

MEASUREMENTS COLLECTION FOR MODEL TRAINING

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to a radio access network (RAN) node, entities, methods, apparatuses, and computer readable
5 medium for measurements collection for model training.

BACKGROUND

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

[0003] An artificial intelligence (AI) model may be obtained by machine learning (ML) or deep learning (DL), may be called as an AI/ML model, and has been widely used in a variety of application areas.

[0004] The AI/ML model may be deployed at a user equipment (UE), a base station (such
25 as a gNB), or a core network function (such as a location management function (LMF)), while the model is trained by a training entity. The training entity may obtain collected data for training, thus the training entity may be called as a data collection entity in this disclosure. However, how the data collection entity may obtain the data for training needs to be further studied.

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SUMMARY

5 [0005] The present disclosure relates to a RAN node, entities, methods, apparatuses, and computer readable medium for measurements collection for model training. According to the proposed solution, the data collection entity may receive physical layer measurements from the RAN node.

10 [0006] In some implementations, there is provided a RAN node. The RAN node comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the RAN node to: receive, from a first entity, a first message indicating to the RAN node to collect and report physical layer measurements to at least one data collection entity; collect the physical layer measurements based on the first message; and transmit, to the at least one data collection entity, a second message comprising some or all of the physical layer measurements, wherein the some or all of the physical layer measurements are used for model training.

15 [0007] In some implementations, there is provided a first entity. The first entity comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the first entity to: obtain information associated with physical layer measurements for model training; and transmit, to a RAN node, a first message indicating to the RAN node to collect and report the physical layer measurements to at least one data collection entity.

20 [0008] In some implementations, there is provided a data collection entity. The first entity comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the data collection entity to: receive, from a RAN node, a second message comprising some or all of physical layer measurements; and use or provide the some or all of the physical layer measurements to a model training entity.

25 [0009] In some implementations, there is provided a method performed by the RAN node. The method comprises: receiving, from a first entity, a first message indicating to the RAN node to collect and report physical layer measurements to at least one data collection entity; collecting the physical layer measurements based on the first message; and transmitting, to the at least one data collection entity, a second message comprising some or all of the physical layer measurements, wherein the some or all of the physical layer measurements are used for model training.

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[0010] In some implementations, there is provided a method performed by the first entity.

The method comprises: obtaining information associated with physical layer measurements for model training; and transmitting, to a RAN node, a first message indicating to the RAN node to collect and report the physical layer measurements to at least one data collection entity.

- 5 **[0011]** In some implementations, there is provided a method performed by the data collection entity. The method comprises: receiving, from a RAN node, a second message comprising some or all of physical layer measurements; and using or providing the some or all of the physical layer measurements to a model training entity.

- 10 **[0012]** In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a first entity, a first message indicating to the RAN node to collect and report physical layer measurements to at least one data collection entity; collect the physical layer measurements based on the first message; and transmit, to the at least one data collection entity, a second message comprising some or all of the physical
15 layer measurements, wherein the some or all of the physical layer measurements are used for model training.

- 20 **[0013]** In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: obtain information associated with physical layer measurements for model training; and transmit, to a RAN node, a first message indicating to the RAN node to collect and report the physical layer measurements to at least one data collection entity.

- 25 **[0014]** In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a RAN node, a second message comprising some or all of physical layer measurements; and use or provide the some or all of the physical layer measurements to a model training entity.

- 30 **[0015]** In some implementations of the method and the RAN node described herein, the first entity comprises an operations administration and maintenance (OAM) system, further comprising: transmitting, to an AMF, a cell traffic trace message.

- [0016]** In some implementations of the method and the RAN node described herein, further comprising: in accordance with a determination that the first message indicates one or more

specific UEs, collecting the physical layer measurements from the one or more specific UEs;
or in accordance with a determination that the first message does not indicate one or more
specific UEs, collecting the physical layer measurements from at least one selected UE.

5 [0017] In some implementations of the method and the RAN node described herein, further
comprising: transmitting, to an RAN distributed unit (DU), part or all information in the first
message, wherein the RAN node is an RAN central unit (CU).

[0018] In some implementations of the method and the RAN node described herein, further
comprising: transmitting, to an RAN CU user plane (UP), part or all information in the first
message, wherein the RAN node is an RAN CU control plane (CP).

10 [0019] In some implementations of the method and the RAN node described herein, further
comprising: transmitting, to a target RAN node, part or all information in the first message,
wherein the RAN node is a source RAN node for a specific UE during handover.

[0020] In some implementations of the method and the data collection entity described
herein, further comprising: transmitting, to the RAN node, a first message indicating to the
15 RAN node to collect and report the physical layer measurements, wherein the first message
comprises a data collection request message.

[0021] In some implementations of the methods, the RAN node, the first entity, and the data
collection entity described herein, the first entity comprises an access and mobility
management function (AMF), the first message comprises a trace start message, and wherein
20 the trace start message comprises an information element (IE) associated with a data
collection configuration indicating to collect and report physical layer measurements.

[0022] In some implementations of the methods, the RAN node, the first entity, and the data
collection entity described herein, the IE associated with the data collection configuration is
comprised in a minimization of drive test (MDT) configuration IE.

25 [0023] In some implementations of the methods, the RAN node, the first entity, and the data
collection entity described herein, the cell traffic trace message comprises one of: a trace
recording session reference, a trace reference, a cell global identity (CGI) of a serving cell,
or at least one address of the at least one data collection entity.

[0024] In some implementations of the methods, the RAN node, the first entity, and the data
30 collection entity described herein, the first entity is one of the at least one data collection
entity, the first message comprises a data collection request message, and wherein the first

message is transmitted via an interface and/or via end-to-end protocol between the RAN node and the first entity.

[0025] In some implementations of the methods, the RAN node, the first entity, and the data collection entity described herein, the data collection request message comprises a partial support indication indicating that some of the physical layer measurements are mandatory.

[0026] In some implementations of the methods, the RAN node, the first entity, and the data collection entity described herein, the physical layer measurements comprise one of: ground-truth channel state information (CSI) in scalar quantization and/or codebook-based quantization, a pair of first information and second information, wherein the first information comprises a raw channel or an eigenvector, and the second information comprises a latent space vector with or without quantization, a pair of third information and fourth information, wherein the third information comprises a latent space vector after quantization, and the fourth information comprises a target CSI to be recovered as proxy model output, one or more CSIs comprising raw channel matrices, precoding matrix indicators (PMIs), or eigenvectors, one or more layer 1 reference signal received power (L1-RSRP) measurements based on Set B or a subset of Set B, wherein the Set B comprises a set of beams for prediction input, one or more L1-RSRP measurements based on Set A or a subset of Set A, wherein the Set A comprises a set of beams for prediction output, one or more L1-RSRP measurements based on Set A or a subset of Set A and corresponding beam indicators, top k beam indicators, a channel impulse response of a reference signal, a power delay profile of a reference signal, a delay profile of a reference signal, a RSRP of a reference signal, a reference signal received quality (RSRQ) of a reference signal, a reference signal time difference (RSTD) of a reference signal, or a ground truth location coordination.

[0027] In some implementations of the methods, the RAN node, the first entity, and the data collection entity described herein, the first message comprises a request for assisting information associated with the physical layer measurements to be collected, wherein the assisting information comprises one of: a timestamp, a scenario, an identity of a cell, a physical layer configuration, a quality indication, or line of sight or non-line of sight.

[0028] In some implementations of the methods, the RAN node, the first entity, and the data collection entity described herein, the first message comprises one of: at least one criterion for data collection, a time duration for the data collection, a periodicity for the data collection, an event for triggering the data collection, or an indication of a manner for the second

message.

5 [0029] In some implementations of the methods, the RAN node, the first entity, and the data collection entity described herein, the at least one criterion comprises one of: a required scenario, a required physical layer configuration, a required quality indication, a required line of sight or non-line of sight, an interested area, an interested frequency, an interested cell, an interested beam, an interested UE type.

