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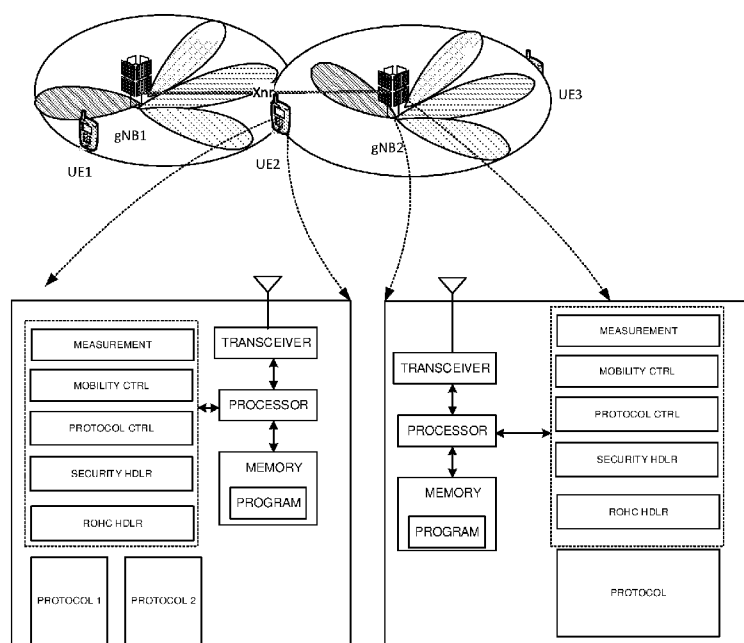


Fig. 1

(57) **Abstract:** Apparatus and methods are provided to support dual protocol stacks to achieve 0ms mobility interruption time in LTE and NR system. For UL packets transmission, UE select to which gNB the PDCPSDU received from upper layer to transmission. UE performs ciphering and integrity protection with the security key and configuration provided by the selected gNB. UE performs header compression with the one ROHC profile or two ROHC profiles as configure by the network. For DL packets reception, UE performs deciphering and integrity verification with the security key and configuration of the gNB where the PDCPPDU is received. UE performs header decompression with the ROHC profile as configure by the network. If two ROHC profiles are configured, UE can perform header decompression before or after PDCP reordering and duplication detection.



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APPARATUS AND METHODS TO SUPPORT DUAL-PROTOCOL FOR MOBILITY ENHANCEMENT

TECHNICAL FIELD

[0001] The disclosed embodiments relate generally to wireless communication, and, more particularly, to reduce mobility interruption time through dual protocol stacks in the new radio access system.

BACKGROUND

[0002] 5G radio access technology will be a key component of the modern access network. It will address high traffic growth and increasing demand for high-bandwidth connectivity. It will also support massive numbers of connected devices and meet the real-time, high-reliability communication needs of mission-critical applications. Both the standalone NR deployment and non-standalone NR with LTE/eLTE deployment will be considered. In order to improve the UE experience quality, it's desirable to reduce the mobility interruption time during handover. Mobility interruption time means the shortest time duration supported by the system during which a user terminal cannot exchange user plane packets with any base station during transitions. The target for mobility interruption time should be 0ms, which is intended for both intra-frequency and inter-frequency mobility for intra-NR mobility.

[0003] In LTE (Rel-8/9), the latency during handover execution is nearly 50 ms from step 7 (*RRC Connection Reconfiguration*) to step 11(*RRC Connection Reconfiguration Complete*), which cannot satisfy the mobility interruption requirement in NR. In order to minimize the service interruption in mobility events, two solutions are considered, i.e. RACH-less handover and “make-before-break” handover. In RACH-less HO, RACH procedure can be skipped during handover. Although the interruption time can be reduced by 4.5/8.5ms with RACH-less HO without performing from step 9.3 to step 10, additional interruption is expected before the preconfigured periodical UL resource is available. The make-before-break solution means that UE continues downlink and uplink with the source cell until the UE performs the first transmission through PUSCH or PRACH to the target eNB. In “make-before-break” HO, UE can continue the data transmission with the source cell after receiving the handover command until RACH is initiated. The interruption time can be reduced by 35ms, since data transmission continues with source cell during the HO execution from step 7 to

step 9.2. Although the interruption is reduced by 35ms, the interruption due to random access procedure and delivering *RRC Connection Reconfiguration Complete* message can't be avoided.

Component/ Step	Description	Time (ms)
7	RRC Connection Reconfiguration Incl. <i>mobilityControlInfo</i>	15
8	SN Status Transfer	0
9.1	Target cell search	0
9.2	UE processing time for RF/baseband re-tuning, security update	20
9.3	Delay to acquire first available PRACH in target eNB	0.5/2.5
9.4	PRACH preamble transmission	1
10	UL Allocation + TA for UE	3/5
11	UE sends RRC Connection Reconfiguration Complete	6
	Minimum/Typical Total delay [ms]	45.5/49.5

Table 1: Minimum/Typical radio access latency components (Rel. 8/Rel. 9) during handover

[0004] In this invention, apparatus and mechanisms are sought to achieve 0ms mobility interruption time during HO through dual protocol stacks.

SUMMARY

[0005] Apparatus and methods are provided to support dual protocol stacks to achieve 0ms mobility interruption time in both LTE and NR system. In one novel aspect, a UE includes multiple function modules, including dual protocols including SDAP, PDCP, RLC, MAC and PHY for each protocol, a dual protocol stack controller to manage the dual protocol stacks, a PDCP reordering module, and a security handler and a header compression handler.

[0006] In one embodiment of UL packets transmission, the header compression is associated to two PDCP transmitting entities. UE determine to which gNB to transmit the PDCPSDU. The PDCPSDU is transmitted to the base station from which UL grant is received. UE applies the security key and configuration as provided by the corresponding base station.

[0007] In one embodiment of UL packets transmission, there are two PDCP transmitting entities corresponding to the source gNB and the target gNB respectively. Each PDCP entity has its own header compression and decompression module and ROHC profile. UE determine to which gNB to transmit the PDCPSDU. The PDCPSDU is transmitted to the base station from which UL grant is received. UE applies the security key and configuration and the ROHC profile as provided by the corresponding base station.

[0008] In one embodiment of DL packets reception, at reception of a PDCP Data PDU from lower layers, each receiving PDCP entity shall determine the COUNT value of the received PDCP Data PDU. Then the receiving PDCP entity shall perform deciphering and integrity verification of the PDCP Data PDU according to the security key and configuration of the corresponding base

station where it is received. UE performs PDCP reordering to the PDCPPDUs received from the source gNB and the target gNB. The PDCPSDUs are delivered to upper layers in ascending order of the associated COUNT value after performing header decompression, if not decompressed before.

[0009] In one embodiment of DL packets reception, at reception of a PDCP Data PDU from lower layers, each receiving PDCP entity shall determine the COUNT value of the received PDCP Data PDU. Then the receiving PDCP entity shall perform deciphering and integrity verification of the PDCP Data PDU according to the security key and configuration of the corresponding base station where it is received. Then the receiving PDCP entity shall perform header decompression of the PDCP Data PDU according to the ROHC profile of the corresponding base station where it is received. UE performs PDCP reordering to the PDCPPDUs received from the source gNB and the target gNB.

