

TIME DOMAIN RRM PREDICTION

TECHNICAL FIELD

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

BACKGROUND

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

[0003] It is considered as one scenario that UE makes RRM measurement prediction or event prediction and reports to network (NW), however, details on time domain prediction are needed for further study.

SUMMARY

25 **[0004]** The present disclosure relates to a UE, a BS, methods, apparatuses, processors, and computer readable medium for a time domain RRM prediction. According to the proposed solution, the UE may be configured with time information of a time window for RRM prediction, and may further transmit RRM prediction information in the time window to the BS.

[0005] In some implementations, there is provided a UE. The UE comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the UE to: receive, from a base station, a configuration indicating time information of a time window for RRM prediction; determine RRM prediction information within the time window based on the configuration; and transmit, to the base station, a report comprising the RRM prediction information.

[0006] In some implementations, there is provided a BS. The BS comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the BS to: transmit, to a UE, a configuration indicating time information of a time window for RRM prediction; and receive, from the UE, a report comprising RRM prediction information within the time window.

[0007] In some implementations, there is provided a method performed by the UE. The method comprises: receiving, from a base station, a configuration indicating time information of a time window for RRM prediction; determining RRM prediction information within the time window based on the configuration; and transmitting, to the base station, a report comprising the RRM prediction information.

[0008] In some implementations, there is provided a method performed by the BS. The method comprises: transmitting, to a UE, a configuration indicating time information of a time window for RRM prediction; and receiving, from the UE, a report comprising RRM prediction information within the time window.

[0009] In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a base station, a configuration indicating time information of a time window for RRM prediction; determine RRM prediction information within the time window based on the configuration; and transmit, to the base station, a report comprising the RRM prediction information.

[0010] In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: transmit, to a UE, a configuration indicating time information of a time window for RRM prediction; and receive, from the UE, a report comprising RRM prediction information within the time window.

[0011] In some implementations of the methods and the UE described herein, further

comprising: in accordance with a determination that the configuration comprises the third value, determining a time length of the time window, wherein the specific time associated with the third value is within the time window.

5 [0012] In some implementations of the methods and the UE described herein, further comprising: in accordance with a determination that it is predicted that at least one of the one or more RRM events for prediction is to be satisfied within the time window, transmitting the report.

10 [0013] In some implementations of the methods and the UE described herein, further comprising: transmitting, to the base station, a notification indicating that the RRM prediction information is available; and receiving, from the base station, a request for requesting the RRM prediction information, wherein the report is comprised in a response to the request.

15 [0014] In some implementations of the methods and the UE described herein, further comprising: keeping UE variables at the UE for a period of time after transmitting the report, wherein the UE variables comprise one of the RRM prediction information or RRM measurement results.

20 [0015] In some implementations of the methods and the UE described herein, further comprising: receiving, from the base station, an indication indicating to the UE to keep UE variables; and keeping the UE variables at the UE after transmitting the report based on the indication, wherein the UE variables comprise one of the RRM prediction information or RRM measurement results.

25 [0016] In some implementations of the methods and the UE described herein, further comprising: receiving, from the base station, a further indication indicating to the UE to release the UE variables; and releasing the UE variables at the UE based on the further indication.

[0017] In some implementations of the methods and the UE described herein, further comprising: releasing the UE variables after a period of time, wherein the period of time is indicated by the BS or predefined.

30 [0018] In some implementations of the methods and the BS described herein, further comprising: receiving, from the UE, a notification indicating that the RRM prediction information is available; and transmitting, to the UE, a request for requesting the RRM prediction information, wherein the report is comprised in a response to the request.

[0019] In some implementations of the methods and the BS described herein, further comprising: transmitting, to the UE, an indication indicating to the UE to keep UE variables, wherein the UE variables comprise one of the RRM prediction information or RRM measurement results.

5 [0020] In some implementations of the methods and the BS described herein, further comprising: transmitting, to the UE, a further indication indicating to the UE to release the UE variables.

[0021] In some implementations of the methods, the UE, the BS described herein, the configuration further comprises a prohibit timer indicating one of: a minimal time interval
10 between two consecutive reports, or a minimal time interval between two consecutive operations for RRM prediction.

[0022] In some implementations of the methods, the UE, the BS described herein, the time information of the time window comprises one of: a time interval value indicating a time length of the time window with a start time being a reference time, a first value and a second
15 value indicating a start time of the time window being the first value after a reference time and an end time of the time window being the second value after the reference time respectively, or a third value indicating a specific time within the time window being the third value after a reference time.

[0023] In some implementations of the methods, the UE, the BS described herein, the
20 reference time comprises one of: a time when the configuration is received, or a time when a trigger condition is met.

[0024] In some implementations of the methods, the UE, the BS described herein, the configuration further comprises one of: information about one or more prediction objects, or one or more RRM events for prediction.

25 [0025] In some implementations of the methods, the UE, the BS described herein, the trigger condition comprises an RRM event being satisfied, and wherein the RRM prediction information comprises predicted RRM measurement results within the time window.

[0026] In some implementations of the methods, the UE, the BS described herein, the trigger condition comprises one of: an RRC resume message being received, an RRC setup
30 message being received, or an RRC state of the UE being transferred to an RRC connected state.

[0027] In some implementations of the methods, the UE, the BS described herein, the notification comprises an RRC resume complete message or an RRC setup complete message, the request comprises a UE information request message, and the response comprises a UE information response message.

5 [0028] In some implementations of the methods, the UE, the BS described herein, the configuration is comprised in one of: an RRC release message, an RRC resume message, an RRC setup message, or a UE information request message.

[0029] In some implementations of the methods, the UE, the BS described herein, the RRM prediction information comprises one of: predicted measurement results on at least one
10 prediction object, an indication of a prediction object which is associated with a predicted measurement result exceeding a threshold, an indication of a predicted RRM event which triggers the report, a time when it is predicted that the RRM event is to be satisfied, an indication of an RRM event which is satisfied and triggers the RRM prediction, an indication of one or more than one object the UE continues measuring, or a time period during which
15 the UE continues measuring.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] FIG. 1 illustrates an example of a wireless communications system in which some embodiments of the present disclosure can be implemented;

[0031] FIG. 2A illustrates a measurement model at a UE in accordance with some example
20 embodiments of the present disclosure;

[0032] FIG. 2B illustrates a schematic diagram of an example communication network in which some embodiments of the present disclosure can be implemented;

[0033] FIG. 3 illustrates a signalling chart illustrating a communication process in accordance with some example embodiments of the present disclosure;

25 [0034] FIG. 4A illustrates a comparison between a time window in the present disclosure and a legacy report in accordance with some example embodiments of the present disclosure;

[0035] FIG. 4B illustrates an example schematic of an information element (IE) of *MeasIdToAddMod* in accordance with some example embodiments of the present disclosure;

[0036] FIG. 5A illustrates an example schematic of a time window in accordance with some
30 example embodiments of the present disclosure;

[0037] FIG. 5B illustrates an example schematic of an IE of *MeasIdToAddMod* in accordance with some example embodiments of the present disclosure;

[0038] FIG. 6 illustrates a signalling chart illustrating a communication process of prediction associated with RRC state transfer in accordance with some example embodiments of the present disclosure;

[0039] FIG. 7 illustrates an example of a device that is suitable for implementing embodiments of the present disclosure;

[0040] FIG. 8 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure;

[0041] FIG. 9 illustrates a flowchart of an example method implemented at a UE in accordance with aspects of the present disclosure; and

[0042] FIG. 10 illustrates a flowchart of an example method implemented at a BS in accordance with aspects of the present disclosure.

[0043] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0044] Principles of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described below. In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0045] References in the present disclosure to “one embodiment,” “an example embodiment,” “an embodiment,” “some embodiments,” and the like indicate that the embodiment(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases do not necessarily refer to the same embodiment(s). Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to

affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0046] It shall be understood that although the terms “first” and “second” or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of embodiments. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms. In some examples, values, procedures, or apparatuses are referred to as “best,” “lowest,” “highest,” “minimum,” “maximum,” or the like. It will be appreciated that such descriptions are intended to indicate that a selection among many used functional alternatives can be made, and such selections need not be better, smaller, higher, or otherwise preferable to other selections.

[0047] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of embodiments. As used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises,” “comprising,” “has,” “having,” “includes” and/or “including,” when used herein, specify the presence of stated features, elements, components and/or the like, but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof. For example, the term “includes” and its variants are to be read as open terms that mean “includes, but is not limited to.” The term “based on” is to be read as “based at least in part on.” The term “one embodiment” and “an embodiment” are to be read as “at least one embodiment.” The term “another embodiment” is to be read as “at least one other embodiment.” The use of an expression such as “A and/or B” can mean either “only A” or “only B” or “both A and B.” Other definitions, explicit and implicit, may be included below.