[0030] In some implementations of the methods, the RAN node, the first entity, and the data collection entity described herein, the first message comprises at least one address of the at least one data collection entity.

10 [0031] In some implementations of the methods, the RAN node, the first entity, and the data collection entity described herein, the some or all of the physical layer measurements in the second message are conveyed in a container of an encoded format.

[0032] In some implementations of the methods, the RAN node, the first entity, and the data collection entity described herein, UE identification information is removed from the some or all of the physical layer measurements in the second message.

15 [0033] In some implementations of the methods, the RAN node, the first entity, and the data collection entity described herein, the some or all of the physical layer measurements in the second message are grouped into a plurality of groups corresponding to a plurality of UEs, and wherein each of the plurality of groups has a unique index.

20 [0034] In some implementations of the methods, the RAN node, the first entity, and the data collection entity described herein, the some or all of the physical layer measurements in the second message are grouped into a plurality of groups corresponding to a plurality of features, wherein each feature is associated with an attribute of the physical layer measurements.

BRIEF DESCRIPTION OF THE DRAWINGS

25 [0035] FIG. 1 illustrates an example of a wireless communications system in which some embodiments of the present disclosure can be implemented;

[0036] FIG. 2 illustrates a schematic diagram of an example communication network in which some embodiments of the present disclosure can be implemented;

30 [0037] FIG. 3 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

[0038] FIG. 4 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

[0039] FIG. 5 illustrates an example of a device that is suitable for implementing embodiments of the present disclosure;

5 [0040] FIG. 6 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure;

[0041] FIG. 7 illustrates a flowchart of an example method implemented at a RAN node in accordance with aspects of the present disclosure;

10 [0042] FIG. 8 illustrates a flowchart of an example method implemented at a first entity in accordance with aspects of the present disclosure; and

[0043] FIG. 9 illustrates a flowchart of an example method implemented at a data collection entity in accordance with aspects of the present disclosure.

[0044] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

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DETAILED DESCRIPTION

[0045] 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.

20 [0046] 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
25 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
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or not explicitly described.

[0047] 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.

[0048] 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.

[0049] FIG. 1 illustrates an example of a wireless communications system 100 in which some embodiments of the present disclosure can be implemented. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network 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 a long term evolution (LTE) network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be

a 5G network, such as a new radio (NR) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless
5 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.

[0050] The one or more network entities 102 may be dispersed throughout a geographic
10 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
15 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.

[0051] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, message, broadcast,
20 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
25 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,
30 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.

[0052] 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.

10 **[0053]** 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.

[0054] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink (SL). For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

25 **[0055]** 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, N3, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the 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).

5 **[0056]** 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
10 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.

[0057] An RU may also be referred to as a radio head, a smart radio head, a remote radio
15 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
20 virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0058] 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
25 split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaption protocol (SDAP), Packet Data Convergence
30 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.

[0059] 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).

[0060] 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.

[0061] 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.

[0062] The core network 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N3, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the core network 106 via a network entity 102. The core network 106 may route traffic (e.g., control

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

5 **[0063]** 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
10 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
15 entities 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0064] 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
20 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
25 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.

[0065] 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
30 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.

[0066] 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.

[0067] 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.

[0068] 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.

[0069] In the present disclosure, the term “data collection entity” may be interchangeably used with a data collection node, an entity for collecting data for model training, a node for collecting data for model training, or the like. in the present disclosure, the term “model training entity” may be interchangeably used with a training entity, an AI/ML model training entity, a training node, an AI/ML model training node, an entity for model training, a node for model training, or the like.

[0070] The 3rd generation partnership project (3GPP) has been discussing using AI/ML technology to optimize physical layer operation, a.k.a. AI for air interface, for the following use cases: channel state information (CSI) feedback compression, CSI time domain prediction, beam spatial domain prediction, beam time domain prediction, AI/ML assisted positioning estimation, direction positioning.

[0071] Depending on the use cases, the AI/ML model could be deployed at a UE/gNB/LMF (i.e., an inference entity), while it could be trained at a gNB, an operations administration and maintenance (OAM) system, an over-the-top (OTT) server, a UE, an LMF, or a core network (CN) function besides the LMF, as listed in Table 1 below.

Table 1: possible combination of AI/ML training entity and inference entity

AI/ML inference entity	Use Case	Offline AI/ML training entity
UE	CSI compression	gNB, OAM, OTT server, UE, CN
	UE side CSI/beam prediction	OTT server, UE, gNB, OAM, CN
	UE side positioning	OTT server, UE, LMF, OAM, CN
gNB	CSI compression	gNB, OAM, OTT server, UE, CN
	gNB side CSI/beam prediction	gNB, OAM, CN, OTT server
	gNB side positioning	gNB, OAM, LMF
LMF	LMF side positioning	LMF

[0072] To train an AI/ML model, the AI/ML training entity needs to collect layer 1 (L1) measurements for the AI/ML training. Some examples of the training data are listed below for each use case.

[0073] In case the AI/ML model is used for CSI compression: (1) For UE side type1 training and UE-first type3 training: ground-truth CSI from network (NW) in scalar quantization and/or codebook-based quantization (e.g., e-type II like); and/or assisted information for categorizing the data for the purpose of differentiating characteristics of data due to specific configuration, scenarios, site etc. (2) For NW first training in training collaboration type 3: CSI generation model training dataset (e.g., raw channel or the eigenvector as model input and latent space vector before or after quantization as model output); and/or assisted information for categorizing the data for the purpose of differentiating characteristics of data due to specific configuration, scenarios, site etc. (3) For UE side proxy model training in monitoring: proxy model training dataset (e.g., the latent space vector after quantization as proxy model input and the target CSI to be recovered as proxy model output); and/or assisted information for categorizing the data for the purpose of differentiating characteristics of data due to specific configuration, scenarios, site etc.

[0074] In case the AI/ML model is used for CSI prediction: Consecutive CSIs (historical CSIs and future CSIs) where the type of CSIs includes raw channel matrices, or precoding matrix indicators (PMIs), or eigenvectors, etc. and/or assistance information for model management e.g., site/scenario/dataset related information.

[0075] In case the AI/ML model is used for Beam prediction: (1) Set B: layer 1 reference signal received power (L1-RSRP) measurement based on Set B or a subset of Set B. (2) Label data can be one of the options: L1-RSRP measurement based on Set A or a subset of Set A; Partial L1-RSRP measurement based on Set A or a subset of Set A + beam indicator; and/or Top-k beam indicator. (3) Time related information, e.g. timestamps. (4) Assistance information includes one or more from Site/Scenarios/Dataset related information, e.g. Dataset ID; gNB-side related assistance information; and/or UE-side related assistance information.

[0076] In case the AI/ML model is used for positioning: (1) Measurement type: channel impulse response (CIR)/ power delay profile (PDP)/ delay profile (DP); and/or reference signal received power (RSRP)/ reference signal received quality (RSRQ)/ reference signal time difference (RSTD). (2) Label type: location coordinate; timing estimation; line of sight (LOS)/ non-line of sight (NLOS). (3) Assistance information; time stamp; quality indicator; RS configuration.

[0077] Since the L1 measurements are determined at a UE, it is to be further studied how a

data collection entity (e.g., an AIML training entity) such as an OAM, an OTT server, an LMF, or a CN function besides the LMF to collect the L1 measurements for training.

[0078] Embodiments of the present disclosure provide a solution of communication. In the solution, the RAN node may report the physical layer measurements to the data collection entity, and thus a further usage (such as model training at a training entity) may be enabled. In some examples, the physical layer measurements may be reported to more than one data collection entity, as such, an additional request for the physical layer measurements may not be needed, and thus the overhead may be reduced. Principles and implementations of the present disclosure will be described in detail below with reference to the figures.

10 [0079] FIG. 2 illustrates a schematic diagram of an example communication network 200 in which some embodiments of the present disclosure can be implemented. As shown in FIG. 2, the communication network 200 may include a RAN node 210, a first entity 220, and a data collection entity 230.

