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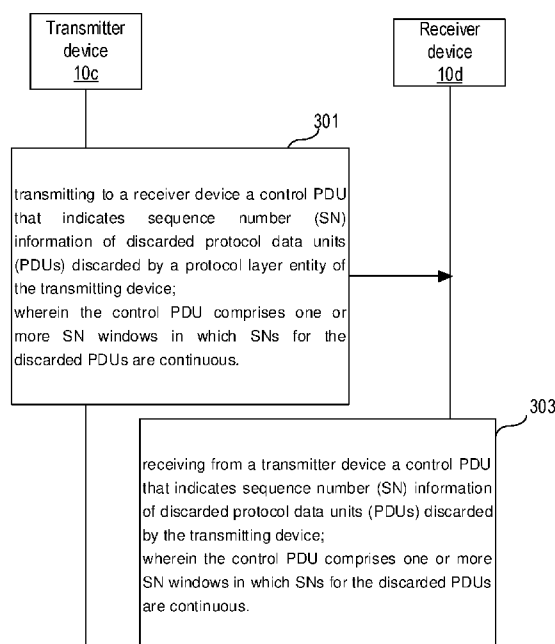


FIG. 4

(57) Abstract: A wireless communication method is provided. A transmitter device transmits to a receiver device a control PDU that indicates sequence number (SN) information of discarded protocol data units (PDUs) discarded by a protocol layer entity of the transmitter device. The control PDU comprises one or more SN windows in which SNs for the discarded PDUs are continuous.



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WIRELESS COMMUNICATION METHOD AND DEVICE

BACKGROUND OF DISCLOSURE

1. Field of Disclosure

[0001] The present disclosure relates to the field of telecommunication, and in particular to a wireless communication method and device.

2. Description of Related Art

[0002] Wireless communication systems, such as the third-generation (3G) of mobile telephone standards and technology are well known. Such 3G standards and technology have been developed by the third Generation Partnership Project (3GPP). The 3rd generation of wireless communications has generally been developed to support macro-cell mobile phone communications. Communication systems and networks have developed towards being a broadband and mobile system. In cellular wireless communication systems, user equipment (UE) is connected by a wireless link to a radio access network (RAN). The RAN comprises a set of base stations (BSs) that provide wireless links to the UEs located in cells covered by the base station, and an interface to a core network (CN) which provides overall network control. As will be appreciated the RAN and CN each conduct respective functions in relation to the overall network. The 3rd Generation Partnership Project has developed the so-called Long Term Evolution (LTE) system, namely, an Evolved Universal Mobile Telecommunication System Territorial Radio Access Network, (E-UTRAN), for a mobile access network where one or more macro-cells are supported by a base station known as an eNodeB or eNB (evolved NodeB). More recently, LTE is evolving further towards the so-called 5G or NR (new radio) systems where one or more cells are supported by a base station known as a gNB.

Technical Problem

[0003] The 5G wireless communication system has been designed to deliver enhanced mobile broadband (eMBB), ultra-reliable low-latency communication (URLLC), and massive machine type communication (mMTC) services. In 5G or NR, features supporting eMBB, URLLC and mMTC was introduced in Release 15 and enhanced in Release 16 and 17.

[0004] Extended reality (XR) is an umbrella term covering Augmented Reality (AR), Mixed Reality (MR) and Virtual Reality (VR). XR applications typically require high throughput and low latency and Cloud Gaming is another application with the same requirement. XR and Cloud Gaming are important applications that will be enabled by 5G.

[0005] XR service is featured by its special traffic streams which is real-time, high data rate, and low latency. XR video streams have are different frames/video slices. For example, a group of pictures (GOP) has I/P/B frames. Some special characteristics of such XR service stream should be considered and supported in 5G.

[0006] On one hand, the data size of different frames varies, and a frame can be segmented

into a group of packets. However, an application can decode frames/video slices if all packets of the frames/video slices are successfully received. A group of packets (referred to as packet group hereafter) belonging to a frame/video slice should be handled as a unit.

[0007] On the other hand, some types of packet groups may be dependent on other packet groups. For example, packets of P frame and B frame depend on the packets of I frame, and packets of B frame depends on the packets of P frame. That is, a dependency does exist between different groups of packets.

[0008] Since the XR service is a real-time service, usually the obsolete packet is useless and should be discard as earlier as possible. Moreover, due to the dependency of a group of packets for XR service, the obsolete packet is usually a group of packets. In another case, if packet transmission failed in a predefined duration, the lost packets would also incur the discarding of a group of packets according to the dependency. The problem includes:

- How to transfer the discarding indication; and
- How to deal with the sequence number (SN) gap due to the discarding in receiving side.

SUMMARY

[0009] An object of the present disclosure is to propose a wireless communication method and device.

[0010] In a first aspect, an embodiment of the invention provides a wireless communication method, executable in a wireless communication device, comprising:

transmitting to a receiver device a control PDU that indicates sequence number (SN) information of discarded protocol data units (PDUs) discarded by a protocol layer entity of the transmitter device;

wherein the control PDU comprises one or more SN windows in which SNs for the discarded PDUs are continuous.

[0011] In a second aspect, an embodiment of the invention provides a wireless communication comprising a processor configured to call and run a computer program stored in a memory, to cause a device in which the processor is installed to execute the disclosed method.

[0012] In a third aspect, an embodiment of the invention provides a wireless communication method, executable in a wireless communication device, comprising:

receiving from a transmitter device a control PDU that indicates sequence number (SN) information of discarded protocol data units (PDUs) discarded by the transmitter device;

wherein the control PDU comprises one or more SN windows in which SNs for the discarded PDUs are continuous.

[0013] In a fourth aspect, an embodiment of the invention provides a wireless communication device comprising a processor configured to call and run a computer program stored in a memory, to cause a device in which the processor is installed to execute the disclosed method.

[0014] The disclosed method may be implemented in a chip. The chip may include a processor,

configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute the disclosed method.

[0015] The disclosed method may be programmed as computer executable instructions stored in non-transitory computer readable medium. The non-transitory computer readable medium, when loaded to a computer, directs a processor of the computer to execute the disclosed method.

[0016] The non-transitory computer readable medium may comprise at least one from a group consisting of: a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a Read-Only Memory, a Programmable Read-Only Memory, an Erasable Programmable Read-Only Memory, EPROM, an Electrically Erasable Programmable Read-Only Memory and a Flash memory.

[0017] The disclosed method may be programmed as a computer program product, which causes a computer to execute the disclosed method.

[0018] The disclosed method may be programmed as a computer program, which causes a computer to execute the disclosed method.

Advantageous Effects

[0019] An embodiment of the disclosure provides a method in which a transmitter device transfers an discarding indication so as to enable a receiver device to properly deal with a sequence number (SN gap) due to group PDU discarding.

[0020] An embodiment of the disclosure provides a method in which a receiver device receives protocol data units (PDUs) according to a discard control PDU so that PDU reception can works smoothly and properly.

BRIEF DESCRIPTION OF DRAWINGS

[0021] In order to more clearly illustrate the embodiments of the present disclosure or related art, the following figures will be described in the embodiments are briefly introduced. It is obvious that the drawings are merely some embodiments of the present disclosure, a person having ordinary skill in this field can obtain other figures according to these figures without paying the premise.

[0022] FIG. 1 illustrates a schematic view of a telecommunication system.

[0023] FIG. 2 illustrates a schematic view showing an embodiment of a network for the disclosed wireless communication method.

[0024] FIG. 3 illustrates a schematic view showing protocol layers of a transmitter device and a receiver device.

[0025] FIG. 4 illustrates a schematic view showing a wireless communication method according to an embodiment of the disclosure.

[0026] FIG. 5 illustrates a schematic view showing an example of packet discarding.

[0027] FIG. 6 illustrates a schematic view showing an example of packet discarding.

[0028] FIG. 7 illustrates a schematic view of a packet data convergence protocol (PDCP) discard

indication protocol data unit (PDU).

[0029] FIG. 8 illustrates a schematic view of a radio link control (RLC) discard indication PDU with 12 bit SN.

[0030] FIG. 9 illustrates a schematic view showing a method of PDU discarding at a receiving PDCP layer entity.

[0031] FIG. 10 illustrates a schematic view showing modified PDU receiving at a receiving RLC layer entity.

[0032] FIG. 11 illustrates a schematic view showing a method of PDU discarding in a receiving PDCP layer entity.

[0033] FIG. 12 illustrates a schematic view showing modified PDU receiving at a receiving RLC layer entity.

[0034] FIG. 13 is a block diagram of a system for wireless communication according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0035] Embodiments of the disclosure are described in detail with the technical matters, structural features, achieved objects, and effects with reference to the accompanying drawings as follows. Specifically, the terminologies in the embodiments of the present disclosure are merely for describing the purpose of the certain embodiment, but not to limit the disclosure.

Abbreviation used in the description are listed in the following:

Table 1

3GPP	Third Generation Partnership Project
5GC	5G Core Network
5GS	5G System
DRB	Dynamic Radio Bearer
eMMB	enhance Mobile Broadband
gNB	Generation Node B
GTP	GPRS Tunnelling Protocol
HARQ	Hybrid Auto Retransmission reQuest
HFN	Hyper Frame Number
MAC	Media Access Control
mMTC	massive Machine Type Communication
PDCP	Packet Data Convergence Protocol
PDU	Protocol Data Unit
QoS	Quality of Service
RAN	Radio Access Network
Rel	Release

RLC	Radio Link Control
SRB	Signalling Radio Bearer
SDU	Service Data Unit
SN	Sequence Number
TB	Transport Block
UE	User Equipment
URLLC	Ultra-Reliable and Low Latency Communication
UM	Unacknowledged Mode
UMD	UM data
UPF	User Plane Function

[0036] This invention disclosed a wireless communication method for processing extended reality (XR) traffic in extended reality (XR) service(s). XR service may include augmented reality (AR), virtual reality (VR), or mixed reality (MR).

[0037] In the description, a packet may be a PDU or a SDU of a protocol layer. For simplicity, the term packet may refer to a PDU or SDU, and the term PDU may refer to a PDU or SDU.

[0038] In the description, a data unit being depended is referred to as a depended data unit, and a data unit depending on the depended data unit is referred to as a dependent data unit. For example, a DRB being depended is referred to as a depended DRB, and a DRB depending on the depended DRB is referred to as a dependent DRB. Similarly, a PDU set being depended is referred to as a depended PDU set, and a PDU set depending on the depended PDU set is referred to as a dependent PDU set. A packet being depended is referred to as a depended packet, and a packet depending on the depended packet is referred to as a dependent packet. A QoS flow being depended is referred to as a depended QoS flow, and a QoS flow depending on the depended QoS flow is referred to as a dependent QoS flow. A sub-QoS flow being depended is referred to as a depended sub-QoS flow, and a sub-QoS flow depending on the depended sub-QoS flow is referred to as a dependent sub-QoS flow.

[0039] As an enhancement to the current QoS framework to support XR service, a concept named as “PDU Set” was introduced in the technical report (TR) 23.700-60 by 3GPP SA2.

[0040] A PDU Set is composed of one or more PDUs carrying a payload of one information unit generated at the application level (e.g. a frame or video slice for XR Services, as used in TR 26.926). In some implementations, all PDUs in a PDU Set are needed by the application layer to use the information unit. In other implementations, the application layer can recover parts or all of the information unit, when some PDUs are missing.

[0041] For XR traffic, such as one or more service traffic streams, a PDU set may be a group of packets or PDUs which can be decoded or processed as a whole unit at the Application layer. XR traffic has some potential dependencies between packets of a PDU set and/or dependencies

between PDU sets. An service traffic stream of an XR service can comprise different types of PDU sets with different importance levels and QoS requirements.