[0048] FIG. 1 illustrates an example of a wireless communications system 100 in which some embodiments of the present disclosure can be implemented. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network (CN) 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as a long term evolution (LTE) network or an LTE-Advanced

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

10 [0049] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. A network entity 102 and a UE 104 may communicate via a communication link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

20 [0050] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, message, broadcast, etc.) for one or more UEs 104 within the geographic coverage area 112. For example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities 102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0051] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a mobile device, a wireless device, a remote device, a remote unit, a handheld device, or a subscriber device, or some other suitable terminology. In some implementations, the UE
5 104 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
10 be mobile in the wireless communications system 100.

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

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

[0054] A network entity 102 may support communications with the CN 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the CN 106 through one or more backhaul links 116 (e.g., via an S1, N2, N3, or another network interface). The network entities 102 may communicate with each other over the backhaul
30 links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the CN 106). In some implementations, one or more

network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0055] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access backhaul (IAB) network, an open RAN (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity 102 may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a RAN Intelligent Controller (RIC) (e.g., a Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) system, or any combination thereof.

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

[0057] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaptation protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer)

functionality and signaling, and may each be at least partially controlled by the CU.

[0058] Additionally, or alternatively, a functional split of the protocol stack may be employed between a DU and an RU such that the DU may support one or more layers of the protocol stack and the RU may support one or more different layers of the protocol stack.

5 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).

10 **[0059]** A CU may be functionally split further into CU control plane (CU-CP) and CU user plane (CU-UP) functions. A CU may be connected to one or more DUs via a midhaul communication link (e.g., F1, F1-C, F1-U), and a DU may be connected to one or more RUs via a fronthaul communication link (e.g., open fronthaul (FH) interface). In some implementations, a midhaul communication link or a fronthaul communication link may be
15 implemented in accordance with an interface (e.g., a channel) between layers of a protocol stack supported by respective network entities 102 that are in communication via such communication links.

[0060] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an
20 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
25 control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the CN 106.

[0061] The CN 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N3, or another network interface). The packet data
30 network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via a network

entity 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

5 **[0062]** In the wireless communications system 100, the network entities 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the network entities 102 and the UEs 104 may support different resource
10 structures. For example, the network entities 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the network entities 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the network entities 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The network
15 entities 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0063] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix (CP). A first numerology (e.g., $\mu=0$) may be associated with a first subcarrier spacing (e.g., 15 kHz) and
20 a normal cyclic prefix. In some implementations, the first numerology (e.g., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu=2$) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic
25 prefix. A fourth numerology (e.g., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0064] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for
30 example, a 10 millisecond (*ms*) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 *ms* duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a

frame may have the same duration.

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

[0066] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the network entities 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the network entities 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the network entities 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0067] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., $\mu=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu=1$), which includes

30 kHz subcarrier spacing; and a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu=3$), which includes 120 kHz subcarrier spacing.

[0068] In RRC_CONNECTED, the UE measures multiple beams (at least one) of a cell and the measurements results (power values) are averaged to derive the cell quality. In doing so, the UE is configured to consider a subset of the detected beams. Filtering takes place at two different levels: at the physical layer to derive beam quality and then at RRC level to derive cell quality from multiple beams. Cell quality from beam measurements is derived in the same way for the serving cell(s) and for the non-serving cell(s). Measurement reports may contain the measurement results of the X best beams if the UE is configured to do so by the gNB.

[0069] FIG. 2A illustrates a measurement model 201 at a UE in accordance with some example embodiments of the present disclosure. as shown in FIG. 2A, there may be K beams of gNB, where K beams correspond to the measurements on synchronizing signal block (SSB) or channel state information (CSI) – reference signal (RS) resources configured for L3 mobility by gNB and detected by UE at layer 1 (L1). Some descriptions on the terms and actions in FIG. 2A are provided below.

[0070] - A: measurements (beam specific samples) internal to the physical layer.

[0071] - Layer 1 filtering: internal layer 1 filtering of the inputs measured at point A. Exact filtering is implementation dependent. How the measurements are actually executed in the physical layer by an implementation (inputs A and Layer 1 filtering) is not constrained by the standard.

[0072] - A1: measurements (i.e. beam specific measurements) reported by layer 1 to layer 3 after layer 1 filtering.

[0073] - Beam Consolidation/Selection: beam specific measurements are consolidated to derive cell quality. The behaviour of the Beam consolidation/selection is standardised and the configuration of this module is provided by RRC signalling. Reporting period at B equals one measurement period at A1.

[0074] - B: a measurement (i.e. cell quality) derived from beam-specific measurements reported to layer 3 after beam consolidation/selection.

[0075] - Layer 3 filtering for cell quality: filtering performed on the measurements provided at point B. The behaviour of the Layer 3 filters is standardised and the configuration of the layer 3 filters is provided by RRC signalling. Filtering reporting period at C equals one measurement period at B.

- 5 [0076] - C: a measurement after processing in the layer 3 filter. The reporting rate is identical to the reporting rate at point B. This measurement is used as input for one or more evaluation of reporting criteria.

[0077] - Evaluation of reporting criteria: checks whether actual measurement reporting is necessary at point D. The evaluation can be based on more than one flow of measurements at reference point C e.g. to compare between different measurements. This is illustrated by
10 input C and C1. The UE shall evaluate the reporting criteria at least every time a new measurement result is reported at point C, C1. The reporting criteria are standardised and the configuration is provided by RRC signalling (UE measurements).

[0078] - D: measurement report information (message) sent on the radio interface.

- 15 [0079] - L3 Beam filtering: filtering performed on the measurements (i.e. beam specific measurements) provided at point A1. The behaviour of the beam filters is standardised and the configuration of the beam filters is provided by RRC signalling. Filtering reporting period at E equals one measurement period at A1.

[0080] - E: a measurement (i.e. beam-specific measurement) after processing in the
20 beam filter. The reporting rate is identical to the reporting rate at point A1. This measurement is used as input for selecting the X measurements to be reported.

[0081] - Beam Selection for beam reporting: selects the X measurements from the measurements provided at point E. The behaviour of the beam selection is standardised and the configuration of this module is provided by RRC signalling.

- 25 [0082] - F: beam measurement information included in measurement report (sent) on the radio interface.

[0083] The third generation partnership project (3GPP) release 19 (Rel-19) has initiated a study item (SI) for artificial intelligence (AI) or machine learning (ML) based mobility. It is proposed to study and evaluate potential benefits and gains of AI/ML aided mobility for
30 network triggered layer 3 (L3)-based handover, considering the aspects comprising AI/ML based RRM measurement and event prediction:

- Cell-level measurement prediction including intra and inter-frequency (UE sided and NW sided model) [RAN2]
 - Inter-cell Beam-level measurement prediction for L3 Mobility (UE sided and NW sided model) [RAN2]
- 5 ● HO failure/RLF prediction (UE sided model) [RAN2]
- Measurement events prediction (UE sided model) [RAN2]

[0084] It is considered as one scenario that UE makes RRM measurement prediction or event prediction and report to NW then NW can make handover (HO) decision taking the UE prediction result into account, e.g., trigger HO before too late. There are three types of prediction:

- Time domain prediction: predicting the future RRM measurement/event of a cell/beam based on measurements of the same cell/beam in the past.
- Frequency domain prediction: predicting the RRM measurement/event of Set A of cells based on measurement of Set B of cells, wherein Set A cells and Set B cells are of different frequencies.
- 15 - Spatial domain prediction: predicting the RRM measurement/event of Set A beams based on measurement of Set B of beams, wherein Set A beams and Set B beams could be different beams, e.g., different directions.

[0085] Embodiments of the present disclosure provide a solution of communication. In the solution, a UE may receive a configuration indicating time information of a time window for RRM prediction. The UE may determine RRM prediction information within the time window based on the configuration, and may further transmit a report to the BS. As such, the BS may be aware of the prediction information and accordingly further decisions may be made may be BS in a more efficient way. Principles and implementations of the present disclosure will be described in detail below with reference to the figures.

[0086] FIG. 2B illustrates a schematic diagram of an example communication network 200 in which some embodiments of the present disclosure can be implemented. As shown in FIG. 2B, the communication network 200 may include a BS 210 and a UE 220, which may communicate with each other. With reference to FIG. 1, the BS 210 may be one network entity 102, and the UE 220 may be one UE 104.

