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(54) Title: METHOD AND APPARATUS OF SUPPORTING DOWNLINK DATA TRANSMISSIONS

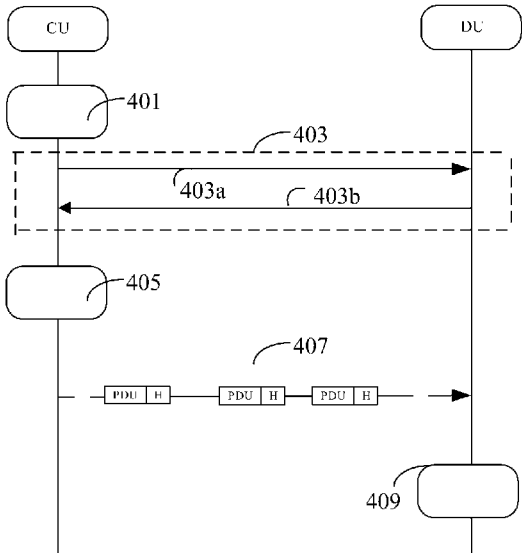


FIG. 4

(57) Abstract: Various aspects of the present disclosure relate to a method and apparatus of supporting downlink data transmissions. An exemplary apparatus is a CU of a RAN node, which may include at least one memory; and at least one processor coupled with the at least one memory and configured to cause the CU to: buffer packets of a QoS flow received from a CN; determine first remaining time related information of the buffered packets; and transmit second remaining time related information of at least in part of the buffered packets to a DU of the RAN node over F1 user plane protocol based on the first remaining time related information of the buffered packets.

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## METHOD AND APPARATUS OF SUPPORTING DOWNLINK DATA TRANSMISSIONS

### TECHNICAL FIELD

**[0001]** The present disclosure relates to wireless communications, and more specifically to technologies of supporting downlink (DL) data transmissions.

### BACKGROUND

**[0002]** A wireless communications system may include one or multiple network communication devices, such as base stations, which 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, or the like). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

### SUMMARY

**[0003]** An article “a” before an element is unrestricted and understood to refer to “at least one” of those elements or “one or more” of those elements. The terms “a,” “at least one,” “one or more,” and “at least one of one or more” may be interchangeable. As used herein, including in the claims, “or” as used in a list of items (e.g., a list of items prefaced by a phrase such as “at least one of” or “one or more of” or “one or both of”) indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase “based on” shall not be

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

**[0004]** Some implementations of the methods and apparatuses described herein may further include a central unit (CU) of a radio access network (RAN) node, which may include: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the CU to: buffer packets of a quality of service (QoS) flow received from a core network (CN); determine first remaining time related information of the buffered packets; and transmit second remaining time related information of at least in part of the buffered packets to a distributed unit (DU) of the RAN node over F1 user plane protocol based on the first remaining time related information of the buffered packets.

**[0005]** In some implementations of the methods and apparatuses described herein, the first remaining time related information of a packet includes remaining time of a timer associated with the packet, elapsed time between receiving the packet from the CN and sending the packet to the DU, arrival time of the packet, remaining time of a timer associated with a first packet of a protocol data unit (PDU) set including the packet, elapsed time between receiving a first packet of a PDU set including the packet from the CN and sending the first packet to the DU, arrival time of a first packet of a PDU set including the packet, or a combination thereof.

**[0006]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the CU to: determine remaining time of the packet based on the first remaining time related information of the packet, wherein the remaining time of the packet is the remaining time of the timer associated with the packet, and the timer associated with the packet is started in response to receiving the packet.

**[0007]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the CU to: determine remaining time of the packet based on the first remaining time related information of the packet, wherein the remaining

time of the packet is the remaining time of the timer associated with the first packet of the PDU set including the packet, and the timer associated with the first packet is started in response to receiving the first packet of the PDU set including the packet.

**[0008]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the CU to: determine remaining time of the packet based on the elapsed time between receiving the packet from the CN and sending the packet to the DU, the arrival time of the packet, the elapsed time between receiving the first packet from the CN and sending the first packet to the DU, or the arrival time of the first packet of the PDU set including the packet.

**[0009]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the CU to: transmit the second remaining time related information of the packet to the DU.

**[0010]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the CU to: determine whether to transmit the second remaining time related information of the packet to the DU based on remaining time of the packet and a threshold, wherein the remaining time of the packet is determined based on the first remaining time related information of the packet; and transmit the second remaining time related information of the packet to the DU in the case that remaining time of the packet is lower than or equal to the threshold.

**[0011]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the CU to: transmit the second remaining time related information of a packet that has a shortest remaining time among delay critical packets and buffer size of the delay critical packets, wherein, the delay critical packets are packets that have not been confirmed as successfully delivered or transmitted to user equipment and whose remaining time is lower than or equal to a threshold or belong to PDU sets including a packet whose remaining time is lower than or equal to the threshold.

**[0012]** In some implementations of the methods and apparatuses described herein, the delay critical packets are packets that have not been confirmed as successfully delivered or transmitted to user equipment and whose remaining time is lower than or equal to the

threshold, and the at least one processor is configured to cause the CU to: for each packet that has not been confirmed as successfully delivered or transmitted to user equipment, determine whether remaining time of the packet that has not been confirmed as successfully delivered or transmitted to user equipment is lower than or equal to the threshold to determine the delay critical packets, wherein, the remaining time of the packet is determined based on the first remaining time related information of the packet; and determine the delay critical packet that has the shortest remaining time and the buffer size of the delay critical packets.

**[0013]** In some implementations of the methods and apparatuses described herein, the delay critical packets are packets that have not been confirmed as successfully delivered or transmitted to user equipment and belong to PDU sets including a packet whose remaining time is lower than or equal to the threshold, and the at least one processor is configured to cause the CU to: for each PDU set including a packet that has not been confirmed as successfully delivered or transmitted to user equipment, determine whether there is any packet among the PDU set whose remaining time is lower than or equal to the threshold to determine the delay critical packets, wherein, the remaining time of a packet among the PDU set is determined based on the first remaining time related information of the packet; and determine the delay critical packet that has the shortest remaining time and the buffer size of the delay critical packets.

**[0014]** In some implementations of the methods and apparatuses described herein, the second remaining time related information includes partial or all of the first remaining time related information, or remaining time determined based on the first remaining time related information, or a combination thereof.

**[0015]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the CU to: determine the second remaining time related information of a packet based on a first remaining time and a threshold, wherein the first remaining time is remaining time of the packet, or shortest remaining time among packets of a PDU set or a QoS flow or a data radio bearer (DRB) including the packet; and transmit the second remaining time related information of the packet to the DU, wherein, the second remaining time related information of the packet indicates whether the packet is delay critical or not.

**[0016]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the CU to: determine that the packet is delay critical in the case that the remaining time of the packet is lower than or equal to the threshold, wherein the remaining time of the packet is determined based on the first remaining time related information of the packet.

**[0017]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the CU to: determine that the packet is delay critical in the case that the shortest remaining time among packets of the PDU set or QoS flow or DRB including the packet is lower than or equal to the threshold, wherein the remaining time of a packet of the PDU set or QoS flow or DRB is determined based on the first remaining time related information of the packet.

**[0018]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the CU to: transmit the second remaining time related information of multiple packets by indicating a list of packet data convergence protocol (PDCP) sequence number (SN)s associated with the multiple packets.

**[0019]** In some implementations of the methods and apparatuses described herein, the CU includes a CU control plane (CP) (CU-CP) and a CU user plane (UP) (CU-UP), and the at least one processor is configured to cause the CU-UP to: determine the first remaining time related information of the buffered packets; determine the second remaining time related information of at least in part of the buffered packets based on the first remaining time related information; and transmit the second remaining time related information to the DU.

**[0020]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the CU-CP to: receive configuration information related to one or both of a timer for determining the first remaining time related information of the received packets and a threshold from the CN or another RAN node; and transmit the configuration information to the CU-UP.

**[0021]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the CU-UP to: determine whether to transmit the second remaining time related information of a packet to the DU based on remaining time of

the packet and the threshold, wherein the remaining time of the packet is determined based on the first remaining time related information of the packet.

**[0022]** In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the DU to: transmit the second remaining time related information of at least in part of the packets of the QoS flow to the DU over a general packet radio service (GPRS) tunnel protocol user plane (GTP-U) extension header of a corresponding packet.

**[0023]** In some implementations of the methods and apparatuses described herein, one or multiple bits in the GTP-U extension header indicate whether the second remaining time related information is present or not.

**[0024]** In some implementations of the methods and apparatuses described herein, the timer associated with the packet or the timer associated with the first packet is a PDCP timer or a timer for packets of a PDU set with low importance.

**[0025]** Some implementations of the methods and apparatuses described herein may further include a processor for wireless communication, which includes at least one controller coupled with at least one memory and configured to cause the processor to: buffer packets of a QoS flow received from a CN; determine first remaining time related information of the buffered packets; and transmit second remaining time related information of at least in part of the packets to a DU of a RAN node over F1 user plane protocol based on the first remaining time related information of the buffered packets.

**[0026]** Some implementations of the methods and apparatuses described herein may further include a DU of a RAN node, which includes: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the DU to: receive packets of a data radio bearer (DRB) from a CU of the RAN node; receive remaining time related information of at least in part of the packets from a CU of the RAN node over F1 user plane protocol; and determine whether to prioritize scheduling of the packets to be transmitted to user equipment based on the received remaining time related information.