[0010] In one embodiment of DL packets reception, at reception of a PDCP Data PDU from lower layers, each receiving PDCP entity shall determine the COUNT value of the received PDCP Data PDU. Then the receiving PDCP entity shall perform deciphering and integrity verification of the PDCP Data PDU according to the security key and configuration of the corresponding base station where it is received. Then UE performs PDCP reordering to the PDCPPDUs received from the source gNB and the target gNB. Then each PDCPPDUs are routed to the corresponding header decompress or module, where the ROHC profile of the corresponding base station is applied.

[0011] In one embodiment, there is one common reception buffer at PDCP layer, which stores the PDCPSDUs. There is one common function for PDCP reordering and duplication detection. There is one common function for header compression/decompression. Those common functions are associated to the two PDCP entities.

[0012] In one embodiment, certain functions in the PDCP entity for source gNB or the target gNB are disabled. In one embodiment, the PDCP reordering function is disabled. In another embodiment, the header compression/decompression is disable. So the PDCPSDU with SN and header are forwarded from one PDCP entity to the other for process.

[0013] The criteria to release the protocol associated to the source gNB are defined.

[0014] In one embodiment, UE release the protocol associated to the source gNB upon delivery of the first DL PDCPSDU of a DRB received from the target gNB to SDAP layer.

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BRIEF DESCRIPTION OF DRAWINGS

[0015] The accompanying drawings, where like numerals indicate like components, illustrate embodiments of the invention.

[0016] Figure 1 is a schematic system diagram illustrating an exemplary wireless network in accordance with embodiments of the current invention.

[0017] Figure 2 illustrates an exemplary NR wireless system with centralization of the upper layers of the NR radio stacks in accordance with embodiments of the current invention.

5 [0018] Figure 3 illustrates an exemplary NR wireless system supporting inter gNB mobility scenario in accordance with embodiments of the current invention.

[0019] Figure 4 illustrates an exemplary user-plane data transmission in PDCP layer with inter-gNB mobility in accordance with embodiments of the current invention.

10 [0020] Figure 5 illustrates an exemplary user-plane data reception in PDCP layer with inter-gNB mobility in accordance with embodiments of the current invention.

[0021] Figure 6 illustrates an exemplary user-plane data transmission in PDCP layer with inter-gNB mobility in accordance with embodiments of the current invention.

[0022] Figure 7 illustrates an exemplary user-plane data reception in PDCP layer with inter-gNB mobility in accordance with embodiments of the current invention.

15 [0023] Figure 8 illustrates an exemplary user-plane data reception in PDCP layer with inter-gNB mobility in accordance with embodiments of the current invention.

[0024] Figure 9 illustrates an exemplary structure of PDCP layer with dual protocol stacks handling PDCP reordering in accordance with embodiments of the current invention.

20 [0025] Figure 10 illustrates an exemplary structure of PDCP layer with dual protocol stacks handling PDCP reordering in accordance with embodiments of the current invention.

[0026] Figure 11 illustrates an exemplary handling with the protocol stack associated to source gNB in accordance with embodiments of the current invention.

DETAILED DESCRIPTION

25 [0027] Reference will now be made in detail to some embodiments of the invention, examples of which are illustrated in the accompanying drawings.

[0028] Figure 1 is a schematic system diagram illustrating an exemplary wireless network in accordance with embodiments of the current invention. Wireless system includes one or more fixed base infrastructure units forming a network distributed over a geographical region. The base unit may also be referred to as an access point, an access terminal, a base station, a Node-B, an eNode-B, 30 a gNB, or by other terminology used in the art. As an example, base stations serve a number of mobile stations within a serving area, for example, a cell, or within a cell sector. In some systems, one or more base stations are coupled to a controller forming an access network that is coupled to

one or more core networks. gNB1 and gNB2 are base stations in NR, the serving area of which may or may not overlap with each other. As an example, UE1 or mobile station is only in the service area of gNB1 and connected with gNB1. UE1 is connected with gNB1 only, gNB1 is connected with gNB2 via Xn interface. UE2 is in the overlapping service area of gNB1 and gNB2. In one embodiment, UE2 is configured with dual protocol stacks and can be connected with gNB1 and gNB2 simultaneously.

[0029] Figure 1 further illustrates simplified block diagrams for UE2 and gNB2, respectively. UE has an antenna, which transmits and receives radio signals. A RF transceiver, coupled with the antenna, receives RF signals from antenna, converts them to baseband signal, and sends them to processor. In one embodiment, the RF transceiver may comprise two RF modules (not shown). A first RF module is used for transmitting and receiving on one frequency band, and the other RF module is used for different frequency bands transmitting and receiving which is different from the first transmitting and receiving. RF transceiver also converts received baseband signals from processor, converts them to RF signals, and sends out to antenna. Processor processes the received baseband signals and invokes different functional modules to perform features in UE. Memory stores program instructions and data to control the operations of mobile station. UE also includes multiple function modules that carry out different tasks in accordance with embodiments of the current invention.

[0030] A measurement module, which controls the RRM measurement according to network's configuration. A mobility controller, which receives RRC message for mobility, e.g. HO command and transmits the response message for HO command. A protocol stack controller, which manages to add or remove the protocol stack associated to source gNB and target gNB. A security handler, which associates the different security keys to different gNBs. A ROHC handler, which determines to use one or more ROHC profiles according to network configuration for different base station and applies the ROHC profile in the corresponding Protocol stack. Protocol Stack 1 and Protocol Stack 2 include SDAP, PDCP, RLC, MAC and PHY layers. In one embodiment, the SDAP layer is optionally configured.

[0031] In one embodiment, the PDCP layer supports the functions of transfer of data, maintenance of PDCP SN, header compression and decompression using the ROHC protocol, ciphering and deciphering, integrity protection and integrity verification, timer based SDU discard, routing for split bearer, duplication, re-ordering and in-order delivery; out of order delivery and duplication discarding.

[0032] In one embodiment, there is one additional PDCP reordering and duplication detection function, which receives the PDCPDUs from both target gNB and source gNB, reorders those

PDCPPDUs based on the SN/COUNT and delivers the PDCPSDUs to upper layer in-sequence order. In one embodiment, the PDCP reordering and duplication detection is also performed by PDCP layer.

[0033] Similarly, gNB2 has an antenna, which transmits and receives radio signals. A RF transceiver, coupled with the antenna, receives RF signals from antenna, converts them to baseband signals, and sends them to processor. RF transceiver also converts received baseband signals from processor, converts them to RF signals, and sends out to antenna. Processor processes the received baseband signals and invokes different functional modules to perform features in gNB2. Memory stores program instructions and data to control the operations of gNB2. gNB2 also includes multiple function modules that carry out different tasks in accordance with embodiments of the current invention.

