for example, TI 3) between the last one of the second set of transmission occasions and the first one of the first set of transmission occasions (for example, adjacent TO 72-1 and TO 71-Z); or any combination thereof.

[0115] In some further embodiments of the example 700, the first time interval TO 1 is based on a first scaler factor and a periodicity of the resource set to which the first resource set and the second resource set belong, the second interval TO 2 is based on a second scaler factor and the periodicity of the resource set to which the first resource set and the second resource set belong, and the third interval TO 3 is based on a third scaler factor and the periodicity of the resource set to which the first resource set and the second resource set belong.

[0116] As a specific non-limiting example of CSI-RS measurement and reporting, a CSI report may be configured for the UE 104 and associated with an SSB/CSI-RS resource set for obtaining measured beams and predicted beams, respectively. The UE 104 may report monitoring results in the CSI report based on X samples no later than CSI reference resource (for example, denoted as 73 in FIG. 7) corresponding to the CSI report (for example, denoted as 74 in FIG. 7). In some examples, each sample may comprise a sum of Y and Z transmission occasions of the SSB/CSI-RS resource set, in which Z transmission occasions close to the CSI reference resource may be used for obtaining measured beams and the remaining Y transmission occasions may be used for obtaining predicted beams.

[0117] In some further embodiments, the first time interval between two adjacent occasions in the Z transmission occasions, the second time interval between two adjacent occasions in the Y transmission occasions, and the third time interval between the most recent occasion among the Y transmission occasions and the farthest occasion among the Z transmission occasions may be indicated by the network entity using three scaler factors α , β , and γ , respectively, which may indicate the three time intervals are $\alpha * T_{SSB/CSI-RS}$,

$\beta * T_{SSB/CSI-RS}$, and $\gamma * T_{SSB/CSI-RS}$, respectively. The value of α , β , or γ may be one of the value set [..., 1/4, 1/2, 1, 2,...] and the $T_{SSB/CSI-RS}$ is the periodicity of the SSB/CSI-RS resource set. In some embodiments, the corresponding transmission occasion of the set 1 and the corresponding transmission occasion of the set 2 is no later than the CSI reference resource (for example, denoted as 73 in FIG. 7) corresponding to the CSI report 1 (for example, denoted as 74 in FIG. 7). In some embodiments, a third gap (for example, denoted as gap 3 in FIG. 7) may be configured by the network entity 102 or specified in the specification.

[0118] FIG. 8 illustrates an example 800 of a first reporting configuration for performance monitoring in accordance with some example embodiments of the present disclosure, and especially shows another example use case of periodic or semi-persistent resource sets for temporal beam prediction.

[0119] As shown in FIG. 8, the first reporting configuration is associated with the first resource set 81 and the second resource set 82, the first resource set 81 and the second resource set 82 belong to different resource sets, and the performance is based on a first measurement of the first resource set 81 and a second measurement of the second resource set 82. It is to be understood that for each valid sample for performance monitoring, the first resource set 81 may be one or more resource sets 81 (for example, including sets 81-1, 81-2, ..., 81-Z, wherein Z is a positive integer) and the second resource set 82 may also be one or more resource sets (for example, including sets 82-1, 82-2, ..., 82-Y, wherein Y is a positive integer). The number of valid samples for performance monitoring can be one or more than one.

[0120] In some embodiments of the example 800, a configuration for the first resource set 81 and the second resource set 82 indicates: a first time interval (for example, TO 1) between different transmissions of a first number of first resource sets (for example, adjacent set 81-1 and set 81-2); a second time interval (for example, TO 2) between different transmissions of a second number of second resource sets (for example, adjacent set 82-1 and set 82-2); a gap between a last one of the transmissions of the second number of the second resource sets (for example, a transmission occasion corresponding to the set 82-1) and a first one of the transmissions of the first number of the first resource sets (for example, a transmission occasion corresponding to the set 81-Z); or any combination thereof.