**[0027]** Some implementations of the methods and apparatuses described herein may further include a DU of a RAN node, which includes: at least one memory; and at least one

processor coupled with the at least one memory and configured to cause the DU to: receive configuration information related to a threshold for data transmission from a CU of the RAN node; determine remaining time of packets to be transmitted; and determine whether to prioritize scheduling of the packets to be transmitted based on the determined remaining time of packets and the threshold.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0028]** Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

**[0029]** Figure 2 is a schematic diagram illustrating an internal structure of a NE or RAN node, e.g., a gNB in accordance with aspects of the present disclosure.

**[0030]** Figure 3 is a schematic diagram illustrating an internal structure of a NE or RAN node according to some other embodiments of the present disclosure.

**[0031]** Figure 4 is an exemplary flow of a method of supporting downlink data transmission in scenarios 1 in accordance with aspects of the present disclosure.

**[0032]** Figure 5 is an exemplary flow of a method of supporting downlink data transmission in scenarios 2 in accordance with aspects of the present disclosure.

**[0033]** Figure 6 illustrates an example of a CU of a RAN node in accordance with aspects of the present disclosure.

**[0034]** Figure 7 illustrates an example of a processor in accordance with aspects of the present disclosure.

**[0035]** Figure 8 illustrates an example of a DU of a RAN node in accordance with aspects of the present disclosure.

**[0036]** Figure 9 illustrates a flowchart of method performed by a CU of a RAN node in accordance with aspects of the present disclosure.

**[0037]** Figure 10 illustrates a flowchart of method performed by a DU of a RAN node in accordance with aspects of the present disclosure.

**[0038]** Figure 11 illustrates a flowchart of method performed by a DU of a RAN node in accordance with aspects of the present disclosure.

#### DETAILED DESCRIPTION

**[0039]** Since 5G system, 3rd generation partnership project (3GPP) has considered introducing extended reality (XR) applications (or services) into the wireless communication system. Regarding XR, it includes augmented reality (AR) and virtual reality (VR), as well as cloud gaming (CG), presents a new promising category of connected devices, applications, and services.

**[0040]** In accordance with 3GPP release (Rel)-18, XR supports that UE reports delay state reports (DSRs) to the network, to assist the network side's uplink (UL) scheduling. Via receiving the DSRs, the network side will be aware of the volume and remaining time of delay critical data buffered in the logical channels or logical channel groups. Regarding delay critical data, it is defined as data whose remaining time is less than a threshold. Based on the above information, the network side will schedule suitable uplink grants to the UE in time, to avoid the delay critical data from exceeding the corresponding delay budget during uplink data transmission.

**[0041]** On the other hand, logical channel prioritization (LCP) is based on fixed priority levels & bucket size for each logic channel (LCH) identifier (LCID). It is a restriction to prioritize the delay critical data if they belong to the lower priority logical channel. Therefore, 3GPP Rel-19 seeks to enhance uplink delay aware scheduling. For example, the gNB can decide logical channel re-prioritization based DSRs and indicate the prioritization status in uplink dynamic grant. A logical channel with a less remaining time may have a higher priority level.

**[0042]** As can be seen, all the aforementioned disclosures only focus on uplink data transmission. There have been no discussions on delay aware scheduling for downlink data transmission yet.

**[0043]** In accordance with aspects of the present disclosure, downlink data transmission will also support delay aware scheduling. For example, a RAN node, e.g., gNB can prioritize

scheduling the delay critical data in time to avoid the delay critical data from exceeding the corresponding delay budget during downlink data transmission.

**[0044]** However, in the case of a RAN node with CU-DU split architecture, e.g., gNB-CU and gNB-DU, the downlink data is usually buffered in gNB-CU (e.g., gNB-CU-UP), and gNB-DU cannot be aware of the remaining time (e.g., remaining delay) of the received (or buffered) packets which will be transmitted to UE. As a result, the gNB-DU cannot perform delay aware scheduling for downlink data transmission. Necessary enhancements over F1 interface between CU and DU are needed to support delay aware scheduling for downlink data transmission.

**[0045]** At least considering the above, aspects of the present disclosure provide a technical of supporting downlink data transmission, e.g., a method and apparatus of supporting downlink data transmission where delay aware scheduling for downlink data transmission is supported even in the case of CU-DU split architecture.

**[0046]** For example, in accordance with some aspects of the present disclosure, e.g., in scenarios that a CU of a RAN node, e.g., gNB-CU buffers the data from CN, the gNB-CU will determine first remaining time related information (or first remaining delay related information or the like) of the packets (e.g., packets of QoS flows received from CN and buffered in gNB-CU). The gNB-CU will determine second remaining time related information associated with at least part of the packets based on the first remaining time related information of the buffered packets (or received packets), and then send the second remaining time related information via F1 user plane protocol to a DU of the RAN node, e.g., gNB-DU, so that the gNB-DU can perform downlink delay aware scheduling.

**[0047]** Exemplary first remaining time related information of a packet may be the remaining time of a timer (e.g., a PDCP discard timer or PSI based PDCP discard timer) associated with the packet, elapsed time between receiving the packet from the CN and sending the packet to the gNB-DU, arrival time of the packet, remaining time of a timer associated with a first packet of a PDU set including the packet, elapsed time between receiving a first packet of a PDU set including the packet from the CN and sending the first packet to the gNB-DU, arrival time of a first packet of a PDU set including the packet, or a combination thereof. Regarding the second remaining time related information, e.g., the

contents and transmissions (e.g., conditions for transmissions to the gNB-DU etc.) of the second remaining time related information, there are various schemes and/or implementations in accordance with aspects of the present disclosure.

**[0048]** For example, in some implementations of the present disclosure, the gNB-CU will determine and transmit the second remaining time related information of each packet to gNB-DU. The second remaining time related information may include partial or all of the first remaining time related information of the corresponding packet and/or other result information determined based on the first remaining time related information (e.g., the remaining time determined based on the elapsed time or arrival time of the packet). For example, in the case that the first remaining time related information of a packet includes the elapsed time of the packet and/or the arrival time of the packet, the gNB-CU will transmit one or both of the elapsed time and arrival time of the packet to the gNB-DU. The gNB-CU may also transmit the remaining time of the packet determined based on the elapsed time of the packet or the arrival time of the packet to the gNB-DU.

**[0049]** In some other implementations of the present disclosure, the gNB-CU may not transmit the second remaining time related information of each packet. The gNB-CU will determine whether the remaining time of a packet is lower than or equal to a threshold (e.g., a configured or predefined threshold). Only in the case that the remaining time of the packet is lower than or equal to the threshold, the gNB-CU will transmit the second remaining time related information of the packet to the gNB-DU. Similarly, the second remaining time related information of the packet may include partial or all of the first remaining time related information of the packet and/or other result information determined based on the first remaining time related information. For example, for a packet, the gNB-CU will transmit the remaining time of a timer associated with the packet to the gNB-DU in the case that the remaining time of a timer associated with the packet is lower than or equal to the threshold.

**[0050]** In some yet other implementations of the present disclosure, the second remaining time related information is only related to delay critical packets, which are packets that have not been confirmed as successfully delivered or transmitted to UE and whose remaining time is lower than or equal to a threshold (e.g., a configured or predefined threshold) or belong to PDU sets each including a packet whose remaining time is lower than or equal to the

threshold. For example, the gNB-CU will determine whether there are delay critical packets based on the remaining time of the buffered packets, and then determine the packet that has the shortest (or smallest) remaining time and buffer size of the delay critical packets. The gNB-CU will send the second remaining time related information (e.g., including partial or all of the first remaining time related information and/or other result information determined based on the first remaining time related information) associated with the packet that has the shortest remaining time and the buffer size of the delay critical packets to the gNB-DU. For example, the gNB-CU will transmit the remaining time of a timer associated with the delay critical packet that has the shortest remaining time among the delay critical packets and the buffer size of the delay critical packets to the gNB-DU.

**[0051]** In some yet other implementations of the present disclosure, for each buffered packet, the gNB-CU will determine the second remaining time related information of the packet based on a first remaining time associated with the packet and a threshold, which indicates whether the packet is delay critical or not. The first remaining time is determined based on the first remaining time related information of the packet, or first remaining time related information of the packets of a PDU set or QoS flow or DRB including the packet. Accordingly, an exemplary first remaining time is the remaining time of the packet, or the shortest remaining time among packets of a PDU set or a QoS flow or a DRB including the packet. Then, gNB-CU will transmit the second remaining time related information of the packet to gNB-DU.

**[0052]** In accordance with some aspects of the present disclosure, e.g., in scenarios that a DU of a RAN node, e.g., gNB-DU buffers the data from CN, the gNB-DU will receive information related to a threshold for data transmission from the CU of the RAN node. The gNB-DU will determine or calculate remaining time of packets to be transmitted. Based on the determined remaining time of packets and the threshold, the gNB-DU will determine whether to prioritize scheduling of the packets to be transmitted.

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

**[0054]** Figure 1 illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100

may include one or more NE 102, one or more UE 104, and a CN 106. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a NR network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) 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, for example, 6G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

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

**[0056]** An NE 102 may provide a geographic coverage area for which the NE 102 may support services for one or more UEs 104 within the geographic coverage area. For example, an NE 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, an NE 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 may be associated with different NE 102.

**[0057]** The one or more UE 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 remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a transmitter device, a receiver device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples.