[0087] In some implementations, a model, such as an AI/ML model, may be deployed at the UE 220. In some examples, the UE 220 may determine prediction information by model inference. It is to be noted that the model at the UE 220 may be omitted in some cases, for example, the UE 220 may utilize some other manners to determine prediction information, and the present disclosure does not limit this aspect.

[0088] It is to be understood that the numbers of BSs or UEs shown in FIG. 2B are only for the purpose of illustration only. The communication network 200 may include any suitable numbers of devices.

[0089] In the present disclosure, the term “RRM event” may also be used, and some examples of the RRM events are provided below:

- [0090] Event A1: Serving becomes better than absolute threshold;
- [0091] Event A2: Serving becomes worse than absolute threshold;
- [0092] Event A3: Neighbour becomes amount of offset better than PCell/PSCell;
- [0093] Event A4: Neighbour becomes better than absolute threshold;
- [0094] Event A5: PCell/PSCell becomes worse than absolute threshold1 AND Neighbour/SCell becomes better than another absolute threshold2;
- [0095] Event A6: Neighbour becomes amount of offset better than SCell;
- [0096] Event D1: Distance between UE and a reference location referenceLocation1 becomes larger than configured threshold distanceThreshFromReference1 and distance between UE and a reference location referenceLocation2 becomes shorter than configured threshold distanceThreshFromReference2;
- [0097] CondEvent A3: Conditional reconfiguration candidate becomes amount of offset better than PCell/PSCell;
- [0098] CondEvent A4: Conditional reconfiguration candidate becomes better than absolute threshold;
- [0099] CondEvent A5: PCell/PSCell becomes worse than absolute threshold1 AND Conditional reconfiguration candidate becomes better than another absolute threshold2;
- [00100] CondEvent D1: Distance between UE and a reference location referenceLocation1 becomes larger than configured threshold distanceThreshFromReference1 and distance between UE and a reference location referenceLocation2 of conditional reconfiguration

candidate becomes shorter than configured threshold distanceThreshFromReference2;

[00101] CondEvent T1: Time measured at UE becomes more than configured threshold t1-Threshold but is less than t1-Threshold + duration;

[00102] Event X1: Serving L2 U2N Relay UE becomes worse than absolute threshold1
5 AND NR Cell becomes better than another absolute threshold2;

[00103] Event X2: Serving L2 U2N Relay UE becomes worse than absolute threshold;

[00104] Event I1: Interference becomes higher than absolute threshold. For event I1, measurement reporting event is based on CLI measurement results, which can either be derived based on SRS-RSRP or CLI-RSSI.

10 **[00105]** It is to be understood that some examples of the “RRM event” listed above are not exhaustive but are not limited, for example the RRM event may include a radio link failure (RLF) event, for example the RRM event may include a handover failure (HOF) event, for example the RRM event may include another one which is not listed herein.

[00106] In the present disclosure, an RRM event may be predicted to be happen, which may
15 also be referred to as any one of: an RRM event is predicted to be satisfied, a predicted RRM event is determined, an RRM event is predicted to occur, it is predicted that the RRM event will happen, it is predicted that the RRM event will be satisfied, etc. the present disclosure does not limit this aspect.

[00107] In the present disclosure, a predicted RRM event, an RRM event for prediction,
20 predicted RRM measurements, predicted RRM measurement results, prediction measurements, prediction results, RRM measurement prediction, or the like may be used interchangeably in some scenarios.

[00108] FIG. 3 illustrates a signalling chart illustrating communication process 300 in accordance with some example embodiments of the present disclosure. The process 300
25 may involve a BS 210 and a UE 220. It would be appreciated that the process 300 may be applied to other communication scenarios, which will not be described in detail.

[00109] In the process 300, the BS 210 transmits a configuration to the UE 220 at 310. In some implementations, the configuration may be referred to as a prediction configuration. In some implementations, the configuration may be used for the UE 220 to determine a time
30 window for RRM prediction. For example, the configuration may include time information

of the time window. In the present disclosure, the time window may be referred to as a time window to predict.

[00110] In some example implementations, the configuration may configure the UE 220 to perform an RRM event prediction in the time window and trigger a report due to a predicted
5 RRM event.

[00111] In some implementations, the configuration may include information about one or more prediction objects. In some implementations, the configuration may include information about one or more RRM events for prediction. In some examples, the configuration may indicate to the UE 220 to predict whether the indicated RRM event(s)
10 associated with the one or more prediction objects will be satisfied.

[00112] In some example embodiments, one of the one or more prediction objects may be a frequency, a cell, or a beam. In some examples, a dedicated IE may be defined, e.g. in RRC signalling, for indicating the one or more prediction objects, for example, the dedicated IE may be “predictionObj”. In some examples, an existing IE may be reused for indicating the
15 one or more prediction objects, for example, the existing IE may be “measObj”.

[00113] In some example embodiments, the one or more RRM events for prediction may be indicated by one or more indexes of the one or more RRM events. As an example, the one or more RRM events may include “Event A2” and “Event A4” as mentioned above. In some examples, one of the one or more RRM events for prediction may be a dedicated new
20 RRM event or an existing event (e.g. configured in “reportConfig”). In some examples, one of the one or more RRM events for prediction may be a radio link failure (RLF) event, for example, the UE 220 may refer to the RLF configured in an IE “RadioLinkMonitoringConfig”. In some examples, one of the one or more RRM events for prediction may be a handover failure (HOF) event.

[00114] In some implementations, the configuration may include time information of the time window for RRM event prediction.

[00115] In some example embodiments, the time information may include a time interval value, which may indicate a time length of the time window. For example, a start time of the time window may be a reference time, and an end time of the time window may be a time
30 interval value after the reference time. In this case, the time window may be represented as [a reference time, a reference time + a time interval value].

[00116] In some example embodiments, the time information may include a first value and a second value, which may be used for determining a start time and an end time of the time window respectively. For example, a start time of the time window may be the first value after a reference time, and an end time of the time window may be the second value after a reference time. In this case, the time window may be represented as [a reference time + a first value, a reference time + a second value].

[00117] In some example embodiments, the time information may include a third value, which may be used for determining a specific time point in the time window. For example, the specific time may be a center time of the time window, e.g., a third value after a reference time. In some examples, a time length of the time window may be predefined, preconfigured, or may be determined by the UE 220 according to UE implementation. For example, the time length may be represented as $2 \cdot \Delta T$, in this case, the time window may be represented as [a reference time + a third value - ΔT , a reference time + a third value + ΔT]. For another example, the specific time may be a start time (or an end time) of the time window, for example, the time window may be represented as [a reference time + a third value, a reference time + a third value + $2 \cdot \Delta T$] or [a reference time + a third value - $2 \cdot \Delta T$, a reference time + a third value].

[00118] In some implementation, the reference time which is used for determining the time window may be a time when the configuration is received at the UE 220, or may be a time when a trigger condition is met. Details of the trigger condition will be provided below.

[00119] In some implementations, the configuration may further indicate a prohibit timer. In some examples, the prohibit timer may be referred to as a minimal gap between two consecutive predictions or two consecutive reports. In some examples, the configuration may include a time length value for indicating the prohibit timer.

[00120] In some example embodiments, the prohibit timer may indicate a minimal time interval between two consecutive reports. For example, for the UE 220, the prohibit timer may be started when a report triggered by an RRM event prediction is transmitted, and no further report which is still triggered by an RRM event prediction will be transmitted when the prohibit timer is running.

[00121] In some example embodiments, the prohibit timer may indicate a minimal time interval between two consecutive operations for RRM prediction, e.g., two consecutive RRM event predictions associated with a same prediction object. For example, for the UE 220,

the prohibit timer may be started when an RRM event of a prediction object is predicted to happen, and the UE 220 is not required to perform a further RRM event prediction for the same prediction object.

[00122] In some implementations, the configuration may be transmitted to the UE 220 via RRC signalling. In some implementations, the configuration may be provided in per measurement ID (e.g. *measId*) or per measurement object (e.g. *measObject*) or per RRM report configuration (e.g. *reportConfig*) or per prediction object manner.

[00123] In some example embodiments, the configuration may be associated with a measurement ID (e.g. *measId*), and the configuration may be transmitted to the UE 220 by an RRC IE “*MeasIdToAddMod*”. In some examples, the measurement ID (e.g. *measId*) is further associated with a measurement object and a report configuration.

