SUPPORT OF MULTI-CELL KPM REPORTING

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to network devices, processors, methods, and a computer readable medium for supporting multi-cell KPM reporting, for example, in open radio access network (O-RAN).

BACKGROUND

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

[0003] In O-RAN, the radio resource management (RRM) function is typically located at the near-real-time (Near-RT) radio access network (RAN) intelligent controller (RIC) by means of the E2 service model over the E2 interface. The E2 service model describes the functions in the E2 node which may be controlled by the Near-RT RIC and the related procedures. For a function exposed in the E2 service model, the Near-RT RIC may, e.g., monitor, suspend/stop, override or control the

behaviour of E2 node. There are some issues to be resolved in key performance measurement (KPM) reporting.

SUMMARY

[0004] The present disclosure relates to methods, devices, and processors that support multi-cell KPM reporting in O-RAN. According to some example embodiments of the present disclosure, multi-cell KPM reporting can be supported, the signaling load for reporting can be reduced, and the efficiency of reporting is greatly improved.

[0005] Some implementations of the method and a first network device described herein may include, transmitting, via the transceiver and to a second network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting; and receiving, via the transceiver and from the second network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting. Therefore, the efficiency of KPM reporting in O-RAN is improved.

[0006] In some implementations of the method and the first network device described herein, the E2SM-KPM action definition may be for multi-cell KPM reporting with the same measurement requirements; and the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements may be for at least two cells, and may include the measurement requirements applied to the at least two cells.

[0007] In some implementations of the method and the first network device described herein, the E2SM-KPM report service style may be for multi-cell KPM reporting with the same measurement requirements; and the E2SM-KPM report service style for multi-cell KPM reporting with the same measurement requirements may be for at least two cells.

[0008] In some implementations of the method and the first network device described herein, the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements may further include one of the following: a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted to the first network device as an integrated report.

[0009] In some implementations of the method and the first network device described herein, the E2SM-KPM action definition may be for multi-cell KPM reporting with different measurement requirements; and the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements may be for at least two cells, and includes the measurement requirements for each of the at least two cells.

[0010] In some implementations of the method and the first network device described herein, the E2SM-KPM report service style may be for multi-cell KPM reporting with different measurement requirements; and the E2SM-KPM report service style for multi-cell KPM reporting with different measurement requirements may be for at least two cells.

[0011] In some implementations of the method and the first network device described herein, the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements may further include one of the following: a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted as an integrated report.

[0012] In some implementations of the method and the first network device described herein, the E2SM-KPM indication message may include an ID of at least one cell, and a measurement report for the at least one cell.

[0013] In some implementations of the method and the first network device described herein, the E2SM-KPM action definition may be identified by an E2SM-KPM action definition format ID.

[0014] In some implementations of the method and the first network device described herein, the E2SM-KPM indication message may be identified by an E2SM-KPM indication message format ID.

[0015] In some implementations of the method and the first network device described herein, the E2SM-KPM action definition may be associated with the E2SM-KPM report service style, and the E2SM-KPM report service style may be associated with a radio access network (RAN) intelligent controller (RIC) style type ID and a RIC style name.

[0016] In some implementations of the method and the first network device described herein, the ID of the E2SM-KPM report service style may be the RIC style type ID.

[0017] Some implementations of the method and the first network device described herein may further include, receiving, via the transceiver and from the second network device, a RAN function definition, wherein the RAN function definition is for multi-cell KPM reporting.

[0018] In some implementations of the method and the first network device described herein, the RAN function definition includes one of the following: a RIC style name of the E2SM-KPM report service style; a RIC style type ID of the E2SM-KPM report service style; an ID of the E2SM-KPM action definition format; an ID of the E2SM-KPM indication message format.

[0019] In some implementations of the method and the first network device described herein, the first network device may be a near-real-time (Near-RT) RIC, and the second network device may be an E2 node.

[0020] Some implementations of the method and a second network device described herein may include, receiving, via the transceiver and from a first network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting; and transmitting, via the transceiver and to the first network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message,

wherein the E2SM-KPM indication message is for multi-cell KPM reporting. Therefore, the efficiency of KPM reporting in O-RAN is improved.

[0021] In some implementations of the method and the second network device described herein, the E2SM-KPM action definition may be for multi-cell KPM reporting with the same measurement requirements; and the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements may be for at least two cells, and includes the measurement requirements applied to the at least two cells.

[0022] In some implementations of the method and the second network device described herein, the E2SM-KPM report service style may be for multi-cell KPM reporting with the same measurement requirements; and the E2SM-KPM report service style for multi-cell KPM reporting with the same measurement requirements may be for at least two cells.

[0023] In some implementations of the method and the second network device described herein, the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements may further include one of the following: a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted to the first network device as an integrated report.

[0024] In some implementations of the method and the second network device described herein, the E2SM-KPM action definition may be for multi-cell KPM reporting with different measurement requirements; and the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements may be for at least two cells, and includes the measurement requirements for each of the at least two cells.

[0025] In some implementations of the method and the second network device described herein, the E2SM-KPM report service style may be for multi-cell KPM reporting with different measurement requirements; and the E2SM-KPM report service style for multi-cell KPM reporting with different measurement requirements may be for at least two cells.

[0026] In some implementations of the method and the second network device described herein, the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements may further include one of the following: a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted as an integrated report.

[0027] In some implementations of the method and the second network device described herein, the E2SM-KPM indication message may include an ID of at least one cell, and a measurement report for the at least one cell.

[0028] In some implementations of the method and the second network device described herein, the E2SM-KPM action definition may be identified by an E2SM-KPM action definition format ID.

[0029] In some implementations of the method and the second network device described herein, the E2SM-KPM indication message may be identified by an E2SM-KPM indication message format ID.

[0030] In some implementations of the method and the second network device described herein, the E2SM-KPM action definition may be associated with the E2SM-KPM report service style, and the E2SM-KPM report service style may be associated with a radio access network (RAN) intelligent controller (RIC) style type ID and a RIC style name.

[0031] In some implementations of the method and the second network device described herein, the ID of the E2SM-KPM report service style may be the RIC style type ID.

[0032] In some implementations of the method and the second network device described herein, may further include, transmitting, via the transceiver and to the first network device, a RAN function definition, wherein the RAN function definition may be for multi-cell KPM reporting.

[0033] In some implementations of the method and the second network device described herein, the RAN function definition may include one of the following: a RIC style name of the E2SM-KPM report service style; a RIC style type ID of the E2SM-

KPM report service style; an ID of the E2SM-KPM action definition format; or an ID of the E2SM-KPM indication message format.

[0034] In some implementations of the method and the second network device described herein, the first network device may be a near-real-time (Near-RT) RIC, and the second network device may be an E2 node.

[0035] Some implementations of processors may include at least one memory; and a controller coupled with the at least one memory and configured to cause the controller to: transmit, via the transceiver and to a second network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting; and receive, via the transceiver and from the second network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting. Therefore, the efficiency of KPM reporting in O-RAN is improved.

[0036] Some implementations of processors may include at least one memory; and a controller coupled with the at least one memory and configured to cause the controller to: receive, via the transceiver and from a first network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting; and transmit, via the transceiver and to the first network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting. Therefore, the efficiency of KPM reporting in O-RAN is improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] FIG. 1A illustrates an example of a wireless communications system that supports multi-cell KPM reporting in O-RAN in accordance with aspects of the present disclosure.

[0038] FIG. 1B illustrates an example of the Near-RT RIC logical architecture and related interfaces associated with aspects of the present disclosure.

[0039] FIG. 1C illustrates an example of an RIC Service REPORT procedure associated with aspects of the present disclosure.

[0040] FIG. 2 illustrates an example signaling chart illustrating an example process that supports multi-cell KPM reporting in O-RAN in accordance with aspects of the present disclosure.

[0041] FIG. 3 illustrates an example signaling chart illustrating multi-cell KPM reporting with same measurement requirements in accordance with aspects of the present disclosure.

[0042] FIG. 4 illustrates an example signaling chart illustrating multi-cell KPM reporting with different measurement requirements in accordance with aspects of the present disclosure.

[0043] FIGS. 5 through 6 illustrate examples of devices that support multi-cell KPM reporting in accordance with aspects of the present disclosure.

[0044] FIGS. 7 through 8 illustrate examples of processors that support multi-cell KPM reporting in accordance with aspects of the present disclosure.