**[0058]** A UE 104 may be able to support wireless communication directly with other UEs 104 over a communication link. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

**[0059]** An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, N2, or network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other or indirectly (e.g., via the CN 106). In some implementations, one or more NE 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).

**[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 evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or

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

**[0061]** The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N2, or another network interface). The packet data network may include an application server. In some implementations, one or more UEs 104 may communicate with the application server. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via an NE 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 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).

**[0062]** In the wireless communications system 100, the NEs 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 NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 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 NEs 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

**[0063]** One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g.,  $\mu=0$ ) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g.,  $\mu=0$ ) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second

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

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

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

**[0066]** In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the NEs 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 NEs 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 NEs 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]** Figure 2 is a schematic diagram illustrating an internal structure of a NE or RAN node, e.g., a gNB in accordance with aspects of the present disclosure.

**[0069]** Referring to Figure 2, in a split RAN architecture, the internal structure of a RAN node (e.g., NE 102) may be split into a CU 200 and at least one DU 202 (e.g., two DUs shown in Figure 2). Although a specific number of DUs 202 are depicted in FIG. 2, it is contemplated that any number of DUs 202 may be included in the RAN node.

**[0070]** The CU 200, e.g., a CU of a gNB (gNB CU, or gNB-CU) and DU 202 e.g., a DU of a gNB (gNB DU, or gNB-DU) are connected with each other by an interface called F1 as specified in 3GPP standard documents. The radio resource control (RRC) layer functionality,

SDAP functionality, and the PDCP layer functionality are located in the CU 200. The RLC layer functionality, media access control (MAC) layer functionality, and the physical (PHY) layer functionality are located in the DU 202.

**[0071]** According to some embodiments of the present disclosure, the CU may be separated into a CU CP unit (also referred to as "CU CP" or "CU-CP") and at least one CU UP unit (or also referred to as "CU UP" or "CU-UP").

**[0072]** Figure 3 is a schematic diagram illustrating an internal structure of a NE or RAN node according to some other embodiments of the present disclosure.

**[0073]** Referring to Figure 3, the CU of the RAN node 300, e.g., a gNB may be separated into a CU-CP 310 and at least one CU-UP 312. The CU-CP 310 and each CU-UP 312 may be connected with each other by an interface called E1 as specified in 3GPP standard documents. The CU-CP 310 and the DU 33 of the RAN node 300 are connected by an interface called F1-C as specified in 3GPP documents. Each CU-UP 312 and the DU 33 are connected by an interface called F1-U as specified in 3GPP standard documents.

**[0074]** For downlink data transmission, a RAN node will receive data from the CN side, e.g., from the user plane function (UPF) of the CN. In the case of the CU-DU split RAN architecture, the received data will be buffered in the CU of the RAN node (hereinafter, scenarios 1) or the DU of the RAN node (hereinafter scenarios 2). In another perspective of view, the buffered data are packets (e.g., PDUs) that have not been confirmed as successfully delivered or transmitted to UE (e.g., by flow control information). The DU may provide transmission status (e.g., the highest NR PDCP PDU sequence number successfully delivered in sequence to the UE) to the CU so that the CU knows that which packets have been confirmed as successfully transmitted to UE or not.

**[0075]** Details of the present disclosure will be illustrated in the following in view of exemplary implementations respectively in scenarios 1 and scenarios 2.

#### Scenarios 1

**[0076]** Figure 4 is an exemplary flow of a method of supporting downlink data transmission in scenarios 1 in accordance with aspects of the present disclosure. Although

the method is illustrated in a system level between a CU of the RAN node (e.g., a gNB-CU) and a DU coupled to the CU, e.g., a gNB-DU, persons skilled in the art should understand that the method implemented in the CU and the DU can be separately implemented and/or incorporated by other apparatus with the like functions.

**[0077]** Referring to Figure 4, the gNB-CU will receive PDU set QoS parameters of a QoS flow from CN side or from another gNB in step 401. For example, the gNB-CU receives the PDU set QoS parameters of a QoS flow in a PDU session setup request message from, e.g., AMF or session management function (SMF) of the CN. For another example, the gNB-CU receives the PDU set QoS parameters of a QoS flow in a handover request message from another gNB, e.g., a source gNB in the case of handover. Exemplary PDU set QoS parameters include PDU set delay budget (PSDB), PDU set error rate (PSER) and PDU set integrated handling information (PSIHI).

**[0078]** The gNB-CU will transmit the PDU set QoS parameters to the gNB-DU, e.g., during DRB setup in step 403. For example, the gNB-CU will map the received QoS flow to a DRB. In step 403a, the gNB-CU will send a UE context setup request or UE context modification request message to the gNB-DU for the DRB setup, and may receive a corresponding UE context setup response or UE context modification response message from the gNB-DU in step 403b. In the UE context setup request or UE context modification request message, the gNB-CU may include the PDU set QoS parameters of the QoS flow.

**[0079]** The gNB-CU will receive packets, e.g., SDAP service data units (SDUs)) of the QoS flow from the CN (e.g., from the UPF) and buffer the packets (e.g., PDUs corresponding to the SDUs) to transmit to the gNB-DU. In step 405, the gNB-CU will determine the first remaining time related information of the buffered packets.

**[0080]** In accordance with some aspects of the present disclosure, the first remaining time related information of a packet may be based on each packet itself. For example, exemplary first remaining time related information of a packet may be the remaining time of a timer associated with the packet, elapsed time between receiving the packet from the CN and sending the packet to the gNB-DU, arrival time of the packet, or a combination thereof. Regarding the arrival time of a packet, it may be the absolute time, e.g. coordinated universal time (UTC) time of the packet arriving at the gNB-CU from the CN side (e.g., UPF), or may

be the system frame number (SFN) timing that represents the arrival time of the packet arriving at the gNB-CU from the CN.

**[0081]** Regarding the timer, the gNB-CU will start a corresponding timer in response to receiving a packet from the CN side. Exemplary timer may be a legacy PDCP discard timer or a PSI based discard timer or other discard timer. The PSI based discard timer is a short timer for the packets of a PDU set with low importance, which may also be defined as a discard timer for low importance, e.g., identified by a parameter *discardTimerForLowImportance*. For example, in accordance with aspects of the present disclosure, an exemplary definition of *discardTimerForLowImportance* is: "*This timer is configured only for DRBs. The duration of the timer is configured by upper layers TS 38.331. In the transmitter, a new timer is started upon reception of an SDU belonging to a low importance PDU Set from upper layer if psi-BasedDiscard is configured and PSI based SDU discard is activated.*"

**[0082]** In accordance with some aspects of the present disclosure, the first remaining time related information of a packet may be based on a PDU set including the packet. Regarding a PDU set, it is composed of one or more PDUs carrying the payload of one unit of information generated at the application level (e.g. a frame or video slice for XR immersion (XRM) services, as used in TR 26.926). For example, exemplary first remaining time related information of a packet based on a PDU set may be remaining time of a timer associated with the first packet of a PDU set including the packet, elapsed time between receiving the first packet of a PDU set including the packet from the CN and sending the first packet to the gNB-DU, arrival time of the first packet of a PDU set including the packet, or a combination thereof. In the case that there is a timer configured, e.g., a PDCP discard timer or a PSI based discard timer, the gNB-CU will start the timer associated with the first packet of a PDU set including the packet in response to receiving the first packet.

**[0083]** The gNB-CU may also determine the second remaining time related information based on the first remaining time related information of the buffered packets in step 405, which will be transmitted to the gNB-DU in step 407. Regarding that, there are various manners or schemes in accordance with aspects of the present disclosure.

**[0084]** For example, in accordance with some aspects of the present disclosure (scheme 1-1), for each packet (e.g., a PDU), the gNB-CU will determine to transmit the second remaining time related information of each packet to the gNB-DU directly (or without any conditions).

**[0085]** In some implementations of the present disclosure, e.g., a timer being configured, the gNB-CU may transmit the second remaining time related information of a packet including part or all of the first remaining time related information of the packet to the gNB-DU in step 407. For example, in the case of a timer is configured or used, the gNB-CU may transmit the remaining time of the timer associated with a packet to the gNB-DU with or without the elapsed time and/or arrival time of the packet. In the case that no timer is configured or used, the gNB-CU may transmit the elapsed time or arrival time of the packet to the gNB-DU, so that the gNB-DU can determine the corresponding remaining time based on the elapsed time or arrival time.

**[0086]** In some implementations of the present disclosure, e.g., no timer being configured, for each packet, the gNB-CU will determine the remaining time of the packet based on the first remaining time related information of packet. The gNB-CU may transmit the remaining time of the packet with or without (part or all of) the first remaining time related information to the gNB-DU in step 407. For example, in the case that no timer is configured, the gNB-CU will calculate the remaining time of the packet based on the elapsed time or arrival time information. An exemplary calculation manner may be: the gNB-CU uses the elapsed time information and PSDB or PDU delay budget (PDB) or access network (AN) PSDB to calculate the remaining time of the packet, wherein, the remaining time of the packet is PSDB (or PDB, or AN PSDB) minus the elapsed time (of the packet or the first packet of the corresponding PDU set). The gNB-CU may only transmit the calculated remaining time of the packet to the gNB-DU in step 407.