[00124] In some examples, if the associated report configuration (represented by *reportConfigId*) for the *measId* is of event triggered *reportType*, that is the measurement report will be triggered by a certain RRM event (e.g., A2/A3/A4 event as configured as part of the report configuration), the UE 220 shall perform the RRM event prediction for the associated measurement object (represented by *measObjectId*) according to the configuration (e.g., time window, prohibit timer).

[00125] In some examples, if the associated report configuration (represented by *reportConfigId*) for the *measId* is of periodical *reportType*, that is the measurement report will be triggered periodically, the UE 220 shall perform the RRM event prediction for the associated measurement object (represented by *measObjectId*) according to the configuration (e.g., time window, prohibit timer).

[00126] For example, the following text box shows an example of the IE “*MeasIdToAddMod*”:

```
-- ASN1START
-- TAG-MEASIDTOADDMODLIST-START

MeasIdToAddModList ::=                SEQUENCE (SIZE (1..maxNrofMeasId)) OF
MeasIdToAddMod

MeasIdToAddMod ::=                    SEQUENCE {
    measId                            MeasId,
    measObjectId                      MeasObjectId,
    reportConfigId                    ReportConfigId,
    predictionConfigId                PredictionConfigId
}
```

PredictionConfigIdToAddModList ::=	SEQUENCE (SIZE (1..maxNrofPredictionConfigId)) OF PredictionConfigToAddMod
PredictionConfigToAddMod ::=	SEQUENCE {
predictionConfigId	PredictionConfigId,
timeWindowToPredict	ENUMERATED {ms100, ms 200, ms500, s1,
s2, s5},	
prohibitTimer	ENUMERATED {ms100, ms 200, ms500, s1, s2,
s5},	OPTIONAL
-- TAG-MEASIDTOADDMODLIST-STOP	
-- ASN1STOP	

[00127] In some example embodiments, the configuration may be associated with a measurement object (e.g. *measObj*), and the configuration may be transmitted to the UE 220 by an RRC IE “*MeasObjectToAddMod*” or an IE “*MeasObjectNR*”. In some examples, the measurement object (e.g. *measObj*) is further associated with a measurement ID and a report configuration.

[00128] In some examples, the UE 220 may perform the RRM event prediction that is associated with this measurement object as configured in the IE *MeasObjectToAddMod*. In some examples, the UE 220 may perform the RRM event prediction for the measurement object, which may be represented by the *reportConfigId* as configured in the *ReportConfigToAddMod*. For example, the following text box shows an example of the IE “*MeasObjectToAddMod*”:

MeasObjectToAddModList ::=	SEQUENCE (SIZE (1..maxNrofObjectId)) OF
MeasObjectToAddMod	
MeasObjectToAddMod ::=	SEQUENCE {
measObjectId	MeasObjectId,
measObject	CHOICE {
measObjectNR	MeasObjectNR,
...,	
measObjectEUTRA	MeasObjectEUTRA,
measObjectUTRA-FDD-r16	MeasObjectUTRA-FDD-r16,
measObjectNR-SL-r16	MeasObjectNR-SL-r16,
measObjectCLI-r16	MeasObjectCLI-r16,
measObjectRxTxDiff-r17	MeasObjectRxTxDiff-r17,
measObjectRelay-r17	SL-MeasObject-r16
}	
predictionConfigId	PredictionConfigId
}	
PredictionConfigIdToAddModList ::=	SEQUENCE (SIZE (1..maxNrofPredictionConfigId)) OF PredictionConfigToAddMod

PredictionConfigToAddMod::=	SEQUENCE {
predictionConfigId	PredictionConfigId,
timeWindowToPredict	ENUMERATED {ms100, ms 200, ms500, s1,
s2, s5},	
prohibitTimer	ENUMERATED {ms100, ms 200, ms500, s1, s2,
s5},	OPTIONAL
-- TAG-MEASOBJECTTOADDMODLIST-STOP	
-- ASN1STOP	

[00129] In some example embodiments, the configuration may be associated with a report configuration (e.g. *reportConfig*) which is configured for a report associated with an RRM event prediction, and the configuration may be transmitted to the UE 220 by an RRC IE “*ReportConfigToAddMod*” or an IE “*ReportConfigNR*”. In some examples, the report configuration (e.g. *reportConfig*) is further associated with a measurement ID and measurement object.

[00130] In some examples, the UE 220 may perform the RRM event prediction for associated measurement object as configured in the *MeasIdToAddMod* IE. In some examples, the UE 220 may perform the RRM event prediction for any measurement object as configured in the *MeasObjectToAddModList* IE.

[00131] In some examples, the IE “*useT312-r16*” may be further configured or shall not be set the value to be true. For example, if *useT312-r16* is configured and set to be true, the UE 220 shall not start the T312 timer if the RRM event is predicted to happen.

[00132] For example, the following text box shows an example of the IE “*ReportConfigToAddMod*”:

```
-- ASN1START
-- TAG-REPORTCONFIGTOADDMODLIST-START

ReportConfigToAddModList ::=          SEQUENCE (SIZE (1..maxReportConfigId)) OF
ReportConfigToAddMod

ReportConfigToAddMod ::=              SEQUENCE {
    reportConfigId                    ReportConfigId,
    reportConfig                      CHOICE {
        reportConfigNR                ReportConfigNR,
        ...,
        reportConfigInterRAT          ReportConfigInterRAT,
        reportConfigNR-SL-r16         ReportConfigNR-SL-r16
    }
}
```

timeWindowToPredict	ENUMERATED {ms100, ms 200, ms500, s1, s2,
s5}, OPTIONAL	
prohibitTimer	ENUMERATED {ms100, ms 200, ms500, s1, s2,
s5}, OPTIONAL	
}	
-- TAG-REPORTCONFIGTOADDMODLIST-STOP	
-- ASN1STOP	

[00133] In some examples, if the configuration in the present disclosure is provided as part of the *ReportConfigNR* IE, the configuration may be configured as one dedicated event P1 inside the *EventTriggerConfig* by *eventId* IE, or the configuration may be configured in the IE *EventTriggerConfig* but outside *eventId* IE and applies to the conventional RRM event such as A2/A3/A4, etc. For example, the following text box shows an example of the IE “*ReportConfigNR*”:

ReportConfigNR ::=	SEQUENCE {
reportType	CHOICE {
periodical	PeriodicalReportConfig,
eventTriggered	EventTriggerConfig,
....	
reportCGI	ReportCGI,
reportSFTD	ReportSFTD-NR,
condTriggerConfig-r16	CondTriggerConfig-r16,
cli-Periodical-r16	CLI-PeriodicalReportConfig-r16,
cli-EventTriggered-r16	CLI-EventTriggerConfig-r16,
rxTxPeriodical-r17	RxTxPeriodical-r17
}	
}	
EventTriggerConfig ::=	SEQUENCE {
eventId	CHOICE {
eventA1	SEQUENCE {
a1-Threshold	MeasTriggerQuantity,
reportOnLeave	BOOLEAN,
hysteresis	Hysteresis,
timeToTrigger	TimeToTrigger
},	
eventA2	SEQUENCE {
a2-Threshold	MeasTriggerQuantity,
reportOnLeave	BOOLEAN,
hysteresis	Hysteresis,
timeToTrigger	TimeToTrigger
},	
eventP1	SEQUENCE {
P1-Threshold	MeasTriggerQuantity,
reportOnLeave	BOOLEAN,
hysteresis	Hysteresis,
timeToTrigger	TimeToTrigger

timeWindowToPredict	ENUMERATED {ms100, ms 200,
ms500, s1, s2, s5}, OPTIONAL	
prohibitTimer	ENUMERATED {ms100, ms 200,
ms500, s1, s2, s5}, OPTIONAL	
},	
{	
measRSSI-ReportConfig-r16	MeasRSSI-ReportConfig-r16
OPTIONAL, -- Need R	
useT312-r16	BOOLEAN
OPTIONAL, -- Need M	
includeCommonLocationInfo-r16	ENUMERATED {true}
OPTIONAL, -- Need R	
includeBT-Meas-r16	SetupRelease {BT-NameList-r16}
OPTIONAL, -- Need M	
includeWLAN-Meas-r16	SetupRelease {WLAN-NameList-r16}
OPTIONAL, -- Need M	
includeSensor-Meas-r16	SetupRelease {Sensor-NameList-r16}
OPTIONAL -- Need M	
},	
{	
timeWindowToPredict	ENUMERATED {ms100, ms 200, ms500, s1, s2, s5},
OPTIONAL	
prohibitTimer	ENUMERATED {ms100, ms 200, ms500, s1, s2, s5},
OPTIONAL	
}	
}	

[00134] In some example embodiments, the configuration may be associated with a prediction configuration (i.e. *reportConfig*), and the configuration may be transmitted to the UE 220 by a dedicated RRC IE, such as a newly defined IE dedicated to RRM event prediction such as an IE “*PredictionObjectToAddMod*”. In some examples, the prediction configuration may be associated with one or more prediction objects and/or one or more RRM events for prediction. For example, the following text box shows an example of the IE “*PredictionObjectToAddMod*”:

PredictionObjectToAddMod ::=	SEQUENCE {
predictObjectId	predictObjectId,
measObjectId	MeasObjectId,
OPTIONAL	
reportConfigId	ReportConfigId,
OPTIONAL	
eventTriggered	EventTriggerConfig
OPTIONAL	
timeWindowToPredict	ENUMERATED {ms100, ms 200, ms500, s1, s2, s5},
prohibitTimer	ENUMERATED {ms100, ms 200, ms500, s1, s2, s5}
}	}

[00135] In some example implementations, the configuration may configure the UE 220 to perform an RRM measurement prediction in the time window and transmit a report due to an occurred RRM event.