[0121] As a specific non-limiting example of CSI-RS measurement and reporting, a CSI report may be configured for the UE 104 and associated with an SSB/CSI-RS resource set (for example, denoted as set 1 in FIG. 8) for obtaining measured beams. The CSI report is further associated with a number Y of other SSB/CSI-RS resource set(s) (for example, denoted as set 2 in FIG. 8) for obtaining predicted beams. The Y sets may correspond to the same transmission configuration indicator (TCI) state list or different TCI state lists. The UE 104 may report results of monitoring in a CSI report based on measurement associated with set 1 and measurement associated with set 2, no later than CSI reference resource (for example, denoted as 83 in FIG. 8) corresponding to the CSI report. In some further embodiments, in the case where the number of valid samples is taken as 1 (i.e., $X=1$), UE may derive the beam measurement for predicted beams based on Y transmission occasions of the set 2 and the beam measurement for measured beams based on Z transmission occasions of the set 1.

[0122] In some further examples, the time interval, TI 1, of two adjacent transmission occasions of set 1 and the second time interval, TI 2, of two adjacent transmission occasions of set 2 may be configured by the network entity 102. In some further examples, the third time interval, TI3, between the most recent transmission occasion among the Y transmission occasions of the set 2 and the farthest transmission occasion among the Z transmission occasions of set 1 may be configured by the network entity 102. In the case where the number of valid samples is taken as being above 1, (i.e., $X > 1$), the UE 104 may report the result of monitoring in the CSI report based on X samples and each sample may be determined according to the present disclosure as described above. In some embodiments of the present disclosure, the corresponding occasion of the set 1 and the corresponding occasion of the set 2 is no later than the CSI reference resource (for example, denoted as 83 in FIG. 8) corresponding to the CSI report 1 (for example, denoted as 84 in FIG. 8). In some embodiments, a third gap (for example, denoted as gap 3 in FIG. 8) may be configured by the network entity 102 or specified in the specification.

[0123] Referring back to FIG. 3, in some embodiments of the present disclosure, the network entity 102 may transmit a reference signal to the UE 104. In some embodiments, the UE 104 may receive 345 the reference signal for beam measurement, to obtain the measured beams by using the first resource set and to obtain the predicated beams by using the second resource set. In some further embodiments, the UE 104 may perform performance determination 350 to determine the performance of the beam prediction

based on a configured number of valid samples. For example, a valid sample may correspond to a first number of first resource sets and a second number of second resource sets. Thereby, the UE 104 can generate data for determining the performance of the beam prediction.

[0124] As non-limiting examples, the performance may comprise: identifiers of a predetermined number of the best measured beams based on a first measurement of the first resource set; identifiers of a predetermined number of the best predicted beams based on a second measurement of the second resource set; an indicator for a first beam prediction success, indicating that the top one measured beam is one of the predetermined number of the best predicted beams; an indicator for a second beam prediction success, indicating that the top one predicted beam is one of the predetermined number of the best predicted beams; an indicator for indicating that at least one of the first beam prediction success or the second beam predication success is less than a performance target; or any combination thereof.

[0125] As a specific non-limiting example of CSI-RS measurement and reporting, the report content of performance monitoring for the functionality/model can be identifiers of top-K predicted beams based on predicted beams and identifiers of top-N measured beams based on measured beams. An exemplary design may be shown in Table 2 below. The identifier may be CSI-RS resource indicator (CRI) or SSB Resource Indicator (SSB-RI), which may be indicated in a field with a bit width of $\text{Log}_2[\text{S1}]$ for the predicted beams or $\text{Log}_2[\text{S2}]$ for the measured beams. In some embodiments, S1 is the number of total predicted beams of the beam prediction functionality or model, and the S2 is the number of measured beams as the benchmark/reference of the beam prediction functionality or model.