15 [0080] The RAN node 210 may be a base station, such as a gNB, or the RAN node 210 may be a CU or a DU of the base station, or the RAN node 210 may be a CU-UP or a CU-CP of a CU. The RAN node 210 may serve multiple UEs such as 201-1 to 201-N as shown in FIG. 2.

[0081] In some implementations, the data collection entity 230 may be the same as an AI/ML model training entity. In some other implementations, the data collection entity 230 may be different from an AI/ML model training entity, for example, the data collection entity 230 may collect data (such as L1 measurements) and provide the data to the AI/ML model training entity. In some embodiments, the data collection entity 230 may be any of an OAM, an OTT server, an LMF, a network data analysis function (NWDAF), a data collection coordination function (DCCF), a data collection application function (DCAF), an application function (AF), another network function in the CN, or the like.

[0082] In some implementations, the data collection entity 230 is outside of a RAN domain, for example, the data collection entity 230 is not a UE or a base station. In some implementations, there may be multiple data collection entities.

30 [0083] In the present disclosure, the first entity 220 may be one of the following: an AMF, an OAM, or a data collection entity. In some implementations, in case the first entity 220 is a data collection entity, it may be the same as or different from the data collection entity 230.

[0084] It is to be understood that the number of devices in FIG. 2 is given for the purpose of illustration without suggesting any limitations to the present disclosure.

[0085] For collecting L1 measurements at a data collection entity 230, a UE may transfer data to the AI/ML training entity, since there may not be an interface there between, the transfer may be performed via a user plane (UP) or a non-access stratum (NAS), however the efficiency may be low and some additional radio resources may be needed. Another possible way may be to utilize the existing trace/ minimization of drive test (MDT) framework, in which an OAM or a trace collection entity (TCE) may collect UE measurements via a gNB. One advantage of using trace/MDT framework is that the trace/MDT framework is based on the radio resource management (RRM) measurement, and it is efficient for the AI/ML training entity to retrieve the training data from the gNB directly. However, there is no agreement on how L1 measurements may be transferred if the trace/MDT framework is used.

[0086] Reference is further made to FIG. 3, which illustrates a signalling chart illustrating communication process 300 in accordance with some example embodiments of the present disclosure. The process 300 may involve a RAN node 210, a first entity 220, and a data collection entity 230, as show in FIG. 2. It would be appreciated that the process 300 may be applied to other communication scenarios, which will not be described in detail.

[0087] The process 300 may be regarded as a trace/MDT-based data collection for L1 measurements collection considering multiple entities. In some implementations, the data to be collected include physical layer measurements (also refer to L1 measurements). In some implementations, the data collection may be also called as measurements collection, L1 measurements collection, or the like. In some implementations, the physical layer measurements (L1 measurements) may be used for model training at an AI/ML training entity (which is the same as or different from the data collection entity 230), for example, the model may be used for any of: CSI feedback compression, CSI time domain prediction, beam spatial domain prediction, beam time domain prediction, AI/ML assisted positioning estimation, or direction positioning.

[0088] In the process 300, the first entity 220 obtains information associated with physical layer measurements at 310. In some implementations, the data collection entity 230 may determine to collect the physical layer measurements, and provides the information associated with physical layer measurements to the first entity 220.

[0089] In some examples, the data collection entity 230 may include an OAM, if the OAM wants to collect L1 measurements to train a NW side CSI/beam prediction AI/ML model, the OAM may provide related information to the first entity 220. In some examples, the data collection entity 230 may include a NWDAF, if the NWDAF wants to collect L1 measurements to train a UE side CSI/beam prediction AI/ML model, the NWDAF may provide related information to the first entity 220. In some examples, the data collection entity 230 may include an LMF, if the LMF wants to collect L1 measurements to train an LMF side positioning AI/ML model, the LMF may provide related information to the first entity 220. For example, the related information may include a data collection configuration for the sake of its own purpose.

[0090] In the process 300, the first entity 220 transmits a first message to the RAN node 210 at 320. The first message may indicate to the RAN node 210 to collect the physical layer measurements and to report the collected physical layer measurements to at least one data collection entity 230. In some examples, the first message may indicate to the RAN node 210 to transmit the collected physical layer measurements (e.g., in a second message) to the at least one data collection entity 230.

[0091] In some example embodiments, the first message may indicate that the physical layer measurements should be reported to at least one data collection entity 230 in a file-based manner or in a streaming-based manner. In some examples, the first message may include at least one data collection configuration.

[0092] In some examples, the first message may indicate multiple data collection entities, for example, multiple addresses of the multiple data collection entities may be included. For example, an address may be in a form of an internet protocol (IP) address, a fully qualified domain name (FQDN), a uniform resource identifier (URI), a uniform resource location (URL), or the like. For example, the IP address may be used for file-based data collection report. For example, the URI may be used for streaming based data collection report.

[0093] For example, the first message may include a list of addresses of the multiple data collection entities, and the first message may further include a data collection configuration for each data collection entity. For example, different data collection entities may be associated with different data collection entities.

[0094] In some implementations, the first entity 220 may be the AMF. In some examples, the first message is transmitted over an NG interface. In some examples, the first message

may be implemented as a trace start message, for example, a signalling-based trace/MDT configuration may be applied. In some examples, the trace start message may include an information element (IE) associated with a data collection configuration, which indicates to collect and report physical layer measurements. For example, a data collection configuration IE may be included.

[0095] In some embodiments, the trace start message includes a trace activation IE, and the trace activation IE includes the data collection configuration IE. In some examples, the trace activation IE further includes an MDT configuration IE, for example, the data collection configuration IE may be in parallel to the MDT configuration IE. In some examples, the data collection configuration IE may include a bitstring which may indicate an activation of the physical layer measurements. For example, a bitstring may include multiple bits (e.g., a bitmap) corresponding multiple measurements, a bit “1” (or “0”) may indicate that a corresponding measurement is activated.

[0096] In some examples, the data collection configuration IE may further other information associated with the collection, such as a criterion, a periodicity, an event which will be discussed below. In some examples, the data collection configuration IE may further include at least one ID or at least one address of the at least one data collection entity 230.

[0097] For a specific example, following Table 2 shows an example of the trace activation IE which includes the data collection configuration IE.

Table 2: data collection configuration in the trace activation IE

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
NG-RAN Trace ID	M		OCTET STRING (SIZE(8))	This IE is composed of the following: Trace Reference defined in TS 32.422 [11] (leftmost 6 octets, with PLMN information encoded as in 9.3.3.5), and Trace Recording Session Reference defined in TS 32.422 [11] (last 2 octets).	-	
...	...	...	...	...	...	...
Trace	M		Transport	For File based	-	

Collection Entity IP Address			Layer Address 9.3.2.4	Reporting. Defined in TS 32.422 [11]. This IE is ignored if the Trace Collection Entity URI IE is present.		
MDT Configuration	O		9.3.1.167		YES	ignore
Trace Collection Entity URI	O		URI 9.3.2.14	For Streaming based Reporting. Defined in TS 32.422 [11].	YES	ignore
Data Collection Configuration List						
>Data Collection Configuration Item						
>> Data Collection Entity IP Address			For file-based data collection report			
>> Data Collection Entity URI			For stream-based data collection report			
>> Data Collection Configuration						

[0098] In some other embodiments, the trace start message includes a trace activation IE, and the trace activation IE includes an MDT configuration IE, where the MDT configuration IE includes the data collection configuration IE. For example, the data collection configuration may be regarded as part of the trace/MDT configuration.

[0099] In some examples, the MDT configuration IE (e.g., the data collection configuration IE) may include a bitstring which may indicate an activation of the physical layer measurements. For example, a bitstring may include multiple bits (e.g., a bitmap) corresponding multiple measurements, a bit “1” (or “0”) may indicate that a corresponding measurement is activated.