[0045] FIGS. 9 through 10 illustrate flowcharts of methods that multi-cell KPM reporting in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0046] 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 may be implemented in various manners other than the ones described below.

[0047] 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.

[0048] References in the present disclosure to "one embodiment," "an example embodiment," "an embodiment," "some embodiments," and the like indicate that the embodiment(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases do not necessarily refer to the same embodiment(s). Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0049] 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.

[0050] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "has", "having", "includes" and/or "including", when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/ or combinations thereof. As used herein, "at least one of the following: <a list of two or more elements>" and "at least one of <a list of two or more elements>" and similar wording, where the list of two or more elements are joined by "and" or "or",

mean at least any one of the elements, or at least any two or more of the elements, or at least all the elements.

[0051] In O-RAN, the RRM function is typically located at the Near-RT RIC by means of the E2 service model over the E2 interface. The E2 service model describes the functions in the E2 node which may be controlled by the Near-RT RIC and the related procedures. For a function exposed in the E2 service model, the Near-RT RIC may, e.g., monitor, suspend/stop, override or control the behavior of E2 node. However, since an E2 node can have large number of cells (with maximum 16384 cells in an E2 node), and each cell can again have several tens to a few hundreds of KPM measurement objects, it needs considering how to support multi-cell KPM reporting. The gravity of the problem and the gaps in the current solution are quite significant. Therefore, the following issues should be considered.

[0052] For addressing the issues above, some example embodiments of the present disclosure provide a solution, where a first network device transmits, to a second network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting, and the first network device receives, from the second network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting. In this way, the solutions of the present disclosure can support multi-cell KPM reporting, and the signaling load for reporting can be reduced, and the efficiency of reporting is greatly improved.

[0053] Aspects of the present disclosure are described in the context of a wireless communications system.

[0054] FIG. 1A illustrates an example of a wireless communications system 100 that supports multi-cell KPM reporting in O-RAN in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations,

the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a 5G network, such as an NR network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0055] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. A network entity 102 and a UE 104 may communicate via a communication link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0056] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, messaging, broadcast, etc.) for one or more UEs 104 within the geographic coverage area 112. For example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network. In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities 102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic

waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0057] 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.

[0058] 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. 1A. 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. 1A. 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.

[0059] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0060] A network entity 102 may support communications with the core network 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the core network 106 through one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The network entities 102 may

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

[0061] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access backhaul (IAB) network, an open RAN (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity 102 may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a RAN intelligent controller (RIC) (e.g., a near-real time RIC (Near-RT RIC), a non-real time RIC (Non-RT RIC)), a service management and orchestration (SMO) system, or any combination thereof.

[0062] An RU may also be referred to as a radio head, a smart radio head, a remote radio head (RRH), a remote radio unit (RRU), or a transmission reception point (TRP). One or more components of the network entities 102 in a disaggregated RAN architecture may be co-located, or one or more components of the network entities 102 may be located in distributed locations (e.g., separate physical locations). In some implementations, one or more network entities 102 of a disaggregated RAN architecture may be implemented as virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0063] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a

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

[0064] 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).

[0065] 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.

[0066] 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.

[0067] The core network 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the core network 106 via a network entity 102. The core network 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the core network 106 (e.g., one or more network functions of the core network 106).

[0068] In the wireless communications system 100, the network entities 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the network entities 102 and the UEs 104 may support different resource structures. For example, the network entities 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the network entities 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the network entities 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The network entities 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0069] 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., μ=0) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., μ=0) associated with the first subcarrier spacing (e.g., 15 kHz) may

utilize one slot per subframe. A second numerology (e.g., μ=1) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., μ=2) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., μ=3) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., μ=4) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0070] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0071] 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., μ=0, μ=1, μ=2, μ=3, μ=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., μ=0) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0072] 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.

[0073] 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., μ=0), which includes 15 kHz subcarrier spacing; a second numerology (e.g., μ=1), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., μ=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., μ=2), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., μ=3), which includes 120 kHz subcarrier spacing.

[0074] In O-RAN, the RRM function is typically located at the Near-RT RIC by means of the E2 service model over the E2 interface. The E2 service model describes the functions in the E2 node which may be controlled by the Near-RT RIC and the related procedures. For a function exposed in the E2 service model, the Near-RT RIC may, e.g., monitor, suspend/stop, override or control the behavior of E2 node. The Near-RT RIC logical architecture and related interfaces are shown in FIG. 1B.

[0075] Near-RT RIC is a logical function that enables near-real-time control and optimization of RAN elements and resources via fine-grained data collection and actions over E2 interface.

[0076] E2 node is a logical node terminating E2 interface. Examples of E2 node are as follows: O-eNB (O-RAN eNB): an eNB or ng-eNB that supports E2 interface; O-CU

(O-RAN central unit): a logical node hosting RRC (radio resource control), SDAP (service data adaption protocol) and PDCP (packet data convergence protocol) protocols; O-CU-CP (O-RAN central unit control plane): a logical node hosting the RRC and the control plane part of the PDCP protocol; O-CU-UP (O-RAN central unit user plane): a logical node hosting the user plane part of the PDCP protocol and the SDAP protocol; O-DU (O-RAN distributed unit): a logical node hosting RLC (radio link control), MAC (medium access protocol) and High-PHY (physical) layers based on a lower layer functional split; or any combination of the above logical node.

[0077] E2 is an interface connecting Near-RT RIC and one or more O-CU-CPs, one or more O-CU-UPs, or one or more O-DUs. An E2 node is connected to only one Near-RT RIC, while a Near-RT RIC can be connected to multiple E2 nodes.

[0078] To obtain the KPM report from the E2 node, the "E2SM-KPM" service model is defined to provide the following REPORT services shown in table 1:

Table 1

RIC Style Type	Style Name	Style Type Description
1	E2 Node Measurement	Used to carry measurement report from a target E2 Node
2	E2 Node Measurement for a single UE	Used to carry measurement report for a single UE of interest from a target E2 Node
3	Condition-based, UE-level E2 Node Measurement	Used to carry UE-level measurement report for a group of UEs per measurement type matching subscribed conditions from a target E2 Node
4	Common Condition-based, UE-level Measurement	Used to carry measurement report for a group of UEs across a set of measurement types satisfying common subscribed conditions from a target E2 Node
5	E2 Node Measurement for multiple UEs	Used to carry measurement report for multiple UE of interest from a target E2 Node

[0079] The E2 node measurements are different from cell-level measurements. For example, regarding UL (uplink) PDCP SDU (service data unit) data volume, the measurement is calculated at the node level defined by the gNBCUUPFunction Information Object Class, which provides the amount of PDCP SDU bits in the uplink delivered from PDCP layer to SDAP layer or UPF (user plane function). And regarding UL total PRB usage, the measurement is calculated at the cell level defined by the

NRCellDU Information Object Class, which provides the total usage of PRBs on the uplink for any purpose.

[0080] To support the cell-level measurement, the E2 node measurement service is used, where the RIC Action Definition IE includes the cell ID to point to a specific cell for collecting measurements within the E2 node. The RIC Action Definition IE is shown in table 2 as follows.

Table 2

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Measurement Information List		*1.. <maxnoofMeasurementInfo>*		
>CHOICE *Measurement Type*				
>>Measurement Name	M		8.3.9 Measurement Type Name	
>>Measurement ID	M		8.3.10 Measurement Type ID	
>List of Labels		*1.. <maxnoofLabelInfo>*		
>>Label Information	M		8.3.11 Measurement Label	
Granularity Period	M		8.3.8 Granularity Period	Collection interval of measurements
Cell Global ID	O		8.3.20 Cell Global ID	Points to a specific cell for generating measurements subscribed by the *Measurement Information List* IE
Distribution Measurement Bin Range Info List		*0.. <maxnoofMeasurementInfo>*		
>CHOICE Measurement Type				
>>Measurement Name	M		8.3.9 Measurement Type Name	
>>Measurement ID	M		8.3.10 Measurement Type ID	

>Bin Range Definition	M		8.3.26	Indicates the value ranges of bins for distribution type measurement

[0081] According to the current specification, O-RAN.WG3.E2GAP-R003-v03.00 "O-RAN WG3; Near-RT RIC and E2 interface; E2 general aspects and principles", the REPORT service involves following steps (also illustrated in FIG. 1C, which shows a RIC Service REPORT according to the current specification). Step 1 includes: Near-RT RIC configures, and subsequently may modify, a RIC Subscription in the E2 Node with information for Indication (Report) that is to be sent by the E2 Node with each occurrence of RIC trigger event condition. Step 2 includes: During normal functioning of an associated procedure in the E2 Node, a RIC Event Trigger is detected. Step 3 includes: After completing any previous RIC actions, E2 Node sends RIC INDICATION message to Near-RT RIC containing the requested REPORT information along with the originating Request ID. Step 4 includes: Associated procedure instance continues in the E2 Node, including any subsequent RIC actions.