**[0087]** In accordance with some aspects of the present disclosure (scheme 1-2), the gNB-CU will determine whether a packet (e.g., a PDU) is delay critical or not based on a threshold, and only transmit the second remaining time related information of the delay critical packet in step 407. For example, in the case that the remaining time of a packet is lower than or equal to the threshold, the gNB-CU will transmit the second remaining time related

information of the packet to the gNB-DU. In the case that there is no remaining time of the packet provided by the gNB-CU, it means that the condition or trigger of indicating the second remaining time related information is not fulfilled in the gNB-CU. The second remaining time related information and the remaining time of a packet can be determined as the same or similar manners as those illustrated in scheme 1-1, and thus will not repeat.

**[0088]** In accordance with some aspects of the present disclosure (scheme 1-3), the gNB-CU will determine and send the second remaining time related information of a packet which has the shortest remaining time and buffer size of the delay critical packets (e.g., delay critical PDUs) (if any) to the gNB-DU. The buffer size of the delay critical packets may represent the data size of the delay critical packets, e.g., delay critical PDCP PDUs or PDCP SDUs. The second remaining time related information of the packet that has the shortest remaining time and buffer size of the delay critical packets is the same as that illustrated in scheme 1-1, and thus will not repeat.

**[0089]** Regarding the delay critical packets, they may be determined in various manners in scheme 1-3.

**[0090]** In some implementations of the present disclosure, the delay critical packets may be determined based on the remaining time of each packet (per packet or per PDU). For example, for each packet that has not been confirmed as successfully delivered or transmitted to UE, the gNB-CU will determine whether the remaining time of the packet that has not been confirmed as successfully delivered or transmitted to UE is lower than or equal to the threshold to determine the delay critical packets.

**[0091]** In some implementations of the present disclosure, the delay critical packets may be determined on the shortest remaining time among packets of a corresponding PDU set (per PDU set). That is, the delay critical packets are packets that have not been confirmed as successfully delivered or transmitted to UE and belong to PDU sets including a packet whose remaining time is lower than or equal to the threshold. For example, for each PDU set including a packet that has not been confirmed as successfully delivered or transmitted to UE, the gNB-CU will determine whether there is any packet among the PDU set whose remaining time (or whether the shortest remaining time) is lower than or equal to the threshold to determine the delay critical packets. Then, the gNB-CU will determine the second remaining

time related information of the packet which has the shortest remaining time and buffer size of the delay critical packets.

**[0092]** In accordance with some aspects of the present disclosure (scheme 1-4), the second remaining time related information is information indicating whether a packet is delay critical or not. For example, the second remaining time related information (also referred to as delay critical indication) may explicitly indicate that the packet is delay critical or not, or indicate the delay critical level of the packet to implicitly indicate that the packet is delay critical or not. Exemplary delay critical levels may include high delay critical, medium delay critical and non-delay critical etc. The gNB-CU will determine whether a packet is delay critical or not based on the threshold in various manners.

**[0093]** In some implementations of the present disclosure, if the remaining time of the packet is lower than or equal to the threshold, the gNB-CU will determine the packet is delay critical and will send the second remaining time related information, e.g., delay critical indication indicating that the packet is delay critical. Otherwise, the gNB-CU will determine the packet is not delay critical, and will send the second remaining time related information, e.g., delay critical indication indicating that the packet is not delay critical, or not send the delay critical indication to imply that the packet is not delay critical.

**[0094]** In some implementations of the present disclosure, if the shortest remaining time among the packets of the PDU set is less than or equal to the threshold, the gNB-CU will decide to put the delay critical indication to the PDU set to indicate the PDU set is delay critical. For example, the gNB-CU will put the delay critical indication indicating delay critical to all packets or all packets to be transmitted of the PDU set that are delay critical. Otherwise, the gNB-CU will determine the PDU set (or the packets of the PDU set) is not delay critical, and will send the delay critical indication indicating that the PDU set (or the packets of the PDU set) is not delay critical, or not send the delay critical indication to imply that the PDU set (or the packets of the PDU set) is not delay critical.

**[0095]** Similarly, in some implementations of the present disclosure, the delay critical indication will be determined per QoS flow or DRB level. For example, if the shortest remaining time among the packets of the QoS flow or DRB is less than or equal to the threshold, the gNB-CU will decide to put the delay critical indication indicating delay critical

to the QoS flow or DRB. For example, the gNB-CU will put the delay critical indication indicating delay critical to all packets or all packets to be transmitted of the QoS flow or DRB. Otherwise, the gNB-CU will decide to put the delay critical indication indicating non-delay-critical to the QoS flow or DRB, e.g., to all packets of the QoS flow or DRB, or not send the delay critical indication to imply that the QoS flow or DRB (or the packets of the QoS flow or DRB) is not delay critical.

**[0096]** In some implementations of the present disclosure, the delay critical indication may be associated with a PDCP SN range or multiple separate PDCP SNs. For example, the gNB-CU may transmit the delay critical indication of multiple packets to the gNB-DU by indicating a list of PDCP SNs or a PDCP range or the like associated with the multiple packets.

**[0097]** In accordance with aspects of the present disclosure, the gNB-CU will send the second remaining time related information and other related information (e.g., the buffer size of the delay critical packets) to the gNB-DU via F1 user plane protocol (e.g., PDU set Information user plane protocol), e.g., in the GTP-U extension header of the packet. In some cases, one or multiple bits in the GTP-U extension header may be used to indicate whether the second remaining time related information is present or not. In some cases, e.g., in scheme 1-3, the GTP-U extension header may also use one or more bits to indicate whether other related information is present or not.

**[0098]** For example, under schemes 1-1 and 1-2, the gNB-CU may include the remaining time of a packet in a DL PDU set information frame of the GTP-U extension header. In some cases, e.g., under scheme 1-2, compared with the legacy GTP-U extension header, one new bit is introduced to indicate whether the remaining time of the packet is present or not, and one or more bytes are introduced in the DL PDU set information frame to indicate the value of the remaining time of the packet, e.g., 10.00ms.

**[0099]** Under scheme 1-3, the gNB-CU may include the shortest remaining time and buffer size of the delay critical PDUs in the PDU set information user plane protocol. For example, the shortest remaining time and buffer size of the delay critical PDUs can be included in the DL PDU set information frame. One new bit may be introduced to indicate whether the shortest remaining time and buffer size of the delay critical PDUs is present or

not and one or more bytes to indicate the value of the remaining time e.g., 10.00ms and corresponding buffer size. In another example, one bit is used to indicate whether the shortest remaining time of the delay critical PDUs is present, while another bit is used to indicate whether the buffer size of the delay critical PDUs is present.

**[0100]** Under scheme 1-4, the gNB-CU may include the delay critical indication in the PDU set information user plane protocol. For example, the delay critical indication can be included in the DL PDU set information frame.

**[0101]** After receiving the second remaining time related information from the gNB-CU, the gNB-DU will determine the delay critical information of the data to be transmitted based on the second remaining time related information and other related information (if any, e.g., the threshold in the case of no delay critical indication is provided). For example, in the case that the remaining time of a packet is provided, the gNB-CU will determine whether the packet is delay critical based on the remaining time and the threshold. In the case that the gNB-CU only provides the elapsed time or arrival time of a packet, the gNB-DU will determine the remaining time of the packet, and then determine whether the packet is delay critical based on the remaining time and the threshold. Based on the delay critical information of the data to be transmitted, the gNB-DU will prioritize the scheduling of related PDUs in step 409. These operations depend on the implementations of the gNB-DU, and will not illustrate in details.

**[0102]** For a RAN node with the split CU, the operations on the CU will be performed by the cooperation between the CU-CP and CU-UP. In accordance with aspects of the present disclosure, the CU-CP will transmit information for determining the first and remaining time related information to the CU-UP, e.g., information related to the timer and/or the threshold etc. Operations in step 405 and step 407 will be performed by the CU-UP. That is, the CU-UP will determine the first remaining time related information of the buffered packets as illustrated in view of a non-split CU (e.g., start a PDCP discard timer of a PDU in response to receiving the packet from the CN side), determine the second remaining time related information based on the first remaining time related information (e.g., determining the remaining time of a packet and/or determine whether to transmit the second remaining timer related information of the packet etc.) as illustrated in view of a non-split CU, and transmit

the second remaining time related information and other related information to the gNB-DU as illustrated in view of a non-split CU. Details will not repeat.

## Scenarios 2

**[0103]** Figure 5 is an exemplary flow of a method of supporting downlink data transmission in scenarios 2 in accordance with aspects of the present disclosure. Although the method is illustrated in a system level between a CU of the RAN node (e.g., a gNB-CU) and a DU coupled to the CU, e.g., a gNB-DU, persons skilled in the art should understand that the method implemented in the CU and the DU can be separately implemented and/or incorporated by other apparatus with the like functions.

**[0104]** Referring to Figure 5, similar to scenarios 1, the gNB-CU will receive PDU set QoS parameters of a QoS flow from CN side or from another gNB in step 501. The gNB-CU will transmit the PDU set QoS parameters to the gNB-DU, e.g., during DRB setup in step 503.

**[0105]** However, different scenarios 1, in some implementations of the present disclosure, the gNB-CU may also transmit the information related to a threshold for data transmission (e.g., a threshold for determining delay critical or not) to the gNB-DU in step 503a, e.g., in a UE context setup request or UE context modification request message. Similarly, the gNB-CU may receive a corresponding UE context setup response or UE context modification response message from the gNB-DU in step 503b. In some other cases, the gNB-DU may receive the information related to threshold from the CN side. The information related to a threshold may be for a PDU set or for a QoS flow or for a DRB.