Table 2

CSI Field	Bit Width
SSB-RI or CRI associated with 1st predicted beam	$\text{log}_2[\text{S1}]$
SSB-RI or CRI associated with 2nd predicted beam	$\text{log}_2[\text{S1}]$
...	...
SSB-RI or CRI associated with K-th predicted beam	$\text{log}_2[\text{S1}]$
SSB-RI or CRI associated with 1st measured beam	$\text{log}_2[\text{S2}]$
SSB-RI or CRI associated with 2nd measured beam	$\text{log}_2[\text{S2}]$
...	...
SSB-RI or CRI associated with N-th measured beam	$\text{log}_2[\text{S2}]$

[0126] As another specific non-limiting example of CSI-RS measurement and reporting, the report content of performance monitoring for the functionality/model may be an indicator for top-1/K beam prediction success or top-N/1 beam prediction success, in the case where the number of valid samples is taken as 1 (i.e., $X = 1$). The number of top-1/K beam prediction success and/or the number of top-N/1 beam prediction success. The top-1/K beam prediction success means that the top-1 measured beam is one of the top-K predicted beams and the top-N/1 beam prediction success means that the top-1 predicted beam is one of the top-N predicted beams, in the case where the number of valid samples is taken as being above 1 (i.e., $X > 1$). An exemplary design may be shown in Table 3 below. The indicator for top-1/K beam prediction success or top-N/1 beam prediction success indicator may be indicated in the CSI field with a bit width of 1, and a number of top-1/K beam prediction success or top-N/1 beam prediction success may be indicated the CSI field with a bit width of $\text{Log2}[X]$.

Table 3

CSI Field	Bit Width
Indicator for top-1/K beam prediction success or top-N/1 beam prediction success	1
OR	OR
Number of top-1/K beam prediction success or top-N/1 beam prediction success	$\text{Log2}[X]$

[0127] As a further specific non-limiting example of CSI-RS measurement and reporting, the report content of performance monitoring for the functionality/model may be an indicator or event for indicating that the number of top-1/K beam prediction success and/or the number of top-N/1 beam prediction success is less than the performance target P_{target} .

[0128] In some embodiments of the present disclosure, the UE 104 may transmit 360 to the network entity 102 a first report 361 including the performance of the beam prediction based on the first reporting configuration 331. As non-limiting examples, the first report 361 includes a first part with a fixed payload and a second part with a payload based on the first part. The first part indicates the number of monitoring results for the beam prediction, and the second part indicates the monitoring results. As a specific non-limiting example of CSI-RS measurement and reporting, the UE 104 may perform performance monitoring for multiple models of a functionality and obtain corresponding multiple results of monitoring. The UE 104 may report the number of monitoring results

for the functionality in the first part (for example, CSI part 1) with a fixed payload and report the multiple monitoring results in the second part (for example, CSI part 2). The payload for reporting the multiple results may be determined based on the CSI report 1. A CSI report format for reporting multiple monitoring results for the functionality/model may be shown in Table 4.

Table 4

CSI Report	CSI Part I	CSI Part II
CSI report #n	$N_{results}$, number of results of monitoring	1st number of Top-1/K beam prediction success
		2nd number of Top-1/K beam prediction success
		3rd number of Top-1/K beam prediction success
		...
		$N_{results}$ -th number of Top-1/K beam prediction success

[0129] Accordingly, the network entity 102 may receive 365 the first report 361, such that the network entity 102 can obtain the performance of the beam prediction of the AI/ML functionality or model monitored by the UE 104. In some further embodiments, the network entity 102 may determine a LCM operation for the UE based on the first report 361 and may transmit 370 to the UE 104 an indication 371 of a LCM operation based on the first report 361. As non-limiting examples, the indication 371 of the LCM operation may include: an identifier of a functionality or model for a beam prediction to be switched to and an identifier of candidate beam that is the top one measured beam; an identifier of a functionality or model for a beam prediction to be deactivated and an identifier of candidate beam that is the top one measured beam; an request for deactivating the beam prediction and an identifier of candidate beam that is the top one measured beam; or any combination thereof.

[0130] For example, regarding functionality/model switching, a LCM operation request may include an identifier of functionality/model switched to and identifier of candidate beam that may be the top-1 measured beam. Regarding functionality/model deactivation, a LCM operation request may include an identifier of deactivated functionality/model and an identifier of candidate beam that may be the top-1 measured beam. As a fallback, a LCM operation request may include non-AI beam measurement request and an identifier of candidate beam that may be the top-1 measured beam, in which the configuration related to non-AI beam management is pre-configured and may

be signaled to activate upon the network entity 102 receiving a fallback request from the UE 104.