[0082] As mentioned above with reference to table 1, there are 5 RIC REPORT service styles supported by the current specification. Wherein the REPORT Service style 1 provides the performance measurement information collection from an E2 Node. This REPORT Service style aims to subscribe to the measurements defined in TS 28.552 and TS 32.425, and uses the RIC Action Definition IE Format 1.

[0083] The REPORT Service RIC Action Definition IE contains measurement types that Near-RT RIC is requesting to subscribe followed by a list of subcounters to be measured for each measurement type, and a granularity period indicating collection interval of those measurements.

[0084] For the measurement types that belong to a measurement object class confined in a single cell (e.g. "EUtranCellFDD" in TS 32.425 [8] or "NRCellDU" in TS 28.552), the Cell Global ID IE shall be included in the IE to point to a specific cell for collecting measurements within the E2 Node. The Cell Global ID IE may not be included if all the subscribed measurement types are cell agnostic, i.e. belonging to measurement object classes not confined in a single cell (e.g. "GNBCUUPFunction" in TS 28.552). In case that both single-cell-confined and cell agnostic measurement types

are subscribed together, the Cell Global ID IE shall be included in the IE and the E2 Node shall ignore the included Cell Global ID IE for those cell agnostic measurement types.

[0085] A measurement ID can be used for subscription instead of a measurement type if an identifier of a certain measurement type was exposed by an E2 Node via the RAN Function Definition IE.

[0086] The REPORT Service style 1 uses the RIC Indication Header IE Format 1, which contains a measurement collection start time as UTC format. The REPORT Service RIC Indication Header IE may carry file format version, sender name, sender type, and vendor name as printable strings.

[0087] The REPORT Service style 1 uses the RIC Indication Message IE Format 1.

[0088] The REPORT Service RIC Indication Message IE carries a set of measurement data reported from an E2 Node. The reported data contains a set of measurement records, each collected at every granularity period during the reporting period. In case the E2 Node is not able to provide reliable data for a granularity period during the reporting period, it may include the optional Incomplete Flag IE, which indicates that the corresponding measurements record in the reported data is not reliable.

[0089] The REPORT Service RIC Indication Message IE optionally carries subscription information, i.e. Measurement Information List IE that indicates the order of measured values for each measurement record in the reported data, or their granularity period. If not present, the original subscription information shall apply.

[0090] The RIC Indication Message IE is part of the RIC INDICATION message sent by the E2 Node to the Near-RT RIC and is required for REPORT action. It is shown in table 3.

Table 3 (Direction: E2 Node → NEAR-RT RIC)

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CHOICE *Indication Message Format*				
>E2SM-KPM Indication Message Format 1	M		8.2.1.4.1	

>E2SM-KPM Indication Message Format 2	M		8.2.1.4.2	
>E2SM-KPM Indication Message Format 3	M		8.2.1.4.3	

[0091] The RAN Function Definition IE is part of the E2 SETUP REQUEST, and RIC SERVICE UPDATE message sent by the E2 Node to the Near-RT RIC and is used to provide all required information for the Near-RT RIC to determine how a given E2 Node has been configured to support a given RAN Function specific E2SM. It is shown in table 4.

Table 4 (Direction: E2 Node → NEAR-RT RIC)

IE/Group Name	Presence	Range	IE type and reference	Semantics description
RAN Function Name	M		8.3.2	
Sequence of Event Trigger styles		*0.. <maxnoofRICStyles>*		
>RIC Event Trigger Style Type	M		8.3.3	
>RIC Event Trigger Style Name	M		8.3.4	
>RIC Event Trigger Format Type	M		8.3.5	
Sequence of Report styles		*0.. <maxnoofRICStyles>*		
>RIC Report Style Type	M		8.3.3	
>RIC Report Style Name	M		8.3.4	
>RIC Report Action Format Type	M		8.3.5	
>Sequence of Measurement Info for Action		*1.. <maxnoofMeasurement Info>*		
>>Measurement Type Name	M		8.3.9	
>>Measurement Type ID	O		8.3.10	
>>Bin Range Definition	O		8.3.26	Indicates the value ranges of bins for distribution type measurement
>RIC Indication Header Format Type	M		8.3.5	Indication header type used by Report style
>RIC Indication Message Format Type	M		8.3.5	Indication message type used by Report

				style

[0092] However, since an E2 node can have large number of cells (with maximum 16384 cells in an E2 node), and each cell can again have several tens to a few hundreds of KPM measurement objects, it needs considering how to support multi-cell KPM reporting. The gravity of the problem and the gaps in the current solution are quite significant. Therefore, the following issues should be considered.

[0093] The first issue is how to support multi-cell KPM reporting with same measurement requirements without change to a single cell handling mechanism in the Near-RT RIC and the E2 node. In current specification, each RIC subscription can only pertain to a given cell, which will produce huge number of RIC subscription request in case of multi-cell KPM reporting.

[0094] Accordingly, some embodiments of the present disclosure propose a solution: defining a new E2SM-KPM REPORT service style type and the corresponding new E2SM-KPM action definition format, used to obtain the measurement reports for multiple cells with the same measurement requirements from a target E2 node in one single RIC subscription request message.

[0095] The new E2SM-KPM REPORT service style is identified by a unique identifier of RIC style type, and the new E2SM-KPM REPORT service style provides the performance measurement information for multiple cells with the same measurement requirements from an E2 node.

[0096] The new E2SM-KPM action definition is identified by a unique identifier of RIC format type, and the new E2SM-KPM action definition contains measurement requirements that the Near-RT RIC is requesting to subscribe, and the IDs of the cells within the E2 node where the cells are requested to report with the same measurement requirements.

[0097] The Near-RT RIC obtains the identifier of the new E2SM-KPM REPORT service style type and the identifier of the new E2SM-KPM action definition format for multiple cells with the same measurement requirements that the E2 node supports through the E2 setup procedure and/or RIC service update procedure. The identifier of the new E2SM-KPM REPORT service style type and the identifier of the new E2SM-

KPM action definition format for multiple cells with the same measurement requirements are included in the RAN function definition IE.

[0098] The second issue is how to support multi-cell KPM reporting in one single RIC indication message. In current specification, each RIC indication message includes the measurement results for a single cell only.

[0099] Accordingly, some embodiments of the present disclosure propose a solution: defining a new E2SM-KPM indication message format, used to carry the measurement reports for multiple cells.

[0100] The new E2SM-KPM indication message format is identified by a unique identifier of RIC format type, and the new E2SM-KPM indication message contains the measurement value for each cell.

[0101] The Near-RT RIC obtains the identifier of the new E2SM-KPM indication message format that the E2 node supports through the E2 setup procedure and/or RIC service update procedure. The identifier of the new E2SM-KPM indication message format is included in the RAN function definition IE.

[0102] The third issue is how to support separate KPM reporting for a separate cell (or a set of cells) when multiple cells are requested in one single RIC subscription request message.

[0103] Accordingly, some embodiments of the present disclosure propose a solution: introducing a reporting method/manner in the new E2SM-KPM REPORT service style type, used to indicate the measurement report for the cell should be sent to the Near-RT RIC as a separate report or an integrated report. The reporting method/manner has an enumerated value of separate, which indicates the measurement report for the cell should be sent as a separate report. And introducing a reporting group containing the IDs of the set of cells where the measurement reports for the set of cells should be sent as an integrated report. That is, the measurement reports for other cells out of the reporting group should not be sent using the same integrated report for the cells within the reporting group.

[0104] The fourth issue is how to support multi-cell KPM reporting with different measurement requirements. In current specification, each RIC subscription can only pertain to a given cell, which will produce huge number of RIC subscription request in

case of multi-cell KPM reporting. In addition, the O-RAN specifies that the E2 node shall send RIC indication message using the same TNLA (transport network layer association) as the RIC subscription. However, since the maximum number of TNLA supported by the E2 node is 32, the legacy solution could not support the multi-cell KPM reporting when the number of interesting cells is larger than 32.