[0034] A measurement module, which controls the RRM measurement through RRC configuration and receives measurement report from the UE side. A mobility controller, which determines the target gNB for mobility. It coordinates with other candidate gNB through Xn interface, make the HO decision and sends HO command to UE. A protocol stack controller, which manage to add or remove the protocol stack associated to source gNB and target gNB. A security handler, which generate one security key corresponding to the gNB. A ROHC handler determines one or more ROHC profiles are configured and associates the ROHC profile to the corresponding base station for each DRB. Protocol Stack includes SDAP, PDCP, RLC, MAC and PHY layers. In one embodiment, the SDAP layer is optionally configured.

[0035] Figure 2 illustrates an exemplary NR wireless system with centralization of the upper layers of the NR radio stacks in accordance with embodiments of the current invention. Different protocol split options between Central Unit and lower layers of gNB nodes may be possible. The functional split between the Central Unit and lower layers of gNB nodes may depend on the transport layer. Low performance transport between the Central Unit and lower layers of gNB nodes can enable the higher protocol layers of the NR radio stacks to be supported in the Central Unit, since the higher protocol layers have lower performance requirements on the transport layer in terms of bandwidth, delay, synchronization and jitter. In one embodiment, SDAP and PDCP layer are located in the central unit, while RLC, MAC and PHY layers are located in the distributed unit.

[0036] Figure 3 illustrates an exemplary NR wireless system supporting inter gNB mobility scenario in accordance with embodiments of the current invention. The intra 5G intra-RAT handover is normally based on Xn-based handover. HO is performed between gNBs through Xn interface, which are connected to the NR core network. Each gNB has the protocol stacks including SDAP, PDCP, RLC, MAC and PHY layers.

[0037] Figure 4 illustrates an exemplary user-plane data transmission in PDCP layer with inter-

gNB mobility in accordance with embodiments of the current invention. In one embodiment of DL packets transmission, for a PDCPSDU received from upper layers, the transmitting PDCP entity at the source gNB shall associate the COUNT value corresponding to TX_NEXT to this PDCPSDU, perform header compression of the PDCPSDU. Set the PDCP SN of the PDCP Data PDU to TX_NEXT modulo $2^{[pdcpsn-size]}$. Determine through which gNB to transmit the PDCPSDU. If the PDCPSDU is to be transmitted through the source gNB, perform integrity protection, and ciphering using the security key and configuration as the source gNB. If the PDCPSDU is to be transmitted through the target gNB, forward the PDCPSDU, the associated SN and the PDCP header after header compression to the target gNB. Then the target gNB performs integrity protection, and ciphering using the security key and configuration as the target gNB. Then the resulting PDCP Data PDU are submitted to lower layer.

[0038] In one embodiment of UL packets transmission, for a PDCPSDU received from upper layers, the transmitting PDCP entity shall associate the COUNT value corresponding to TX_NEXT to this PDCPSDU, perform header compression of the PDCPSDU and set the PDCP SN of the PDCP Data PDU to TX_NEXT modulo $2^{[pdcpsn-size]}$. In this case, the header compression is associated to two PDCP transmitting entities. UE determine to which gNB to transmit the PDCPSDU. The PDCPSDU is transmitted to the base station from which UL grant is received. If the PDCPSDU is to be transmitted to the source gNB, perform integrity protection, and ciphering using the security key and configuration as the source gNB. If the PDCPSDU is to be transmitted to the target gNB, performs integrity protection, and ciphering using the security key and configuration as the target gNB. Then the resulting PDCP Data PDU are submitted to lower layer associated to the selected base station.

[0039] Figure 5 illustrates an exemplary user-plane data reception in PDCP layer with inter-gNB mobility in accordance with embodiments of the current invention. In one embodiment of DL packets reception, at reception of a PDCP Data PDU from lower layers, each receiving PDCP entity shall determine the COUNT value of the received PDCP Data PDU, i.e. RCVD_COUNT. 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 the receiving PDCP entity is associated to the source gNB, perform ciphering and integrity verification with the security key and configuration of the source gNB. If the receiving PDCP entity is associated to the target cell, perform ciphering and integrity verification with the security key and configuration of the target cell. If the received PDCP Data PDU with COUNT value = RCVD_COUNT is not discarded before, the receiving PDCP entity shall store the resulting PDCPSDU in the reception buffer. UE perform PDCP reordering for the PDCPSDUs stored

in the reception buffer according to the COUNT value. The PDCPSDUs are delivered to upper layers in ascending order of the associated COUNT value after performing header decompression, if not decompressed before.

[0040] In one embodiment of UL packets reception, both the source gNB and the target gNB have the receiving PDCP entity. At reception of a PDCP Data PDU from lower layers, each receiving PDCP entity shall determine the COUNT value of the received PDCP Data PDU, i.e. RCVD_COUNT. 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 the receiving PDCP entity is associated to the source gNB, perform ciphering and integrity verification with the security key and configuration of the source gNB. If the receiving PDCP entity is associated to the target gNB, perform ciphering and integrity verification with the security key and configuration of the target gNB. Then the receiving PDCP entity of the target gNB forwards the PDCPSDUs, SN and headers to the source gNB. If the received PDCP Data PDU with COUNT value = RCVD_COUNT is not discarded before, the receiving PDCP entity of the source gNB shall store the resulting PDCPSDU in the reception buffer. Then the source gNB perform PDCP reordering for the PDCPSDUs stored in the reception buffer according to the COUNT value. The PDCPSDUs are delivered to upper layers in ascending order of the associated COUNT value after performing header decompression, if not decompressed before.

[0041] In another embodiment, the PDCP reordering, duplication detection, common reception buffer and header compression/decompression is performed by the target gNB.

[0042] Figure 6 illustrates an exemplary user-plane data transmission in PDCP layer with inter-gNB mobility in accordance with embodiments of the current invention. In one embodiment of DL packets transmission, for a PDCPSDU received from upper layers, the transmitting PDCP entity at the source gNB shall associate the COUNT value corresponding to TX_NEXT to this PDCPSDU. Set the PDCP SN of the PDCP Data PDU to TX_NEXT modulo $2^{[pdcpsn-size]}$. Determine through which gNB to transmit the PDCPSDU. If the PDCPSDU is to be transmitted through the source gNB, perform header compression of the PDCPSDU based on the ROHC profile of the source gNB, perform integrity protection, and ciphering using the security key and configuration as the source gNB. If the PDCPSDU is to be transmitted through the target gNB, forward the PDCPSDU and the associated SN to the target gNB. Then the target gNB performs header compression of the PDCPSDU based on the ROHC profile of the target gNB, performs integrity protection, and ciphering using the security key and configuration as the target gNB. Then the resulting PDCP Data PDU are submitted to lower layer.