[0042] With reference to FIG. 1, a telecommunication system including a UE 10a, a UE 10b, a base station (BS) 20a, and a network entity device 30 executes the disclosed method according to an embodiment of the present disclosure. FIG. 1 is shown for illustrative, not limiting, and the system may comprise more UEs, BSs, and CN entities. Connections between devices and device components are shown as lines and arrows in the FIGs. The UE 10a may include a processor 11a, a memory 12a, and a transceiver 13a. The UE 10b may include a processor 11b, a memory 12b, and a transceiver 13b. The base station 20a may include a processor 21a, a memory 22a, and a transceiver 23a. The network entity device 30 may include a processor 31, a memory 32, and a transceiver 33. Each of the processors 11a, 11b, 21a, and 31 may be configured to implement proposed functions, procedures and/or methods described in the description. Layers of radio interface protocol may be implemented in the processors 11a, 11b, 21a, and 31. Each of the memory 12a, 12b, 22a, and 32 operatively stores a variety of programs and information to operate a connected processor. Each of the transceivers 13a, 13b, 23a, and 33 is operatively coupled with a connected processor, transmits and/or receives radio signals or wireline signals. The UE 10a may be in communication with the UE 10b through a sidelink. The base station 20a may be an eNB, a gNB, or one of other types of radio nodes, and may configure radio resources for the UE 10a and UE 10b.

[0043] The network entity device 30 may be a node in a CN. CN may include LTE CN or 5G core (5GC) which includes user plane function (UPF), session management function (SMF), 5G core access and mobility management function (AMF), unified data management (UDM), policy control function (PCF), control plane (CP)/user plane (UP) separation (CUPS), authentication server (AUSF), network slice selection function (NSSF), and the network exposure function (NEF).

[0044] An example of the UE in the description may include one of the UE 10a or UE 10b. An example of the base station in the description may include the base station 20a. Uplink (UL) transmission of a control signal or data may be a transmission operation from a UE to a base station. Downlink (DL) transmission of a control signal or data may be a transmission operation from a base station to a UE. A DL control signal may comprise downlink control information (DCI) or a radio resource control (RRC) signal, from a base station to a UE.

[0045] FIG. 2 is a model of a transport network for XR service supported by 5G system. A UE 10 is a 5G terminal which can support XR service and XR application and can be referred to as a client, a client terminal, or an XR client. A gNB 20 is 5G radio node. The gNB 20 communicates with the UE 10 and provides NR user plane and control plane protocol terminations towards the UE via NR Uu interface. The gNB 20 connects via NG interface to a 5GC 300. An UPF 30b is an UPF in the 5GC 300 which is a 5G Core Network. DN 40 is a data network (DN) 40 where an XR server 41 providing XR service is located. The DN 40 can provide network operator services,

Internet access, or 3rd party services. The XR server 41 may include a processor 411, a memory 412, and a transceiver 413. The processor 411 may be configured to implement XR service related functions, procedures and/or methods described in the description. Layers of radio interface protocol may be implemented in the processor 411. The memory 412 operatively stores a variety of programs and information to operate a connected processor. The transceiver 413 is operatively coupled with a connected processor, transmits and/or receives radio signals or wireline signals.

[0046] Each of the processors 411, 11a, 11b, 21a, and 31 may include an application-specific integrated circuit (ASICs), other chipsets, logic circuits and/or data processing devices. Each of the memory 412, 12a, 12b, 22a, and 32 may include read-only memory (ROM), a random access memory (RAM), a flash memory, a memory card, a storage medium and/or other storage devices. Each of the transceivers 413, 13a, 13b, 23a, and 33 may include baseband circuitry and radio frequency (RF) circuitry to process radio frequency signals. When the embodiments are implemented in software, the techniques described herein may be implemented with modules, procedures, functions, entities, and so on, that perform the functions described herein. The modules may be stored in a memory and executed by the processors. The memory may be implemented within a processor or external to the processor, in which those may be communicatively coupled to the processor via various means are known in the art. A device executing the wireless communication method may be a transmitter device that transmits an XR traffic flow of an XR service to a receiver device or a receiver device that receives the XR traffic flow. The XR traffic flow may comprise one or more service traffic streams of the XR service. For example, the device executing the wireless communication method may comprise the gNB 20, an XR server 41 in data network 40, or a UE. That is, the XR server 41 in data network 40 may operate as a transmitter device that executes a wireless communication method in some XR traffic delivery occasions, while one or more XR clients (e.g., one or more of the UE 10, UE 10a, and UE 10b) operates as the receiver device receiver the XR traffic flow sent from the transmitter device. Similarly, an XR client (e.g., one or more of the UE 10, UE 10a, and UE 10b) may operate as a transmitter device to execute a wireless communication method in some XR traffic delivery occasions, while another XR client or the XR server 41 operates as the receiver device receiver the XR traffic flow sent from the transmitter device. Alternatively, the transmitter device may comprise an intermediate device between the UE 10 and the XR server 41. The UE 10 may comprise an embodiment of the UE 10a or UE 10b. The gNB 20 may comprise an embodiment of the base station 20a. Note that although the gNB 20 and UPF/5GC 30b are described as an example in the description, the wireless communication method may be executed by a base station, such as another gNB, an eNB, a base station integrating an eNB and a gNB, or a base station for beyond 5G technologies. The UPF/5GC 30b may comprise another network entity of 5GC.

[0047] A service traffic stream 5, such as an XR stream of an XR service, is established between

the UE 10 and the XR server 41. The stream 5 comprise a traffic flow 51 from the XR server 41 to the UE 10 and a traffic flow 52 from the UE 10 to the XR server 41.

[0048] In the description, a layer, such as an application layer, a PDCP layer, an RLC layer, an MAC layer, or physical layer (PHY layer or L1 layer), may be a protocol layer entity in a transmitter device or a receiver device. The a protocol layer entity may be implemented by a program or a software module executed by a processor or implemented by a hardware module in a integrated circuit (IC).

[0049] With reference to FIG. 3, an example of the the transmitter device is shown as transmitter device 10c, and an example of the the receiver device is shown as receiver device 10d. The transmitter device 10c comprise a physical layer (PHY layer or L1 layer) 14c, MAC layer 15c, RLC layer 16c, PDCP layer 17c, RRC layer 18c, and application layer 19c. The receiver device 10d comprise a physical layer (PHY layer or L1 layer) 14d, MAC layer 15d, RLC layer 16d, PDCP layer 17d, RRC layer 18d, and application layer 19d. For example, when the application layer 19c of the transmitter device 10c sends a PDU through lower layers (i.e., PDCP layer 17c, RLC layer 16c, MAC layer 15c, and physical layer 14c) to the application layer 19d of the receiver device 10d, the layers in transmitter device 10c serves as transmitting protocol layer entities at the transmitting side, and the layers in receiver device 10d serves as receiving protocol layer entities at the receiving side. Embodiments of the disclosed may be implemented in the PDCP layer or RLC layer. One or more steps (or blocks) in of embodiments of the disclosure may be implemented as computer programs, instructions, software module(s) stored in a memory of the transmitter device, or circuits or hardware module(s) in a processor of the transmitter device, or IC chip(s), circuits, or plug-in(s) of the transmitter device.

[0050] A video stream of an XR service will be encoded and compressed in form of frames quasi-periodically with the respective frame periodicity of 1/60, 1/90, or 1/120 the second. Since the transmitter device may divide a video stream of an XR service into a number of transport units, encapsulate and transmit each of the transport units into a transport packet transmitted across the network, the transmission mechanism of the XR service is actually based on packet instead of frame. The size of each of the packets may be variable, the number of the packets may be variable and configurable based on one or more parameters of the QoS requirements and characteristics of the XR service, such as packet delay budget (PDB), packet error rate (PER), packet loss rate (PLR), frame error rate, frame delay budget, resolution, frame rate, and/or data rate.

[0051] With reference to FIG. 4, the transmitter device 10c and the receiver device 10d execute an embodiment of the disclosed method and initiate an XR service.

[0052] The transmitter device 10c transmits to the receiver device 10d a control PDU that indicates sequence number (SN) information of discarded protocol data units (PDUs) discarded by a protocol layer entity of the transmitter device (310). The control PDU comprises one or more

SN windows in which SNs for the discarded PDUs are continuous.

[0053] The receiver device 10d receives from the transmitter device 10c a control PDU that indicates sequence number (SN) information of discarded protocol data units (PDUs) discarded by the transmitter device (303).

[0054] The control PDU comprises one or more SN windows in which SNs for the discarded PDUs are continuous. The control PDU may be a control PDU of a protocol layer, such as PDCP, RLC, and/or others. The control PDU comprises a field of E that indicates whether or not configuration of another SN window follows the field of E. Thus, multiple SN windows can be indicated in one control PDU. The 301 and 303 may be performed at the protocol layer.

[0055] In an embodiment, the control PDU being a packet data convergence protocol (PDCP) discard indication PDU comprises a field of PDU type indicating a PDU type of PDCP discard indication PDU.

[0056] The PDCP discard indication PDU comprises configuration of an SN window among the one or more SN windows, and the configuration of the SN window comprises:

- a field of MinDC in the PDCP discard indication PDU means Minimum Discard COUNT corresponding to the minimum PDCP PDU SN in the SN window; and
- a field of MaxDC in the PDCP discard indication PDU means Maximum Discard COUNT corresponding to the maximum PDCP PDU SN in the SN window.

[0057] In an embodiment, a protocol layer entity of the receives discards received PDUs in the SN window when a PDCP data PDU is received from a lower layer.

[0058] In an embodiment, the protocol layer entity is PDCP layer and the lower layer is a radio link control (RLC) layer.

[0059] In an embodiment, the protocol layer entity modifies a parameter that indicating an count value of a waiting PDU in a PDCP layer of the receiver device to MaxDC+1 when a PDCP data PDU is received from a lower layer, wherein the waiting PDU has not been transmitted to an upper layer. In an embodiment, the parameter is RX_DELIV or RX_NEXT.

[0060] In an embodiment, the protocol layer entity modifies a parameter that indicating an count value of a waiting PDU in a PDCP layer of the receiver device to MaxDC+1 when a timer t-Reordering expires, wherein the waiting PDU has not been transmitted to an upper layer. In an embodiment, the parameter is RX_DELIV.

[0061] In an embodiment, the control PDU being a radio link control (RLC) discard indication PDU comprises a field of PDU type indicating a PDU type of RLC discard indication PDU.

[0062] The RLC discard indication PDU comprises configuration of an SN window among the one or more SN windows, and the configuration of the SN window comprises:

- a field of MinSN in the RLC discard indication PDU means the Minimum Discard SN corresponding to the minimum RLC PDU SN in the SN window; and
- a field of MaxSN in the RLC discard indication PDU means the Maximum Discard SN

corresponding to the maximum RLC PDU SN in the SN window.

[0063] In an embodiment, a protocol layer entity of the receiver discards received PDUs in the SN window when an UMD PDU is received from a lower layer.

[0064] In an embodiment, the protocol layer entity is RLC layer and the lower layer is a medium access control (MAC) layer.

[0065] In an embodiment, the protocol layer entity modifies a parameter that indicating an earliest SN for reassembly in an RLC layer of the receiver device to MaxSN+1 when an UMD PDU is placed in a reception buffer of the RLC layer. In an embodiment, the parameter is RX_Next_Reassembly or RX_Next_Highest.

[0066] In an embodiment, the protocol layer entity modifies a parameter that indicating an earliest SN for reassembly in an RLC layer of the receiver device to MaxSN+1 when a timer t-Reassembly expires. In an embodiment, the parameter is RX_Next_Reassembly.

[0067] Packet discarding and indication:

[0068] As a PDU Set can comprise a plurality of packets or PDUs, including dependent PDUs and depended PDUs, the PDU discarding can include discarding a group of packets for one or more PDU Sets. As illustrated in FIG. 5, PDUs in PDU set (SN=n+1) and PDU set(SN=n+2) are discarded. As shown in FIG. 6, PDUs in PDU set (SN=n+1) and PDU set(SN=n+3) are discarded.

[0069] When the packet discarding happens for DRB, a SN gap will be incurred which can impact the receive operation. A method to deal with the SN gap due to the packet discarding is disclosed in the following, especially for the transmission based on PDCP and UM RLC protocol.

[0070] The transmitter device transmits a control PDU to a receiver device to indicate SN information of the discarded PDUs. The indicated SN information includes one or more of the following:

- The minimum SN among the discarded PDU(s);
- The maximum SN among the discarded PDU(s);
- One or more SN windows in which the SNs for the discarded PDU(s) are continuous, each window comprises:
 - The minimum SN of the SN window; and
 - The maximum SN of the SN window.