[0105] Accordingly, some embodiments of the present disclosure propose a solution: defining a new E2SM-KPM REPORT service style type and the corresponding new E2SM-KPM action definition format, used to obtain the measurement reports for multiple cells with different measurement requirements from a target E2 node in one single RIC subscription request message.

[0106] The new E2SM-KPM REPORT service style is identified by a unique identifier of RIC style type, and the new E2SM-KPM REPORT service style provides the performance measurement information for multiple cells with different measurement requirements from an E2 node.

[0107] The new E2SM-KPM action definition is identified by a unique identifier of RIC format type, and the new E2SM-KPM action definition contains the multiple cell IDs, where each cell ID is associated with the corresponding measurement requirements that the Near-RT RIC is requesting to subscribe.

[0108] The Near-RT RIC obtains the identifier of the new E2SM-KPM REPORT service style type and the identifier of the new E2SM-KPM action definition format for multiple cells with different measurement requirements that the E2 node supports through the E2 setup procedure and/or RIC service update procedure. The identifier of the new E2SM-KPM REPORT service style type and the identifier of the new E2SM-KPM action definition format for multiple cells with different measurement requirements are included in the RAN function definition IE.

[0109] In one aspect of the solution of the present disclosure, a first network device transmits, via the transceiver and to a second network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting. The first network device

receives, via the transceiver and from the second network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting. In this way, the solutions of the present disclosure can support multi-cell KPM reporting, and the signaling load for reporting can be reduced, and the efficiency of reporting is greatly improved.

[0110] FIG. 2 illustrates an example signaling chart illustrating an example process 200 that supports multi-cell KPM reporting in O-RAN in accordance with aspects of the present disclosure. The process 200 may involve a first network device 210 and a second network device 220. The first network device 210 may be a Near-RT RIC, and the second network device 220 may be an E2 node.

[0111] In the example process 200, the first network device 210 transmits 222, via the transceiver and to the second network device 220, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition 223, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting. Correspondingly, the second apparatus 220 receives 224, via the transceiver and from the first network device 210, the identifier (ID) of the E2SM-KPM report service style and the at least one value of the E2SM-KPM action definition 223. Then, the second apparatus 220 transmits 226, via the transceiver and to the first network device 210, one or more measurement reports for at least one cell using an E2SM-KPM indication message 227, wherein the E2SM-KPM indication message 227 is for multi-cell KPM reporting. Correspondingly, the first network device 210 receives 228, via the transceiver and from the second network device 220, the one or more measurement reports.

[0112] In some embodiments, the identifier (ID) of the E2SM-KPM report service style and the at least one value of the E2SM-KPM action definition 223 may be transmitted via an RIC SUBSCRIPTION REQUEST message. In some embodiments, the identifier (ID) of the E2SM-KPM report service style and the at least one value of the E2SM-KPM action definition 223 may be transmitted via other messages, for example, an RIC SUBSCRIPTION MODIFICATION REQUEST message.

[0113] In some embodiments, the one or more measurement reports carried by the E2SM-KPM indication message 227 may be transmitted via an RIC INDICATION message.

[0114] In some embodiments, for multi-cell KPM reporting, a new E2SM-KPM REPORT service style type is defined. The new E2SM-KPM report service style may be associated with a radio access network (RAN) intelligent controller (RIC) style type ID and a RIC style name. The ID of the E2SM-KPM report service style may be the RIC style type ID. Below table 5 is an example of the "E2SM-KPM" service model supporting multi-cell KPM reporting with same measurement requirements, where the 6 of the RIC style type is the identifier and the "E2 Node Measurement for multiple cells with same measurement requirements" of the style name is the name.

Table 5

RIC Style Type	Style Name	Style Type Description
1	E2 Node Measurement	Used to carry measurement report from a target E2 Node
2	E2 Node Measurement for a single UE	Used to carry measurement report for a single UE of interest from a target E2 Node
3	Condition-based, UE-level E2 Node Measurement	Used to carry UE-level measurement report for a group of UEs per measurement type matching subscribed conditions from a target E2 Node
4	Common Condition-based, UE-level Measurement	Used to carry measurement report for a group of UEs across a set of measurement types satisfying common subscribed conditions from a target E2 Node
5	E2 Node Measurement for multiple UEs	Used to carry measurement report for multiple UE of interest from a target E2 Node
6	**E2 Node Measurement for multiple cells with same measurement requirements**	**Used to carry measurement report for multiple cells with same measurement requirements from a target E2 Node**

[0115] Below table 6 is an example of the "E2SM-KPM" service model supporting multi-cell KPM reporting with different measurement requirements, where the 7 of the RIC style type is the identifier and the "E2 Node Measurement for multiple cells with different measurement requirements" of the style name is the name.

Table 6

RIC Style Type	Style Name	Style Type Description

1	E2 Node Measurement	Used to carry measurement report from a target E2 Node
2	E2 Node Measurement for a single UE	Used to carry measurement report for a single UE of interest from a target E2 Node
3	Condition-based, UE-level E2 Node Measurement	Used to carry UE-level measurement report for a group of UEs per measurement type matching subscribed conditions from a target E2 Node
4	Common Condition-based, UE-level Measurement	Used to carry measurement report for a group of UEs across a set of measurement types satisfying common subscribed conditions from a target E2 Node
5	E2 Node Measurement for multiple UEs	Used to carry measurement report for multiple UE of interest from a target E2 Node
7	**E2 Node Measurement for multiple cells with different measurement requirements**	**Used to carry measurement report for multiple cells with different measurement requirements from a target E2 Node**

[0116] In some embodiments, for multi-cell KPM reporting, a corresponding new E2SM-KPM action definition format is further defined. The E2SM-KPM action definition may be identified by an E2SM-KPM action definition format ID. The E2SM-KPM action definition may include: a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted to the first network device as an integrated report.

[0117] Below table 7 is an example of the new E2SM-KPM action definition format for multi-cell KPM reporting with the same measurement requirements, where the "6" is the identifier of the new E2SM-KPM action definition format. The measurement requirements may include the measurement type (e.g., measurement name, measurement ID), label information and granularity period.

Table 7 E2SM-KPM Action Definition Format **6**

IE/Group Name	Semantics description
List of Subscribed Cell IDs	Points to a list of cells of interest
>Cell ID	Globally unique identifier of a cell in the E2 node.
>>Reporting Method	Indicates the measurement report for the cell should be sent as a separate report or an integrated report.
Measurement Requirements	
>Measurement Information List	
>>CHOICE *Measurement Type*	
>>>Measurement Name	The name of a given measurement type, such as Average delay DL

	(Downlink) air-interface, Average RLC packet delay in the UL, DL total PRB (Physical Resource Block) usage. The detailed description of measurement name is in 3GPP TS28.552, 3GPP TS38.425 and O-RAN E2SM-KPM.
>>>Measurement ID	The identifier of a given measurement type.
>>List of Labels	
>>>Label Information	Necessary sub-counters applicable to an associated measurement type, such as slice ID, 5QI (5G Quality of service Identifier), QCI (Quality of service Class Identifier). The detailed description of label information is in O-RAN E2SM-KPM.
>Granularity Period	Collection interval of measurements
Reporting Group	Points to a set of cells where the measurement reports should be sent as an integrated report.

[0118] Following table 8 is an example of the new E2SM-KPM action definition format for the multi-cell KPM reporting with different measurement requirements. The "7" is the identifier of the new E2SM-KPM action definition format for the multi-cell KPM reporting with different measurement requirements.

Table 8 E2SM-KPM Action Definition Format **7**

IE/Group Name	**Semantics description**
List of Subscribed Measurement Reports	Points to a list of cells and the corresponding measurement requirements for each cell
>Cell ID	Globally unique identifier of a cell in the E2 node.
>Reporting Method	Indicates the measurement report for the cell should be sent as a separate report or an integrated report.
>Measurement Requirements	
>>Measurement Information List	
>>>CHOICE *Measurement Type*	
>>>>Measurement Name	The name of a given measurement type, such as Average delay DL air-interface, Average RLC packet delay in the UL, DL total PRB usage. The detailed description of measurement name is in 3GPP TS28.552, 3GPP TS38.425 and O-RAN E2SM-KPM.
>>>>Measurement ID	The identifier of a given measurement type.
>>>List of Labels	
>>>>Label Information	Necessary sub-counters applicable to an associated measurement type, such as slice ID, 5QI, QCI. The detailed description of label information is in O-RAN E2SM-KPM.
>>Granularity Period	Collection interval of measurements
Reporting Group	Points to a set of cells where the measurement reports should be sent as an integrated report.