[00100] In some examples, the MDT configuration IE (e.g., the data collection configuration IE) may further other information associated with the collection, such as a criterion, a periodicity, an event which will be discussed below. In some examples, the MDT configuration IE (e.g., the data collection configuration IE) may further include at least one ID or at least one address of the at least one data collection entity 230. In some examples, a new job type may be defined, for example, the newly defined job type may be “data collection”.

[00101] For a specific example, following Table 3 shows an example of the MDT configuration IE which includes the data collection configuration IE.

Table 3: data collection configuration in the MDT configuration IE

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
MDT Activation	M		ENUMERATED (Immediate MDT only, Logged MDT only, Immediate MDT and Trace, Data Collection, ...)		-	
...	...	...	...	...	...	...
CHOICE MDT Mode	M				-	
>Immediate MDT						
>>Measurements to Activate	M		BITSTRING (SIZE(8))	Each position in the bitmap indicates a MDT measurement, as defined in TS 37.320 [41]. First Bit = M1, Second Bit = M2, Third Bit = M4, Fourth Bit = M5, Fifth Bit = M6, Sixth Bit = M7, Seventh Bit = logging of M1 from event triggered measurement reports according to existing RRM configuration, other bits reserved for future use.	-	

				Value “1” indicates “activate” and value “0” indicates “do not activate”.		
>> Data Collection to Activate	O		BITSTRING (SIZE(8))	Each position in the bitmap indicates a L1 measurement to collect. First Bit = M11 Second Bit = M12 Third Bit = M13		
>>M1 Configuration	C-ifM1		9.3.1.171		-	
>>M4 Configuration	C-ifM4		9.3.1.172		-	
>>M5 Configuration	C-ifM5		9.3.1.173		-	
>>M6 Configuration	C-ifM6		9.3.1.174		-	
>>M7 Configuration	C-ifM7		9.3.1.175		-	
>>M11 Configuration				L1 RSRP Measurement		
>>M12 Configuration				CSI raw channel metrics		
>>M13 Configuration				Top-k beam indicator		

[00102] In some implementations, the first entity 220 may be the OAM system. In some examples, the first message may be transmitted directly, for example, a management-based trace/MDT configuration may be applied. In some examples, the first message may include at least one data collection configuration which is configured by the OAM system.

[00103] In some example embodiments, the first message may indicate the physical layer measurements, for example, a bitmap may be used. In some examples, the physical layer measurements may include ground-truth CSI in scalar quantization and/or codebook-based quantization, e.g., an e-type II like CSI ground truth value. In some examples, the physical layer measurements may include a pair of first information and second information, wherein the first information comprises a raw channel or an eigenvector, and the second information comprises a latent space vector with or without quantization, e.g., the first information may be further used as a model input and the second information may be further used as a model output. In some examples, the physical layer measurements may include a pair of third information and fourth information, wherein the third information comprises a latent space

vector after quantization, and the fourth information comprises a target CSI to be recovered as proxy model output, e.g., the third information may be further used as a proxy model input and the fourth information may be further used as a proxy model output. In some examples, the physical layer measurements may include one or more CSIs, such as raw channel matrices, PMIs, or eigenvectors. In some examples, the physical layer measurements may include one or more L1-RSRP measurements based on Set B or a subset of Set B, where the Set B comprises a set of beams for prediction input, and the Set B may be represented as one or more synchronization signal block (SSB) indexes. In some examples, the physical layer measurements may include one or more L1-RSRP measurements based on Set A or a subset of Set A, where the Set A comprises a set of beams for prediction output, and the Set A may be represented as one or more SSB indexes. In some examples, the physical layer measurements may include one or more L1-RSRP measurements based on Set A or a subset of Set A and corresponding beam indicators. In some examples, the physical layer measurements may include top k beam indicators, for example, the top k best beam may be indicated. In some examples, the physical layer measurements may include one or more of: a CIR, a PDP, a DP, L1-RSRP, L1-RSRQ, or L1-RSTD of a measured reference signal. In some examples, the physical layer measurements may include a ground truth location coordination, for example, it may be a known location coordination of a power receiving unit (PRU), for example, it may be an estimated location determined by using another positioning method (e.g., without using an AI/ML model).

[00104] In some example embodiments, the first message may further indicate to the RAN node 210 to provide assisting information for collecting the physical layer measurements. In some examples, the first message may include a request for the assisting information. In some examples, the assisting information may include a timestamp for data collection, e.g., a time when the physical layer measurements are collected. In some examples, the assisting information may include a scenario for the data collection, for example, the scenario may be one of indoor, outdoor, large cell, small cell, or the like. In some examples, the assisting information may include an identity of a cell for the data collection, for example, a cell ID of a serving cell in which a UE is located, where the physical layer measurements may be determined by the UE. In some examples, the assisting information may include a physical layer configuration for the data collection, for example, a physical layer configuration which is configured by the RAN node 210 to the UE. In some examples, the assisting information may include a quality indication for the data collection. For example, a quality indication

may indicate whether the physical layer measurements are reliable or not, whether the physical layer measurements are accurate or not. For example, a quality indication may indicate a reliable rate or an accurate rate of the physical layer measurements. For example, if a signal-to-noise ratio (SNR) is low, then the physical layer measurements may be of low quality. In some examples, the assisting information may include a NLOS or a LOS.

[00105] In some example embodiments, the first message may include at least one criterion for data collection. In some examples, the at least one criterion may indicate one or more of: a required scenario, a required physical layer configuration, a required quality indication, a required line of sight or non-line of sight. In some examples, the at least one criterion may indicate an interested area, e.g., a list of interested areas. In some examples, the at least one criterion may indicate an interested frequency, e.g., a list of interested frequencies. In some examples, the at least one criterion may indicate an interested cell, e.g., cell information of a list of interested cells may be included in the first message. In some examples, the at least one criterion may indicate an interested beam, e.g., a list of interested SSB indexes may be included in the first message. In some examples, the at least one criterion may indicate an interested UE type, e.g., an IoT UE type, a stationary UE type, a moving UE type, or a multi-input multi-output (MIMO) capable UE type.

[00106] In some example embodiments, the first message may indicate a time duration and/or a periodicity for the data collection. In some examples, the time duration may be represented by a time interval value. In some examples, the time duration may be represented by a start time and an end time.

[00107] In some example embodiments, the first message may indicate one or more events for triggering the data collection.

[00108] In some example embodiments, the first message may indicate one or more specific UEs. For example, information of one specific UE or multiple specific UEs may be included.

[00109] In some example embodiments, the first message may include an indication of a manner for a second message to the at least one data collection entity 230. In some examples, the first message may indicate to the RAN node 210 to report the second message in a per UE manner or in a per feature manner, which will be discussed below.

[00110] In the process 300, upon receiving the first message from the first entity 220, the RAN node 210 collects the physical layer measurements at 330.

[00111] In some implementations, if the first message indicates one or more specific UEs, then the RAN node 210 may collect the physical layer measurements from the one or more specific UEs.

5 [00112] In some implementations, if the first message does not indicate one or more specific UEs, then the RAN node 210 may select at least one UE, and may collect the physical layer measurements from the selected UE(s). In some examples, the RAN node 210 may select at least one UE based on at least one criterion indicated by the first message, for example, the at least one UE meets the at least one criterion.

10 [00113] In some implementations, if the first message indicates at least one criterion, the RAN node 210 may collect the physical layer measurements according to the at least one criterion.

[00114] In some implementations, if the first message indicates a time duration and/or a periodicity, the RAN node 210 may collect the physical layer measurements according to the time duration and/or the periodicity.

15 [00115] In some implementations, the RAN node 210 may configure the one or more specific UEs or the selected at least one UE to report the physical layer measurements.

[00116] In addition or alternatively, in case of RAN CU DU split architecture, the CU of the RAN node 210 may receive the first message, and in addition the CU may forward part or all information in the first message to the DU of the RAN node 210, e.g. over F1 interface.