- 5 **[00136]** In some implementations, the configuration may indicate time information of a time window and/or a prohibit timer, details of which may refer to those discussed above and will not be repeated herein for brevity. In some examples, the reference time for determining the time window may be a time when an RRM event is occurred (or satisfied).

- 10 **[00137]** In some implementations, the configuration may further indicate one or more prediction objects. In some examples, the UE 220 may perform an RRM measurement prediction associated with the one or more prediction objects.

[00138] In some example embodiments, the configuration may be transmitted to the UE 220 by an RRC IE “*MeasObjectToAddMod*” or an IE “*MeasObjectNR*”. For example, the following text box shows an example of the IE “*MeasObjectToAddMod*”:

```
-- ASN1START
-- TAG-MEASOBJECTTOADDMODLIST-START

MeasObjectToAddModList ::= SEQUENCE (SIZE (1..maxNrofObjectId)) OF
MeasObjectToAddMod

MeasObjectToAddMod ::= SEQUENCE {
    measObjectId,
    measObject
    CHOICE {
        measObjectNR,
        ...,
        measObjectEUTRA,
        measObjectUTRA-FDD-r16,
        measObjectNR-SL-r16,
        measObjectCLI-r16,
        measObjectRXTxDiff-r17,
        measObjectRelay-r17
    }
}

predictionConfigId PredictionConfigId
}

PredictionConfigIdToAddModList ::= SEQUENCE (SIZE
(1..maxNrofPredictionConfigId)) OF PredictionConfigToAddMod

PredictionConfigToAddMod ::= SEQUENCE {
    predictionConfigId,
    timeWindowToPredict
    ENUMERATED {ms100, ms 200, ms500, s1,
s2, s5},
    prohibitTimer
    ENUMERATED {ms100, ms 200, ms500, s1, s2,
s5},
    OPTIONAL
}
```

-- TAG-MEASOBJECTTOADDMODLIST-STOP
-- ASN1STOP

[00139] In some example implementations, the configuration may configure the UE 220 to perform an RRM measurement prediction in the time window and transmit a report in an early measurement report. In some implementations, the RRM measurement prediction
5 may be performed by the UE 220 in an RRC connected state or in an RRC inactive/idle state.

[00140] In some implementations, the configuration may be included in one of: an RRC release message, an RRC resume message, an RRC setup message, or an UE information request message. Details of related embodiments may refer to FIG. 6 below.

[00141] In some implementations, the configuration may indicate time information of a time
10 window, details of which may refer to those discussed above and will not be repeated herein for brevity. In some examples, the reference time for determining the time window may be a time when the configuration is received or may be a time when the RRC state of the UE 220 is transferred from an RRC inactive/idle state to an RRC connected state.

[00142] Continue referring to FIG. 3, the UE 220 determines RRM prediction information
15 within the time window at 320, e.g. based on the configuration received at 310.

[00143] In some example implementations, the UE 220 may determine a time window based on a reference time being a time when the configuration is received, and the UE 220 may predict whether one or more RRM events for prediction (e.g. indicated by the configuration) will be happen. For example, a model inference may be performed by the UE 220 by using
20 an AI/ML model in some cases. In some examples, the determined RRM prediction information may indicate one or more of the following: a predicted RRM event, a time when the predicted RRM event is to happen, or an indication of a predicted RRM event which triggers the report. For example, an indication of the predicted RRM event which triggers the report may be represented an IE *ReportConfigID* or an IE *eventId* which has been
25 configured in the IE “*ReportConfigToAddModlist*”.

[00144] In some example implementations, the UE 220 may determine a reference time being a time when an RRM event occurs, such as A2, A3, A4, A5 event, etc. In some example embodiments, the UE 220 may determine a time window based on a reference time being a time when the RRM event occurs, and the UE 220 may predict RRM measurement

results within the time window. For example, a model inference may be performed by the UE 220 by using an AI/ML model in some cases. In some examples, the determined RRM prediction information may indicate one or more of the following: an indication of an RRM event which occurred and triggers the measurement prediction, predicted measurement results e.g. associated with at least one prediction object, an indication of a prediction object which is associated with a predicted measurement result exceeding a threshold. For example, an indication of a prediction object which is associated with a predicted measurement result exceeding a threshold may be an indication of a best beam or a best cell with a largest measurement result, such as reference signal received power (RSRP) or a reference signal received quality (RSRQ).

[00145] In some example implementations, the UE 220 may determine a time window based on a reference time being a time when the configuration (such as RRC release or RRC resume) is received, and the UE 220 may predict RRM measurement results within the time window. For example, a model inference may be performed by the UE 220 by using an AI/ML model in some cases. In some examples, the determined RRM prediction information may indicate one or more of the following: predicted measurement results e.g. associated with at least one prediction object, an indication of a prediction object which is associated with a predicted measurement result exceeding a threshold (such as a measurement result with a largest RSRP).

[00146] In the process 300, the UE 220 transmits a report to the BS 210 at 330, where the report includes the RRM prediction information.

[00147] In some examples, the report may be transmitted by a measurement report. In some examples, a transmission of the report may be triggered by a predicted RRM event within the time window.

[00148] In some examples, the report may be transmitted in an RRC resume complete message, e.g. the configuration is included in the RRC release/resume message.

[00149] In some example embodiments, the report may be transmitted based on a request from the BS 210. In some examples, the BS 210 may transmit a request (such as a UE information request message) to the UE 220 for requesting the RRM prediction information, and the UE 220 may transmit a response (such as a UE information response message) to the request, where the response may include the RRM prediction information.

[00150] In some example embodiments, the report may include the RRM prediction information, for example one or more of the following may be included: a predicted RRM event, a time when the predicted RRM event is to happen, an indication of a predicted RRM event which triggers the report, an indication of an RRM event which occurred and triggers the measurement prediction, predicted measurement results e.g. associated with at least one prediction object, an indication of a prediction object which is associated with a predicted measurement result exceeding a threshold.

[00151] In some implementations, the UE 220 may determine to continue performing measurements after transmitting the report. In some example embodiments, the report may include an indication of one or more than one object that the UE 220 continues measuring. In some example embodiments, the report may include an indication of a time period during which the UE 220 continues measuring.

[00152] In some examples, the UE 220 would like to continue measuring one or multiple concerned objects (such as beams or cells) in the near future, e.g. for sake of AI monitoring to determine whether a previous prediction is correct. For example, a time period during which the UE 220 will continue measuring may also be indicated to the BS 210, so that the BS 210 may be aware of the behaviours at the UE 220.

[00153] In some example embodiments, the report may be transmitted by a measurement report which is related to a measurement ID (i.e. *measId*) associated with the configuration. In some examples, the UE 220 may record a number of reports, for example, the *numberOfReportsSent* as defined in the *VarMeasReportList* for the *measId* may be incremented by 1.

[00154] In some example embodiments, if a number of reports have been sent is less than a threshold, the report at 330 may be transmitted. For example, the report may be transmitted only if the *numberOfReportsSent* as defined in the *VarMeasReportList* for the *measId* is less than a *reportAmount* defined within a corresponding *reportConfig* for the *measId*.