[0119] In some embodiments, for multi-cell KPM reporting, a new E2SM-KPM indication message format is further defined. The E2SM-KPM indication message may be identified by an E2SM-KPM indication message format ID. The E2SM-KPM action definition may be associated with the E2SM-KPM report service style. Below table 9 is an example of the new E2SM-KPM indication message format, where the "4" is the identifier of the new E2SM-KPM indication message format.

Table 9 E2SM-KPM Indication Message Format **4**

IE/Group Name	Semantics description
List of Cell Measurement Reports	
>Cell ID	
>Measurement Report	Contains Measurement Data for a cell for a Reporting Period.

[0120] The E2SM-KPM indication message may include an ID of at least one cell, and a measurement report for the at least one cell. In other words, the new E2SM-KPM indication message contains the measurement report for each cell. For example, for multi-cell KPM reporting with the same measurement requirements, the RIC SUBSCRIPTION REQUEST message (which contains the new E2SM-KPM action definition format) contains the following information as in table 10, where the measurement value for the cell 1 should be sent as a separate report, and the measurement value for the cell 2 and cell 3 should be sent in one integrated report.

Table 10

6
Cell 1, separate, Cell 2, Cell 3, Cell 4, Cell 5, Cell 6
DL total PRB usage
Slice ID 1
1000ms
Reporting Group 1 <Cell 2, Cell 3>

[0121] For example, for multi-cell KPM reporting with the different measurement requirements, the RIC SUBSCRIPTION REQUEST message (which contains the new E2SM-KPM action definition format) contains the following information as in table 11,

where the measurement value for the cell 1 should be sent as a separate report, and the measurement value for the cell 2 and cell 3 should be sent in one integrated report.

Table 11

7
Cell 1, Average delay DL air-interface, Slice ID 1, 1000ms, Separate
Cell 2, DL total PRB usage, Slice ID 2, 2000ms
Cell 3, Average RLC packet delay in the UL, Slice ID 3, 1000ms
Cell 4, Average DL UE throughput, Slice ID 4, 3000ms
Reporting Group 1 <Cell 2, Cell 3>

[0122] In some embodiments, the E2SM-KPM action definition may be for multi-cell KPM reporting with the same measurement requirements, and the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements may be for at least two cells, and includes the measurement requirements applied to the at least two cells.

[0123] In some embodiments, the E2SM-KPM report service style may be for multi-cell KPM reporting with the same measurement requirements, and the E2SM-KPM report service style for multi-cell KPM reporting with the same measurement requirements may be for at least two cells.

[0124] In some embodiments, the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements may further include one of the following: a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted to the first network device as an integrated report.

[0125] In some embodiments, the E2SM-KPM action definition may be for multi-cell KPM reporting with different measurement requirements, and the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements may be for at least two cells, and includes the measurement requirements for each of the at least two cells.

[0126] In some embodiments, the E2SM-KPM report service style may be for multi-cell KPM reporting with different measurement requirements, and the E2SM-KPM report service style for multi-cell KPM reporting with different measurement requirements may be for at least two cells.

[0127] In some embodiments, the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements may further include one of the following: a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted as an integrated report.

[0128] In some embodiments, the first network device 210 may receive, via the transceiver and from the second network device 220, a RAN function definition, and the RAN function definition is for multi-cell KPM reporting. In some embodiments, the RAN function definition may be received via an E2 SETUP REQUEST message. Alternatively, the RAN function definition may be received via other messages, e.g., an RIC SERVICE UPDATE message.

[0129] In some embodiments, the RAN function definition may include one of the following: a RIC style name of the E2SM-KPM report service style; a RIC style type ID of the E2SM-KPM report service style; an ID of the E2SM-KPM action definition format; or an ID of the E2SM-KPM indication message format.

[0130] In view of above, the following methods are proposed in the disclosure:

[0131] First, to define a new E2SM-KPM REPORT service style type and the corresponding new E2SM-KPM action definition format, used to obtain the measurement reports for multiple cells with the same measurement requirements. The new E2SM-KPM REPORT service style is identified by a unique identifier of RIC style type, and the new E2SM-KPM REPORT service style provides the performance measurement information for multiple cells with the same measurement requirements from an E2 node. The new E2SM-KPM action definition is identified by a unique identifier of RIC format type, and the new E2SM-KPM action definition contains measurement requirements that the Near-RT RIC is requesting to subscribe, and the IDs

of the cells within the E2 node where the cells are requested to report with the same measurement requirements.

[0132] Second, to define a new E2SM-KPM indication message format to support multi-cell KPM reporting in one single RIC indication message. The new E2SM-KPM indication message format is identified by a unique identifier of RIC format type, and the new E2SM-KPM indication message contains the measurement value for each cell.

[0133] Third, to introduce a reporting method in the new E2SM-KPM REPORT service style type, used to support separate KPM reporting for a separate cell (or a set of cells) when multiple cells are requested in one single RIC subscription request message. The reporting method has an enumerated value of separate, which indicates the measurement report for the cell should be sent as a separate report. Introduce a reporting group containing the IDs of the set of cells where the measurement reports for the set of cells should be sent as an integrated report. That is, the measurement reports for other cells out of the reporting group should not be sent using the same integrated report for the cells within the reporting group.

[0134] Fourth, to define a new E2SM-KPM REPORT service style type and the corresponding new E2SM-KPM action definition format, used to obtain the measurement reports for multiple cells with different measurement requirements. The new E2SM-KPM REPORT service style is identified by a unique identifier of RIC style type, and the new E2SM-KPM REPORT service style provides the performance measurement information for multiple cells with different measurement requirements from an E2 node. The new E2SM-KPM action definition is identified by a unique identifier of RIC format type, and the new E2SM-KPM action definition contains the multiple cell IDs, where each cell ID is associated with the corresponding measurement requirements that the Near-RT RIC is requesting to subscribe.

[0135] In this way, multi-cell KPM reporting can be supported, the signaling load for reporting can be reduced, and the efficiency of reporting is greatly improved.

[0136] FIG. 3 illustrates an example signaling chart illustrating multi-cell KPM reporting with same measurement requirements.

[0137] At step 301, the E2 node transmits the RAN Function Definition for multi-cell KPM reporting with the same measurement requirements to the Near-RT RIC by

transmitting the E2 SETUP REQUEST message. It is noted that, the E2 node may transmit the RAN Function Definition for multi-cell KPM reporting with the same measurement requirements to the Near-RT RIC via other messages, e.g., RIC SERVICE UPDATE message.

[0138] The RAN Function Definition for multi-cell KPM reporting with the same measurement requirements includes the following information:

[0139] 1. The name and the identifier of the new E2SM-KPM REPORT service style for the multi-cell KPM reporting with the same measurement requirements. Table 5 above is an example, where the 6 of the RIC style type is the identifier and the "E2 Node Measurement for multiple cells with same measurement requirements" of the style name is the name.

[0140] 2. The identifier of the new E2SM-KPM action definition format, where the new E2SM-KPM action definition contains measurement requirements that the Near-RT RIC is requesting to subscribe, and the IDs of the cells within the E2 node where the cells are requested to report with the same measurement requirements. The new E2SM-KPM action definition format for multi-cell KPM reporting with the same measurement requirements may further includes at least one of the following information: 1) reporting method/manner which indicates that the measurement report for the cell should be sent to the Near-RT RIC as a separate report or an integrated report; 2) reporting group which indicates that the measurement report for the set of cells in the reporting group should be sent as an integrated report. That is, the measurement reports for other cells out of the reporting group should not be sent using the same integrated report for the cells within the reporting group. Table 7 above is an example of the new E2SM-KPM action definition format for multi-cell KPM reporting with the same measurement requirements, where the 6 is the identifier of the new E2SM-KPM action definition format. The measurement requirements may include the measurement type (e.g., measurement name, measurement ID), label information and granularity period.

[0141] 3. The identifier of the new E2SM-KPM indication message format, where the new E2SM-KPM indication message contains the measurement report for each cell. Table 9 above is an example of the new E2SM-KPM indication message format, where the 4 is the identifier of the new E2SM-KPM indication message format.

[0142] At step 302, the Near-RT RIC replies with the E2 SETUP RESPONSE message. It is noted that if the step is a RIC SERVICE UPDATE message, the Near-RT RIC replies with a RIC SERVICE UPDATE ACKNOWLEDGE message.