[0043] In one embodiment of UL packets transmission, for a PDCPSDU received from upper layers, the transmitting PDCP entity corresponding to the source gNB shall associate the COUNT value corresponding to TX_NEXT to this PDCPSDU and set the PDCP SN of the PDCP Data PDU to TX_NEXT modulo $2^{[pdcpsn-size]}$. UE determine to which gNB to transmit the PDCPSDU. The PDCPSDU is transmitted to the base station from which UL grant is received. If the PDCPSDU is to be transmitted to the source gNB, perform header compression of the PDCPSDU with ROHC profile of the source gNB, perform integrity protection, and ciphering using the security key and configuration as the source gNB. If the PDCPSDU is to be transmitted to the target gNB, perform header compression of the PDCPSDU with ROHC profile of the target gNB, performs integrity protection, and ciphering using the security key and configuration as the target gNB. Then the resulting PDCP Data PDU are submitted to lower layer associated to the selected base station.

[0044] Figure 7 illustrates an exemplary user-plane data reception in PDCP layer with inter-gNB mobility in accordance with embodiments of the current invention. In one embodiment of DL packets reception, at reception of a PDCP Data PDU from lower layers, each receiving PDCP entity shall determine the COUNT value of the received PDCP Data PDU, i.e. RCVD_COUNT. 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 the receiving PDCP entity is associated to the source gNB, perform deciphering and integrity verification with the security key and configuration of the source gNB, and perform header decompression of the PDCPSDU based on the ROHC profile of the source gNB. If the receiving PDCP entity is associated to the target gNB, perform deciphering and integrity verification with the security key and configuration of the target gNB and perform header decompression of the PDCPSDU based on the ROHC profile of the target gNB. If the received PDCP Data PDU with COUNT value = RCVD_COUNT is not discarded before, the receiving PDCP entity shall store the resulting PDCPSDU in the reception buffer. UE perform PDCP reordering for the PDCPSDUs stored in the reception buffer according to the COUNT value. The PDCPSDUs are delivered to upper layers in ascending order of the associated COUNT value.

[0045] In one embodiment of UL packets reception, both the source gNB and the target gNB have the receiving PDCP entity. At reception of a PDCP Data PDU from lower layers, each receiving PDCP entity shall determine the COUNT value of the received PDCP Data PDU, i.e. RCVD_COUNT. 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 the receiving PDCP entity is associated to the source gNB, perform deciphering and integrity verification with the security key and

configuration of the source gNB, and performs header decompress or based on the ROHC profile of source gNB. If the receiving PDCP entity is associated to the target gNB, perform deciphering and integrity verification with the security key and configuration of the target gNB, and performs header decompress or based on the ROHC profile of target gNB. Then the receiving PDCP entity of the target gNB forwards the PDCPSDUs and SN to the source gNB. If the received PDCP Data PDU with COUNT value = RCVD_COUNT is not discarded before, the receiving PDCP entity of the source gNB shall store the resulting PDCPSDU in the reception buffer. Then the source gNB perform PDCP reordering for the PDCPSDUs stored in the reception buffer according to the COUNT value. The PDCPSDUs are delivered to upper layers in ascending order of the associated COUNT value.

[0046] Figure 8 illustrates an exemplary user-plane data reception in PDCP layer with inter-gNB mobility in accordance with embodiments of the current invention. In one embodiment of DL packets reception, at reception of a PDCP Data PDU from lower layers, each receiving PDCP entity shall determine the COUNT value of the received PDCP Data PDU, i.e. RCVD_COUNT. 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 the receiving PDCP entity is associated to the source gNB, perform deciphering and integrity verification with the security key and configuration of the source gNB. If the receiving PDCP entity is associated to the target gNB, perform deciphering and integrity verification with the security key and configuration of the target gNB. If the received PDCP Data PDU with COUNT value = RCVD_COUNT is not discarded before, the receiving PDCP entity shall store the resulting PDCPSDU in the reception buffer. UE perform PDCP reordering for the PDCPSDUs stored in the reception buffer according to the COUNT value. UE should route each PDCPSDU to the corresponding header decompression module. There are two header decompression modules corresponding to the source gNB and the target gNB respectively. For the header decompression module corresponding to source gNB/target gNB, UE perform header decompression of the PDCPSDU based on the ROHC profile of the source gNB/target gNB. The PDCPSDUs are delivered to upper layers in ascending order of the associated COUNT value.

[0047] In one embodiment of UL packets reception, both the source gNB and the target gNB have the receiving PDCP entity. At reception of a PDCP Data PDU from lower layers, each receiving PDCP entity shall determine the COUNT value of the received PDCP Data PDU, i.e. RCVD_COUNT. 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 the receiving PDCP entity is associated to

the source gNB, perform deciphering and integrity verification with the security key and configuration of the source gNB. If the receiving PDCP entity is associated to the target gNB, perform deciphering and integrity verification with the security key and configuration of the target gNB. Then the receiving PDCP entity of the target gNB forwards the PDCPSDUs, SN and header to
5 the source gNB. If the received PDCP Data PDU with COUNT value = RCVD_COUNT is not discarded before, the receiving PDCP entity of the source gNB shall store the resulting PDCPSDU in the reception buffer. Then the source gNB perform PDCP reordering for the PDCPSDUs stored in the reception buffer according to the COUNT value. There are two header decompression modules at the source gNB. However, one of the header decompression module performs header decompression
10 for the PDCPSDUs forwarded from the target gNB with the ROHC profiles corresponding to the target gNB. The PDCPSDUs are delivered to upper layers in ascending order of the associated COUNT value.

[0048] In another embodiment, the PDCP reordering, duplication detection, common reception buffer and header compression/decompression is performed by the target gNB.

15 [0049] Figure 9 illustrates an exemplary structure of PDCP layer with dual protocol stacks handling PDCP reordering in accordance with embodiments of the current invention. In one embodiment, each PDCP entity has the function of header add/remove, integrity protection/verification and ciphering/deciphering. There are two PDCP entities corresponding to the source gNB and the target gNB respectively. There is one common reception buffer and one
20 common function for PDCP reordering and duplication detection. There is one common function for header compression and decompression. In one embodiment, each PDCP entity has the function of header add/remove, integrity protection/verification, ciphering/deciphering and header compression/decompression. There are two PDCP entities corresponding to the source gNB and the target gNB respectively. There is one common reception buffer and one common function for PDCP
25 reordering and duplication detection.

[0050] Figure 10 illustrates an exemplary structure of PDCP layer with dual protocol stacks handling PDCP reordering in accordance with embodiments of the current invention. In one embodiment, each PDCP entity has the function of header add/remove, integrity protection/verification, ciphering/deciphering, header compression/decompression and PDCP
30 reordering and duplication detection. There are two PDCP entities corresponding to the source gNB and the target gNB respectively. In one embodiment, certain functions in one PDCP entity are disabled, while the PDCPSDUs and SNs are forwarded to the other PDCP entity for processing. In one embodiment, the PDCP reordering the duplication function in the PDCP entity of target gNB is disabled, so the PDCPSDUs and SNs received from the target gNB are processed by the PDCP

reordering the duplication function in the PDCP entity of the source gNB. In one embodiment, the PDCP reordering the duplication function and header compression/decompression in the PDCP entity of target gNB is disabled, so the PDCPSDUs, SNs received from the target gNB as well as the headers are processed by the PDCP entity of the source gNB.