20 [00117] In addition or alternatively, in case of RAN CU-CP CU-UP split architecture, the CU-CP of the RAN node 210 may receive the first message, and in addition the CU-CP may forward part or all information in the first message to the CP-UP of the RAN node 210, e.g. over E1 interface.

25 [00118] In addition or alternatively, during a handover of a UE (such as a specific UE indicated by the first message or a UE selected by the RAN node 210), the RAN node 210 may be a source gNB for the handover, and the RAN node 210 may further transmit part or all information in the first message to a target RAN node (e.g. a target gNB), e.g. over Xn interface.

30 [00119] In some implementations, in case the first entity 220 is the OAM system, in addition or alternatively, the RAN node 210 may further transmit a cell traffic trace message to an AMF. In some example embodiments, the cell traffic trace message may include one or

more of: a trace recording session reference, a trace reference, a cell global identity (CGI) of a serving cell, or at least one address of the at least one data collection entity.

[00120] In some examples, in case a data collection anonymization is required, then an international mobile equipment identity (IMEI)-track area code (TAC) may be included in the second message, and the RAN node 210 may transmit a cell traffic trace message to the AMF via NG interface, where the cell traffic trace message includes a trace recording session reference, a trace reference, a serving cell CGI, and at least one address (in the form of IP address, FQDN, URI, or URL) of the at least one data collection entity. For example, the cell traffic trace message may further indicate a job type (which may be “data collection”) in a privacy indicator IE.

[00121] Upon receiving the cell traffic trace message from the RAN node 210, the AMF may further look up the subscriber identities (IMEI(SV)) of the given cell from its database, and transmit, to the at least one data collection entity 230, the IMEI-TAC together with the trace recording session reference, the trace reference, and the serving cell CGI.

[00122] For a specific example, following Table 4 shows an example of the cell traffic trace message which includes the at least one address of the at least one data collection entity.

Table 4: at least one address in the cell traffic trace message

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.3.1.1		YES	ignore
AMF UE NGAP ID	M		9.3.3.1		YES	reject
RAN UE NGAP ID	M		9.3.3.2		YES	reject
NG-RAN Trace ID	M		OCTET STRING (SIZE(8))	This IE is composed of the following: Trace Reference defined in TS 32.422 [11] (leftmost 6 octets, with PLMN information encoded as in 9.3.3.5), and Trace Recording Session Reference	YES	ignore

				defined in TS 32.422 [11] (last 2 octets).		
NG-RAN CGI	M		9.3.1.73		YES	ignore
Trace Collection Entity IP Address	M		Transport Layer Address 9.3.2.4	For File based Reporting. Defined in TS 32.422 [11]. This IE is ignored if the <i>Trace Collection Entity URI</i> IE is present	YES	ignore
Privacy Indicator	O		ENUMERATED (Immediate MDT, Logged MDT, Data Collection ...)		YES	ignore
Trace Collection Entity URI	O		URI 9.3.2.14	For Streaming based Reporting. Defined in TS 32.422 [11].	YES	ignore
Data Collection Entity List						
> Data Collection Entity IP Address			For file-based data collection report			
> Data Collection Entity URI			For stream-based data collection report			

[00123] In the process 300, the RAN node 210 transmits a second message to the at least one data collection entity 230 at 340, where the second message may include some or all of the physical layer measurements. Specifically, the second message may include collected

5 physical layer measurements.

[00124] In some implementations, if the first message request assisting information associated with the physical layer measurements, in other words, the RAN node 210 is configured to provide the assisting information, then the second message may further include the requested assisting information.

[00125] In some implementations, the collected physical layer measurements may be grouped in multiple groups, and at least one of the multiple groups may be included in the second message and be transmitted to the at least one data collection entity 230.

5 [00126] In some example embodiments, the grouping operation may be in a specific manner, such as per UE manner or per feature manner. The per UE manner may also be called as a UE centric manner, and the per feature manner may also be called as per functionality manner, a feature centric manner, or the like. In some examples, if the first message includes an indication of the manner, then the indicated manner may be used by the RAN node 210.

10 [00127] In some implementations, the collected physical layer measurements may be grouped in multiple groups corresponding to multiple UEs. In some embodiments, a UE centric manner may be used, for example, the collected physical layer measurements from the same UE are grouped and associated with a unique ID/index. For example, the unique ID/index may not be any UE specific ID used in the network, e.g., a subscription permanent identifier (SUPI), mobile electronics installations (MEI), a radio network temporary
15 identifier (RNTI). For example, the unique ID/index may be assigned by the RAN node 210 to differentiate UEs. In some examples, time stamps of measurements in a group may also be included in the second message, for example, the measurements in the group may be determined by the same UE at different time points.

20 [00128] In some examples, if there is another RAN node, it may assign a different ID/index for the same UE, that is, different RAN nodes could assign different IDs/indexes to the same UE under mobility scenario.

[00129] It is to be understood that the group of collected physical layer measurements corresponding to a specific UE may be useful in case of temporal prediction AI/ML model training, for example a sequence of physical layer measurements measured by the same UE
25 at different time points are used as model input.

[00130] In some implementations, the collected physical layer measurements may be grouped in multiple groups corresponding to multiple features. In some embodiments, the multiple features may be associated with multiple attributes of the physical layer measurements. For example, the feature may be a specific beam, a specific beam set, a
30 specific location (e.g., a ground truth location) or the like.

[00131] In some embodiments, a feature centric manner may be used. For example, the collected physical layer measurements of the same beam set B are grouped together, while

there is no need to further differentiate whether those physical layer measurements come from different UEs, and there could be no need to further differentiate whether those physical layer measurements are measured at different time points. In some examples, the feature centric manner may be useful in case of spatial domain prediction, where physical layer measurements of certain beam set B are used as input to predict the physical layer measurements of certain beam set A at the same time point.

[00132] For another example, in case of fingerprint-based positioning, a combination of physical layer measurements and ground truth location are used for training.

[00133] In some embodiments, in case the feature centric manner is used, the UE information or time information are not included in the second message, for example, the UE information or the time information may not be necessary.

[00134] In the process 300, the physical layer measurements in the second message may be used for further usage. In some implementations, the data collection entity 230 uses or provides the physical layer measurements at 350.

[00135] In some embodiments, if the data collection entity 230 may be used as a model training entity, then the data collection entity 230 may further train an AI/ML model by using the physical layer measurements, for example, a training set may be constructed based on the physical layer measurements.

[00136] In some embodiments, if there is another model training entity, then the data collection entity 230 may further provide (e.g. transmit) the physical layer measurements to the model training entity. For example, the model training entity may further train an AI/ML model by using the physical layer measurements.

[00137] According to some embodiments discussed with reference to FIG. 3, the RAN node may report the physical layer measurements to the data collection entity, and thus a further usage (such as model training at a training entity) may be enabled. In some examples, the physical layer measurements may be reported to more than one data collection entity, as such, an additional request for the physical layer measurements may not be needed, and thus the overhead may be reduced.

[00138] Reference is further made to FIG. 4, which illustrates a signalling chart illustrating communication process 400 in accordance with some example embodiments of the present disclosure. The process 400 may involve a RAN node 210 and a data collection entity 230 as show in FIG. 2. It would be appreciated that the process 400 may be applied to other

communication scenarios, which will not be described in detail.

[00139] The process 400 may be regarded as a dedicated procedure for L1 measurements collection. In some implementations, the data to be collected include physical layer measurements (also refer to L1 measurements). In some implementations, the data
5 collection may be also called as measurements collection, L1 measurements collection, or the like. In some implementations, the physical layer measurements (L1 measurements) may be used for model training at an AI/ML training entity (which is the same as or different from the data collection entity 230), for example, the model may be used for any of: CSI
10 feedback compression, CSI time domain prediction, beam spatial domain prediction, beam time domain prediction, AI/ML assisted positioning estimation, or direction positioning.