[00155] In some examples, the report may be transmitted to the BS 210 by an IE “*MeasResults*”. For example, the following text box shows an example of the IE “*MeasResults*”:

MeasResults ::=	SEQUENCE {
measId	MeasId,
measResultServingMOList	MeasResultServMOList,
measResultNeighCells	CHOICE {

measResultListNR	MeasResultListNR,
....	
measResultListEUTRA	MeasResultListEUTRA,
measResultListUTRA-FDD-r16	MeasResultListUTRA-FDD-r16,
sl-MeasResultsCandRelay-r17	OCTET STRING -- Contains PC5
SL-MeasResultListRelay-r17	
}	
OPTIONAL,	
....	
[[	
predictedTimeToHappen	ENUMERATED {ms100, ms 200, ms500, s1, s2,
s5},	
predictedRRMEvent	ReportConfigId
]]	
}	

[00156] In some example implementations, the RRM prediction information may be kept at the UE 220 for a time period after transmitting the report. In some example embodiments, the UE 220 may determine some RRM measurement results and keep them at the UE 220 for a time period. For ease of description, “UE variables” are used to represent the RRM prediction information and/or RRM measurement results.

[00157] In some example embodiments, the UE 220 may determine the keep the UE variables for a period of time after transmitting the report, that is the UE variables are not discarded by the UE 220 immediately, e.g. based on a decision made by the UE 220 it self, based on a predefined rule, or based on an indication (or command) from the BS 210.

[00158] In some example embodiments, the BS 210 may transmit a further configuration to the UE 220, where the further configuration may include further information of a time period, and the further configuration may indicate to the UE 220 to keep the UE variable for the time period after transmitting the report. In some examples, the configuration at 310 and the further configuration may be included in a same message or in separate messages.

[00159] In some examples, the time period may be indicated in a similar way with the time window discussed above. For example, the further time information may include a further time interval value indicating a time length of the time period. For example, a start time of the time period may be a time when transmitting the report.

[00160] On the other side of communication, alternatively, the BS 210 may further perform one or more operations based on prediction results from the UE 220. For example, the BS 210 may make a HO decision before too late.

[00161] According to some embodiments with reference to FIG. 3, an RRM prediction on time domain may be enabled at the UE 220 based on a configuration from the BS 210. As such, a further decision may be made by the BS 210 according to a report from the UE 220, and accordingly the communication may be more efficient.

5 [00162] FIG. 4A illustrates a comparison between a time window in the present disclosure and a legacy report in accordance with some example embodiments of the present disclosure.

[00163] As shown in FIG. 4A, in legacy, the NW may configure the UE with certain RRM event A1/A2/A3 ... , and the UE will trigger measurement report 412 that contains the measurement result of concerned measurement object (which could be a L3 measurement
10 result of a beam or a cell or a frequency). In many cases, the occurrence of an RRM event (e.g., A2/A3/A4/A5) indicates a poor connection quality with the current serving cell and a handover is required. However, determining an RRM event takes time (e.g., a TimeToTrigger period 414 configured by the network), and thus sometimes waiting until the actual RRM event happening is suboptimal and the handover could be too late.

15 [00164] As shown in FIG. 4A, in the present disclosure, a time window 411 is configured by the BS 210, for example, the BS 210 may configure the UE 220 to perform the RRM event prediction proactively and triggering a measurement report 413 due to a predicted RRM event. In this case, the BS 210 may know the predicted RRM event, and may further trigger a handover before too late.

20 [00165] It is to be understood that the end times of the time window 411 and the time to trigger period 414 are not necessarily the same. For example, an end time of the time window 411 may be configured to be before or after the end of the period 414.

[00166] FIG. 4B illustrates an example schematic of an IE 420 of *MeasIdToAddMod* in accordance with some example embodiments of the present disclosure. As shown in FIG.
25 4B, the IE 420 indicates a measurement ID (MeasId), a measurement object ID (MeasObjectId), and a report configuration ID (RepotConfigId). In some examples, the configuration in the present disclosure may be provided per measurement ID (MeasId), per measurement object ID (MeasObjectId), or per report configuration ID (RepotConfigId).

[00167] For example, the configuration in the present disclosure may be associated with the
30 measurement ID (MeasId) so as to indicate when to transmit a report of an RRM prediction of what object. For example, the configuration in the present disclosure may be associated with the measurement object ID (MeasObjectId) so as to indicate a prediction object, such as

an object to be measured. For example, the configuration in the present disclosure may be associated with the report configuration ID (RepotConfigId) so as to indicate an RRM event for prediction to trigger the report.

[00168] FIG. 5A illustrates an example schematic of a time window 510 in accordance with some example embodiments of the present disclosure. As shown in FIG. 5A, the UE 220 may determine whether an RRM event occurs, and in response to that an RRM event occurs, perform an RRM measurement prediction and transmit a report including the predicted RRM measurement results at 512. For example, the predicted RRM measurement results may be determined for the time window 514.

[00169] FIG. 5B illustrates an example schematic of an IE 520 of *MeasIdToAddMod* in accordance with some example embodiments of the present disclosure. As shown in FIG. 5B, the IE 520 indicates a measurement ID (MeasId), a measurement object ID (MeasObjectId), and a report configuration ID (RepotConfigId). In FIG. 5B, the event to trigger an RRM prediction may be an occurrence of an RRM event. For example, if an RRM event occurs, the UE 220 performs an RRM measurement prediction to determine the predicted RRM measurement results.

[00170] FIG. 6 illustrates a signalling chart illustrating a communication process 600 of prediction associated with RRC state transfer in accordance with some example embodiments of the present disclosure.

[00171] In the process 600, the BS 210 transmits an RRC release message to the UE 220 at 610, in addition, the UE 220 enters an RRC inactive/idle state based on the RRC release message at 610. In some examples, when there is no UL and DL traffic for the UE 220, the BS 210 may transfer the UE 220 into the RRC inactive/idle state by using the RRC release message.

[00172] In some implementations, the RRC release message may include the configuration in the present disclosure, e.g., indicating a time window, a prohibit timer, etc. In some examples, the RRC release message may include the configuration which indicates to the UE 220 to perform an RRM prediction for early measurement. For example, the configuration may configure the UE 220 to perform an RRM measurement prediction.

[00173] In some examples, the configuration in the RRC release message may include time information of a time window, details of which may refer to those discussed with reference to FIG. 3. In some examples, the configuration in the RRC release message may indicate

one or more prediction objects, for example, the one or more prediction objects may be concerned objects indicated by an IE *MeasIdleCarrierNR* or a newly defined IE which is not limited in the present disclosure. For example, the following text box shows an example of the IE “*MeasIdleCarrierNR*”:

RRCRelease-v1610-IEs ::=	SEQUENCE {
voiceFallbackIndication-r16	ENUMERATED {true}
OPTIONAL, -- Need N	
measIdleConfig-r16	SetupRelease {MeasIdleConfigDedicated-r16}
OPTIONAL, -- Need M	
nonCriticalExtension	RRCRelease-v1650-IEs
OPTIONAL	
}	
MeasIdleConfigDedicated-r16 ::=	SEQUENCE {
measIdleCarrierListNR-r16	SEQUENCE (SIZE (1..maxFreqIdle-r16)) OF
MeasIdleCarrierNR-r16	OPTIONAL, -- Need N
measIdleCarrierListEUTRA-r16	SEQUENCE (SIZE (1..maxFreqIdle-r16)) OF
MeasIdleCarrierEUTRA-r16	OPTIONAL, -- Need N
measIdleDuration-r16	ENUMERATED {sec10, sec30, sec60, sec120, sec180,
sec240, sec300, spare},	
validityAreaList-r16	ValidityAreaList-r16
OPTIONAL, -- Need N	
...	
}	
MeasIdleCarrierNR-r16 ::=	SEQUENCE {
carrierFreq-r16	ARFCN-ValueNR,
ssbSubcarrierSpacing-r16	SubcarrierSpacing,
frequencyBandList	MultiFrequencyBandListNR
OPTIONAL, -- Need R	
measCellListNR-r16	CellListNR-r16
OPTIONAL, -- Need R	
reportQuantities-r16	ENUMERATED {rsrp, rsrq, both},
qualityThreshold-r16	SEQUENCE {
idleRSRP-Threshold-NR-r16	RSRP-Range
OPTIONAL, -- Need R	
idleRSRQ-Threshold-NR-r16	RSRQ-Range
OPTIONAL -- Need R	
}	
OPTIONAL, -- Need R	
ssb-MeasConfig-r16	SEQUENCE {
nrofSS-BlocksToAverage-r16	INTEGER (2..maxNrofSS-BlocksToAverage)
OPTIONAL, -- Need S	
absThreshSS-BlocksConsolidation-r16	ThresholdNR
OPTIONAL, -- Need S	
smtc-r16	SSB-MTC
OPTIONAL, -- Need S	
ssb-ToMeasure-r16	SSB-ToMeasure
OPTIONAL, -- Need S	
deriveSSB-IndexFromCell-r16	BOOLEAN,
ss-RSSI-Measurement-r16	SS-RSSI-Measurement
OPTIONAL -- Need S	
}	
OPTIONAL, -- Need S	

beamMeasConfigIdle-r16	BeamMeasConfigIdle-NR-r16
OPTIONAL, -- Need R	
timeWindowToPredict	ENUMERATED {ms100, ms 200, ms500,
s1, s2, s5},	
OPTIONAL	
...	
}	

[00174] In the process 600, the BS 210 transmits an RRC resume message (or an RRC setup message) to the UE 220 at 630. In some examples, the RRC resume message (or the RRC setup message) may trigger the UE 220 entering an RRC connected state.