[0071] As an embodiment, the PDU discarding is performed in PDCP, a PDCP control PDU can be defined as FIG. 7 and named as a PDCP discard indication PDU:

- For the field of a PDU type in the PDCP discard indication PDU, a new PDU Type is defined as the PDU discard indicator (i.e., a PDU type of the PDCP discard indication PDU).
- A field of MinDC in the PDCP discard indication PDU means Minimum Discard COUNT corresponding to the minimum PDCP PDU SN in the SN window.
- A field of MaxDC in the PDCP discard indication PDU means Maximum Discard COUNT corresponding to the maximum PDCP PDU SN in the SN window. MinDC and MaxDC are

configuration of an SN window.

- A field of E in the PDCP discard indication PDU is an optional extension bit to indicates whether or not another SN window follows. A value 1 for the field of E means another SN window follows and a value 0 means no other SN window follows. Specifically, a value 1 for the field of E means configuration of a subsequent SN window follows the configuration of the SN window before the field E and a value 0 means no configuration of any other SN window follows the configuration of an SN window before the field E.

[0072] As an embodiment, the PDU discarding is performed in RLC. As shown in FIG. 8, an RLC control PDU can be defined for RLC UM data transfer and named RLC discard indication PDU:

- A new field of CPT (Control PDU Type) in the RLC discard indication PDU is defined as the PDU discard indicator (i.e., a PDU type of the RLC discard indication PDU).
- A field of MinSN in the RLC discard indication PDU means the Minimum Discard SN corresponding to the minimum RLC PDU SN in the SN window.
- A field of MaxSN in the RLC discard indication PDU means the Maximum Discard SN corresponding to the maximum RLC PDU SN in the SN window. MinDC and MaxDC are configuration of an SN window.
- A field of E in the RLC discard indication PDU is an optional extension bit to indicates whether or not another SN window follows. A value 1 for the field of E means another SN window follows and a value 0 means no other SN window follows. Specifically, a value 1 for the field of E means configuration of a subsequent SN window follows the configuration of the SN window before the field E and a value 0 means no configuration of any other SN window follows the configuration of an SN window before the field E.
- The length of the SN can be different and the format of the RLC control PDU can be different accordingly.

[0073] PDU reception based on the discarding indication:

[0074] The following definitions are used in the description. The definitions conform to and can be found in 3GPP TS 38.323:

[0075] RX_NEXT: This state variable indicates the COUNT value of the next PDCP SDU expected to be received. The initial value is 0, except for sidelink broadcast and groupcast, and for SRBs configured with state variables continuation. For NR sidelink communication for broadcast and groupcast, the initial value of the SN part of RX_NEXT is $(x + 1) \text{ modulo } (2[\text{sl-PDCP-SN-Size}])$, where x is the SN of the first received PDCP Data PDU. For target SRB configured with state variables continuation, the initial value is the value stored in PDCP entity for the corresponding source SRB. For source SRB configured with state variables continuation, the initial value is the value stored in PDCP entity for the corresponding target SRB.

[0076] For NR sidelink communication for broadcast and groupcast, it is up to UE implementation to select the HFN part for RX_NEXT such that initial value of RX_DELIV should

be a positive value.

[0077] RX_DELIV: This state variable indicates the COUNT value of the first PDCP SDU not delivered to the upper layers, but still waited for. The initial value is 0, except for sidelink broadcast and groupcast, and for SRBs configured with state variables continuation. For NR sidelink communication for broadcast and groupcast, the initial value of the SN part of RX_DELIV is $(x - 0.5 \times 2^{[\text{sl-PDCP-SN-Size}-1]}) \bmod (2^{[\text{sl-PDCP-SN-Size}]})$, where x is the SN of the first received PDCP Data PDU. For target SRB configured with state variables continuation, the initial value is the value stored in PDCP entity for the corresponding source SRB. For source SRB configured with state variables continuation, the initial value is the value stored in PDCP entity for the corresponding target SRB.

[0078] The parameter sl-PDCP-SN-Size is defined in 3GPP TS 38.331. sl-PDCP-SN-Size is a PDCP sequence number size for unicast NR sidelink communication, 12 or 18 bits, as specified in TS 38.323. For groupcast and broadcast NR sidelink communication, only 18bits is applicable.

[0079] RX_REORD: This state variable indicates the COUNT value following the COUNT value associated with the PDCP Data PDU which triggered t-Reordering. For target SRB configured with state variables continuation, the initial value is the value stored in PDCP entity for the corresponding source SRB. For source SRB configured with state variables continuation, the initial value is the value stored in PDCP entity for the corresponding target SRB.

[0080] t-Reordering: The duration of the timer t-Reordering is configured by upper layers as specified in TS 38.331, except for the case of NR sidelink communication. For NR sidelink communication, the t-Reordering timer is determined by the UE implementation. This timer is used to detect loss of PDCP Data PDUs as specified in clause 5.2.2 of TS 38.323. If t-Reordering is running, t-Reordering shall not be started additionally, i.e. only one t-Reordering per receiving PDCP entity is running at a given time.

[0081] A receiver device receive the PDUs according to the discard control PDU as follows:

[0082] As an embodiment, the PDU discarding is performed in PDCP, an PDCP control PDU is defined as PDCP discard indication PDU illustrated in FIG. 7. After the PDCP entity receives an PDCP discard indication PDU, based on current PDCP protocol, the receive operation is illustrated in the following as an enhancement to TS 38.323 and the highlighted content is something new:

Table 2

5.2.2 Receive operation:

5.2.2.1 Actions when a PDCP Data PDU is received from lower layers:

In this clause, following definitions are used:

- HFN(State Variable): the HFN part (i.e. the number of the most significant bits equal to HFN length) of the State Variable;
- SN(State Variable): the SN part (i.e. the number of the least significant bits equal to PDCP SN length) of the State Variable;
- RCVD_SN: the PDCP SN of the received PDCP Data PDU, included in the PDU header;
- RCVD_HFN: the HFN of the received PDCP Data PDU, calculated by the receiving PDCP entity;
- RCVD_COUNT: the COUNT of the received PDCP Data PDU = [RCVD_HFN, RCVD_SN].

At the reception of a PDCP Data PDU from lower layers, a receiving PDCP entity shall determine the COUNT value of the received PDCP Data PDU, i.e. RCVD_COUNT, as follows:

- if $RCVD_SN < SN(RX_DELIV) - Window_Size$:
 - $RCVD_HFN = HFN(RX_DELIV) + 1$.
- else if $RCVD_SN \geq SN(RX_DELIV) + Window_Size$:
 - $RCVD_HFN = HFN(RX_DELIV) - 1$.
- else:
 - $RCVD_HFN = HFN(RX_DELIV)$;
- $RCVD_COUNT = [RCVD_HFN, RCVD_SN]$.

After determining the COUNT value of the received PDCP Data PDU = RCVD_COUNT, the receiving PDCP entity shall:

- perform deciphering and integrity verification of the PDCP Data PDU using COUNT = RCVD_COUNT;
- if integrity verification fails:
 - indicate the integrity verification failure to upper layer;
 - discard the PDCP Data PDU and consider it as not received;
- if RCVD_COUNT < RX_DELIV; or
- if MinDC <= RCVD_COUNT <= MaxDC, the MinDC and MaxDC belong to the same SN window among the SN windows included in the PDCP discard indication PDU. The procedure is as illustrated in FIG. 9; or
- if the PDCP Data PDU with COUNT = RCVD_COUNT has been received before:
 - discard the PDCP Data PDU;

If the received PDCP Data PDU with COUNT value = RCVD_COUNT is not discarded above, the receiving PDCP entity shall:

- store the resulting PDCP SDU in the reception buffer;
- if RCVD_COUNT >= RX_NEXT:
 - update RX_NEXT to RCVD_COUNT + 1.
 - If the MinDC <= RX_NEXT <= MaxDC (this part is optional)
 - update RX_NEXT to MaxDC + 1.
 - Optionally, if there are more than one SN window, repeat for all the SN windows included in the PDCP discard indication PDU until RX_NEXT is not in the scope of MinDC <= RX_NEXT <= MaxDC for any SN window. The procedure is similar as illustrated in FIG. 10.
- if *outOfOrderDelivery* is configured:
 - deliver the resulting PDCP SDU to upper layers after performing header decompression using EHC.

- if $RCVD_COUNT = RX_DELIV$:
 - deliver to upper layers in ascending order of the associated COUNT value after performing header decompression, if not decompressed before;
 - all stored PDCP SDU(s) with consecutively associated COUNT value(s) starting from $COUNT = RX_DELIV$;
- update RX_DELIV to the COUNT value of the first PDCP SDU which has not been delivered to upper layers, with COUNT value $> RX_DELIV$;
- **If the $MinDC \leq RX_DELIV \leq MaxDC$**
 - **update RX_DELIV to $MaxDC + 1$;**
 - **Optionally, if there are more than one SN window, repeat for all the SN windows included in the PDCP discard indication PDU until RX_DELIV is not in the scope of $MinDC \leq RX_DELIV \leq MaxDC$ for any SN window. The procedure is as illustrated in FIG. 10.**
- if *t-Reordering* is running, and if $RX_DELIV \geq RX_REORD$:
 - stop and reset *t-Reordering*.
- if *t-Reordering* is not running (includes the case when *t-Reordering* is stopped due to actions above), and $RX_DELIV < RX_NEXT$:
 - update RX_REORD to RX_NEXT ;
 - start *t-Reordering*.

5.2.2.2 Actions when a *t-Reordering* expires

When *t-Reordering* expires, the receiving PDCP entity shall:

- deliver to upper layers in ascending order of the associated COUNT value after performing header decompression, if not decompressed before:
 - all stored PDCP SDU(s) with associated COUNT value(s) $< RX_REORD$;

- all stored PDCP SDU(s) with consecutively associated COUNT value(s) starting from RX_REORD;
- update RX_DELIV to the COUNT value of the first PDCP SDU which has not been delivered to upper layers, with COUNT value $\geq$ RX_REORD;
- If the $\text{MinDC} \leq \text{RX_DELIV} \leq \text{MaxDC}$
 - update RX_DELIV to $\text{MaxDC} + 1$;
 - Optionally, if there are more than one SN window, repeat for all the SN windows included in the PDCP discard indication PDU until RX_DELIV is not in the scope of $\text{MinDC} \leq \text{RX_DELIV} \leq \text{MaxDC}$ for any SN window. The procedure is as illustrated in FIG. 10.
- if $\text{RX_DELIV} < \text{RX_NEXT}$:
 - update RX_REORD to RX_NEXT;
 - start *t*-Reordering.

[0083] With reference to FIG. 9, the receiver device executes the following operations:

[0084] A protocol layer entity (e.g., PDCP layer) in the receiver device receives and decodes a PDCP discard indication PDU from the transmitter device (C101). The protocol layer entity decodes the PDCP discard indication PDU to determine whether any SN window is indicated in the PDCP discard indication PDU.

[0085] When one or more SN windows is indicated in the PDCP discard indication PDU, the protocol layer entity obtains each of the one or more SN windows as a current SN window and performs the following operations for each SN window. When receiving a PDCP data PDU (C102), the protocol layer entity obtains the current SN window with [MinCD, MaxCD] (C103) and determines whether a parameter RCVD_COUNT associated with the PDCP data PDU is in the range [MinCD, MaxCD] (C104), that is, whether $\text{RCVD_COUNT} \leq \text{MaxCD}$, that is, whether RCVD_COUNT associated with the PDCP data PDU meets the condition $\text{MinCD} \leq \text{RCVD_COUNT} \leq \text{MaxCD}$.

[0086] When RCVD_COUNT associated with the PDCP data PDU meets the condition $\text{MinCD} \leq \text{RCVD_COUNT} \leq \text{MaxCD}$, the protocol layer entity discards the PDCP data PDU (C106).