[00140] There is a direct interface or an end-to-end (E2E) protocol between the data collection entity 230 and the RAN node 210. For example, if the data collection entity 230 is an AMF, there is a known interface with the RAN node 210. For example, if the data
15 collection entity 230 is an LMF, there is an E2E protocol (e.g., NRPPa) with the RAN node 210.

[00141] In the process 400, the data collection entity 230 determines information associated with physical layer measurements at 410. In some implementations, the data collection entity 230 may determine to collect the physical layer measurements, and accordingly
20 generate the information associated with physical layer measurements. In some implementations, there may be more than one data collection entity, for example, there may be one or more data collection entities other than the data collection entity 230, and the data collection entity 230 may determine the information associated with the physical layer measurements based on a combination of information from the data collection entity 230 and the one or more data collection entities other than the data collection entity 230.

[00142] In the process 400, the data collection entity 230 transmits a first message to the RAN node 210 at 420. The first message may indicate to the RAN node 210 to collect the physical layer measurements and to report the collected physical layer measurements to at
25 least one data collection entity, where the at least one data collection entity includes the data collection entity 230. For example, the at least one data collection entity may further include one or more data collection entities other than the data collection entity 230. In
30 some examples, the first message may indicate to the RAN node 210 to transmit the collected physical layer measurements (e.g., in a second message) to the at least one data collection

entity.

[00143] In some example embodiments, the first message may indicate that the physical layer measurements should be reported to at least one data collection entity 230 in a file-based manner or in a streaming-based manner. In some examples, the first message may include at least one data collection configuration.

[00144] In some implementations, the first message may be a data collection request message. In some embodiments, the data collection request message may include a data collection configuration. In some examples, details of the first message may refer to those discussed with reference to FIG. 3, and thus will not be repeated herein.

[00145] In some embodiments, the first message may further include a partial support indication. In some examples, the partial support indication may indicate that some of the physical layer measurements are mandatory.

[00146] In some examples, the partial support indication may indicate whether a partial support is allowed. In some examples, the RAN node 210 can provide only part of the physical layer measurements. In some cases, all the physical layer measurements (such as M kinds of L1 measurements) are mandatory input for training an AI/ML model, then the partial support should not be enabled (i.e., disabled or not allowed). In some other cases, some of the physical layer measurements are optional input for training an AI/ML model, then the partial support can be enabled (i.e., allowed).

[00147] In some examples, the partial support indication may be indicated by an IE (such as one indicator IE) in the data collection request message. In some examples, the partial support indication may include multiple indicators corresponding to multiple physical layer measurements, and each indicator may indicate whether a corresponding physical layer measurement a mandatory or optional measurement.

[00148] In some embodiments, the first message may further include ID information associated with a data collection session. In some examples, the ID information may be used for indicating a triggered data collection session.

[00149] In some embodiments, the first message may further include one or more addresses of the one or more data collection entities other than the data collection entity 230. For example, an address may be in a form of an IP address, a FQDN, a URI, a URL, or the like.

[00150] For example, the first message may include a list of addresses of multiple data

collection entities, and the first message may further include a data collection configuration for each data collection entity.

[00151] For a specific example, following Table 5 shows an example of a list of addresses in a data collection request message.

5 Table 5: a list of addresses in the data collection request message

Data Collection Configuration List					
>Data Collection Configuration Item					
>> Data Collection Entity IP Address			For file-based data collection report		
>> Data Collection Entity URI			For stream-based data collection report		
>> Data Collection Configuration					

[00152] As a specific example, assuming that the data collection entity 230 is the LMF. If the LMF wants to collect data to train an AI/ML model and the AI/ML model will be used for AI based positioning in a specific cell. In some examples, the LMF may configure the RAN node 210 to collect, from capable UEs within a specific cell, all the DL CSI measurements for certain SSBs together with associated ground truth location information via the data collection request message via a NR positioning protocol A (NRPPa) protocol. In some examples, the data collection request message may indicate a time duration (e.g., the next one hour), which may indicate to the RAN node to report the collected measurement in one time manner after the next one hour. In some examples, the data collection request message may further indicate a time duration (e.g. the next one hour) and a periodicity (every 1 min), which may indicate to the RAN node 210 to periodically (every 1min) report the collected measurements within next one hour.

[00153] In addition or alternatively, the RAN node 210 may transmit a response to the data collection entity 230 at 425. In some implementations, the response to the first message may be a data collection response message. In some implementations, the response is transmitted over a direct interface or an E2E protocol.

[00154] In some examples, if all of the physical layer measurements indicated by the first message may be collected by the RAN node 210, or if some of the physical layer measurements which are mandatory (a partial support is enabled or allowed) can be collected by the RAN node 210, then the data collection response message may be transmitted to the data collection entity 230.

[00155] In the process 400, upon receiving the first message, the RAN node 210 collects

some or all physical layer measurements at 430. The operation 430 may be similar with the operation 330 discussed with reference to FIG. 3, and thus will not be repeated herein.

[00156] In addition or alternatively, in case of RAN CU DU split architecture, the CU of the RAN node 210 may receive the first message, and in addition the CU may forward part or all information in the first message to the DU of the RAN node 210, e.g. over F1 interface.

[00157] In addition or alternatively, in case of RAN CU-CP CU-UP split architecture, the CU-CP of the RAN node 210 may receive the first message, and in addition the CU-CP may forward part or all information in the first message to the CP-UP of the RAN node 210, e.g. over E1 interface.

[00158] In addition or alternatively, during a handover of a UE (such as a specific UE indicted by the first message or a UE selected by the RAN node 210), the RAN node 210 may be a source gNB for the handover, and the RAN node 210 may further transmit part or all information in the first message to a target RAN node (e.g. a target gNB), e.g. over X1 interface.

[00159] In the process 400, the RAN node 210 transmits a second message to the at least one data collection entity (includes the data collection entity 230) at 440, where the second message may include some or all of the physical layer measurements. Specifically, the second message may include collected physical layer measurements.

[00160] In some implementations, the second message may be a data collection report message, and the second message may be transmitted via a direct interface or an E2E protocol between the RAN node 210 and the data collection entity 230.

[00161] In some implementations, the second message may include an ID which is the same as that included in the first message (a data collection request message).

[00162] In some example embodiments, the collected physical layer measurements in the second message may be conveyed in a container of an encoded format. In some example embodiments, UE identification information may be removed from the collected physical layer measurements in the second message. For example, the RAN node 210 may eliminate the UE identification information in the data collection report message.

[00163] In some implementations, the collected physical layer measurements may be grouped in multiple groups, and at least one of the multiple groups may be included in the second message and be transmitted to the data collection entity 230.

[00164] In some example embodiments, the grouping operation may be in a specific manner, such as per UE manner or per feature manner. The per UE manner may also be called as a UE centric manner, and the per feature manner may also be called as a feature centric manner. In some examples, if the first message includes an indication of the manner, then the indicated manner may be used by the RAN node 210.

[00165] In some implementations, the collected physical layer measurements may be grouped in multiple groups corresponding to multiple UEs. In some embodiments, a UE centric manner may be used, for example, the collected physical layer measurements from the same UE are grouped and associated with a unique ID/index. For example, the unique ID/index may not be any UE specific ID used in the network. In some examples, time stamps of measurements in a group may also be included in the second message, for example, the measurements in the group may be determined by the same UE at different time points.

[00166] In some examples, if there is another RAN node, it may assign a different ID/index for the same UE, that is, different RAN nodes could assign different IDs/indexes to the same UE under mobility scenario.

[00167] It is to be understood that the group of collected physical layer measurements corresponding to a specific UE may be useful in case of temporal prediction AI/ML model training, for example a sequence of physical layer measurements measured by the same UE at different time points are used as model input.

[00168] In some implementations, the collected physical layer measurements may be grouped in multiple groups corresponding to multiple features. In some embodiments, the multiple features may be associated with multiple attributes of the physical layer measurements. For example, the feature may be a specific beam, a specific beam set, a specific location (e.g., a ground truth location) or the like.