5 [00175] In the process 600, the UE 220 performs an RRM measurement prediction at 640. It is to be understood that although 640 is shown after 630, the present disclosure does not limit in this aspect.

[00176] In some examples, the RRM measurement prediction may be triggered by a reception of the RRC release message at 610. For example, the RRM measurement
10 prediction may be performed when the UE 220 is at an RRC inactive/idle state. For example, a start time of the time window may be a time when the RRC release message is received.

[00177] In some other examples, the RRM measurement prediction may be triggered by a reception of the RRC resume message (or the RRC setup message) at 630 or triggered by a
15 transfer from an RRC inactive/idle state to an RRC connected state. For example, the RRM measurement prediction may be performed when the UE 220 is at an RRC connected state. For example, a start time of the time window may be a time when the RRC resume message (or the RRC setup message) is received, or a time when entering the RRC connected state.

[00178] In some embodiments, the UE 220 may determine prediction results by performing
20 the RRM prediction at 640. In some examples, the prediction results may include predicted measurement results associated with one or more prediction objects, such as beams/cells. In some examples, the prediction results may include an indication of an object with a predicted measurement result exceeding a threshold, for example, a best beam or a best cell may be indicated. In some examples, the prediction results may include a predicted RRM
25 event and/or a time when the predicted RRM event is to happen.

[00179] In the process 600, the UE 220 transmits an RRC resume complete message (or an RRC setup complete message) to the BS 210 at 650.

- [00180] In some implementations, the RRC resume message (or the RRC setup message) at 630 may include a request for the prediction results. For example, an IE “*idleModeMeasurementReq*” may be used for the request. For example, the request in the RRC resume message (or the RRC setup message) may be referred to as an early measurement request, a prediction result request, etc. In this case, the RRC resume complete message (or the RRC setup complete message) may include the prediction results. For example, the prediction results may be referred to as predicted early measurement results, predicted RRM measurement results, etc. For example, the prediction results may be transmitted via an IE “*VarMeasIdleReport*”.
- 10 [00181] In some other implementations, the RRC resume complete message (or the RRC setup complete message) at 650 may include a notification indicating that the prediction results are available at the UE 220. In addition or alternatively, the BS 210 may further transmit a UE information request message to the UE 220 requesting the prediction results, for example, an IE “*idleModeMeasurementReq*” may be used for the request. In addition
- 15 or alternatively, the UE 220 may further transmit a UE information response message to the BS 210, which includes the prediction results. In some examples, the UE 220 may continue performing measurements after transmitting the RRC resume complete message (or the RRC setup complete message) at 650, in some examples, the UE information response message may further include the measurement results.
- 20 [00182] In the process 600, the UE 220 keeps UE variables for a period of time at 660.
- [00183] In some implementations, the UE 220 may decide to maintain the UE variables by its own decision. In some examples, the UE 220 may keep (or maintain) the UE variables by default, e.g. for a period of time. For example, the period of time may be predefined, or may be determined by the UE 220. For example, it is upon UE implementation for how
- 25 long the UE 220 will keep the UE variables. Optionally, the UE 220 may transmit an indication of the period of time to the BS 210, for example, the indication of the period of time may be included in the report at 650.
- [00184] In some implementations, the UE 220 may keep (or maintain) the UE variables based on an indication (or command) from the BS 210.
- 30 [00185] In some example embodiments, the BS 210 may transmit an indication (or command) to the UE 220, and the indication may indicate to the UE 220 to keep (or maintain) the UE variables. For example, the indication (or command) may be included in the RRC resume

message (or the RRC setup message) at 630. For example, the indication (or command) may be included in a separate message different from the RRC resume message (or the RRC setup message) at 630.

5 [00186] In some example embodiments, the UE 220 may keep (or maintain) the UE variables for a period of time, and may further discard (or release) the UE variables after the period of time. In some examples, the period of time may be predefined. In some examples, the period of time may be preconfigured, for example, it may be associated with the indication (or command). In some examples, the period of time may be indicated together with the indication (or command). In some examples, the indication (or command) may further
10 indicate the period of time. For example, the UE 220 is expected to keep the UE variables for the period of time after a transmission of the report.

[00187] In some other example embodiments, the UE 220 may keep (or maintain) the UE variables, and may further discard (or release) the UE variables based on a further indication (or a further command). In some examples, the BS 210 may transmit a further indication
15 (or a further command) indicating to the UE 220 to discard (or release) the UE variables.

[00188] On the other side of communication, the BS 210 may further perform one or more operations based on prediction results from the UE 220. For example, the BS 210 may make a HO decision before too late.

[00189] It is to be noted that the operations in the process 600 are illustrated for example
20 without any limitation, for example, some of the operations may be modified, updated, or omitted in some cases, or additional operations may be further included. For example, in some implementations, the RRC release message does not include the configuration for RRM prediction. In some implementations, the configuration may be included in the RRC resume message or the RRC setup message or the UE information request message. In some
25 examples, the configuration in the RRC resume message or the RRC setup message or the UE information request message may indicate one or more of: time information of the time window for prediction, one or more prediction objects, etc. details of which will not be repeated herein. For example, in some implementations, the UE 220 may continue measuring one or more objects for a time period after the prediction at 640, for example, the
30 UE 220 may transmit, to the BS 210, information of the one or more objects the UE 220 continues measuring and the time period during which the UE 220 continues measuring.

[00190] It should be understood that process 600 may be regarded as specific embodiments of process 300, in some scenarios, some details with reference to FIG. 3 are also applied for the process 600.

5 [00191] In some scenarios, early measurement may be supported to fasten the procedure for NW to configure UE with carrier aggregation (CA) or dual-connectivity (DC) in legacy. In particular, when transferring the UE to the RRC inactive/idle state, NW can configure the UE to perform measurement when UE is in the RRC inactive/idle state. After the UE enters the RRC connected state again, NW can request the UE to report the measurement result just before the UE enters RRC connected state. In such way, NW can configure the UE with
10 CA (adding SCells for master cell group (MCG)) or DC (adding secondary cell group (SCG)) as soon as possible if needed.

[00192] According to embodiments with reference to FIG. 6, the UE 220 can provide the predicted RRM measurement results to the BS 210, accordingly the BS 210 may configure CA or DC for the UE 220 as soon as possible if needed. Therefore, the communication
15 procedure may be more efficient.

[00193] FIG. 7 illustrates an example of a device 700 in accordance with aspects of the present disclosure. The device 700 may be an example of a BS 210 or a UE 220 as described herein. The device 700 may support wireless communication with a BS 210, a UE 220, or any combination thereof. The device 700 may include components for bi-directional
20 communications including components for transmitting and receiving communications, such as a processor 702, a memory 704, a transceiver 706, and, optionally, an I/O controller 708. 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).

25 [00194] The processor 702, the memory 704, the transceiver 706, 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 702, the memory 704, the transceiver 706, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

30 [00195] In some implementations, the processor 702, the memory 704, the transceiver 706, 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.

5 In some implementations, the processor 702 and the memory 704 coupled with the processor 702 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 702, instructions stored in the memory 704).

[00196] For example, the processor 702 may support wireless communication at the device 700 in accordance with examples as disclosed herein. The processor 702 may be configured
10 to operable to support a means for operations discussed above.

[00197] The processor 702 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 702 may be
15 configured to operate a memory array using a memory controller. In some other implementations, a memory controller may be integrated into the processor 702. The processor 702 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 704) to cause the device 700 to perform various functions of the present disclosure.

20 [00198] The memory 704 may include random access memory (RAM) and read-only memory (ROM). The memory 704 may store computer-readable, computer-executable code including instructions that, when executed by the processor 702 cause the device 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. In some
25 implementations, the code may not be directly executable by the processor 702 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 704 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.