5 **[0051]** Figure 11 illustrates an exemplary handling with the protocol stack associated to source gNB in accordance with embodiments of the current invention. In one embodiment, UE release the protocol associated to the source gNB upon transmission of *RRC Reconfiguration Complete* message. In one embodiment, UE release the protocol associated to the source gNB upon successfully reception of the *RRC Reconfiguration Complete* message. In one embodiment, UE determines that
10 the *RRC Reconfiguration Complete* message is successfully received by the target gNB upon reception of RLC ACK. The RLC layer sends source protocol indication to the protocol controller upon reception of the RLCACK for the *RRC Reconfiguration Complete* message. In another embodiment, UE determines that the *RRC Reconfiguration Complete* message is successfully received by the target gNB upon reception of HARQ ACK. The MAC layer sends source protocol
15 indication to the protocol controller upon reception of the HARQACK for the *RRC Reconfiguration Complete* message.

[0052] In one embodiment, UE release the protocol associated to the source gNB upon successfully reception of the first DL data packet of a DRB from the target gNB. In one embodiment, UE determines it receives a data packet of a DRB at PDCP layer, i.e. upon reception of a DL PDCP
20 data PDU for a DRB. The PDCP layer sends source protocol indication to the protocol controller, which release the protocol for the source gNB. In one embodiment, UE release the protocol associated to the source gNB upon successfully reception of the first DL transport block from the target gNB in PDSCH channel. The MAC layer or the PHY layer sends source protocol indication to the protocol controller, which release the protocol for the source gNB.

25 **[0053]** In one embodiment, UE release the protocol associated to the source gNB upon transmission of the first UL data packet of a DRB to the target gNB. In one embodiment, UE determines it transmits a data packet of a DRB at PDCP layer, i.e. upon transmission of a UL PDCP data PDU for a DRB. The PDCP layer sends source protocol indication to the protocol controller, which release the protocol for the source gNB. In one embodiment, UE release the protocol
30 associated to the source gNB upon transmission of the first UL transport block to the target gNB in PUSCH channel. The MAC layer or the PHY layer sends source protocol indication to the protocol controller, which release the protocol for the source gNB.

[0054] In one embodiment, UE release the protocol associated to the source gNB upon successfully transmission of the first UL data packet of a DRB to the target gNB. In one embodiment,

UE determines it transmits a data packet of a DRB at PDCP layer, i.e. upon transmission of a UL PDCP data PDU for a DRB. UE determines that the PDCP data PDU is successfully received by the target gNB upon reception of RLCACK or HARQACK from RLC layer or MAC/PHY layer. The RLC layer or MAC/PHY sends source protocol indication to the protocol controller, which release the protocol for the source gNB. In one embodiment, UE release the protocol associated to the source gNB upon successfully transmission of the first UL transport block to the target gNB in PUSCH channel. UE determines the TB is successfully received by the target gNB upon reception of HARQACK. The MAC layer or the PHY layer sends source protocol indication to the protocol controller, which release the protocol for the source gNB.

[0055] In one embodiment, UE release the protocol associated to the source gNB upon delivery of the first DL PDCPSDU of a DRB received from the target gNB to SDAP layer.

CLAIMS

1. A method for a PDCPSDU received from upper layers for UL packets transmission with dual PDCP transmitting entities associated to the source gNB and the target gNB respectively during HO comprising:

5 associating the COUNT value corresponding to TX_NEXT to this PDCPSDU by one PDCP transmitting entity;

selecting the gNB through which to transmit the PDCPSDU;

perform header compression with a ROHC profile as configured by the network;

10 performing integrity protection, and ciphering by the PDCP transmitting entity associated to the selected gNB using the security key and configuration as the selected gNB; and

submitting the resulting PDCP data PDU to the lower layer associated to the selected gNB.

2. The method of claim 1, wherein the associating the COUNT value is performed by the PDCP transmitting entity of source gNB.

15 3. The method of claim 1, wherein UE selects the gNB for the PDCPSDU transmission if a UL grant is received from the gNB.

4. The method of claim 1, wherein one ROHC profile is configured by the source gNB.

5. The method of claim 1, wherein one ROHC profile is configured by the target gNB.

6. The method of claim 1, wherein two ROHC profiles are configured by both the source gNB and the target gNB.

20 7. The method of claim 6, further comprising performing header compression by the PDCP transmitting entity associated to the selected gNB with the ROHC profile configured by the selected gNB.

25 8. A method for a PDCP data PDU received from lower layers for DL packets reception with dual PDCP receiving entities associated to the source gNB and the target gNB respectively during HO comprising:

determining the COUNT value of the received PDCP Data PDU by the PDCP receiving entity associated to the gNB from which the PDU is received;

performing deciphering and integrity verification of the PDCP Data PDU with the security key and configuration provided by the gNB from which the PDU is received;

30 performing PDCP reordering and duplication detection for the PDCPSDU if stored in the reception buffer;

performing header decompression of the PDCPSDU based on the ROHC profile configured by the network; and

delivering the PDCPSDU to upper layer in ascending order of the associated COUNT value.

9. The method of claim 8, wherein one ROHC profile is configured by the source gNB.

10. The method of claim 8, wherein one ROHC profile is configured by the target gNB.

5 11. The method of claim 8, wherein two ROHC profiles are configured by both the source gNB and the target gNB.

12. The method of claim 11, further comprising performing header decompression by the PDCP receiving entity associated to the gNB from which the PDCPPDU is received and applying the ROHC profile configured by the gNB.

13. The method of claim 11, wherein PDCP reordering is performed after header decompression.

10 14. The method of claim 11, wherein PDCP reordering is performed before header decompression.

15. The method of claim 14, further comprising routing the PDCPSDU after PDCP reordering to the corresponding header decompression module associated to the gNB from which the PDCPPDU is received.

15 16. A method to release the protocol stacks of source gNB with dual protocol stacks associated to the source gNB and the target gNB respectively during HO comprising:

releasing the PDCP, RLC, MAC and PHY associated to the source gNB when an event occurs.

17. The method of claim 16, wherein the events including but not limited to the following events:

20 Upon transmission of Reconfiguration complete message to the target gNB;
Upon successfully transmission of Reconfiguration Complete message to the target gNB;
Upon transmission of the first UL PDCP data PDU to the target gNB;
Upon successfully transmission of the first PDCP data PDU to the target gNB; and
Upon reception of the first DL PDCP data PDU from the target gNB.