[0131] As further non-limiting examples, the indication 371 of the LCM operation may be an implicit indication, such that the network entity 102 may (re)configure, activate, or deactivate CSI resource setting and CSI report setting of functionality/model. In some embodiments, the indication 371 of the LCM operation may be an indication by dedicated signaling, such that the network entity 102 may indicate an identifier of a functionality/model by the dedicated signaling, e.g., dedicated MAC CE, to activate or deactivate the functionality/model. In some embodiments, before the indication takes effect, the UE 104 may perform beam failure detection and beam failure recovery in the case of detecting a beam failure. In another example, before the indication takes effect, the UE 104 may perform monitoring on a physical downlink control channel (PDCCH) (for example, in control resource set for beam failure recovery (CORESET-BFR)) until receiving a radio resource control (RRC) configuration. The used transmit beam is the reported top one measured beam.

[0132] FIG. 9 illustrates an example of a device 900 that supports performance monitoring for beam prediction in accordance with aspects of the present disclosure. The device 900 may be an example of a network entity 102 or a UE 104 as described herein. The device 900 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 900 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 902, a memory 904, a transceiver 906, and, optionally, an I/O controller 908. 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).

[0133] The processor 902, the memory 904, the transceiver 906, 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 902, the memory 904, the transceiver 906, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0134] In some implementations, the processor 902, the memory 904, the transceiver 906, 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 902 and the memory 904 coupled with the processor 902 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 902, instructions stored in the memory 904).

[0135] For example, the processor 902 may support wireless communication at the device 900 in accordance with examples as disclosed herein. The processor 902 may be configured to operable to support a means for receiving a first resource configuration including a first resource set for obtaining measured beams and a second resource configuration including a second resource set for obtaining predicated beams; obtaining a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and transmitting a first report including the performance of the beam prediction based on the first reporting configuration. In another embodiment, the processor 902 may be configured to operable to support a means for transmitting a first resource configuration including a first resource set for obtaining measured beams and a second resource configuration including a second resource set for obtaining predicated beams; configuring a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and receiving a first report including the performance of the beam prediction based on the first reporting configuration.

[0136] The processor 902 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 902 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 902. The

processor 902 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 904) to cause the device 900 to perform various functions of the present disclosure.

[0137] The memory 904 may include random access memory (RAM) and read-only memory (ROM). The memory 904 may store computer-readable, computer-executable code including instructions that, when executed by the processor 902 cause the device 900 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 902 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 904 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.

[0138] The I/O controller 908 may manage input and output signals for the device 900. The I/O controller 908 may also manage peripherals not integrated into the device 900. In some implementations, the I/O controller 908 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 908 may utilize an operating system such as iOS®, ANDROID®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In some implementations, the I/O controller 908 may be implemented as part of a processor, such as the processor 906. In some implementations, a user may interact with the device 900 via the I/O controller 908 or via hardware components controlled by the I/O controller 908.

[0139] In some implementations, the device 900 may include a single antenna 910. However, in some other implementations, the device 900 may have more than one antenna 910 (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 906 may communicate bi-directionally, via the one or more antennas 910, wired, or wireless links as described herein. For example, the transceiver 906 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 906 may also include a modem to modulate the packets, to provide the modulated packets to one or more

antennas 910 for transmission, and to demodulate packets received from the one or more antennas 910. The transceiver 906 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0140] A transmit chain may be configured to generate and transmit signals (e.g., control information, data, packets). The transmit chain may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmit chain may also include one or more antennas 910 for transmitting the amplified signal into the air or wireless medium.

[0141] 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 910 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.

[0142] FIG. 10 illustrates an example of a processor 1000 that supports performance monitoring for beam prediction in accordance with aspects of the present disclosure. The processor 1000 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 1000 may include a controller 1002 configured to perform various operations in accordance with examples as described herein. The processor 1000 may optionally include at least one memory 1004. Additionally, or alternatively, the processor 1000 may optionally include one or more arithmetic-logic units (ALUs) 1000. 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).

[0143] The processor 1000 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 1000) 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).