30 [00199] The I/O controller 708 may manage input and output signals for the device 700. The I/O controller 708 may also manage peripherals not integrated into the device 700. In some implementations, the I/O controller 708 may represent a physical connection or port to

an external peripheral. In some implementations, the I/O controller 708 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 708 may be implemented as part of a processor, such as the processor 702. In some
5 implementations, a user may interact with the device 700 via the I/O controller 708 or via hardware components controlled by the I/O controller 708.

[00200] In some implementations, the device 700 may include a single antenna 710. However, in some other implementations, the device 700 may have more than one antenna 710 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may
10 be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 706 may communicate bi-directionally, via the one or more antennas 710, wired, or wireless links as described herein. For example, the transceiver 706 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 706 may also include a modem to modulate the packets, to provide the
15 modulated packets to one or more antennas 710 for transmission, and to demodulate packets received from the one or more antennas 710. The transceiver 706 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[00201] A transmit chain may be configured to generate and transmit signals (e.g., control information, data, packets). The transmit chain may include at least one modulator for
20 modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the
25 modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmit chain may also include one or more antennas 710 for transmitting the amplified signal into the air or wireless medium.

[00202] A receive chain may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receive chain may include one or more
30 antennas 710 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.

[00203] FIG. 8 illustrates an example of a processor 800 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, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 800 may optionally include one or more arithmetic-logic units (ALUs) 806. 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).

[00204] 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).

[00205] 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.

[00206] 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
5 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
10 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.

[00207] 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 implementations, the memory 804 may reside within or on a
15 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).

[00208] 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
20 various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 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. For example, the processor 800 and/or the controller 802 may be coupled with or to the memory 804, the
25 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.

[00209] The one or more ALUs 806 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 806 may reside within or on a processor chipset (e.g., the processor 800). In some
30 other implementations, the one or more ALUs 806 may reside external to the processor

chipset (e.g., the processor 800). One or more ALUs 806 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 806 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 806 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 806 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 806 to handle conditional operations, comparisons, and bitwise operations.

10 [00210] The processor 800 may support wireless communication in accordance with examples as disclosed herein. The processor 800 may be configured to or operable to support a means for operations described in some embodiments of the present disclosure.

[00211] FIG. 9 illustrates a flowchart of a method 900 performed by a UE in accordance with aspects of the present disclosure. The operations of the method 900 may be implemented by a device or its components as described herein. For example, the operations of the method 900 may be performed by the UE 220 in FIG. 2B. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

20 [00212] At 910, the method may include receiving, from a base station, a configuration indicating time information of a time window for RRM prediction. The operations of 910 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 910 may be performed by the UE 220 as described with reference to FIG. 2B.

25 [00213] At 920, the method may include determining RRM prediction information within the time window based on the configuration. The operations of 920 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 920 may be performed by the UE 220 as described with reference to FIG. 2B.

[00214] At 930, the method may include transmitting, to the base station, a report comprising the RRM prediction information. The operations of 930 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 930 may be performed by the UE 220 as described with reference to FIG. 2B.

[00215] FIG. 10 illustrates a flowchart of a method 1000 performed by a BS 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 the BS 210 in FIG. 2B. In some
5 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.

[00216] At 1010, the method may include transmitting, to a UE, a configuration indicating time information of a time window for RRM prediction. The operations of 1010 may be
10 performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1010 may be performed by the BS 210 as described with reference to FIG. 2B.

[00217] At 1020, the method may include receiving, from the UE, a report comprising RRM prediction information within the time window. The operations of 1020 may be performed
15 in accordance with examples as described herein. In some implementations, aspects of the operations of 1020 may be performed by the BS 210 as described with reference to FIG. 2B.

[00218] 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
20 the methods may be combined.

[00219] 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
25 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).

[00220] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed
30 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
5 functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations.

[00221] 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
10 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
15 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.

[00222] 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
20 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
25 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.

[00223] 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
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disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A user equipment (UE) comprising:
at least one memory; and
5 at least one processor coupled with the at least one memory and configured to cause the UE to:
receive, from a base station, a configuration indicating time information of a time window for radio resource management (RRM) prediction;
determine RRM prediction information within the time window based on the
10 configuration; and
transmit, to the base station, a report comprising the RRM prediction information.
2. The UE of claim 1, wherein the configuration further comprises a prohibit timer
15 indicating one of:
a minimal time interval between two consecutive reports, or
a minimal time interval between two consecutive operations for RRM prediction.
3. The UE of claim 1, wherein the time information of the time window comprises
20 one of:
a time interval value indicating a time length of the time window with a start time being a reference time,
a first value and a second value indicating a start time of the time window being the first value after a reference time and an end time of the time window being the second value
25 after the reference time respectively, or
a third value indicating a specific time within the time window being the third value after a reference time.
4. The UE of claim 3, wherein the at least one processor is further configured to
30 cause the UE to:
in accordance with a determination that the configuration comprises the third value, determine a time length of the time window, wherein the specific time associated with the third value is within the time window.

5. The UE of claim 3, wherein the reference time comprises one of:
a time when the configuration is received, or
a time when a trigger condition is met.

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6. The UE of claim 1, wherein the configuration further comprises one of:
information about one or more prediction objects, or
one or more RRM events for prediction.

10 7. The UE of claim 6, wherein the at least one processor is configured to cause the
UE to transmit the report by:

in accordance with a determination that it is predicted that at least one of the one or
more RRM events for prediction is to be satisfied within the time window, transmitting the
report.

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8. The UE of claim 5, wherein the trigger condition comprises an RRM event
being satisfied, and wherein the RRM prediction information comprises predicted RRM
measurement results within the time window.

20 9. The UE of claim 5, wherein the trigger condition comprises one of:
an RRC resume message being received,
an RRC setup message being received, or
an RRC state of the UE being transferred to an RRC connected state.

25 10. The UE of claim 9, wherein the at least one processor is further configured to
cause the UE to:

transmit, to the base station, a notification indicating that the RRM prediction
information is available; and

30 receive, from the base station, a request for requesting the RRM prediction
information,

wherein the report is comprised in a response to the request.

11. The UE of claim 10, wherein the notification comprises an RRC resume
complete message or an RRC setup complete message, the request comprises a UE

information request message, and the response comprises a UE information response message.

12. The UE of claim 5, wherein the configuration is comprised in one of: an RRC release message, an RRC resume message, an RRC setup message, or a UE information request message.

13. The UE of claim 9, wherein the at least one processor is further configured to cause the UE to:
10 keep UE variables at the UE for a period of time after transmitting the report, wherein the UE variables comprise one of the RRM prediction information or RRM measurement results.

14. The UE of claim 9, wherein the at least one processor is further configured to cause the UE to:
15 receive, from the base station, an indication indicating to the UE to keep UE variables;
and
keep the UE variables at the UE after transmitting the report based on the indication, wherein the UE variables comprise one of the RRM prediction information or RRM measurement results.
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15. The UE of claim 14, wherein the at least one processor is further configured to cause the UE to:
receive, from the base station, a further indication indicating to the UE to release the
25 UE variables; and
release the UE variables at the UE based on the further indication.

16. The UE of claim 14, wherein the at least one processor is further configured to cause the UE to:
30 release the UE variables after a period of time, wherein the period of time is indicated by the BS or predefined.

17. The UE of claim 1, wherein the RRM prediction information comprises one of: predicted measurement results on at least one prediction object,

an indication of a prediction object which is associated with a predicted measurement result exceeding a threshold,

an indication of a predicted RRM event which triggers the report,

a time when it is predicted that the RRM event is to be satisfied,

5 an indication of an RRM event which is satisfied and triggers the RRM prediction,

an indication of one or more than one object the UE continues measuring, or

a time period during which the UE continues measuring.

18. A base station comprising:

10 at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the base station to:

transmit, to a user equipment (UE), a configuration indicating time information of a time window for radio resource management (RRM) prediction; and

15 receive, from the UE, a report comprising RRM prediction information within the time window.

19. The base station of claim 18, wherein the configuration further comprises a prohibit timer indicating one of:

20 a minimal time interval between two consecutive reports, or

a minimal time interval between two consecutive operations for RRM prediction.

20. The base station of claim 18, wherein the RRM prediction information comprises one of:

25 predicted measurement results on at least one prediction object,

an indication of a prediction object which is associated with a predicted measurement result exceeding a threshold,

an indication of a predicted RRM event which triggers the report,

a time when it is predicted that the RRM event is to be satisfied,

30 an indication of an RRM event which is satisfied and triggers the RRM prediction,

an indication of one or more than one object the UE continues measuring, or

a time period during which the UE continues measuring.