[0087] When RCVD_COUNT associated with the PDCP data PDU does not meet the condition $\text{MinCD} \leq \text{RCVD_COUNT} \leq \text{MaxCD}$, the protocol layer entity determines whether the SN window is the last SN window in the windows indicated by the PDCP discard indication PDU (C105). If

the SN window is not the last SN window, the protocol layer entity obtains a next one of the one or more SN windows indicated by the PDCP discard indication PDU as the current SN window (C107) and performs step C104. If the SN window is the last SN window, the execution terminates.

[0088] With reference to FIG. 10, the receiver device executes the following operations:

[0089] A protocol layer entity (e.g., PDCP layer) in the receiver device receives and decodes a PDCP discard indication PDU from the transmitter device (C201). The protocol layer entity decodes the PDCP discard indication PDU to determine whether more than one SN window is indicated in the PDCP discard indication PDU and multiple SN windows indicated in the PDCP discard indication PDU are not sorted (C203).

[0090] When more than one SN window is indicated in the PDCP discard indication PDU and not sorted, the protocol layer entity sorts all the SN windows according to the value of MinCD and MaxCD for each SN window in ascending order (C204) and obtains each of the one or more SN windows as a current SN window and performs the following operations for each SN window.

[0091] When receiving a PDCP data PDU (C205), the protocol layer entity obtains the current SN window with [MinCD, MaxCD] (C206) and determines whether a parameter RX_DELIV associated with the PDCP data PDU is in the range [MinCD, MaxCD] (C207), that is, whether RX_DELIV associated with the PDCP data PDU meets the condition $\text{MinCD} \leq \text{RX_DELIV} \leq \text{MaxCD}$.

[0092] When RX_DELIV associated with the PDCP data PDU does not meet the condition $\text{MinCD} \leq \text{RX_DELIV} \leq \text{MaxCD}$, the protocol layer entity do nothing to the RX_DELIV and performs C209.

[0093] When RX_DELIV associated with the PDCP data PDU meets the condition $\text{MinCD} \leq \text{RX_DELIV} \leq \text{MaxCD}$, the protocol layer entity updates the RX_DELIV to MaxDC+1 (C208).

[0094] The protocol layer entity determines whether the SN window is the last SN window in the windows indicated by the PDCP discard indication PDU (C209). If the SN window is not the last SN window, the protocol layer entity obtains a next one of the one or more SN windows indicated by the PDCP discard indication PDU as the current SN window (C210) and performs step C207. If the SN window is the last SN window, the execution terminates.

[0095] The following definition are used in the embodiment. The definitions conform to and can be found in 3GPP TS 38.322:

[0096] TX_NEXT: TX_Next – UM send state variable This state variable holds the value of the SN to be assigned for the next newly generated UMD PDU with segment. It is initially set to 0, and is updated after the UM RLC entity submits a UMD PDU including the last segment of an RLC SDU to lower layers.

[0097] RX_Next_Reassembly: RX_Next_Reassembly is a UM receive state variable. This state variable holds the value of the earliest SN that is still considered for reassembly. It is initially set to 0. For groupcast and broadcast of NR sidelink communication, it is initially set to the SN of the

first received UMD PDU containing an SN.

[0098] RX_Next_Highest: RX_Next_Highest is a Highest received state variable. This state variable holds the value of the SN following the SN of the RLC SDU with the highest SN among received RLC SDUs. It is initially set to 0.

[0099] t-Reassembly: This t-Reassembly timer is used by the receiving side of an AM RLC entity and receiving UM RLC entity in order to detect loss of RLC PDUs at lower layer (see sub clauses 5.2.2.2 and 5.2.3.2 of TS 38.322). If t-Reassembly is running, t-Reassembly shall not be started additionally, i.e. only one t-Reassembly per RLC entity is running at a given time.

[00100] As an embodiment, the PDU discarding is performed in RLC UM data transfer, an RLC control PDU is defined as RLC discard indication PDU illustrated in FIG. 8. After an RLC entity of the receiver device receives an RLC discard indication PDU, based on current RLC protocol, the receive operation is provided as follows as an enhancement to TS 38.322 and the highlighted content is something new:

Table 3

5.2.2 UM data transfer

5.2.2.1 Transmit operations

5.2.2.1.1 General

When submitting a UMD PDU to lower layer, the transmitting UM RLC entity shall:

- if the UMD PDU contains a segment of an RLC SDU, set the SN of the UMD PDU to TX_Next;
- if the UMD PDU contains a segment that maps to the last byte of an RLC SDU, then increment TX_Next by one.

5.2.2.2 Receive operations

5.2.2.2.1 General

The receiving UM RLC entity shall maintain a reassembly window according to state variable RX_Next_Highest as follows:

- a SN falls within the reassembly window if $(RX_Next_Highest - UM_Window_Size) \leq SN < RX_Next_Highest$;
- a SN falls outside of the reassembly window otherwise.

When receiving an UMD PDU from lower layer, the receiving UM RLC entity shall:

- either deliver the UMD PDU to upper layer after removing the RLC header, discard the received UMD PDU, or place it in the reception buffer (see clause 5.2.2.2.2);
- if the received UMD PDU was placed in the reception buffer:
 - update state variables, reassemble and deliver RLC SDUs to upper layer and start/stop *t-Reassembly* as needed (see clause 5.2.2.2.3).

When *t-Reassembly* expires, the receiving UM RLC entity shall:

- update state variables, discard RLC SDU segments and start *t-Reassembly* as needed (see clause 5.2.2.2.4).

5.2.2.2.2 Actions when an UMD PDU is received from lower layer

When an UMD PDU is received from lower layer, the receiving UM RLC entity shall:

- if the UMD PDU header does not contain an SN:
 - remove the RLC header and deliver the RLC SDU to upper layer.
- else if $(RX_Next_Highest - UM_Window_Size) \leq SN < RX_Next_Reassembly$:
 - discard the received UMD PDU.
- **else if $MinSN \leq SN \leq MaxSN$, the $MinSN$ and $MaxSN$ belong to the same SN window among the SN windows included in the RLC discard indication PDU. The procedure is as illustrated in FIG. 11:**
 - **discard the received UMD PDU.**
- else:
 - place the received UMD PDU in the reception buffer.

5.2.2.2.3 Actions when an UMD PDU is placed in the reception buffer

When an UMD PDU with $SN = x$ is placed in the reception buffer, the receiving UM RLC entity shall:

- if all byte segments with $SN = x$ are received:
 - reassemble the RLC SDU from all byte segments with $SN = x$, remove RLC headers and deliver the reassembled RLC SDU to upper layer;
- if $x = RX_Next_Reassembly$:
 - update $RX_Next_Reassembly$ to the SN of the first $SN > current\ RX_Next_Reassembly$ that has not been reassembled and delivered to upper layer.
- **If the $MinSN \leq RX_Next_Reassembly \leq MaxSN$**

- update RX_Next_Reassembly to MaxSN + 1;
- Optionally, if there are more than one SN window, repeat for all the SN windows included in the RLC discard indication PDU until RX_Next_Reassembly is not in the scope of $\text{MinSN} \leq \text{RX_Next_Reassembly} \leq \text{MaxSN}$ for any SN window . The procedure is as illustrated in FIG. 12.
- else if x falls outside of the reassembly window:
 - update RX_Next_Highest to x + 1;
 - If the $\text{MinSN} \leq \text{RX_Next_Highest} \leq \text{MaxSN}$ (this part is optional)
 - update RX_Next_Highest to MaxSN + 1;
 - Optionally, if there are more than one SN window, repeat for all the SN windows included in the RLC discard indication PDU until RX_Next_Highest is not in the scope of $\text{MinSN} \leq \text{RX_Next_Highest} \leq \text{MaxSN}$ for any SN window . The procedure is similar as illustrated in FIG. 12.
 - discard any UMD PDUs with SN that falls outside of the reassembly window;
 - if RX_Next_Reassembly falls outside of the reassembly window:
 - set RX_Next_Reassembly to the SN of the first SN $\geq (\text{RX_Next_Highest} - \text{UM_Window_Size})$ that has not been reassembled and delivered to upper layer.
 - If the $\text{MinSN} \leq \text{RX_Next_Reassembly} \leq \text{MaxSN}$
 - update RX_Next_Reassembly to MaxSN + 1;
 - Optionally, if there are more than one SN window, repeat for all the SN windows included in the RLC discard indication PDU until RX_Next_Reassembly is not in the scope of $\text{MinSN} \leq$

RX_Next_Reassembly $\leq$ MaxSN for any SN window. The procedure is as illustrated in FIG. 12.

- if *t-Reassembly* is running:
 - if RX_Timer_Trigger $\leq$ RX_Next_Reassembly; or
 - if RX_Timer_Trigger falls outside of the reassembly window and RX_Timer_Trigger is not equal to RX_Next_Highest; or
 - if RX_Next_Highest = RX_Next_Reassembly + 1 and there is no missing byte segment of the RLC SDU associated with SN = RX_Next_Reassembly before the last byte of all received segments of this RLC SDU:
 - stop and reset *t-Reassembly*.
- if *t-Reassembly* is not running (includes the case when *t-Reassembly* is stopped due to actions above):
 - if RX_Next_Highest > RX_Next_Reassembly + 1; or
 - if RX_Next_Highest = RX_Next_Reassembly + 1 and there is at least one missing byte segment of the RLC SDU associated with SN = RX_Next_Reassembly before the last byte of all received segments of this RLC SDU:
 - start *t-Reassembly*;
 - set RX_Timer_Trigger to RX_Next_Highest.

5.2.2.2.4 Actions when *t-Reassembly* expires

When *t-Reassembly* expires, the receiving UM RLC entity shall:

- update RX_Next_Reassembly to the SN of the first SN $\geq$ RX_Timer_Trigger that has not been reassembled;
- **If the MinSN $\leq$ RX_Next_Reassembly $\leq$ MaxSN**
- update RX_Next_Reassembly to MaxSN + 1;

- Optionally, if there are more than one SN window, repeat for all the SN windows included in the RLC discard indication PDU until $RX_Next_Reassembly$ is not in the scope of $MinSN \leq RX_Next_Reassembly \leq MaxSN$ for any SN window.

The procedure is as illustrated in FIG. 12.

- discard all segments with $SN < updated\ RX_Next_Reassembly$;
- if $RX_Next_Highest > RX_Next_Reassembly + 1$; or
- if $RX_Next_Highest = RX_Next_Reassembly + 1$ and there is at least one missing byte segment of the RLC SDU associated with $SN = RX_Next_Reassembly$ before the last byte of all received segments of this RLC SDU:
 - start t-Reassembly;
 - set $RX_Timer_Trigger$ to $RX_Next_Highest$.

[00101] With reference to FIG. 11, the receiver device executes the following operations:

[00102] A protocol layer entity (e.g., RLC layer) in the receiver device receives and decodes a RLC discard indication PDU from the transmitter device (D101). The protocol layer entity decodes the RLC discard indication PDU to determine whether any SN window is indicated in the RLC discard indication PDU.

[00103] When one or more SN windows is indicated in the RLC discard indication PDU, the protocol layer entity obtains each of the one or more SN windows as a current SN window and performs the following operations for each SN window. When receiving a RLC data PDU (D102), the protocol layer entity obtains the current SN window with $[MinSN, MaxSN]$ (D103) and determines whether an SN associated with the RLC data PDU is in the range $[MinSN, MaxSN]$ (D104), that is, whether SN associated with the RLC data PDU meets the condition $MinSN \leq SN \leq MaxSN$.

[00104] When SN associated with the RLC data PDU meets the condition $MinSN \leq SN \leq MaxSN$, the protocol layer entity discards the RLC data PDU (D106).

[00105] When SN associated with the RLC data PDU does not meet the condition $MinSN \leq SN \leq MaxSN$, the protocol layer entity determines whether the SN window is the last SN window in the windows indicated by the RLC discard indication PDU (D105). If the SN window is not the last SN window, the protocol layer entity obtains a next one of the one or more SN windows indicated by the RLC discard indication PDU as the current SN window (D107) and performs step D104. If the SN window is the last SN window, the execution terminates.