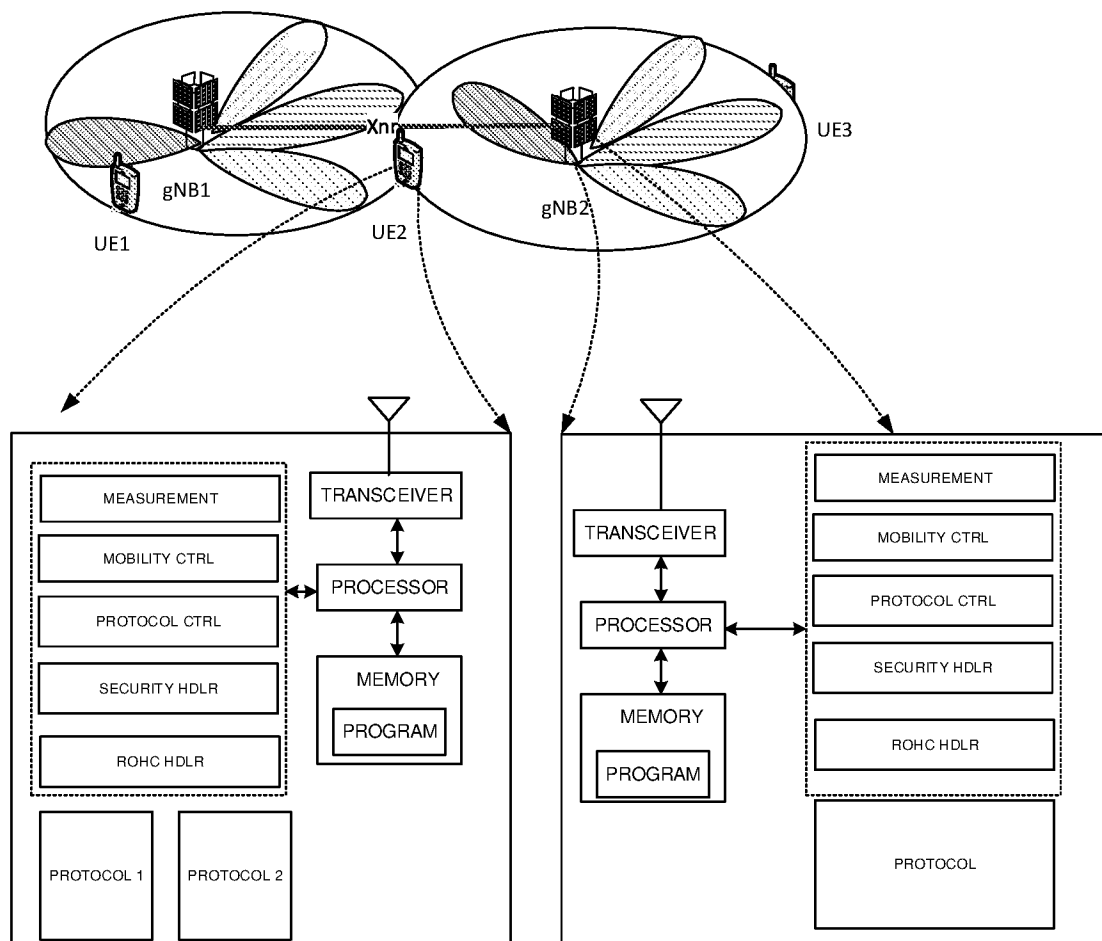


Fig. 1

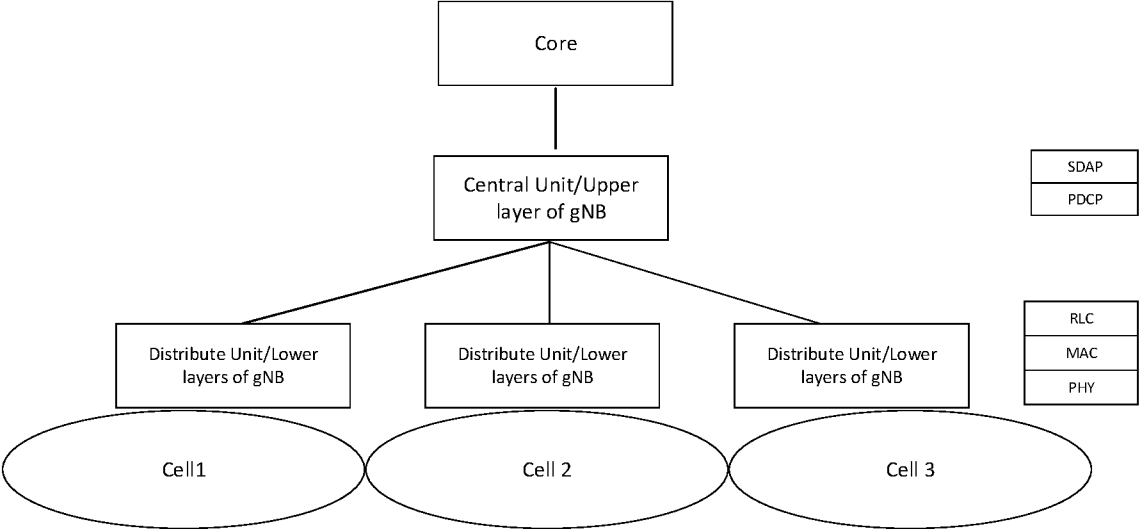


Fig. 2