[00169] In some embodiments, a feature centric manner may be used. For example, the collected physical layer measurements of the same beam set B are grouped together, while there is no need to further differentiate whether those physical layer measurements come from different UEs, and there could be no need to further differentiate whether those physical layer measurements are measured at different time points. In some examples, the feature centric manner may be useful in case of spatial domain prediction, where physical layer measurements of certain beam set B are used as input to predict the physical layer measurements of certain beam set A at the same time point.

[00170] For another example, in case of fingerprint-based positioning, a combination of physical layer measurements and ground truth location are used for training.

[00171] In some embodiments, in case the feature centric manner is used, the UE information or time information are not included in the second message, for example, the UE information
5 or the time information may not be necessary.

[00172] As a specific example, assuming that the data collection entity 230 is the LMF, and the LMF may configure the RAN node 210 to collect, from capable UEs within a specific cell, all the DL CSI measurements for certain SSBs together with associated ground truth location information via the data collection request message via a NRPPa protocol. In
10 addition, the LMF may further indicate a time duration (e.g. the next one hour) and a periodicity (every 1 min), which may indicate to the RAN node 210 to periodically (every 1min) report the collected measurements within next one hour. In this case, the RAN node 210 may configure capable UEs within the specific cell to measure and report the CSI measurements for certain SSBs, and the RAN node 210 may further report to the LMF using
15 a data collection report message periodically within the time duration.

[00173] In the process 400, the physical layer measurements in the second message may be used for further usage. In some implementations, the data collection entity 230 uses or provides the physical layer measurements at 450.

[00174] In some embodiments, if the data collection entity 230 may be used as a model
20 training entity, then the data collection entity 230 may further train an AI/ML model by using the physical layer measurements, for example, a training set may be constructed based on the physical layer measurements.

[00175] In some embodiments, if there is another model training entity, then the data collection entity 230 may further provide (e.g. transmit) the physical layer measurements to
25 the model training entity. For example, the model training entity may further train an AI/ML model by using the physical layer measurements.

[00176] According to some embodiments discussed with reference to FIG. 4, an existing interface or protocol between the data collection entity and the RAN node may be used for a procedure for requesting and reporting the physical layer measurements, as such, the data
30 collection entity may obtain the physical layer measurements, and accordingly a model training may be well performed.

[00177] FIG. 5 illustrates an example of a device 500 that is suitable for implementing

embodiments of the present disclosure. The device 500 may be an example of a RAN node as described herein. The device 500 may support wireless communication with the RAN node 210, the first entity 220, the data collection entity 230, or any combination thereof. The device 500 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 502, a memory 504, a transceiver 506, and, optionally, an I/O controller 508. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

10 [00178] The processor 502, the memory 504, the transceiver 506, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. For example, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

15 [00179] In some implementations, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some implementations, the processor 502 and the memory 504 coupled with the processor 502 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 502, instructions stored in the memory 504).

25 [00180] For example, the processor 502 may support wireless communication at the device 500 in accordance with examples as disclosed herein. The processor 502 may be configured to operable to support a means for transmitting, to a first RAN node, a request for adding a direct path between the first RAN node and a UE, wherein there has been an indirect path between the second RAN node and the UE via a relay UE; and means for receiving, from the first RAN node, a response at least comprising a first configuration of the direct path. The processor 502 may be configured to operable to support a means for receiving, from a second RAN node, a request for adding a direct path between the first RAN node and a UE, wherein there has been an indirect path between the second RAN node and the UE via a relay UE;

and means for transmitting, to the second RAN node, a response at least comprising a first configuration of the direct path. The processor 502 may be configured to operable to support a means for transmitting, to a second RAN node, a request for PCell change or for releasing an indirect path, wherein there are a direct path between the first RAN node and a UE and the indirect path between the second RAN node and the UE via a relay UE; and means for receiving, from the second RAN node, a response for accepting the request or rejecting the request. The processor 502 may be configured to operable to support a means for receiving, from a first RAN node, a request for PCell change or for releasing an indirect path, wherein there are a direct path between the first RAN node and a UE and the indirect path between the second RAN node and the UE via a relay UE; and means for transmitting, to the first RAN node, a response for accepting the request or rejecting the request.

[00181] The processor 502 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor 502 may be configured to operate a memory array using a memory controller. In some other implementations, a memory controller may be integrated into the processor 502. The processor 502 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 504) to cause the device 500 to perform various functions of the present disclosure.

[00182] The memory 504 may include random access memory (RAM) and read-only memory (ROM). The memory 504 may store computer-readable, computer-executable code including instructions that, when executed by the processor 502 cause the device 500 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 502 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 504 may include, among other things, a basic I/O system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[00183] The I/O controller 508 may manage input and output signals for the device 500. The I/O controller 508 may also manage peripherals not integrated into the device M02. In some implementations, the I/O controller 508 may represent a physical connection or port to

an external peripheral. In some implementations, the I/O controller 508 may utilize an operating system such as iOS®, ANDROID®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In some implementations, the I/O controller 508 may be implemented as part of a processor, such as the processor 502. In some
5 implementations, a user may interact with the device 500 via the I/O controller 508 or via hardware components controlled by the I/O controller 508.

[00184] In some implementations, the device 500 may include a single antenna 510. However, in some other implementations, the device 500 may have more than one antenna 510 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may
10 be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 506 may communicate bi-directionally, via the one or more antennas 510, wired, or wireless links as described herein. For example, the transceiver 506 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 506 may also include a modem to modulate the packets, to provide the
15 modulated packets to one or more antennas 510 for transmission, and to demodulate packets received from the one or more antennas 510. The transceiver 506 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[00185] 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
20 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
25 modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmit chain may also include one or more antennas 510 for transmitting the amplified signal into the air or wireless medium.

[00186] 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
30 antennas 510 for receive the signal over the air or wireless medium. The receive chain may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receive chain may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation

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

[00187] FIG. 6 illustrates an example of a processor 600 that is suitable for implementing some embodiments of the present disclosure. The processor 600 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 600 may include a controller 602 configured to perform various operations in accordance with examples as described herein. The processor 600 may optionally include at least one memory 604, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 600 may optionally include one or more arithmetic-logic units (ALUs) 606. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[00188] The processor 600 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 600) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[00189] The controller 602 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. For example, the controller 602 may operate as a control unit of the processor 600, generating control signals that manage the operation of various components of the processor 600. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[00190] The controller 602 may be configured to fetch (e.g., obtain, retrieve, receive)

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

[00191] The memory 604 may include one or more caches (e.g., memory local to or included in the processor 600 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 604 may reside within or on a
15 processor chipset (e.g., local to the processor 600). In some other implementations, the memory 604 may reside external to the processor chipset (e.g., remote to the processor 600).

[00192] The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 600, cause the processor 600 to perform
20 various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 602 and/or the processor 600 may be configured to execute computer-readable instructions stored in the memory 604 to cause the processor 600 to perform various functions. For example, the processor 600 and/or the controller 602 may be coupled with or to the memory 604, the
25 processor 600, the controller 602, and the memory 604 may be configured to perform various functions described herein. In some examples, the processor 600 may include multiple processors and the memory 604 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[00193] The one or more ALUs 606 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 606 may reside within or on a processor chipset (e.g., the processor 600). In some
30 other implementations, the one or more ALUs 606 may reside external to the processor

chipset (e.g., the processor 600). One or more ALUs 606 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 606 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 606 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 606 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 606 to handle conditional operations, comparisons, and bitwise operations.

10 [00194] The processor 600 may support wireless communication in accordance with examples as disclosed herein. The processor 600 may be configured to or operable to support a means for operations described in some embodiments of the present disclosure.