[0143] At step 303, if the Near-RT RIC wants to obtain the KPM report, the Near-RT RIC transmits the RIC SUBSCRIPTION REQUEST message to the target E2 node, containing the identifier and values of the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements. It is noted that, the Near-RT RIC may send the value of E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements to the E2 node via other messages, e.g., RIC SUBSCRIPTION MODIFICATION REQUEST message.

[0144] For example, the RIC SUBSCRIPTION REQUEST message contains the information as in table 10 above, where the measurement value for the cell 1 should be sent as a separate report, and the measurement value for the cell 2 and cell 3 should be sent in one integrated report.

[0145] At reception of the RIC SUBSCRIPTION REQUEST message, at step 304, the E2 node sends the RIC SUBSCRIPTION RESPONSE message back to the Near-RT RIC. It is noted that, if the step 303 is a RIC SUBSCRIPTION MODIFICATION REQUEST message, the E2 node sends a RIC SUBSCRIPTION MODIFICATION RESPONSE message.

[0146] At step 305, the E2 node performs the measurement for the multiple cells.

[0147] At step 306, the E2 node sends the RIC INDICATION message to the Near-RT RIC, containing the measurement report for each cell using the E2SM-KPM indication message format 4. In one example, if there is not reporting method/manner with separate and reporting group, the RIC INDICATION message includes the measurement reports for all the cells included in the E2SM-KPM action definition format 6. In another example, if there is the reporting method/manner with separate for the cell, the RIC INDICATION message includes the measurement report for the cell as a separate report. In another example, if there is the reporting group with a set of cells, the RIC INDICATION message includes the measurement reports for the set of cells as an integrated report.

[0148] Take the values of the RIC SUBSCRIPTION REQUEST message in the step 303 as an example (as in table 10). The E2 node shall: transmit a first RIC INDICATION message to the Near-RT RIC, including the measurement report of cell 1; transmit a second RIC INDICATION message to the Near-RT RIC, including the measurement report of cell 2 and the measurement report of cell 3; transmit a third RIC INDICATION message to the Near-RT RIC, including the measurement report of cell 4, the measurement report of cell 5 and the measurement report of cell 6.

[0149] In view of above, the solution provided by the embodiment described with reference of FIG. 3 can support multi-cell KPM reporting with same measurement requirements without change to a single cell handling mechanism in the Near-RT RIC and the E2 node, and the signaling load for reporting can be reduced, and the efficiency of reporting is greatly improved.

[0150] FIG. 4 illustrates an example signaling chart illustrating multi-cell KPM reporting with different measurement requirements.

[0151] At step 401, the E2 node transmits the RAN Function Definition for multi-cell KPM reporting with different measurement requirements to the Near-RT RIC by transmitting the E2 SETUP REQUEST message. It is noted that, the E2 node may send the RAN Function Definition for multi-cell KPM reporting with different measurement requirements to the Near-RT RIC via other messages, e.g., RIC SERVICE UPDATE message.

[0152] The RAN Function Definition for multi-cell KPM reporting with different measurement requirements includes the following information:

[0153] 1. The name and the identifier of the new E2SM-KPM REPORT service style for the multi-cell KPM reporting with different measurement requirements. Table 6 above is an example, where the 7 of the RIC style type is the identifier and the "E2 Node Measurement for multiple cells with different measurement requirements" of the style name is the name.

[0154] 2. The identifier of the new E2SM-KPM action definition format, where the new E2SM-KPM action definition contains the IDs of the cells and the measurement requirements for each cell. The new E2SM-KPM action definition format for multi-cell KPM reporting with different measurement requirements may further includes at least

one of the following information: 1) reporting method/manner, which indicates the measurement report for the cell should be sent to the Near-RT RIC as a separate report or an integrated report; 2) reporting group, which indicates the measurement report for the set of cells in the reporting group should be sent as an integrated report. That is, the measurement reports for other cells out of the reporting group should not be sent using the same integrated report for the cells within the reporting group. Above table 8 is an example of the new E2SM-KPM action definition format for the multi-cell KPM reporting with different measurement requirements. The 7 is the identifier of the new E2SM-KPM action definition format for the multi-cell KPM reporting with different measurement requirements.

[0155] 3. The identifier of the new E2SM-KPM indication message format, where the new E2SM-KPM indication message contains the measurement report for each cell, as illustrated in the embodiment of FIG. 3. Table 9 above is an example of the new E2SM-KPM indication message format, where the 4 is the identifier of the new E2SM-KPM indication message format.

[0156] At step 402, the Near-RT RIC replies with the E2 SETUP RESPONSE message. It is noted that, if the step is a RIC SERVICE UPDATE message, the Near-RT RIC replies with a RIC SERVICE UPDATE ACKNOWLEDGE message.

[0157] At step 403, if the Near-RT RIC wants to obtain the KPM report, the Near-RT RIC sends the RIC SUBSCRIPTION REQUEST message to the target E2 node, containing the identifier and values of the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements. It is noted that, the Near-RT RIC may send the value of E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements to the E2 node via other messages, e.g., RIC SUBSCRIPTION MODIFICATION REQUEST message. For example, the RIC SUBSCRIPTION REQUEST message contains the information as in above table 11, where the measurement value for the cell 1 should be sent as a separate report, and the measurement value for the cell 2 and cell 3 should be sent in one integrated report.

[0158] At reception of the RIC SUBSCRIPTION REQUEST message, at step 404, the E2 node transmits the RIC SUBSCRIPTION RESPONSE message back to the Near-RT RIC. It is noted that, if the step 403 is a RIC SUBSCRIPTION

MODIFICATION REQUEST message, the E2 node transmits a RIC SUBSCRIPTION MODIFICATION RESPONSE message.

[0159] At step 405, the E2 node performs the measurement for the multiple cells.

[0160] At step 406, the E2 node transmits the RIC INDICATION message to the Near-RT RIC, containing the measurement report for each cell using the E2SM-KPM indication message format 4. In one example, if there is not reporting method/manner with separate and reporting group, the RIC INDICATION message includes the measurement reports for all the cells included in the E2SM-KPM action definition format 7. In another example, if there is the reporting method/manner with separate for the cell, the RIC INDICATION message includes the measurement report for the cell as a separate report. In another example, if there is the reporting group with a set of cells, the RIC INDICATION message includes the measurement reports for the set of cells as an integrated report.

[0161] Take the values of the RIC SUBSCRIPTION REQUEST message in the step 403 as example (as in table 11). The E2 node shall: transmit a first RIC INDICATION message to the Near-RT RIC, including the measurement report of cell 1; transmit a second RIC INDICATION message to the Near-RT RIC, including the measurement report of cell 2 and the measurement report of cell 3; transmit a third RIC INDICATION message to the Near-RT RIC, including the measurement report of cell 4.

[0162] In view of above, the solution provided by the embodiment described with reference of FIG. 4 can support multi-cell KPM reporting with different measurement requirements without change to a single cell handling mechanism in the Near-RT RIC and the E2 node, and the signaling load for reporting can be reduced, and the efficiency of reporting is greatly improved.

[0163] FIG. 5 illustrates an example of a device 500 that supports multi-cell KPM reporting in accordance with aspects of the present disclosure. The device 500 may be an example of a first network device 210 or a Near-RT RIC as described herein. The device 500 may support wireless communication with one or more network entities 102, UEs 104, 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).

[0164] 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.

[0165] 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).

[0166] 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, via the transceiver and to a second network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting; and receiving, via the transceiver and from the second network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting. Therefore, the efficiency of KPM reporting in O-RAN is improved.

The processor 502 may be further configured to operable to support a means for other actions described in FIG 2.

[0167] 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.

[0168] 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.

[0169] 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 506. In some implementations, a user may interact with the device 500 via the I/O controller 508 or via hardware components controlled by the I/O controller 508.

[0170] 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 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 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.

[0171] A transmit chain may be configured to generate and transmit signals (e.g., control information, data, packets). The transmit chain may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmit chain may also include one or more antennas 510 for transmitting the amplified signal into the air or wireless medium.

[0172] A receive chain may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receive chain may include one or more antennas 510 for receive the signal over the air or wireless medium. The receive chain may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receive chain may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receive chain may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0173] FIG. 6 illustrates an example of a device 600 that supports multi-cell KPM reporting in accordance with aspects of the present disclosure. The device 600 may be an example of a second network device 220 or an E2 node as described herein. The device 600 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 600 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 602, a memory 604, a transceiver 606, and, optionally, an I/O controller 608. 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).