[0144] The controller 1002 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 1000 to cause the processor 1000 to support various operations in accordance with examples as described herein. For example, the controller 1002 may operate as a control unit of the processor 1000, generating control signals that manage the operation of various components of the processor 1000. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0145] The controller 1002 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 1004 and determine subsequent instruction(s) to be executed to cause the processor 1000 to support various operations in accordance with examples as described herein. The controller 1002 may be configured to track memory address of instructions associated with the memory 1004. The controller 1002 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 1002 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 1000 to cause the processor 1000 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 1002 may be configured to manage flow of data within the processor 1000. The controller 1002 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 1000.

[0146] The memory 1004 may include one or more caches (e.g., memory local to or included in the processor 1000 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 1004 may reside within or on a processor chipset (e.g., local to the processor 1000). In some other implementations, the memory 1004 may reside external to the processor chipset (e.g., remote to the processor 1000).

[0147] The memory 1004 may store computer-readable, computer-executable code including instructions that, when executed by the processor 1000, cause the processor 1000 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 1002 and/or the processor 1000 may be configured to execute computer-readable instructions stored in the memory 1004 to cause the processor 1000 to perform various functions (e.g., functions or tasks supporting transmit power prioritization). For example, the processor 1000 and/or the controller 1002 may be coupled with or to the memory 1004, the processor 1000, the controller 1002, and the memory 1004 may be configured to perform various functions described herein. In some examples, the processor 1000 may include multiple processors and the memory 1004 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.

[0148] The one or more ALUs 1000 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 1000 may reside within or on a processor chipset (e.g., the processor 1000). In some other implementations, the one or more ALUs 1000 may reside external to the processor chipset (e.g., the processor 1000). One or more ALUs 1000 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 1000 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 1000 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 1000 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND),

enabling the one or more ALUs 1000 to handle conditional operations, comparisons, and bitwise operations.

[0149] The processor 1000 may support wireless communication in accordance with examples as disclosed herein. The processor 1002 may be configured to or operable to support a means for receiving a first resource configuration including a first resource set for obtaining measured beams and a second resource configuration including a second resource set for obtaining predicated beams; obtaining a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and transmitting a first report including the performance of the beam prediction based on the first reporting configuration. In another embodiment, the processor 1002 may be configured to operable to support a means for transmitting a first resource configuration including a first resource set for obtaining measured beams and a second resource configuration including a second resource set for obtaining predicated beams; configuring a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and receiving a first report including the performance of the beam prediction based on the first reporting configuration..

[0150] FIG. 11 illustrates a flowchart of a method 1100 that supports performance monitoring for beam prediction in accordance with aspects of the present disclosure. The operations of the method 1100 may be implemented by a device or its components as described herein. For example, the operations of the method 1100 may be performed by a UE 104 as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0151] At 1105, the method may include receiving a first resource configuration including a first resource set for obtaining measured beams and a second resource configuration including a second resource set for obtaining predicated beams. The operations of 1105 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1105 may be performed by a device as described with reference to FIG. 1.

[0152] At 1110, the method may include obtaining a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set. The operations of 1110 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1110 may be performed by a device as described with reference to FIG. 1.

[0153] At 1115, the method may include transmitting a first report including the performance of the beam prediction based on the first reporting configuration. The operations of 1115 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1115 may be performed by a device as described with reference to FIG. 1.

[0154] FIG. 12 illustrates a flowchart of a method 1200 that supports performance monitoring for beam prediction in accordance with aspects of the present disclosure. The operations of the method 1200 may be implemented by a device or its components as described herein. For example, the operations of the method 1200 may be performed by a network entity 102 as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0155] At 1205, the method may include transmitting a first resource configuration including a first resource set for obtaining measured beams and a second resource configuration including a second resource set for obtaining predicated beams. The operations of 1205 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1205 may be performed by a device as described with reference to FIG. 1.

[0156] At 1210, the method may include configuring a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set. The operations of 1210 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1210 may be performed by a device as described with reference to FIG. 1.

[0157] At 1215, the method may include receiving a first report including the performance of the beam prediction based on the first reporting configuration. The operations of 1215 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1215 may be performed by a device as described with reference to FIG. 1.

[0158] 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.

[0159] 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).

[0160] 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.

[0161] 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.