[00195] FIG. 7 illustrates a flowchart of a method 700 performed by a RAN node in accordance with aspects of the present disclosure. The operations of the method 700 may be implemented by a device or its components as described herein. For example, the operations of the method 700 may be performed by the RAN node 210 in FIG. 2. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

20 [00196] At 710, the method may include receiving, from a first entity, a first message indicating to the RAN node to collect and report physical layer measurements to at least one data collection entity. The operations of 710 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 710 may be performed by the RAN node 210 as described with reference to FIG. 2.

25 [00197] At 720, the method may include collecting the physical layer measurements based on the first message. The operations of 720 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 720 may be performed by the RAN node 210 as described with reference to FIG. 2.

[00198] At 730, the method may include transmitting, to the at least one data collection entity, a second message comprising some or all of the physical layer measurements, wherein the some or all of the physical layer measurements are used for model training. The operations of 730 may be performed in accordance with examples as described herein. In some

implementations, aspects of the operations of 730 may be performed by the RAN node 210 as described with reference to FIG. 2.

[00199] FIG. 8 illustrates a flowchart of a method 800 performed by a first entity in accordance with aspects of the present disclosure. The operations of the method 800 may be implemented by a device or its components as described herein. For example, the operations of the method 800 may be performed by the first entity 220 in FIG. 2. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[00200] At 810, the method may include obtaining information associated with physical layer measurements for model training. The operations of 810 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 810 may be performed by the first entity 220 as described with reference to FIG. 2.

[00201] At 820, the method may include transmitting, to a RAN node, a first message indicating to the RAN node to collect and report the physical layer measurements to at least one data collection entity. The operations of 820 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 820 may be performed by the first entity 220 as described with reference to FIG. 2.

[00202] FIG. 9 illustrates a flowchart of a method 900 performed by a data collection entity in accordance with aspects of the present disclosure. The operations of the method 900 may be implemented by a device or its components as described herein. For example, the operations of the method 900 may be performed by the data collection entity 230 in FIG. 2. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[00203] At 910, the method may include receiving, from a RAN node, a second message comprising some or all of physical layer measurements. The operations of 910 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 910 may be performed by the data collection entity 230 as described with reference to FIG. 2.

[00204] At 920, the method may include using or providing the some or all of the physical

layer measurements to a model training entity. The operations of 920 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 920 may be performed by the data collection entity 230 as described with reference to FIG. 2.

5 [00205] 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.

10 [00206] 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.

20 [00207] 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.

30 [00208] 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.

5 [00209] 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
10 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
15 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.

[00210] 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
20 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 radio access network (RAN) node comprising:
at least one memory; and
5 at least one processor coupled with the at least one memory and configured to cause the RAN node to:
receive, from a first entity, a first message indicating to the RAN node to collect and report physical layer measurements to at least one data collection entity;
collect the physical layer measurements based on the first message; and
10 transmit, to the at least one data collection entity, a second message comprising some or all of the physical layer measurements, wherein the some or all of the physical layer measurements are used for model training.
2. The RAN node of claim 1, wherein the first entity comprises an access and
15 mobility management function (AMF), the first message comprises a trace start message, and wherein the trace start message comprises an information element (IE) associated with a data collection configuration indicating to collect and report physical layer measurements.
3. The RAN node of claim 2, wherein the IE associated with the data collection
20 configuration is comprised in a minimization of drive test (MDT) configuration IE.
4. The RAN node of claim 1, wherein the first entity comprises an operations
administration and maintenance (OAM) system, and wherein the at least one processor is
further configured to cause the RAN node to:
25 transmit, to an AMF, a cell traffic trace message.
5. The RAN node of claim 4, wherein the cell traffic trace message comprises one
of:
a trace recording session reference,
30 a trace reference,
a cell global identity (CGI) of a serving cell, or
at least one address of the at least one data collection entity.

6. The RAN node of claim 1, wherein the first entity is one of the at least one data collection entity, the first message comprises a data collection request message, and wherein the first message is transmitted via an interface and/or via end-to-end protocol between the RAN node and the first entity.

5

7. The RAN node of claim 6, wherein the data collection request message comprises a partial support indication indicating that some of the physical layer measurements are mandatory.

10

8. The RAN node of any of claims 1-7, wherein the physical layer measurements comprise one of:

ground-truth channel state information (CSI) in scalar quantization and/or codebook-based quantization,

15 a pair of first information and second information, wherein the first information comprises a raw channel or an eigenvector, and the second information comprises a latent space vector with or without quantization,

a pair of third information and fourth information, wherein the third information comprises a latent space vector after quantization, and the fourth information comprises a target CSI to be recovered as proxy model output,

20 one or more CSIs comprising raw channel matrices, precoding matrix indicators (PMIs), or eigenvectors,

one or more layer 1 reference signal received power (L1-RSRP) measurements based on Set B or a subset of Set B, wherein the Set B comprises a set of beams for prediction input,

25 one or more L1-RSRP measurements based on Set A or a subset of Set A, wherein the Set A comprises a set of beams for prediction output,

one or more L1-RSRP measurements based on Set A or a subset of Set A and corresponding beam indicators,

top k beam indicators,

a channel impulse response of a reference signal,

30 a power delay profile of a reference signal,

a delay profile of a reference signal,

a RSRP of a reference signal,

a reference signal received quality (RSRQ) of a reference signal,

a reference signal time difference (RSTD) of a reference signal, or

a ground truth location coordination.

9. The RAN node of any of claims 1-8, wherein the first message comprises a request for assisting information associated with the physical layer measurements to be collected, wherein the assisting information comprises one of:

5 a timestamp,
a scenario,
an identity of a cell,
a physical layer configuration,
10 a quality indication, or
line of sight or non-line of sight.

10. The RAN node of any of claims 1-9, wherein the first message comprises one of:

15 at least one criterion for data collection,
a time duration for the data collection,
a periodicity for the data collection,
an event for triggering the data collection, or
an indication of a manner for the second message.

20 11. The RAN node of claim 10, wherein the at least one criterion comprises one of:
a required scenario,
a required physical layer configuration,
a required quality indication,
25 a required line of sight or non-line of sight,
an interested area,
an interested frequency,
an interested cell,
an interested beam,
30 an interested user equipment (UE) type.

12. The RAN node of any of claims 1-11, wherein the first message comprises at least one address of the at least one data collection entity.

13. The RAN node of any of claims 1-12, wherein the some or all of the physical layer measurements in the second message are conveyed in a container of an encoded format.

5 14. The RAN node of any of claims 1-13, wherein UE identification information is removed from the some or all of the physical layer measurements in the second message.

15 15. The RAN node of any of claims 1-14, wherein the some or all of the physical layer measurements in the second message are grouped into a plurality of groups corresponding to a plurality of UEs, and wherein each of the plurality of groups has a unique index.

16 16. The RAN node of any of claims 1-14, wherein the some or all of the physical layer measurements in the second message are grouped into a plurality of groups corresponding to a plurality of features, wherein each feature is associated with an attribute of the physical layer measurements.

17 17. The RAN node of any of claims 1-16, wherein the RAN node is an RAN central unit (CU), and the at least one processor is further configured to cause the RAN node to:
20 transmit, to an RAN distributed unit (DU), part or all information in the first message.

18 18. The RAN node of any of claims 1-16, wherein the RAN node is a source RAN node for a specific UE during handover, and the at least one processor is further configured to cause the RAN node to:
25 transmit, to a target RAN node, part or all information in the first message.

19. A first entity comprising:
at least one memory; and
at least one processor coupled with the at least one memory and configured to cause
30 the first entity to:

obtain information associated with physical layer measurements for model training; and

transmit, to a radio access network (RAN) node, a first message indicating to the RAN node to collect and report the physical layer measurements to at least one data

collection entity.

20. A data collection entity comprising:
- at least one memory; and
- 5 at least one processor coupled with the at least one memory and configured to cause the data collection entity to:
- receive, from a radio access network (RAN) node, a second message comprising some or all of physical layer measurements; and
- use or provide the some or all of the physical layer measurements to a model
- 10 training entity.