[0174] The processor 602, the memory 604, the transceiver 606, 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 602, the memory 604, the transceiver 606, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0175] In some implementations, the processor 602, the memory 604, the transceiver 606, 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 602 and the memory 604 coupled with the processor 602 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 602, instructions stored in the memory 604).

[0176] For example, the processor 602 may support wireless communication at the device 600 in accordance with examples as disclosed herein. The processor 602 may be configured to operable to support a means for receiving, via the transceiver and from a first network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-

KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting; and transmitting, via the transceiver and to the first network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting. The processor 602 may be further configured to operable to support a means for other actions described in FIGS. 2-4.

[0177] The processor 602 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 602 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 602. The processor 602 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 604) to cause the device 600 to perform various functions of the present disclosure.

[0178] The memory 604 may include random access memory (RAM) and read-only memory (ROM). The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 602 cause the device 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 602 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 604 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.

[0179] The I/O controller 608 may manage input and output signals for the device 600. The I/O controller 608 may also manage peripherals not integrated into the device M02. In some implementations, the I/O controller 608 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 608 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 608 may be implemented as part of a processor, such as the processor 606. In some implementations, a user may interact with the device 600 via the I/O controller 608 or via hardware components controlled by the I/O controller 608.

[0180] In some implementations, the device 600 may include a single antenna 610. However, in some other implementations, the device 600 may have more than one antenna 610 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 606 may communicate bi-directionally, via the one or more antennas 610, wired, or wireless links as described herein. For example, the transceiver 606 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 606 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 610 for transmission, and to demodulate packets received from the one or more antennas 610. The transceiver 606 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0181] A transmit chain may be configured to generate and transmit signals (e.g., control information, data, packets). The transmit chain may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmit chain may also include one or more antennas 610 for transmitting the amplified signal into the air or wireless medium.

[0182] A receive chain may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receive chain may include one or more antennas 610 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.

[0183] FIG. 7 illustrates an example of a processor 700 that supports multi-cell KPM reporting in accordance with aspects of the present disclosure. The processor 700 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 700 may include a controller 702 configured to perform various operations in accordance with examples as described herein. The processor 700 may optionally include at least one memory 704. Additionally, or alternatively, the processor 700 may optionally include one or more arithmetic-logic units (ALUs) 700. 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).

[0184] The processor 700 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 700) 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).

[0185] The controller 702 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 700 to cause the processor 700 to support various operations in accordance with examples as described herein. For example, the controller 702 may operate as a control unit of the processor 700, generating control signals that manage the operation of various components of the processor 700. These control signals include enabling or

disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0186] The controller 702 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 704 and determine subsequent instruction(s) to be executed to cause the processor 700 to support various operations in accordance with examples as described herein. The controller 702 may be configured to track memory address of instructions associated with the memory 704. The controller 702 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 702 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 700 to cause the processor 700 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 702 may be configured to manage flow of data within the processor 700. The controller 702 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 700.

[0187] The memory 704 may include one or more caches (e.g., memory local to or included in the processor 700 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 704 may reside within or on a processor chipset (e.g., local to the processor 700). In some other implementations, the memory 704 may reside external to the processor chipset (e.g., remote to the processor 700).

[0188] The memory 704 may store computer-readable, computer-executable code including instructions that, when executed by the processor 700, cause the processor 700 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 702 and/or the processor 700 may be configured to execute computer-readable instructions stored in the memory 704 to cause the processor 700 to perform various functions (e.g., functions or tasks supporting transmit power prioritization). For example, the processor 700 and/or the controller 702 may be coupled with or to the memory 704, the processor 700, the controller 702, and the memory 704 may be configured to perform various functions described herein. In some examples, the processor 700 may include multiple processors and the memory 704 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.

[0189] The one or more ALUs 700 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 700 may reside within or on a processor chipset (e.g., the processor 700). In some other implementations, the one or more ALUs 700 may reside external to the processor chipset (e.g., the processor 700). One or more ALUs 700 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 700 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 700 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 700 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 700 to handle conditional operations, comparisons, and bitwise operations.

[0190] The processor 700 may support wireless communication in accordance with examples as disclosed herein. The processor 702 may be configured to or operable to support a means for transmitting, via the transceiver and to a second network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting; and receiving, via the transceiver and from the second network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting. The processor 502 may be further configured to operable to support a means for other actions described in FIGS. 2-4.

[0191] FIG. 8 illustrates an example of a processor 800 that supports control resource set transmission in accordance with aspects of the present disclosure. The processor 800 may be an example of a processor configured to perform various

operations in accordance with examples as described herein. The processor 800 may include a controller 802 configured to perform various operations in accordance with examples as described herein. The processor 800 may optionally include at least one memory 804. Additionally, or alternatively, the processor 800 may optionally include one or more arithmetic-logic units (ALUs) 800. 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).

[0192] The processor 800 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 800) 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).

[0193] The controller 802 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 800 to cause the processor 800 to support various operations in accordance with examples as described herein. For example, the controller 802 may operate as a control unit of the processor 800, generating control signals that manage the operation of various components of the processor 800. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0194] The controller 802 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 804 and determine subsequent instruction(s) to be executed to cause the processor 800 to support various operations in accordance with examples as described herein. The controller 802 may be configured to track memory address of instructions associated with the memory 804. The controller 802 may be

configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 802 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 800 to cause the processor 800 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 802 may be configured to manage flow of data within the processor 800. The controller 802 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 800.

[0195] The memory 804 may include one or more caches (e.g., memory local to or included in the processor 800 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 804 may reside within or on a processor chipset (e.g., local to the processor 800). In some other implementations, the memory 804 may reside external to the processor chipset (e.g., remote to the processor 800).

[0196] The memory 804 may store computer-readable, computer-executable code including instructions that, when executed by the processor 800, cause the processor 800 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 802 and/or the processor 800 may be configured to execute computer-readable instructions stored in the memory 804 to cause the processor 800 to perform various functions (e.g., functions or tasks supporting transmit power prioritization). For example, the processor 800 and/or the controller 802 may be coupled with or to the memory 804, the processor 800, the controller 802, and the memory 804 may be configured to perform various functions described herein. In some examples, the processor 800 may include multiple processors and the memory 804 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.

[0197] The one or more ALUs 800 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 800 may reside within or on a processor chipset (e.g., the processor 800). In some other implementations, the one or more ALUs 800 may reside external to the

processor chipset (e.g., the processor 800). One or more ALUs 800 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 800 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 800 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 800 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 800 to handle conditional operations, comparisons, and bitwise operations.

[0198] The processor 800 may support wireless communication in accordance with examples as disclosed herein. The processor 802 may be configured to or operable to support a means for receiving, via the transceiver and from a first network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting; and transmitting, via the transceiver and to the first network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting. The processor 602 may be further configured to operable to support a means for other actions described in FIGS. 2-4.

[0199] FIG. 9 illustrates a flowchart of a method 900 that supports multi-cell KPM reporting 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 a first network device 210 or a Near-RT RIC as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0200] At 905, the method includes transmitting, via the transceiver and to a second network device, an identifier (ID) of an E2 service model key performance

measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting. The operations of 905 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 905 may be performed by a device as described with reference to FIG. 1A.

[0201] At 910, the method includes receive, via the transceiver and from the second network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting. 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 a device as described with reference to FIG. 1A.

[0202] In some embodiment, the E2SM-KPM action definition may be for multi-cell KPM reporting with the same measurement requirements; and the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements may be for at least two cells, and may include the measurement requirements applied to the at least two cells.

[0203] In some embodiment, the E2SM-KPM report service style may be for multi-cell KPM reporting with the same measurement requirements; and the E2SM-KPM report service style for multi-cell KPM reporting with the same measurement requirements is for at least two cells.

[0204] In some embodiment, the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements may further include one of the following: a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted to the first network device as an integrated report.

[0205] In some embodiment, the E2SM-KPM action definition may be for multi-cell KPM reporting with different measurement requirements; and

[0206] the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements may be for at least two cells, and includes the measurement requirements for each of the at least two cells.

[0207] In some embodiment, the E2SM-KPM report service style may be for multi-cell KPM reporting with different measurement requirements; and the E2SM-KPM report service style for multi-cell KPM reporting with different measurement requirements may be for at least two cells.

[0208] In some embodiment, the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements may further include one of the following: a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted as an integrated report.

[0209] In some embodiment, the E2SM-KPM indication message may include an ID of at least one cell, and a measurement report for the at least one cell.

[0210] In some embodiment, the E2SM-KPM action definition may be identified by an E2SM-KPM action definition format ID.