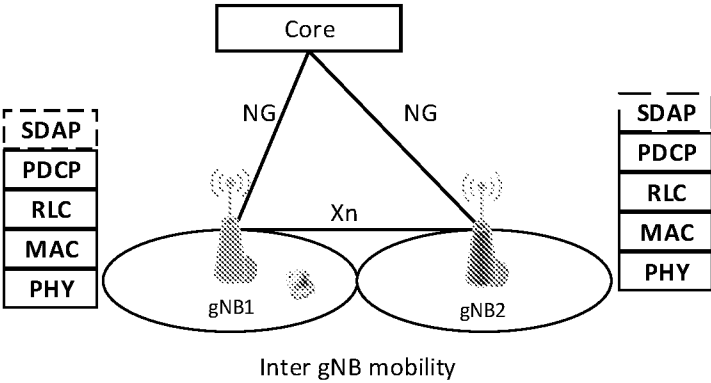


Fig 3

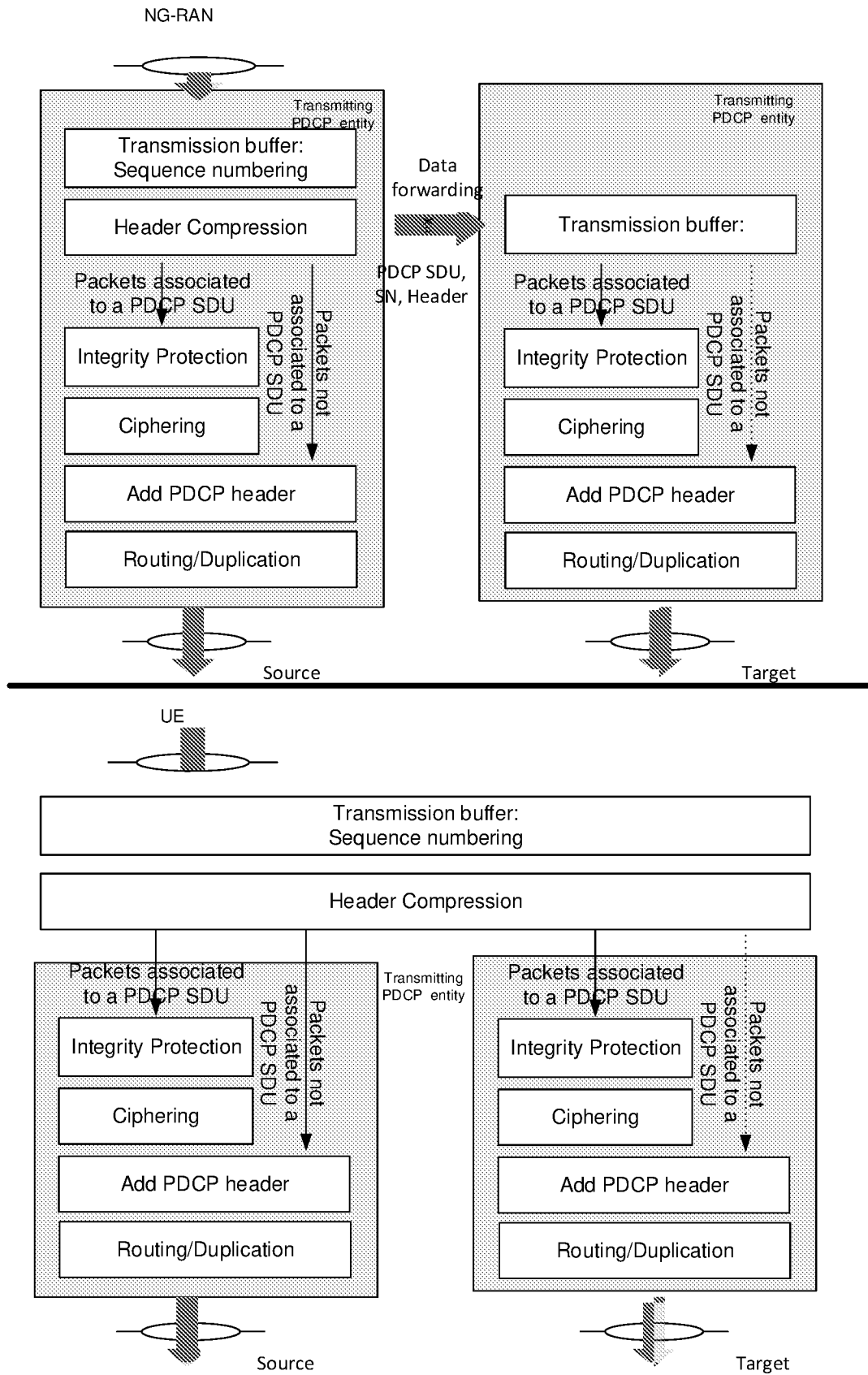


Fig. 4

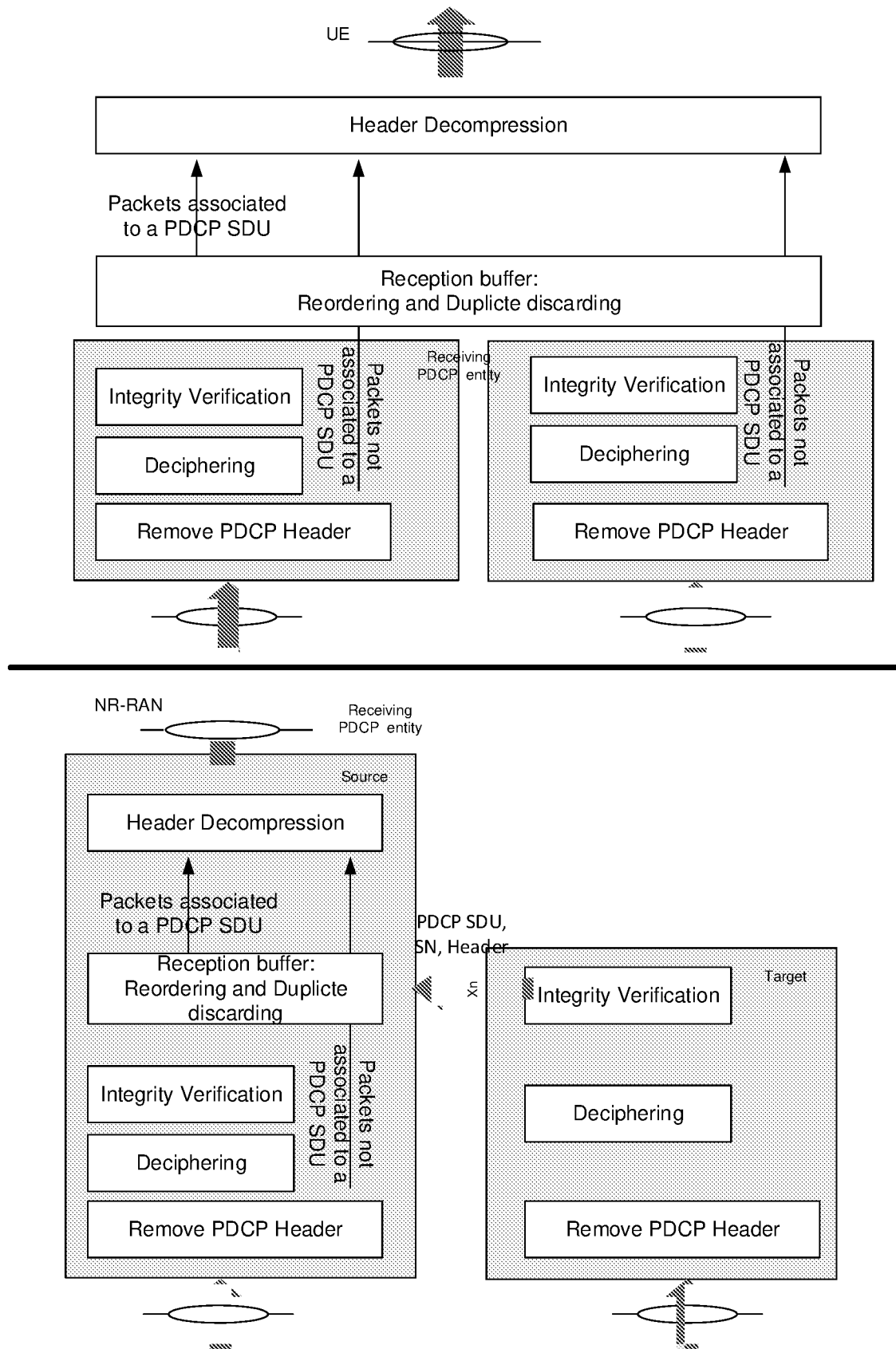