[0162] As used herein, including in the claims, an article “a” before an element is unrestricted and understood to refer to “at least one” of those elements or “one or more” of those elements. The terms “a,” “at least one,” “one or more,” and “at least one of one or more” may be interchangeable. As used herein, including in the claims, “or” as used in a list of items (e.g., a list of items prefaced by a phrase such as “at least one of” or “one or more of” or “one or both of”) indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase “based on” shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as “based on condition A” may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase “based on” shall be construed in the same manner as the phrase “based at least in part on. Further, as used herein, including in the claims, a “set” may include one or more elements.

[0163] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A user equipment, comprising:
a processor; and
a transceiver coupled to the processor,
wherein the processor is configured to:
receive, via the transceiver, a first resource configuration indicating a first resource set for obtaining measured beams and a second resource configuration indicating a second resource set for obtaining predicated beams;
obtain a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and
transmit, via the transceiver, a first report including the performance of the beam prediction based on the first reporting configuration.
2. The user equipment of claim 1, wherein the first reporting configuration is associated with the first resource set and a second reporting configuration for the second resource set, and the performance is based on a first measurement of the first resource set and a second report corresponding to the second reporting configuration for the second resource set.
3. The user equipment of claim 2, wherein:
a first gap between a report occasion associated with the second report for the second resource set and a transmission occasion associated with the first measurement of the first resource set is less than or equal to a first threshold; and
a second gap between report occasions associated with the second reports is greater than or equal to a second threshold.
4. The user equipment of claim 1, wherein the first reporting configuration is associated with the first resource set and the second resource set, the first resource set and the second resource set belong to different resource sets, and the performance is based on

a first measurement of the first resource set and a second measurement of the second resource set.

5. The user equipment of claim 4, wherein the first resource set and the second resource set are triggered by a downlink signaling, and a configuration for the first resource set and the second resource set indicates at least one of the following:

a first offset between a transmission of the downlink signaling and a transmission of the first resource set;

a second offset between a transmission of the downlink signaling and a transmission of the second resource set, wherein the first offset is greater than the second offset;

a first time interval between different transmissions of first resource sets; or

a second time interval between different transmissions of second resource sets.

6. The user equipment of claim 4, wherein the first resource set and the second resource set are triggered by a downlink signaling, and a configuration for the first resource set and the second resource set indicates at least one of the following:

a first offset between a transmission of the downlink signaling and a first one of transmissions of a first number of first resource sets, and a second offset between the transmission of the downlink signaling and a first one of transmissions of a second number of second resource sets; or

a first offset between a last one of the transmissions of a second number of second resource sets and a first one of transmissions of a first number of first resource sets, and a second offset between a transmission of the downlink signaling and a first one of transmissions of the second number of second resource sets,

wherein the first one of the transmissions of the first number of the first resource sets is later than the last one of the transmissions of the second number of the second resource sets.

7. The user equipment of claim 4, wherein a configuration indicates at least one of the following:

a first gap between a transmission of the second resource set and a transmission of the first resource set is less than or equal to a first threshold;

a second gap between different transmissions of second resource sets is greater than or equal to a second threshold; or

a difference between channel quality associated with a first reference signal based on the first resource set and channel quality associated with a second reference signal based on the second resource set is less than or equal to a threshold, wherein the second reference signal and the first reference signal have a same resource indicator or are quasi co-located.

8. The user equipment of claim 4, wherein a configuration for the first resource set and the second resource set indicates at least one of the following:

a first time interval between different transmissions of a first number of first resource sets;

a second time interval between different transmissions of a second number of second resource sets; or

a gap between a last one of the transmissions of the second number of the second resource sets and a first one of the transmissions of the first number of the first resource sets.

9. The user equipment of claim 1, wherein the first reporting configuration is associated with the first resource set and the second resource set that are different subsets of a same resource set, and the performance is based on a first measurement of the first resource set and a second measurement of the second resource set.

10. The user equipment of claim 9, wherein an association configuration for the first resource set and the second resource set comprises or indicates one of the following:

a bitmap indicating the first resource set or the second resource set;

the first resources in the resource set configured to be the second resource set or the last resources in the resource set configured to be the first resource set; or

a table of a pattern of the first resource set or the second resource set and a code point of the pattern.