[0211] In some embodiment, the E2SM-KPM indication message may be identified by an E2SM-KPM indication message format ID.

[0212] In some embodiment, the E2SM-KPM action definition may be associated with the E2SM-KPM report service style, and the E2SM-KPM report service style may be associated with a radio access network (RAN) intelligent controller (RIC) style type ID and a RIC style name.

[0213] In some embodiment, the ID of the E2SM-KPM report service style may be the RIC style type ID.

[0214] In some embodiment, the method may further include receiving, via the transceiver and from the second network device, a RAN function definition, wherein the RAN function definition is for multi-cell KPM reporting.

[0215] In some embodiment, the RAN function definition may include one of the following: a RIC style name of the E2SM-KPM report service style; a RIC style type ID

of the E2SM-KPM report service style; an ID of the E2SM-KPM action definition format; or an ID of the E2SM-KPM indication message format.

[0216] In some embodiment, the first network device may be a near-real-time (Near-RT) RIC, and the second network device may be an E2 node.

[0217] FIG. 10 illustrates a flowchart of a method 1000 that supports multi-cell KPM reporting in accordance with aspects of the present disclosure. The operations of the method 1000 may be implemented by a device or its components as described herein. For example, the operations of the method 1000 may be performed by a second network device 220 or an E2 node as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0218] At 1005, the method includes receiving, via the transceiver and from a first network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting. The operations of 1005 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1005 may be performed by a device as described with reference to FIG. 1A.

[0219] At 1010, the method includes transmitting, via the transceiver and to the first network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting. The operations of 1010 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1010 may be performed by a device as described with reference to FIG. 1A.

[0220] In some embodiment, the E2SM-KPM action definition may be for multi-cell KPM reporting with the same measurement requirements; and the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements

may be for at least two cells, and may include the measurement requirements applied to the at least two cells.

[0221] In some embodiment, the E2SM-KPM report service style may be for multi-cell KPM reporting with the same measurement requirements; and the E2SM-KPM report service style for multi-cell KPM reporting with the same measurement requirements may be for at least two cells.

[0222] In some embodiment, the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements may further include one of the following: a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted to the first network device as an integrated report.

[0223] In some embodiment, the E2SM-KPM action definition may be for multi-cell KPM reporting with different measurement requirements; and the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements may be for at least two cells, and may include the measurement requirements for each of the at least two cells.

[0224] In some embodiment, the E2SM-KPM report service style may be for multi-cell KPM reporting with different measurement requirements; and the E2SM-KPM report service style for multi-cell KPM reporting with different measurement requirements may be for at least two cells.

[0225] In some embodiment, the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements may further include one of the following: a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted as an integrated report.

[0226] In some embodiment, the E2SM-KPM indication message may include an ID of at least one cell, and a measurement report for the at least one cell.

[0227] In some embodiment, the E2SM-KPM action definition may be identified by an E2SM-KPM action definition format ID.

[0228] In some embodiment, the E2SM-KPM indication message may be identified by an E2SM-KPM indication message format ID.

[0229] In some embodiment, the E2SM-KPM action definition may be associated with the E2SM-KPM report service style, and the E2SM-KPM report service style may be associated with a radio access network (RAN) intelligent controller (RIC) style type ID and a RIC style name.

[0230] In some embodiment, the ID of the E2SM-KPM report service style may be the RIC style type ID.

[0231] In some embodiment, the method may further include transmitting, via the transceiver and to the first network device, a RAN function definition, wherein the RAN function definition is for multi-cell KPM reporting.

[0232] In some embodiment, the RAN function definition may include one of the following: a RIC style name of the E2SM-KPM report service style; a RIC style type ID of the E2SM-KPM report service style; an ID of the E2SM-KPM action definition format; or an ID of the E2SM-KPM indication message format.

[0233] In some embodiment, the first network device may be a near-real-time (Near-RT) RIC, and the second network device may be an E2 node.

[0234] 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.

[0235] 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.

[0236] 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.

[0237] 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.

[0238] As used herein, including in the claims, an article "a" before an element is unrestricted and understood to refer to "at least one" of those elements or "one or more" of those elements. The terms "a," "at least one," "one or more," and "at least one of one or more" may be interchangeable. As used herein, including in the claims, "or" as used in a list of items (e.g., a list of items prefaced by a phrase such as "at least one of" or "one or more of" or "one or both of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase "based on" shall not be construed as a

reference to a closed set of conditions. For example, an example step that is described as "based on condition A" may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase "based on" shall be construed in the same manner as the phrase "based at least in part on. Further, as used herein, including in the claims, a "set" may include one or more elements.

[0239] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

What is claimed is:

1. A first network device comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

transmit, via the transceiver and to a second network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting; and

receive, via the transceiver and from the second network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting.

2. The first network device of claim 1, wherein:

the E2SM-KPM action definition is for multi-cell KPM reporting with the same measurement requirements; and

the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements is for at least two cells, and includes the measurement requirements applied to the at least two cells.

3. The first network device of claim 1, wherein:

the E2SM-KPM report service style is for multi-cell KPM reporting with the same measurement requirements; and

the E2SM-KPM report service style for multi-cell KPM reporting with the same measurement requirements is for at least two cells.

4. The first network device of claim 2, wherein the E2SM-KPM action definition for multi-cell KPM reporting with the same measurement requirements further includes one of the following:

a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or

a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted to the first network device as an integrated report.

5. The first network device of claim 1, wherein:

the E2SM-KPM action definition is for multi-cell KPM reporting with different measurement requirements; and

the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements is for at least two cells, and includes the measurement requirements for each of the at least two cells.

6. The first network device of claim 1, wherein:

the E2SM-KPM report service style is for multi-cell KPM reporting with different measurement requirements; and

the E2SM-KPM report service style for multi-cell KPM reporting with different measurement requirements is for at least two cells.

7. The first network device of claim 5, wherein the E2SM-KPM action definition for multi-cell KPM reporting with different measurement requirements further includes one of the following:

a field of reporting manner which indicates that a measurement report for a cell is to be transmitted to the first network device as a separate report or an integrated report; or

a field of reporting group which indicates that a measurement report for a set of cells in a reporting group is to be transmitted as an integrated report.

8. The first network device of claim 1, wherein the E2SM-KPM indication message includes an ID of at least one cell, and a measurement report for the at least one cell.

9. The first network device of claim 1, wherein the E2SM-KPM action definition is identified by an E2SM-KPM action definition format ID.

10. The first network device of claim 1, wherein the E2SM-KPM indication message is identified by an E2SM-KPM indication message format ID.

11. The first network device of claim 1, wherein the E2SM-KPM action definition is associated with the E2SM-KPM report service style, and the E2SM-KPM report service style is associated with a radio access network (RAN) intelligent controller (RIC) style type ID and a RIC style name.

12. The first network device of claim 1, wherein the ID of the E2SM-KPM report service style is the RIC style type ID.

13. The first network device of claim 1, wherein the processor is further configured to:

receive, via the transceiver and from the second network device, a RAN function definition, wherein the RAN function definition is for multi-cell KPM reporting.

14. The first network device of claim 13, wherein the RAN function definition includes one of the following:

a RIC style name of the E2SM-KPM report service style;

a RIC style type ID of the E2SM-KPM report service style;

an ID of the E2SM-KPM action definition format; or

an ID of the E2SM-KPM indication message format.

15. The first network device of any of claims 1-14, wherein the first network device is a near-real-time (Near-RT) RIC, and the second network device is an E2 node.

16. A method performed by a first network device, the method comprising:

transmitting, via the transceiver and to a second network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting; and

receiving, via the transceiver and from the second network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting.

17. A second network device comprising:

a processor; and

a transceiver coupled to the processor,

wherein the processor is configured to:

receive, via the transceiver and from a first network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report

service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting; and

transmit, via the transceiver and to the first network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting.

18. A method performed by a second network device, the method comprising:

receiving, via the transceiver and from a first network device, an identifier (ID) of an E2 service model key performance measurement (E2SM-KPM) report service style and at least one value of an E2SM-KPM action definition, wherein the E2SM-KPM report service style is for multi-cell key performance measurement (KPM) reporting and the E2SM-KPM action definition is for multi-cell KPM reporting; and

transmitting, via the transceiver and to the first network device, one or more measurement reports for at least one cell using an E2SM-KPM indication message, wherein the E2SM-KPM indication message is for multi-cell KPM reporting.