**[0106]** In some implementations of the present disclosure, the gNB-CU may also include the information related to a timer (e.g., a PDCP timer or PSI based PDCP discard timer) in the UE context setup request or UE context modification request message to the gNB-DU in step 503a. Similarly, in some cases, the gNB-DU may receive the information related to the timer from the CN side. The information related to a timer may be for a PDU set or for a QoS flow or for a DRB.

**[0107]** The gNB-DU will receive packets from the gNB-CU and buffer the packets in step 505. Then, the gNB-DU will determine the remaining time of the buffered packets and

determine whether to prioritize the scheduling of the corresponding packets in step 507 in various manners as illustrated in scenarios 1.

**[0108]** For example, in the case that a timer for determining the remaining time is configured, the gNB-DU will start the timer in response to receiving a packet (e.g., PDCP PDU). The remaining time of the packet is the remaining time of the timer. In the case that no timer is configured, the gNB-DU will calculate the remaining time of a packet based on the elapsed time or arrival time of the packet. In the case that the remaining time of the packet is less than or equal to the threshold, the gNB-DU will prioritize the scheduling of packet.

**[0109]** Similarly, in some implementations of the present disclosure, the gNB-DU will determine whether to prioritize the scheduling of packets based on the PDU set or QoS flow or DRB.

**[0110]** For example, in response to receiving the PDUs of a PDU set, the gNB-DU will start the timer for each PDU. In the case of PDU set based determination, when the smallest remaining time of the packets (e.g., the first one) is less than or equal to the threshold (e.g., delay critical), the gNB-DU will determine to prioritize the scheduling of the packets of the PDU set. In the case of QoS flow or DRB based determination, when the smallest remaining time of the packets of the QoS flow or DRB is less than or equal to the threshold, the gNB-DU determine to prioritize the scheduling of the packets of the PDU set.

**[0111]** Figure 6 illustrates an example of a CU 600 of a RAN node in accordance with aspects of the present disclosure. The CU 600 may include a processor 602, a memory 604, a controller 606, and a transceiver 608. The processor 602, the memory 604, the controller 606, or the transceiver 608, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

**[0112]** The processor 602, the memory 604, the controller 606, or the transceiver 608, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any

combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

**[0113]** The processor 602 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 602 may be configured to operate the memory 604. In some other implementations, the memory 604 may be integrated into the processor 602. The processor 602 may be configured to execute computer-readable instructions stored in the memory 604 to cause the CU 600 to perform various functions of the present disclosure.

**[0114]** The memory 604 may include volatile or non-volatile memory. The memory 604 may store computer-readable, computer-executable code including instructions when executed by the processor 602 cause the CU 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 604 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

**[0115]** In some implementations, the processor 602 and the memory 604 coupled with the processor 602 may be configured to cause the CU 600 to perform one or more of the functions described herein (e.g., executing, by the processor 602, instructions stored in the memory 604). For example, the processor 602 may support wireless communication at the CU 600 in accordance with examples as disclosed herein. The CU 600 may be configured to support a means for buffering packets of a QoS flow received from a CN; a means for determining first remaining time related information of the buffered packets; and a means for transmitting second remaining time related information of at least in part of the packets to a DU of a RAN node over F1 user plane protocol based on the first remaining time related information of the buffered packets.

**[0116]** The controller 606 may manage input and output signals for the CU 600. The controller 606 may also manage peripherals not integrated into the CU 600. In some implementations, the controller 606 may utilize an operating system such as iOS®,

ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 606 may be implemented as part of the processor 602.

**[0117]** In some implementations, the CU 600 may include at least one transceiver 608. In some other implementations, the CU 600 may have more than one transceiver 608. The transceiver 608 may represent a wireless transceiver. The transceiver 608 may include one or more receiver chains 610, one or more transmitter chains 612, or a combination thereof.

**[0118]** A receiver chain 610 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 610 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 610 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 610 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 receiver chain 610 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

**[0119]** A transmitter chain 612 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 612 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 612 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 612 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

**[0120]** Figure 7 illustrates an example of a processor 700 in accordance with aspects of the present disclosure. The processor 700 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 700 may include a controller 702 configured to perform various operations in accordance with examples as described herein. The processor 700 may optionally include at least one

memory 704, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 700 may optionally include one or more arithmetic-logic units (ALUs) 706. 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).

**[0121]** The processor 700 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 700) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

**[0122]** The controller 702 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 700 to cause the processor 700 to support various operations in accordance with examples as described herein. For example, the controller 702 may operate as a control unit of the processor 700, generating control signals that manage the operation of various components of the processor 700. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

**[0123]** The controller 702 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 704 and determine subsequent instruction(s) to be executed to cause the processor 700 to support various operations in accordance with examples as described herein. The controller 702 may be configured to track memory address of instructions associated with the memory 704. The controller 702 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 702 may be configured to interpret the instruction and determine

control signals to be output to other components of the processor 700 to cause the processor 700 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 702 may be configured to manage flow of data within the processor 700. The controller 702 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 700.

**[0124]** The memory 704 may include one or more caches (e.g., memory local to or included in the processor 700 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 704 may reside within or on a processor chipset (e.g., local to the processor 700). In some other implementations, the memory 704 may reside external to the processor chipset (e.g., remote to the processor 700).

**[0125]** The memory 704 may store computer-readable, computer-executable code including instructions that, when executed by the processor 700, cause the processor 700 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 702 and/or the processor 700 may be configured to execute computer-readable instructions stored in the memory 704 to cause the processor 700 to perform various functions. For example, the processor 700 and/or the controller 702 may be coupled with or to the memory 704, the processor 700, the controller 702, and the memory 704 may be configured to perform various functions described herein. In some examples, the processor 700 may include multiple processors and the memory 704 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

**[0126]** The one or more ALUs 706 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 706 may reside within or on a processor chipset (e.g., the processor 700). In some other implementations, the one or more ALUs 706 may reside external to the processor chipset (e.g., the processor 700). One or more ALUs 706 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 706 may receive input operands and an operation code, which determines

an operation to be executed. One or more ALUs 706 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 706 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 706 to handle conditional operations, comparisons, and bitwise operations.

**[0127]** The processor 700 may support wireless communication in accordance with examples as disclosed herein. The processor 700 may be configured to or operable to support a means for buffering packets of a QoS flow received from a CN; a means for determining first remaining time related information of the buffered packets; and a means for transmitting second remaining time related information of at least in part of the packets to a DU of a RAN node over F1 user plane protocol based on the first remaining time related information of the buffered packets.

**[0128]** Figure 8 illustrates an example of a DU 800 of a RAN node in accordance with aspects of the present disclosure. The DU 800 may include a processor 802, a memory 804, a controller 806, and a transceiver 808. The processor 802, the memory 804, the controller 806, or the transceiver 808, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

**[0129]** The processor 802, the memory 804, the controller 806, or the transceiver 808, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

**[0130]** The processor 802 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 802 may be configured to operate the memory 804. In some other implementations, the memory 804 may be integrated into the processor 802. The

processor 802 may be configured to execute computer-readable instructions stored in the memory 804 to cause the DU 800 to perform various functions of the present disclosure.

**[0131]** The memory 804 may include volatile or non-volatile memory. The memory 804 may store computer-readable, computer-executable code including instructions when executed by the processor 802 cause the DU 800 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 804 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

**[0132]** In some implementations, the processor 802 and the memory 804 coupled with the processor 802 may be configured to cause the DU 800 to perform one or more of the functions described herein (e.g., executing, by the processor 802, instructions stored in the memory 804). For example, the processor 802 may support wireless communication at the DU 800 in accordance with examples as disclosed herein. The DU 800 may be configured to support a means for receiving packets of a DRB from a CU of the RAN node; a means for receiving remaining time related information of at least in part of the packets from a CU of the RAN node over F1 user plane protocol; and a means for determining whether to prioritize scheduling of the packets to be transmitted to user equipment based on the received remaining time related information.

**[0133]** In some implementations, the processor 802 and the memory 804 coupled with the processor 802 may be configured to cause the DU 800 to perform one or more of the functions described herein (e.g., executing, by the processor 802, instructions stored in the memory 804). For example, the processor 802 may support wireless communication at the DU 800 in accordance with examples as disclosed herein. The DU 800 may be configured to support a means for receiving configuration information related to a threshold for data transmission from a CU of the RAN node; a means for determining remaining time of packets to be transmitted; and a means for determining whether to prioritize scheduling of the packets to be transmitted based on the determined remaining time of packets and the threshold.

**[0134]** The controller 806 may manage input and output signals for the DU 800. The controller 806 may also manage peripherals not integrated into the DU 800. In some implementations, the controller 806 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 806 may be implemented as part of the processor 802.

**[0135]** In some implementations, the DU 800 may include at least one transceiver 808. In some other implementations, the DU 800 may have more than one transceiver 808. The transceiver 808 may represent a wireless transceiver. The transceiver 808 may include one or more receiver chains 810, one or more transmitter chains 812, or a combination thereof.

**[0136]** A receiver chain 810 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 810 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 810 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 810 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 receiver chain 810 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

**[0137]** A transmitter chain 812 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 812 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 812 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 812 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

**[0138]** Figure 9 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by a CU of a RAN

node as described herein. In some implementations, the CU may execute a set of instructions to control the function elements of the CU to perform the described functions.

**[0139]** At step 901, the method may include buffering packets of a QoS flow received from a CN. The operations of step 901 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 901 may be performed by a CU as described with reference to Figure 6.