11. The user equipment of claim 1, wherein the first reporting configuration is associated with the first resource set and the second resource set that belong to a same

resource set, wherein the first resource set includes a first set of transmission occasions, the second resource set includes a second set of transmission occasions, and the performance is based on the first set of transmission occasions and the second set of transmission occasions.

12. The user equipment of claim 11, wherein a configuration for the first set of transmission occasions and the second set of transmission occasions indicates at least one of the following:

- a first time interval between different occasions of the first set of transmission occasions;
- a second time interval between different occasions of the second set of transmission occasions; or
- a third time interval between the last one of the second set of transmission occasions and the first one of the first set of transmission occasions.

13. The user equipment of claim 1, wherein the processor is further configured to: transmit, via the transceiver, a request for monitoring the performance of the beam prediction through one of the following:

- a physical random access channel (PRACH), wherein the user equipment is configured with a dedicated RACH occasion (RO) and dedicated preamble associated with the beam prediction;
- a dedicated medium access control (MAC) control element (CE) comprising an identifier for the beam prediction;
- a dedicated scheduling request (SR), wherein the user equipment is configured with a plurality of dedicated SR resources, a dedicated SR resource among the plurality of dedicated SR resources is associated with a beam prediction; or
- a beam report associated with the beam prediction or beam management.

14. The user equipment of claim 1, wherein the first reporting configuration comprises at least one of the following:

- an identifier of a functionality or model for the beam prediction;
- the number of the predicted beams;
- the number of the measured beams;

- the number of valid samples for reporting the performance;
- the number of the first resource sets for a valid sample and the number of the second resource sets for a valid sample; or
- a performance target for the UE to detect the performance of the beam prediction.

15. The user equipment of claim 1, wherein the processor is further configured to:

- receive, via the transceiver, a reference signal for beam measurement, to obtain the measured beams by using the first resource set and to obtain the predicated beams by using the second resource set; and
- determine the performance of the beam prediction based on a configured number of valid samples, wherein a valid sample corresponds to a first number of first resource sets and a second number of second resource sets.

16. The user equipment of claim 1, wherein the performance comprises at least one of the following:

- identifiers of a predetermined number of the best measured beams based on a first measurement of the first resource set;
- identifiers of a predetermined number of the best predicted beams based on a second measurement of the second resource set;
- an indicator for a first beam prediction success, indicating that the top one measured beam is one of the predetermined number of the best predicted beams;
- an indicator for a second beam prediction success, indicating that the top one predicted beam is one of the predetermined number of the best predicted beams; or
- an indicator for indicating that at least one of the first beam prediction success or the second beam predication success is less than a performance target.

17. The user equipment of claim 1, wherein the processor is further configured to:

- receive, via the transceiver, an indication of a lifecycle management (LCM) operation based on the first report, wherein the indication of the LCM operation includes at least one of the following:

- an identifier of a functionality or model for a beam prediction to be switched to
 - and an identifier of candidate beam that is the top one measured beam;

an identifier of a functionality or model for a beam prediction to be deactivated and an identifier of candidate beam that is the top one measured beam; or

an request for deactivating the beam prediction and an identifier of candidate beam that is the top one measured beam.

18. A network entity, comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

transmit, via the transceiver, a first resource configuration indicating a first resource set for obtaining measured beams and a second resource configuration indicating a second resource set for obtaining predicated beams;

transmit, via the transceiver, a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and

receive, via the transceiver, a first report including the performance of the beam prediction based on the first reporting configuration.

19. A method, comprising the steps of:

receiving a first resource configuration including a first resource set for obtaining measured beams and a second resource configuration including a second resource set for obtaining predicated beams;

obtaining a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and

transmitting a first report including the performance of the beam prediction based on the first reporting configuration.

20. A method, comprising the steps of:

transmitting a first resource configuration including a first resource set for obtaining measured beams and a second resource configuration including a second resource set for obtaining predicated beams;

configuring a first reporting configuration for the first resource set to report performance of a beam prediction, wherein the performance is based on the first resource set and the second resource set; and

receiving a first report including the performance of the beam prediction based on the first reporting configuration.