[00106] With reference to FIG. 12, the receiver device executes the following operations:

[00107] A protocol layer entity (e.g., RLC layer) in the receiver device receives and decodes a RLC discard indication PDU from the transmitter device (D201). The protocol layer entity decodes the RLC discard indication PDU to determine whether more than one SN window is indicated in the RLC discard indication PDU and multiple SN windows indicated in the RLC discard indication PDU are not sorted (D203).

[00108] When more than one SN window is indicated in the RLC discard indication PDU and not sorted, the protocol layer entity sorts all the SN windows according to the value of MinSN and MaxSN for each SN window in ascending order (D204) and obtains each of the one or more SN windows as a current SN window and performs the following operations for each SN window.

[00109] When receiving a RLC data PDU (D205), the protocol layer entity obtains the current SN window with [MinSN, MaxSN] (D206) and determines whether a parameter RX_NEXT associated with the RLC data PDU is in the range [MinSN, MaxSN] (D207), that is, whether RX_NEXT associated with the RLC data PDU meets the condition $MinSN \leq RX_NEXT \leq MaxSN$. The RX_NEXT may include RX_Next_Reassembly and/or RX_Next_Highest.

[00110] When RX_NEXT associated with the RLC data PDU does not meet the condition $MinSN \leq RX_NEXT \leq MaxSN$, the protocol layer entity do nothing to the RX_NEXT and performs D209.

[00111] When RX_NEXT associated with the RLC data PDU meets the condition $MinSN \leq RX_NEXT \leq MaxSN$, the protocol layer entity updates the RX_NEXT to MaxDC+1 (D208).

[00112] The protocol layer entity determines whether the SN window is the last SN window in the windows indicated by the RLC discard indication PDU (D209). If the SN window is not the last SN window, the protocol layer entity obtains a next one of the one or more SN windows indicated by the RLC discard indication PDU as the current SN window (D210) and performs step D206. If the SN window is the last SN window, the execution terminates.

[00113] FIG. 13 is a block diagram of an example system 700 for wireless communication according to an embodiment of the present disclosure. Embodiments described herein may be implemented into the system using any suitably configured hardware and/or software. FIG. 13 illustrates the system 700 including a radio frequency (RF) circuitry 710, a baseband circuitry 720, a processing unit 730, a memory/storage 740, a display 750, a camera 760, a sensor 770, and an input/output (I/O) interface 780, coupled with each other as illustrated.

[00114] The processing unit 730 may include circuitry, such as, but not limited to, one or more single-core or multi-core processors. The processors may include any combinations of general-purpose processors and dedicated processors, such as graphics processors and application processors. The processors may be coupled with the memory/storage and configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems running on the system.

[00115] The radio control functions may include, but are not limited to, signal modulation, encoding, decoding, radio frequency shifting, etc. In some embodiments, the baseband circuitry

may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry may support communication with 5G NR, LTE, an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry. In various embodiments, the baseband circuitry 720 may include circuitry to operate with signals that are not strictly considered as being in a baseband frequency. For example, in some embodiments, baseband circuitry may include circuitry to operate with signals having an intermediate frequency, which is between a baseband frequency and a radio frequency.

[00116] In various embodiments, the system 700 may be a mobile computing device such as, but not limited to, a laptop computing device, a tablet computing device, a netbook, an ultrabook, a smartphone, etc. In various embodiments, the system may have more or less components, and/or different architectures. Where appropriate, the methods described herein may be implemented as a computer program. The computer program may be stored on a storage medium, such as a non-transitory storage medium.

[00117] The embodiment of the present disclosure is a combination of techniques/processes that can be adopted in 3GPP specification to create an end product.

[00118] If the software function unit is realized and used and sold as a product, it can be stored in a readable storage medium in a computer. Based on this understanding, the technical plan proposed by the present disclosure can be essentially or partially realized as the form of a software product. Or, one part of the technical plan beneficial to the conventional technology can be realized as the form of a software product. The software product in the computer is stored in a storage medium, including a plurality of commands for a computational device (such as a personal computer, a server, or a network device) to run all or some of the steps disclosed by the embodiments of the present disclosure. The storage medium includes a USB disk, a mobile hard disk, a read-only memory (ROM), a random access memory (RAM), a floppy disk, or other kinds of media capable of storing program codes.

[00119] While the present disclosure has been described in connection with what is considered the most practical and preferred embodiments, it is understood that the present disclosure is not limited to the disclosed embodiments but is intended to cover various arrangements made without departing from the scope of the broadest interpretation of the appended claims.

What is claimed is:

1. A wireless communication method, executable in a wireless communication device, wherein the wireless communication device operates as a transmitter device, and the method comprises: transmitting to a receiver device a control PDU that indicates sequence number (SN) information of discarded protocol data units (PDUs) discarded by a protocol layer entity of the transmitter device;

wherein the control PDU comprises one or more SN windows in which SNs for the discarded PDUs are continuous.

2. The method of claim 1, wherein the discarded PDUs are discarded by a packet data convergence protocol (PDCP) layer entity or a radio link control (RLC) entity of the transmitter device.

3. The method of claim 1, wherein the control PDU being a packet data convergence protocol (PDCP) discard indication PDU comprises a field of PDU type indicating a PDU type of PDCP discard indication PDU.

4. The method of claim 3, wherein the PDCP discard indication PDU comprises configuration of an SN window among the one or more SN windows, and the configuration of the SN window comprises:

□ a field of MinDC in the PDCP discard indication PDU means Minimum Discard COUNT corresponding to the minimum PDCP PDU SN in the SN window; and

□ a field of MaxDC in the PDCP discard indication PDU means Maximum Discard COUNT corresponding to the maximum PDCP PDU SN in the SN window.

5. The method of claim 1, wherein the control PDU being a radio link control (RLC) discard indication PDU comprises a field of PDU type indicating a PDU type of RLC discard indication PDU.

6. The method of claim 5, wherein the RLC discard indication PDU comprises configuration of an SN window among the one or more SN windows, and the configuration of the SN window comprises:

□ a field of MinSN in the RLC discard indication PDU means the Minimum Discard SN corresponding to the minimum RLC PDU SN in the SN window; and

□ a field of MaxSN in the RLC discard indication PDU means the Maximum Discard SN corresponding to the maximum RLC PDU SN in the SN window.

7. The method of claim 1, wherein the control PDU comprises a field of E that indicates whether or not configuration of another SN window follows the field of E.

8. A wireless communication device comprising:

a processor, configured to call and run a computer program stored in a memory, to cause a device in which the processor is installed to execute the method of any of claims 1 to 7.

9. A chip, comprising:

a processor, configured to call and run a computer program stored in a memory, to cause a device

in which the chip is installed to execute the method of any of claims 1 to 7.

10. A computer readable storage medium, in which a computer program is stored, wherein the computer program causes a computer to execute the method of any of claims 1 to 7.

11. A computer program product, comprising a computer program, wherein the computer program causes a computer to execute the method of any of claims 1 to 7.

12. A computer program, wherein the computer program causes a computer to execute the method of any of claims 1 to 7.

13. A wireless communication method, executable in a wireless communication device, wherein the wireless communication device operates as a receiver device, and the method comprises: receiving from a transmitter device a control PDU that indicates sequence number (SN) information of discarded protocol data units (PDUs) discarded by the transmitter device; wherein the control PDU comprises one or more SN windows in which SNs for the discarded PDUs are continuous.

14. The method of claim 13, wherein the control PDU being a packet data convergence protocol (PDCP) discard indication PDU comprises a field of PDU type indicating a PDU type of PDCP discard indication PDU.

15. The method of claim 14, wherein the PDCP discard indication PDU comprises configuration of an SN window among the one or more SN windows, and the configuration of the SN window comprises:

- a field of MinDC in the PDCP discard indication PDU means Minimum Discard COUNT corresponding to the minimum PDCP PDU SN in the SN window; and

- a field of MaxDC in the PDCP discard indication PDU means Maximum Discard COUNT corresponding to the maximum PDCP PDU SN in the SN window.

16. The method of claim 15, further comprising:

discarding received PDUs in the SN window when a PDCP data PDU is received from a lower layer.

17. The method of claim 16, wherein the lower layer is a radio link control (RLC) layer.

18. The method of claim 15, further comprising:

modifying a parameter that indicating an count value of a waiting PDU in a PDCP layer of the receiver device to MaxDC+1 when a PDCP data PDU is received from a lower layer, wherein the waiting PDU has not been transmitted to an upper layer.

19. The method of claim 18, wherein the parameter is RX_DELIV or RX_NEXT.

20. The method of claim 15, further comprising:

modifying a parameter that indicating an count value of a waiting PDU in a PDCP layer of the receiver device to MaxDC+1 when a timer t-Reordering expires, wherein the waiting PDU has not been transmitted to an upper layer.

21. The method of claim 18, wherein the parameter is RX_DELIV.

22. The method of claim 13, wherein the control PDU being a radio link control (RLC) discard

indication PDU comprises a field of PDU type indicating a PDU type of RLC discard indication PDU.

23. The method of claim 22, wherein the RLC discard indication PDU comprises configuration of an SN window among the one or more SN windows, and the configuration of the SN window comprises:

- a field of MinSN in the RLC discard indication PDU means the Minimum Discard SN corresponding to the minimum RLC PDU SN in the SN window; and
- a field of MaxSN in the RLC discard indication PDU means the Maximum Discard SN corresponding to the maximum RLC PDU SN in the SN window.

24. The method of claim 23, further comprising:

discarding received PDUs in the SN window when an UMD PDU is received from a lower layer.

25. The method of claim 24, wherein the lower layer is a medium access control (MAC) layer.

26. The method of claim 23, further comprising:

modifying a parameter that indicating an earliest SN for reassembly in an RLC layer of the receiver device to MaxSN+1 when an UMD PDU is placed in a reception buffer of the RLC layer.

27. The method of claim 26, wherein the parameter is RX_Next_Reassembly or RX_Next_Highest.

28. The method of claim 23, further comprising:

modifying a parameter that indicating an earliest SN for reassembly in an RLC layer of the receiver device to MaxSN+1 when a timer t-Reassembly expires.

29. The method of claim 26, wherein the parameter is RX_Next_Reassembly.

30. The method of claim 13, wherein the control PDU comprises a field of E that indicates whether or not configuration of another SN window follows the field of E.

31. A wireless communication device comprising:

a processor, configured to call and run a computer program stored in a memory, to cause a device in which the processor is installed to execute the method of any of claims 13 to 30.

32. A chip, comprising:

a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute the method of any of claims 13 to 30.

33. A computer readable storage medium, in which a computer program is stored, wherein the computer program causes a computer to execute the method of any of claims 13 to 30.

34. A computer program product, comprising a computer program, wherein the computer program causes a computer to execute the method of any of claims 13 to 30.