**[0140]** At step 903, the method may include determining first remaining time related information of the buffered packets. The operations of step 903 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 903 may be performed by a CU as described with reference to Figure 6.

**[0141]** At step 905, the method may include transmitting second remaining time related information of at least in part of the packets to a DU of a RAN node over F1 user plane protocol based on the first remaining time related information of the buffered packets. The operations of step 905 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 905 may be performed by a CU as described with reference to Figure 6.

**[0142]** It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

**[0143]** Figure 10 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by a DU of a RAN node as described herein. In some implementations, the DU may execute a set of instructions to control the function elements of the DU to perform the described functions.

**[0144]** At step 1001, the method may include receiving packets of a DRB from a CU of the RAN node. The operations of step 1001 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1001 may be performed by a DU as described with reference to Figure 8.

**[0145]** At step 1003, the method may include receiving remaining time related information of at least in part of the packets from a CU of the RAN node over F1 user plane protocol. The operations of step 1003 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1003 may be performed by a DU as described with reference to Figure 8.

**[0146]** At step 1005, the method may include determining whether to prioritize scheduling of the packets to be transmitted to user equipment based on the received remaining time related information. The operations of step 1005 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1055 may be performed by a DU as described with reference to Figure 8.

**[0147]** Figure 11 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by a DU of a RAN node as described herein. In some implementations, the DU may execute a set of instructions to control the function elements of the DU to perform the described functions.

**[0148]** At step 1101, the method may include receiving configuration information related to a threshold for data transmission from a CU of the RAN node. The operations of step 1101 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1101 may be performed by a DU as described with reference to Figure 8.

**[0149]** At step 1103, the method may include determining remaining time of packets to be transmitted. The operations of step 1103 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1103 may be performed by a DU as described with reference to Figure 8.

**[0150]** At step 1105, the method may include determining whether to prioritize scheduling of the packets to be transmitted based on the determined remaining time of packets and the threshold. The operations of step 1105 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1105 may be performed by a DU as described with reference to Figure 8.

**[0151]** It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

**[0152]** The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

## CLAIMS

What is claimed is:

1. A central unit (CU) of a radio access network (RAN) node, comprising:
  - at least one memory; and
  - at least one processor coupled with the at least one memory and configured to cause the CU to:
    - buffer packets of a quality of service (QoS) flow received from a core network (CN);
    - determine first remaining time related information of the buffered packets;
    - and
    - transmit second remaining time related information of at least in part of the buffered packets to a distributed unit (DU) of the RAN node over F1 user plane protocol based on the first remaining time related information of the buffered packets.
2. A CU of claim 1, wherein, the first remaining time related information of a packet comprises remaining time of a timer associated with the packet, elapsed time between receiving the packet from the CN and sending the packet to the DU, arrival time of the packet, remaining time of a timer associated with a first packet of a protocol data unit (PDU) set including the packet, elapsed time between receiving a first packet of a PDU set including the packet from the CN and sending the first packet to the DU, arrival time of a first packet of a PDU set including the packet, or a combination thereof.
3. A CU of claim 2, wherein, the at least one processor is configured to cause the CU to:
  - determine remaining time of the packet based on the first remaining time related information of the packet, wherein the remaining time of the packet is the remaining time of the timer associated with the packet, and the timer associated with the packet is started in response to receiving the packet.
4. A CU of claim 2, wherein, the at least one processor is configured to cause the CU to:

determine remaining time of the packet based on the first remaining time related information of the packet, wherein the remaining time of the packet is the remaining time of the timer associated with the first packet of the PDU set including the packet, and the timer associated with the first packet is started in response to receiving the first packet of the PDU set including the packet.

5. A CU of claim 2, wherein, the at least one processor is configured to cause the CU to: determine remaining time of the packet based on the elapsed time between receiving the packet from the CN and sending the packet to the DU, the arrival time of the packet, the elapsed time between receiving the first packet from the CN and sending the first packet to the DU, or the arrival time of the first packet of the PDU set including the packet.

6. A CU of claim 2, wherein, the at least one processor is configured to cause the CU to: transmit the second remaining time related information of the packet to the DU.

7. A CU of claim 1, wherein, the at least one processor is configured to cause the CU to: determine whether to transmit the second remaining time related information of the packet to the DU based on remaining time of the packet and a threshold, wherein the remaining time of the packet is determined based on the first remaining time related information of the packet; and

transmit the second remaining time related information of the packet to the DU in the case that remaining time of the packet is lower than or equal to the threshold.

8. A CU of claim 1, wherein, the at least one processor is configured to cause the CU to: transmit the second remaining time related information of a packet that has a shortest remaining time among delay critical packets and buffer size of the delay critical packets, wherein, the delay critical packets are packets that have not been confirmed as successfully delivered or transmitted to user equipment and whose remaining time is lower than or equal to a threshold or belong to protocol data unit (PDU) sets including a packet whose remaining time is lower than or equal to the threshold.

9. A CU of claim 8, wherein, the delay critical packets are packets that have not been confirmed as successfully delivered or transmitted to user equipment and whose remaining time is lower than or equal to the threshold, and the at least one processor is configured to cause the CU to:

for each packet that has not been confirmed as successfully delivered or transmitted to user equipment, determine whether remaining time of the packet that has not been confirmed as successfully delivered or transmitted to user equipment is lower than or equal to the threshold to determine the delay critical packets, wherein, the remaining time of the packet is determined based on the first remaining time related information of the packet; and

determine the delay critical packet that has the shortest remaining time and the buffer size of the delay critical packets.

10. A CU of claim 1, wherein, the at least one processor is configured to cause the CU to:

determine the second remaining time related information of a packet based on a first remaining time and a threshold, wherein the first remaining time is remaining time of the packet, or shortest remaining time among packets of a protocol data unit (PDU) set or a QoS flow or a data radio bearer (DRB) including the packet; and

transmit the second remaining time related information of the packet to the DU, wherein, the second remaining time related information of the packet indicates whether the packet is delay critical or not.

11. A CU of claim 10, wherein, the at least one processor is configured to cause the CU to:

determine that the packet is delay critical in the case that the remaining time of the packet is lower than or equal to the threshold, wherein the remaining time of the packet is determined based on the first remaining time related information of the packet.

12. A CU of claim 10, wherein, the at least one processor is configured to cause the CU to:

determine that the packet is delay critical in the case that the shortest remaining time among packets of the PDU set or QoS flow or DRB including the packet is lower than or equal to the threshold, wherein the remaining time of a packet of the PDU set or QoS flow or DRB is determined based on the first remaining time related information of the packet.

13. A CU of claim 1, wherein, the CU comprises a CU control plane (CP) (CU-CP) and a CU user plane (UP) (CU-UP), and the at least one processor is configured to cause the CU-UP to:

- determine the first remaining time related information of the buffered packets;
- determine the second remaining time related information of at least in part of the buffered packets based on the first remaining time related information; and
- transmit the second remaining time related information to the DU.

14. A CU of claim 13, wherein, the at least one processor is configured to cause the CU-CP to:

- receive configuration information related to one or both of a timer for determining the first remaining time related information of the received packets and a threshold from the CN or another RAN node; and
- transmit the configuration information to the CU-UP.

15. A CU of claim 1, wherein, the at least one processor is configured to cause the DU to:

- transmit the second remaining time related information of at least in part of the packets of the QoS flow to the DU over a general packet radio service (GPRS) tunnel protocol user plane (GTP-U) extension header of a corresponding packet.

16. A CU of claim 15, wherein, one or multiple bits in the GTP-U extension header indicate whether the second remaining time related information is present or not.

17. A CU of claim 2, wherein, the timer associated with the packet or the timer associated with the first packet is a packet data convergence protocol (PDCP) timer or a timer for packets of a PDU set with low importance.

18. A processor for wireless communication, comprising:  
at least one controller coupled with at least one memory and configured to cause the processor to:

buffer packets of a quality of service (QoS) flow received from a core network (CN);

determine first remaining time related information of the buffered packets;

and

transmit second remaining time related information of at least in part of the packets to a distributed unit (DU) of a radio access network (RAN) node over F1 user plane protocol based on the first remaining time related information of the buffered packets.

19. A distributed unit (DU) of a radio access network (RAN) node, comprising:  
at least one memory; and  
at least one processor coupled with the at least one memory and configured to cause the DU to:

receive packets of a DRB from a central unit (CU) of the RAN node;

receive remaining time related information of at least in part of the packets from a central unit (CU) of the RAN node over F1 user plane protocol; and

determine whether to prioritize scheduling of the packets to be transmitted to user equipment based on the received remaining time related information.

20. A distributed unit (DU) of a radio access network (RAN) node, comprising:  
at least one memory; and  
at least one processor coupled with the at least one memory and configured to cause the DU to:

receive configuration information related to a threshold for data transmission from a central unit (CU) of the RAN node;

determine remaining time of packets to be transmitted ; and

determine whether to prioritize scheduling of the packets to be transmitted based on the determined remaining time of packets and the threshold.