35. A computer program, wherein the computer program causes a computer to execute the method of any of claims 13 to 30.

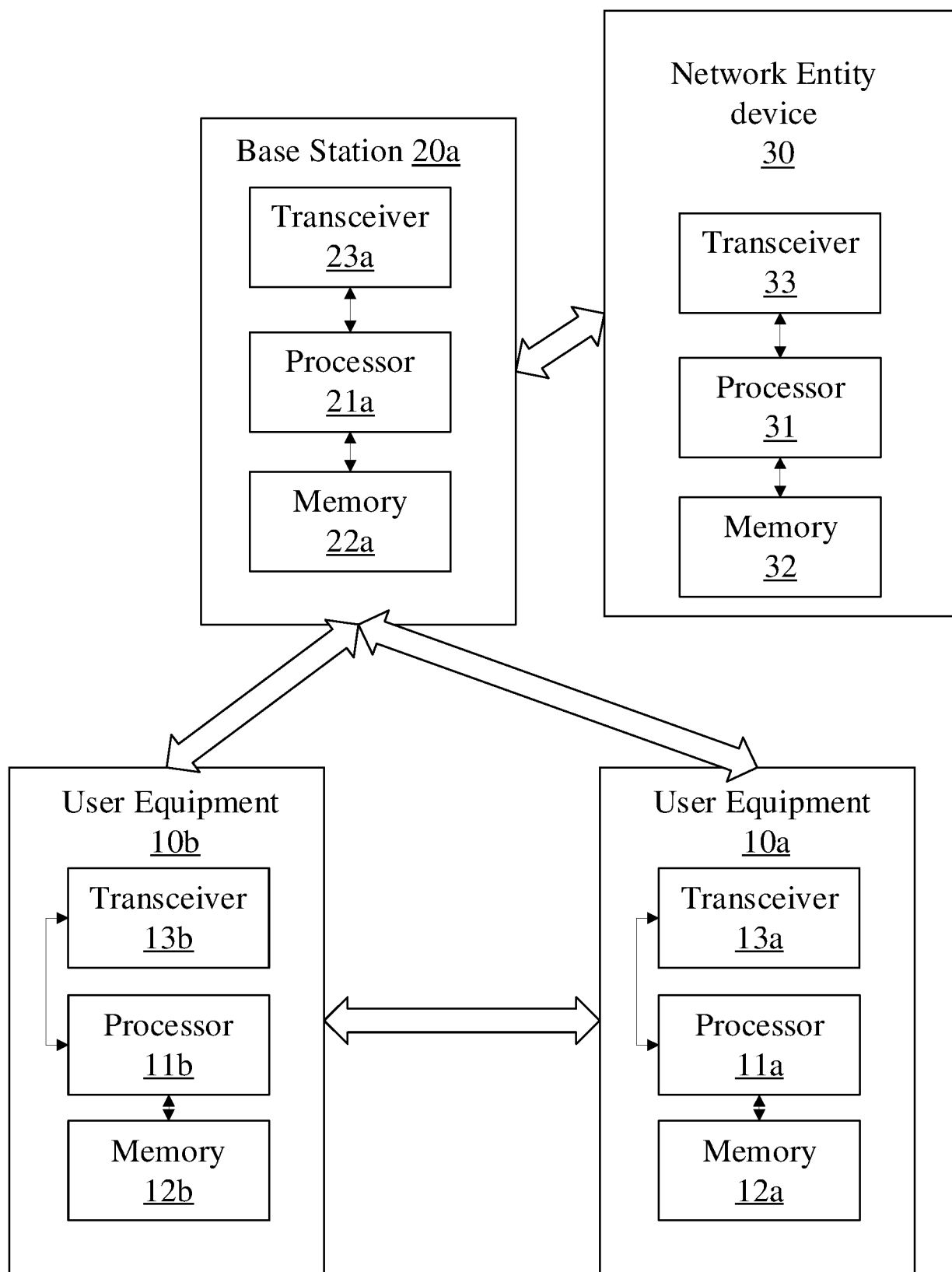


FIG. 1

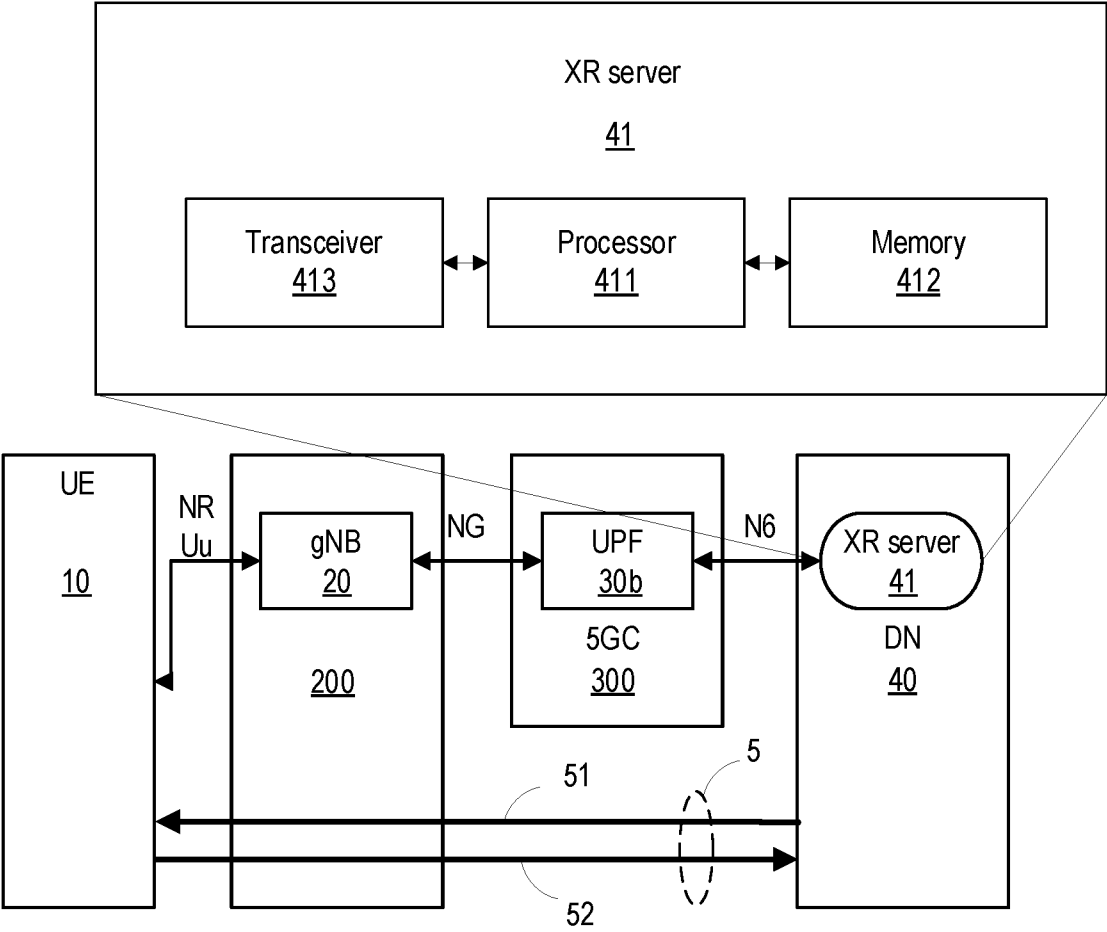


FIG. 2

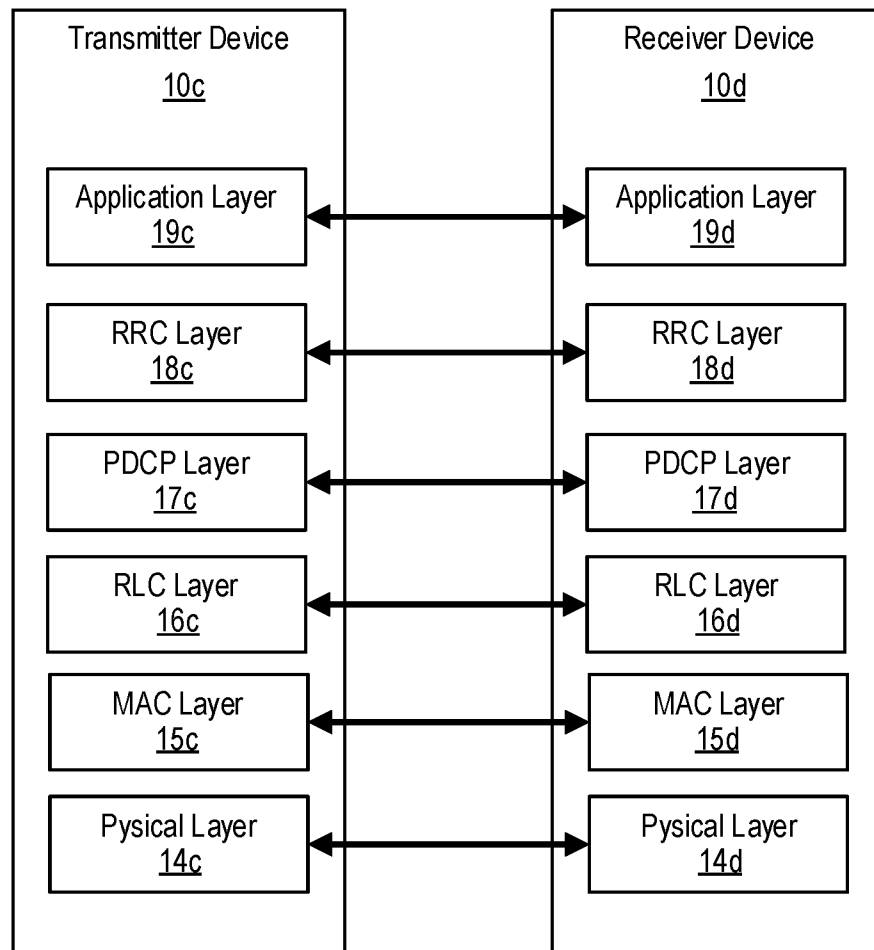


FIG. 3

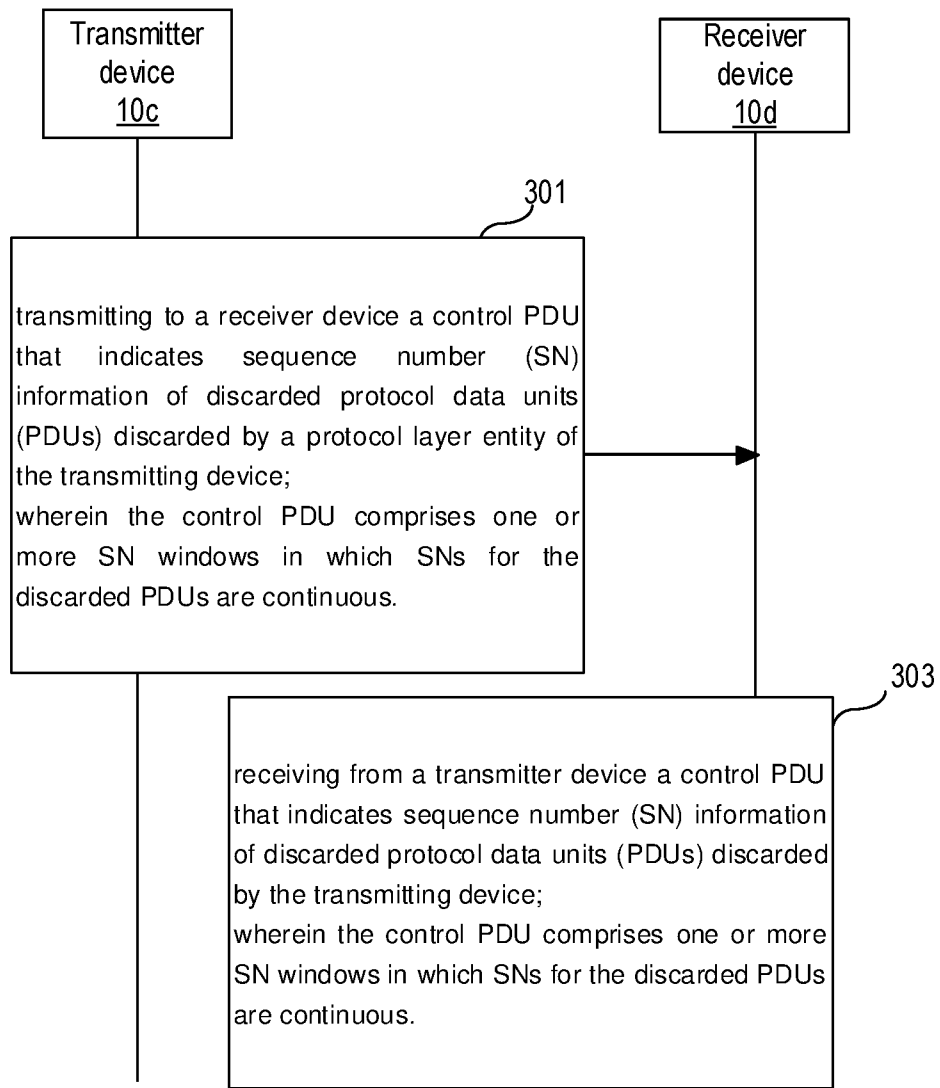
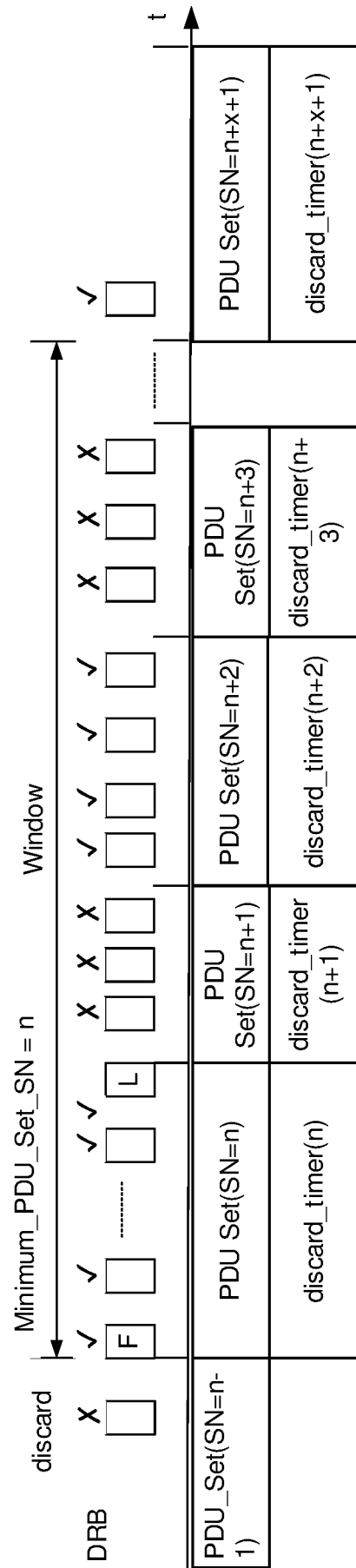
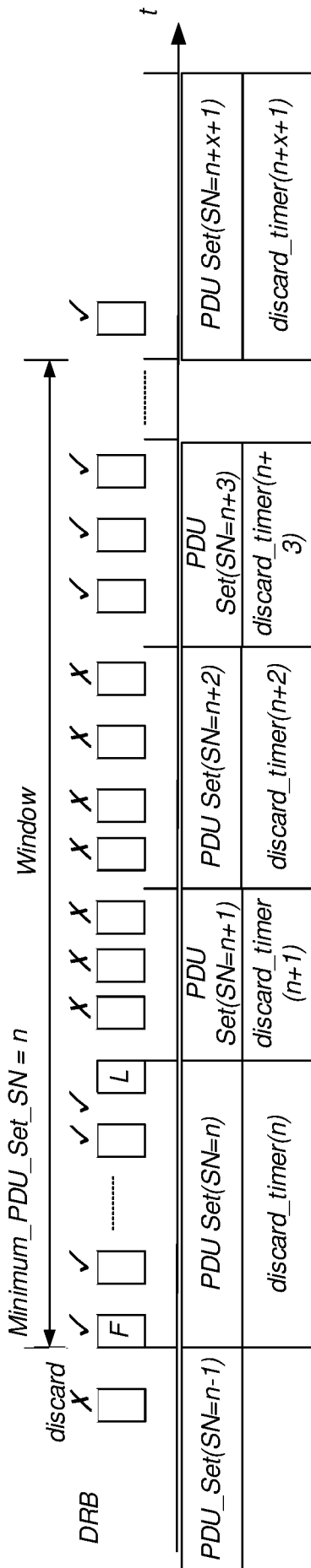


FIG. 4



D/C	PDU Type	R	R	MinDC					Oct 1
MinDC									Oct 2
MinDC (cont.)									Oct 3
MinDC (cont.)									Oct 4
MinDC (cont.)				MaxDC					Oct 5
MaxDC									Oct 6
MaxDC (cont.)									Oct 7
MaxDC (cont.)									Oct 8
MaxDC (cont.)				E	R				Oct 9
...									Oct 5+N

FIG. 7

D/C	CPT	R	R	R	R				Oct 1
MinSN									Oct 2
MinSN (cont.)		R	R	R	R				Oct 3
MaxSN									Oct 4
MaxSN (cont.)		E	R	R	R				Oct 5
...									Oct 5+N

FIG. 8

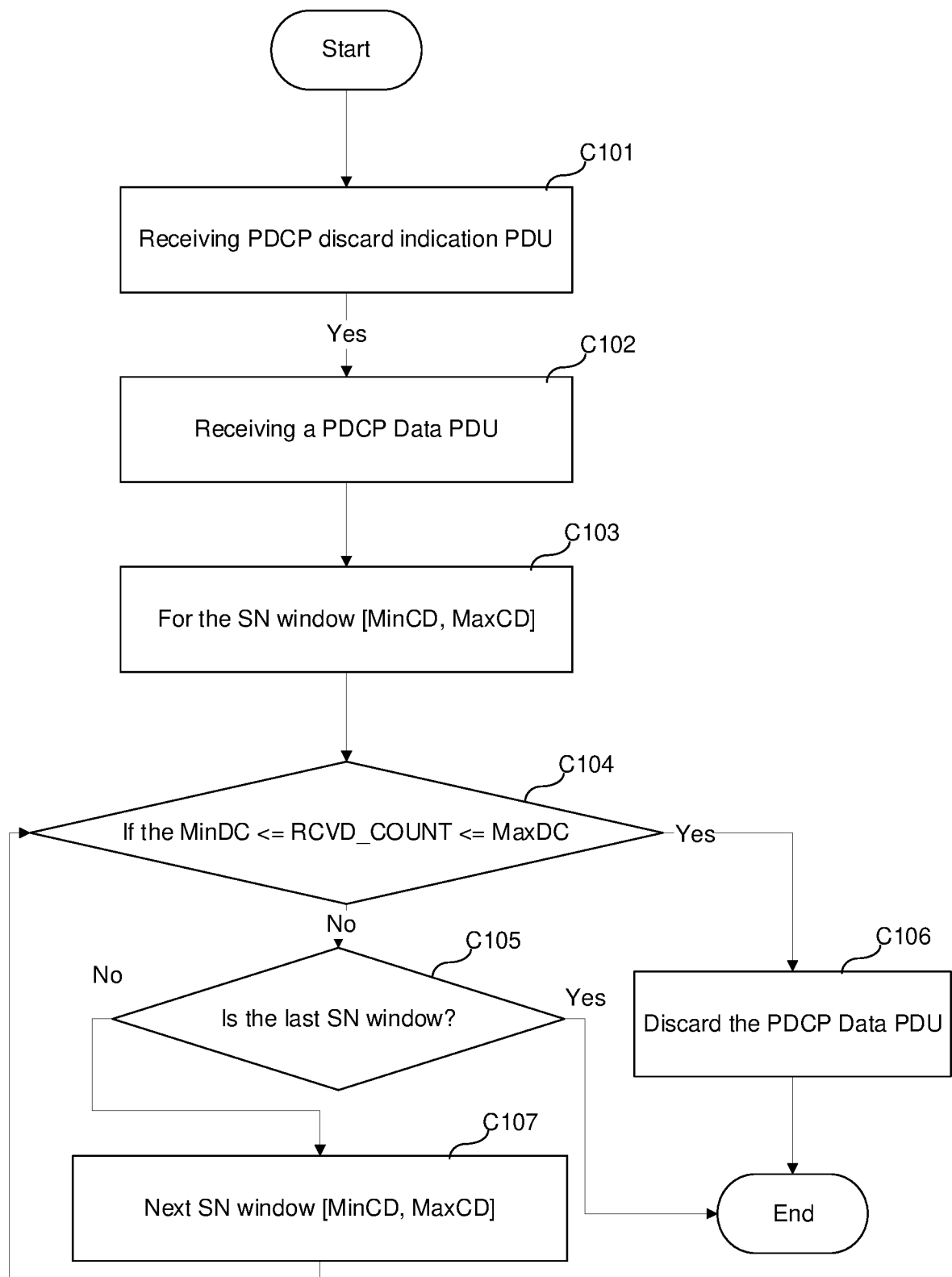


FIG. 9

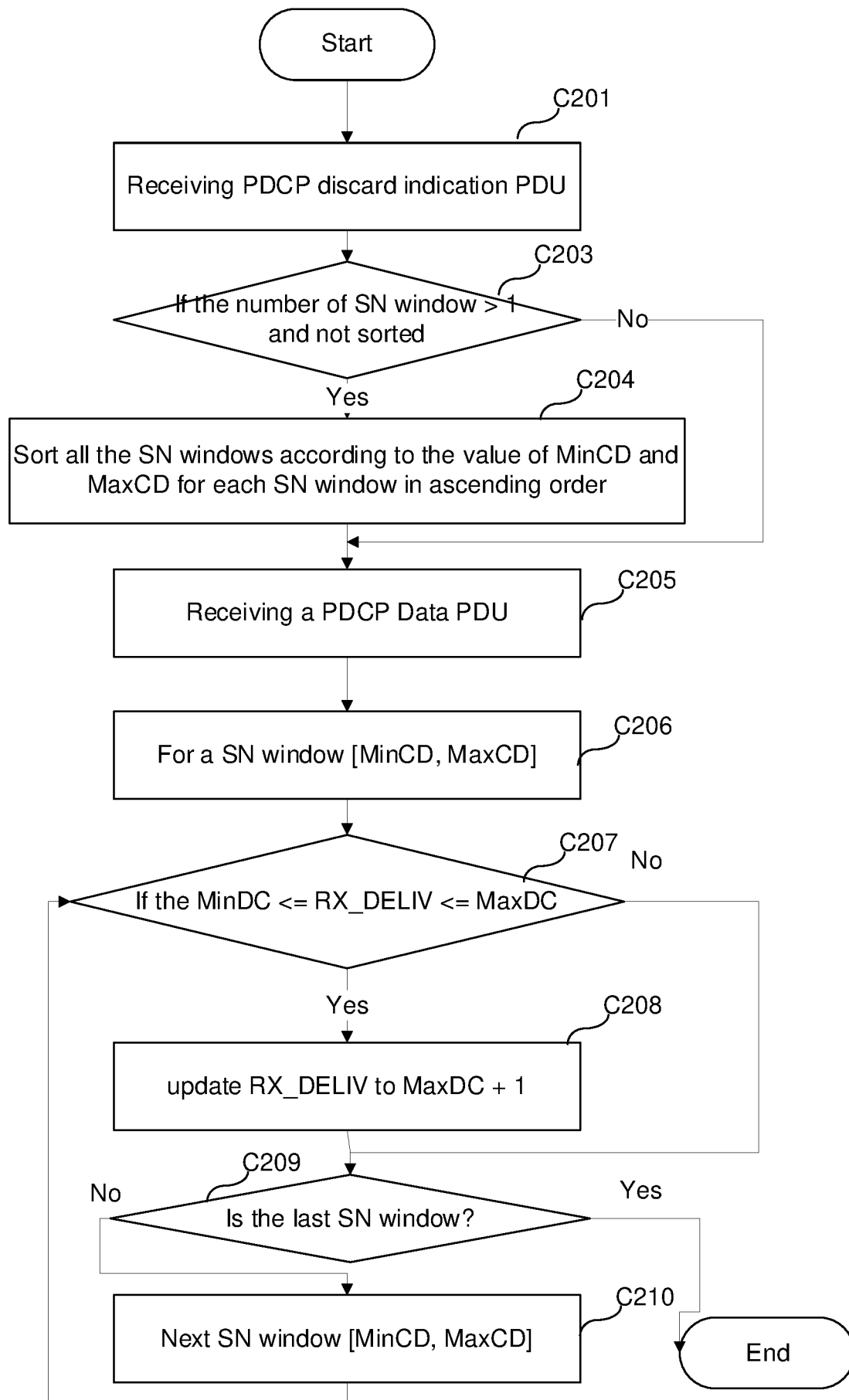


FIG. 10

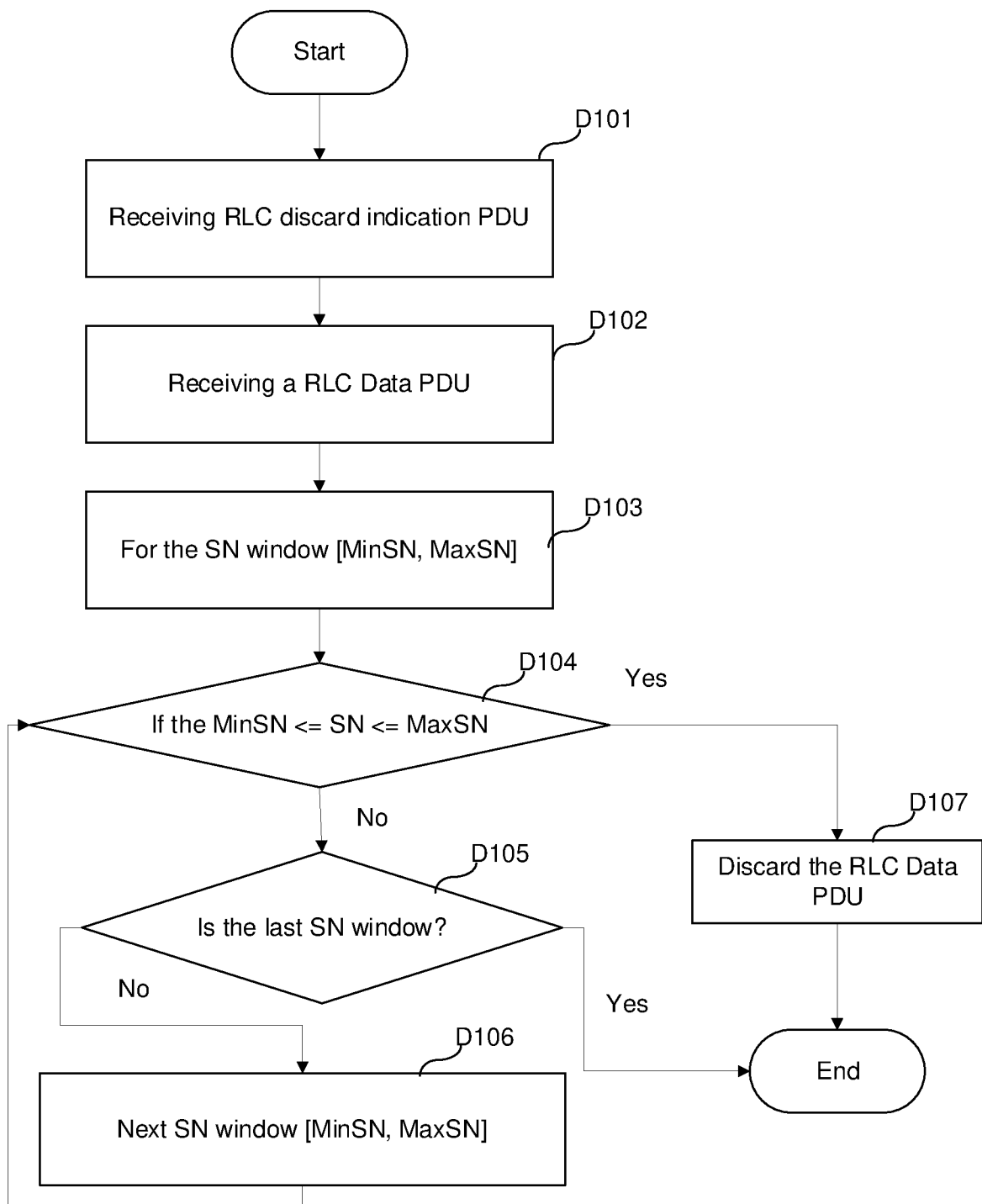


FIG. 11

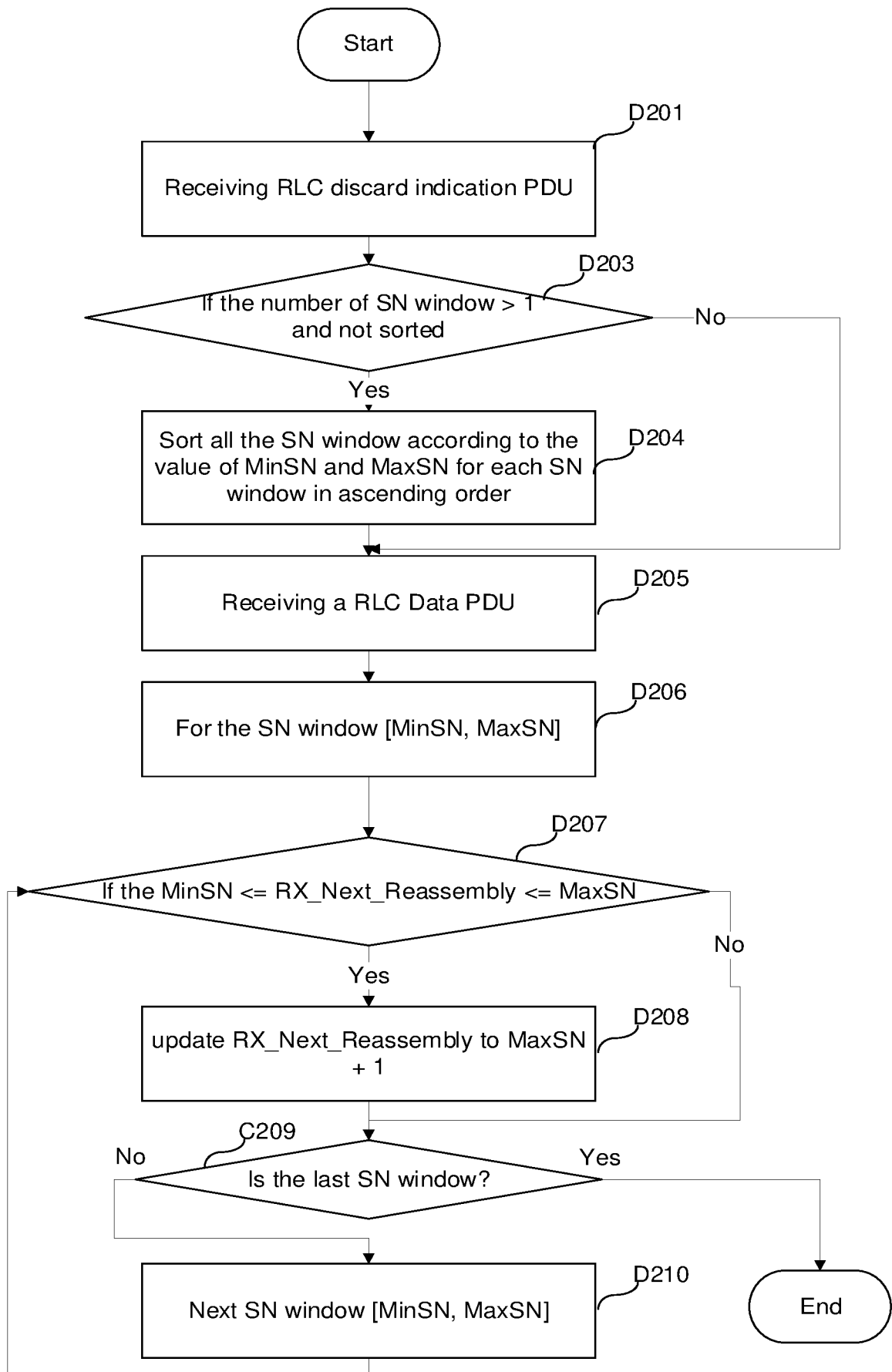


FIG. 12

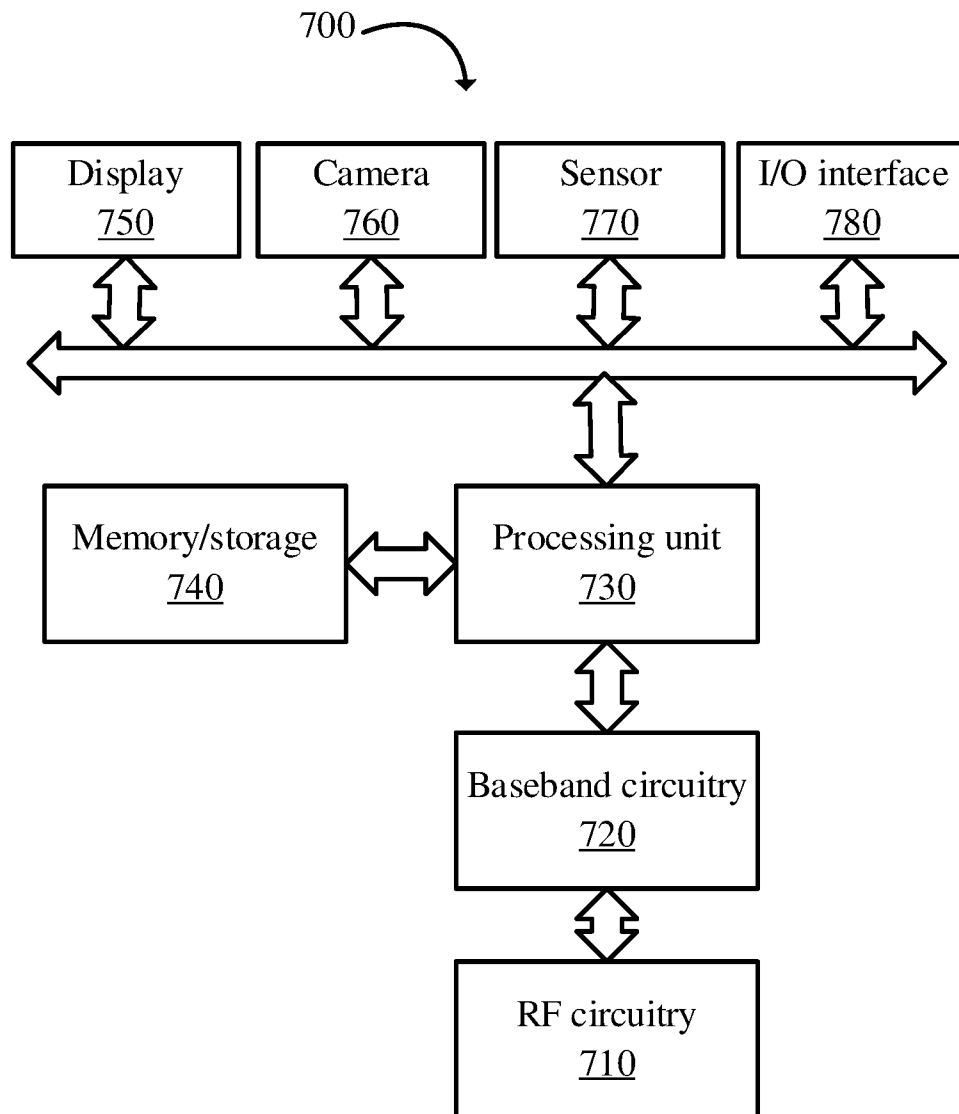


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/122836

A. CLASSIFICATION OF SUBJECT MATTER

H04L27/00(2006.01)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: H04L, H04W

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)

ENTXT, CNTXT, DWPI, 3GPP: PDU, protocol data unit, SN, sequence number, PDCP, packet data convergence protocol, RLC, radio link control, discard, indicate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2022081073 A1 (TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)) 21 April 2022 (2022-04-21) description, page 9 line 2-page 14 line 8	1-35
A	US 2022150693 A1 (SAMSUNG ELECTRONICS CO., LTD.) 12 May 2022 (2022-05-12) the whole document	1-35
A	WO 2020141894 A1 (LG ELECTRONICS INC.) 09 July 2020 (2020-07-09) the whole document	1-35
A	WO 2022146039 A1 (SAMSUNG ELECTRONICS CO., LTD.) 07 July 2022 (2022-07-07) the whole document	1-35
A	NSN et al. "PDCP window handling for split bearers" 3GPP TSG-RAN WG2 Meeting #86 R2-142087, 23 May 2014 (2014-05-23), the whole document	1-35



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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“D” document cited by the applicant in the international application

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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

31 May 2023

Date of mailing of the international search report

07 June 2023

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2022/122836

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2022081073	A1	21 April 2022	None			
US	2022150693	A1	12 May 2022	KR	20220063750	A	17 May 2022
				WO	2022103139	A1	19 May 2022
				KR	20220063695	A	17 May 2022
WO	2020141894	A1	09 July 2020	None			
WO	2022146039	A1	07 July 2022	KR	20220094987	A	06 July 2022