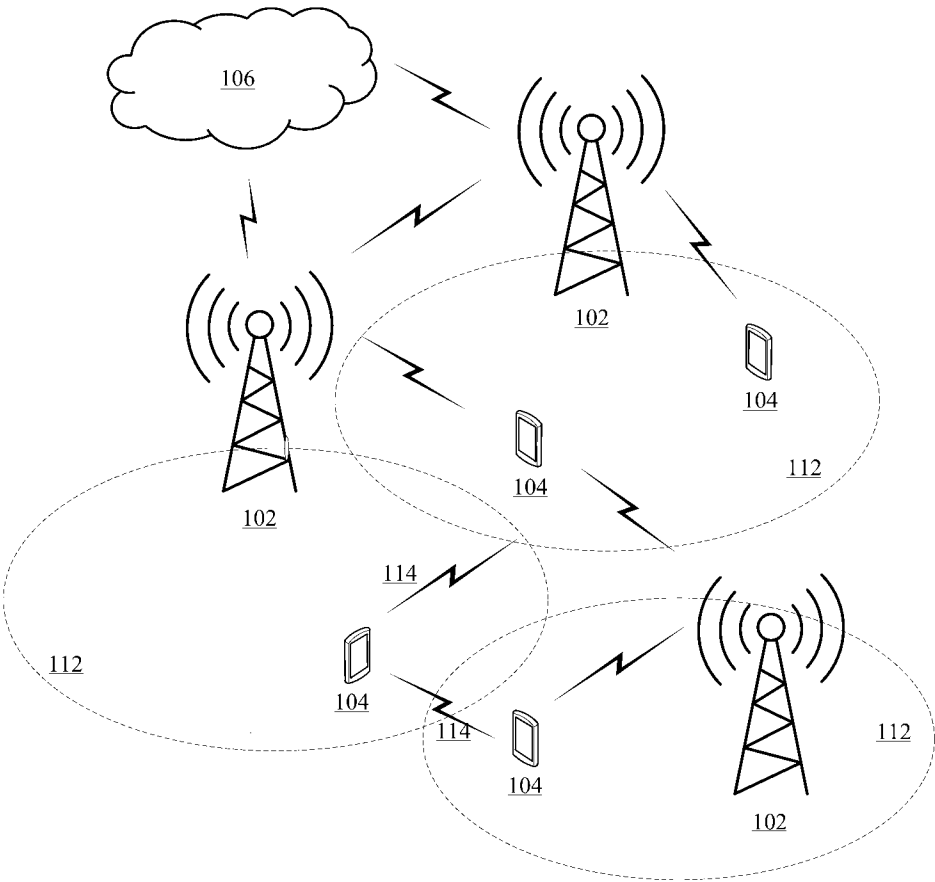


Figure 1

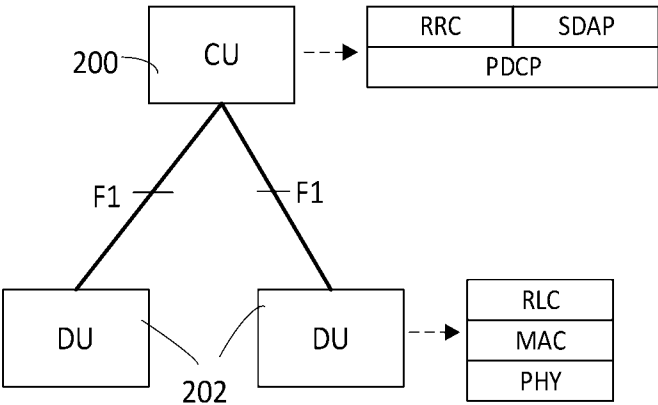


FIG. 2

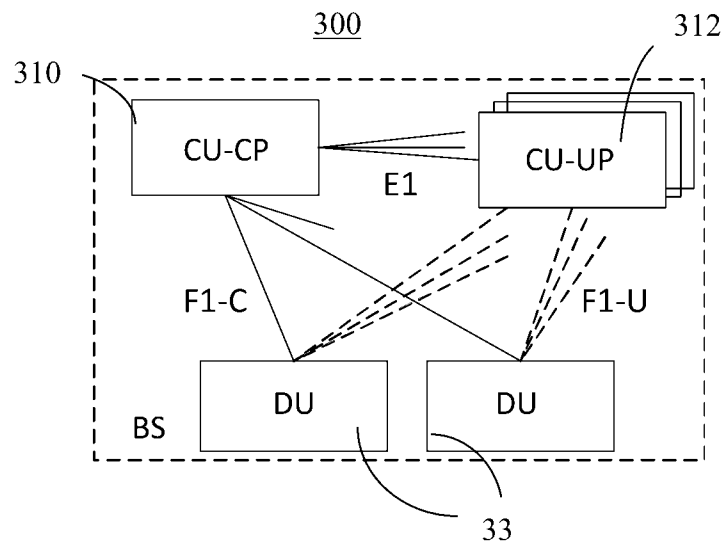


FIG. 3

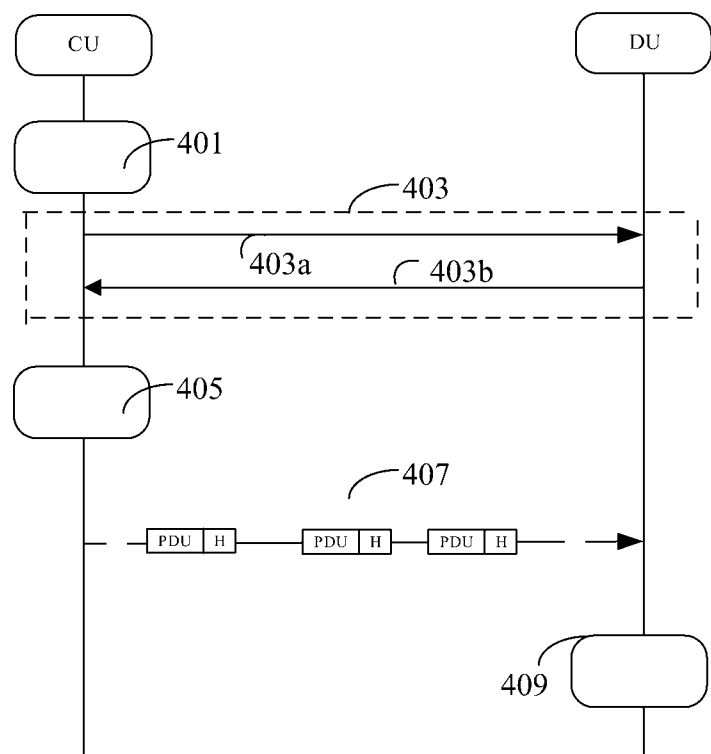


FIG. 4

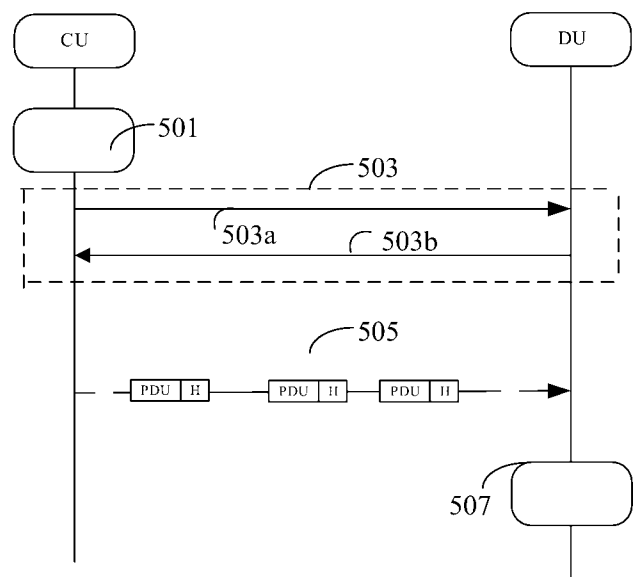


Figure 5

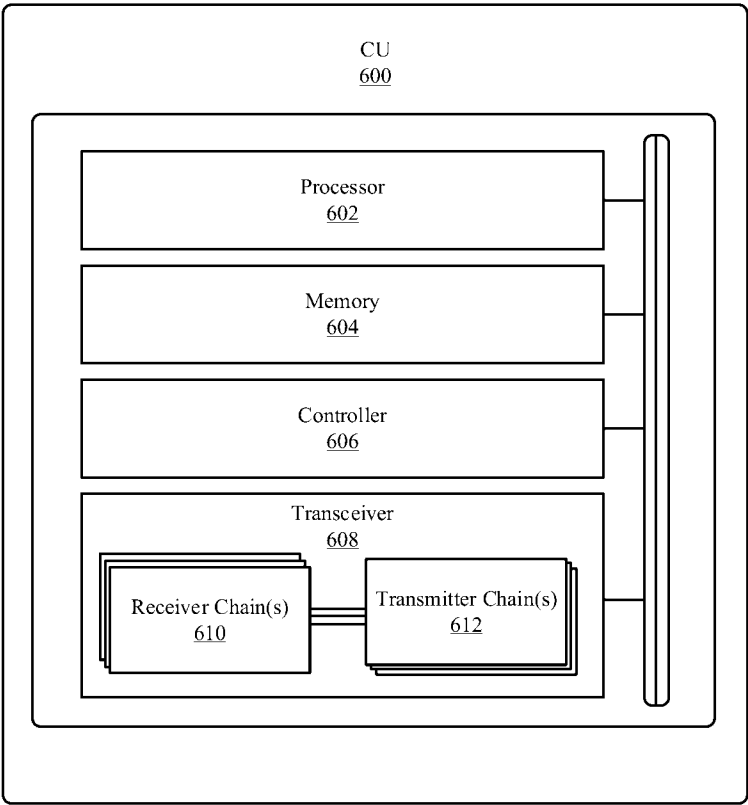


Figure 6

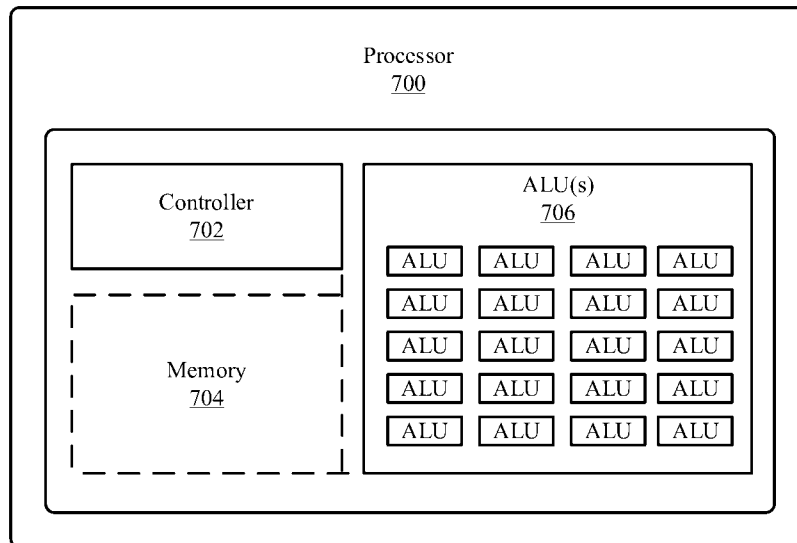


Figure 7

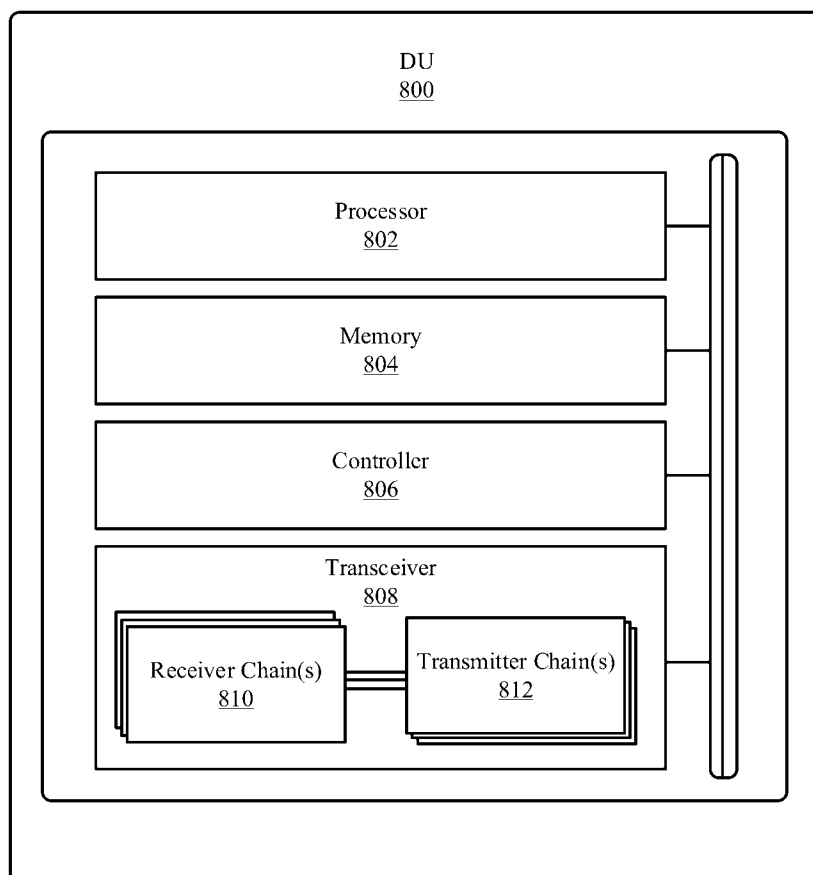


Figure 8

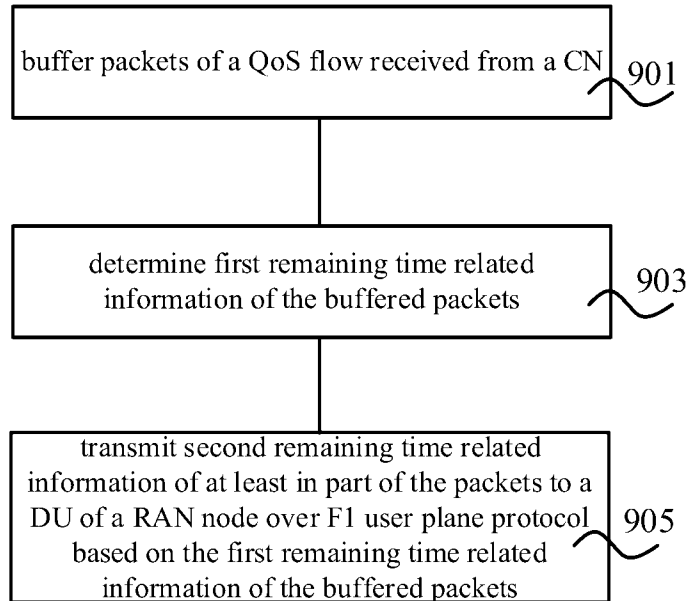


Figure 9

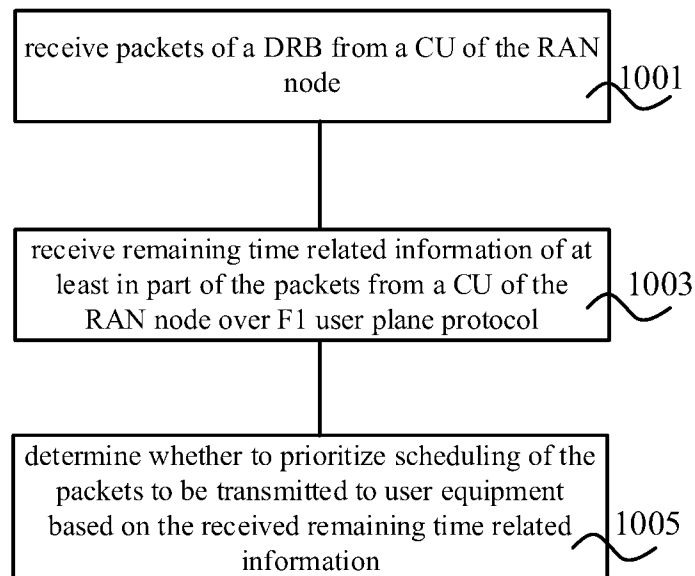


Figure 10

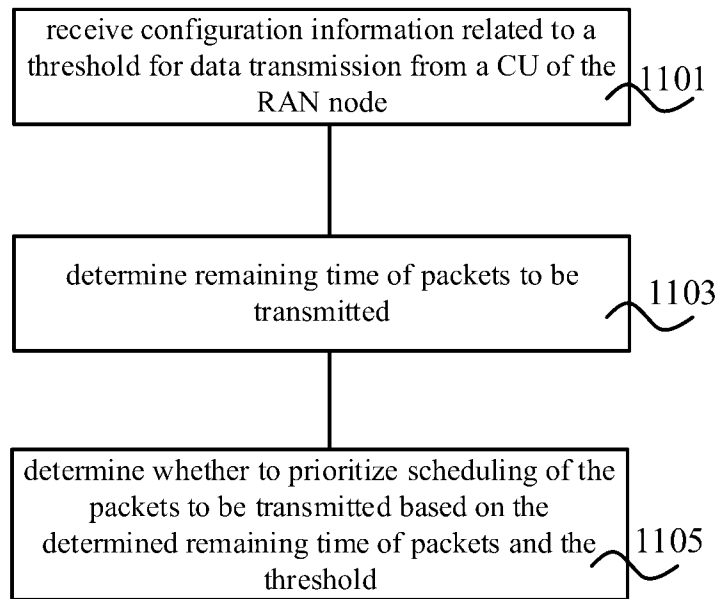


Figure 11

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/072541

**A. CLASSIFICATION OF SUBJECT MATTER**

H04W 28/02(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W; H04L; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

3GPP,CJFD,CNTXT,ENTXT,ENTXTC,WPABS,WPABSC:delay, budget, packet delay budget ,PDB, left, remaining, time, timer, buffer, centralized unit, central unit, CU, distributed unit, DU, priority

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                             | Relevant to claim No. |
|-----------|--------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | WO 2023203550 A1 (ERICSSON TELEFON AB L M) 26 October 2023 (2023-10-26)<br>description, paragraphs [0074]-[0094],[0148]-[0157] | 1-20                  |
| A         | US 2020107339 A1 (QUALCOMM INC) 02 April 2020 (2020-04-02)<br>the whole document                                               | 1-20                  |
| A         | WO 2024009254 A1 (LENOVO SINGAPORE PTE LTD) 11 January 2024 (2024-01-11)<br>the whole document                                 | 1-20                  |



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents:

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“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

27 September 2024

Date of mailing of the international search report

29 September 2024

Name and mailing address of the ISA/CN

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**INTERNATIONAL SEARCH REPORT**  
**Information on patent family members**

International application No.  
**PCT/CN2024/072541**

| Patent document<br>cited in search report |            |    | Publication date<br>(day/month/year) | Patent family member(s) |             |    | Publication date<br>(day/month/year) |
|-------------------------------------------|------------|----|--------------------------------------|-------------------------|-------------|----|--------------------------------------|
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