Fig. 5

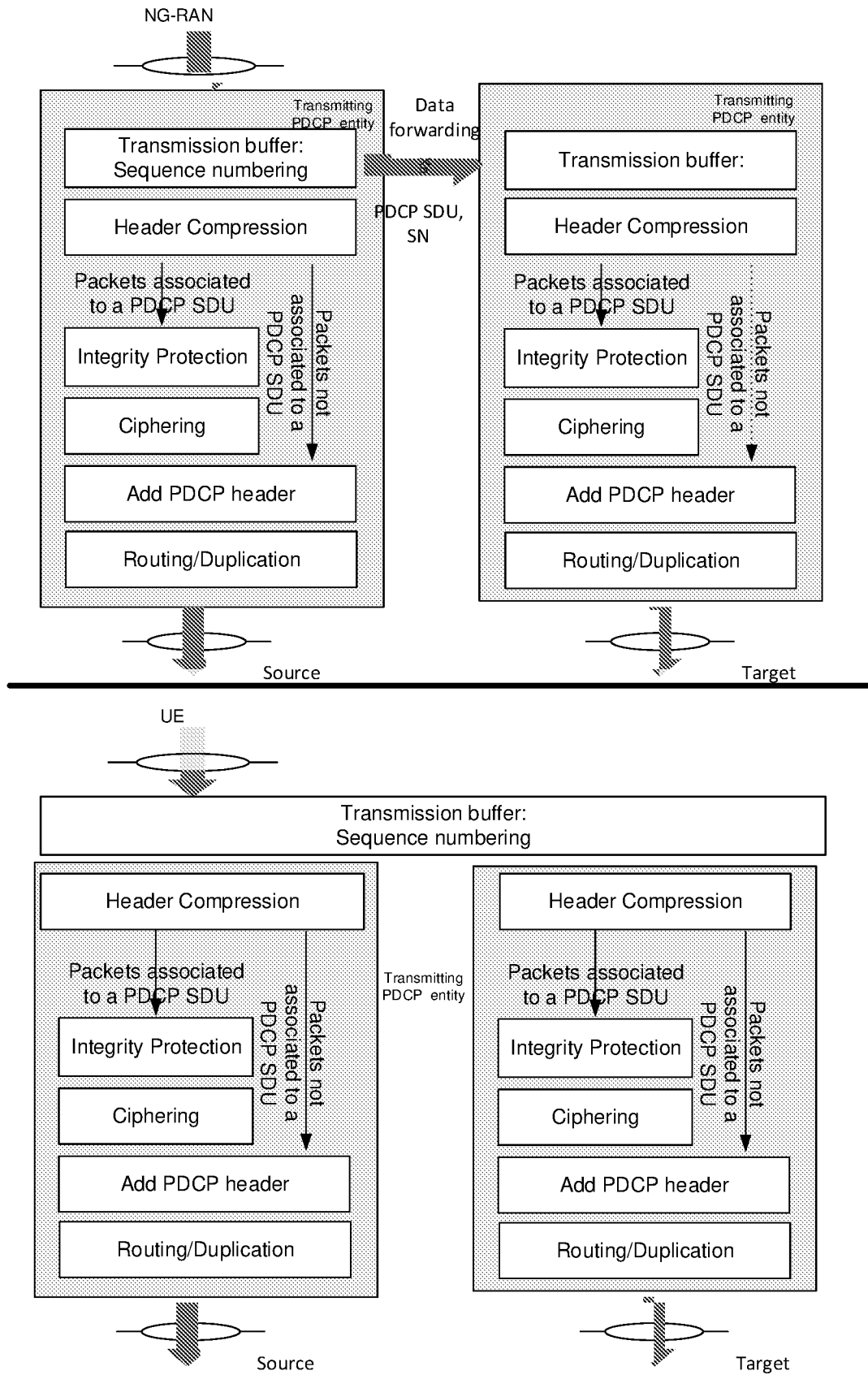


Fig. 6

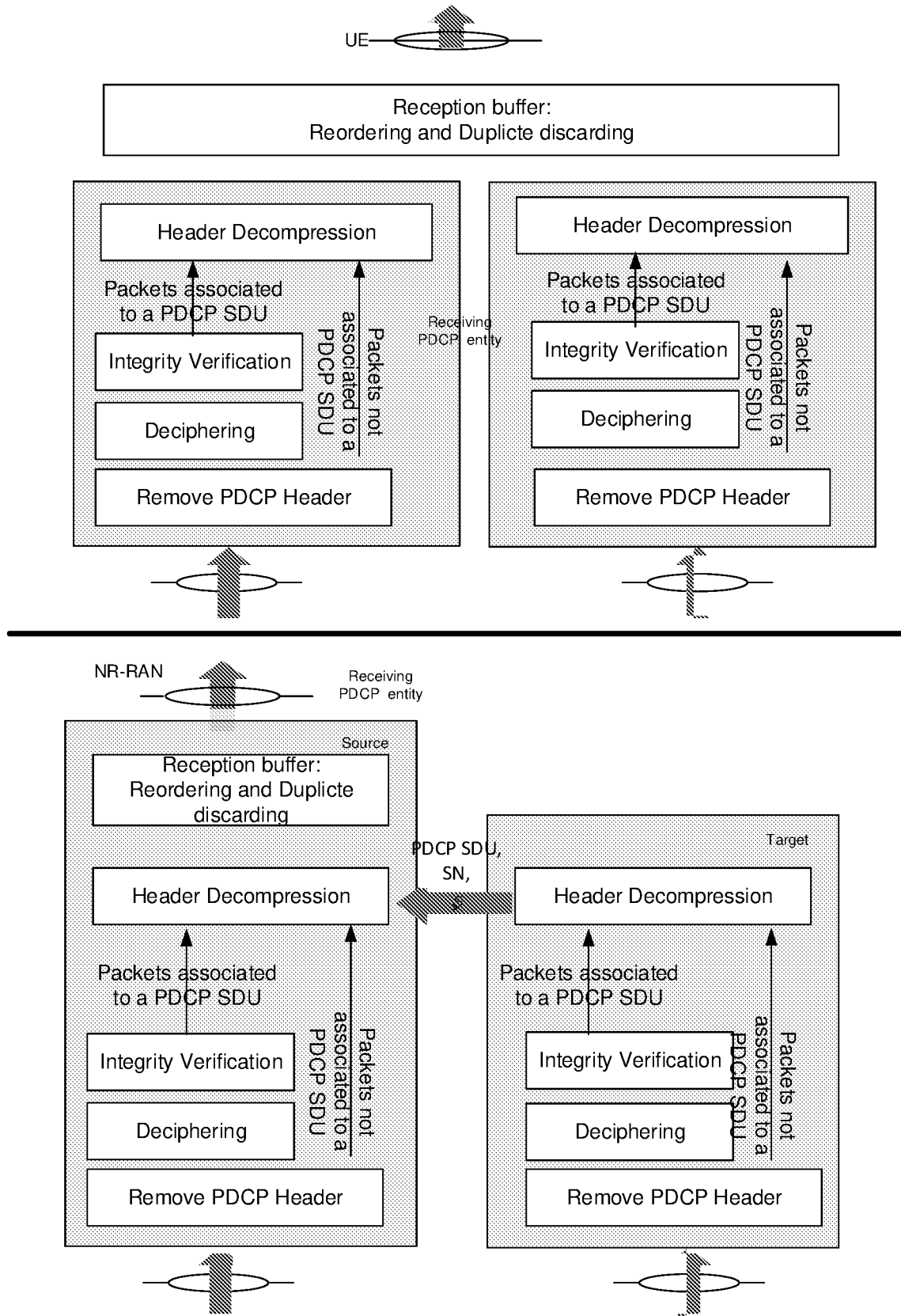


Fig. 7

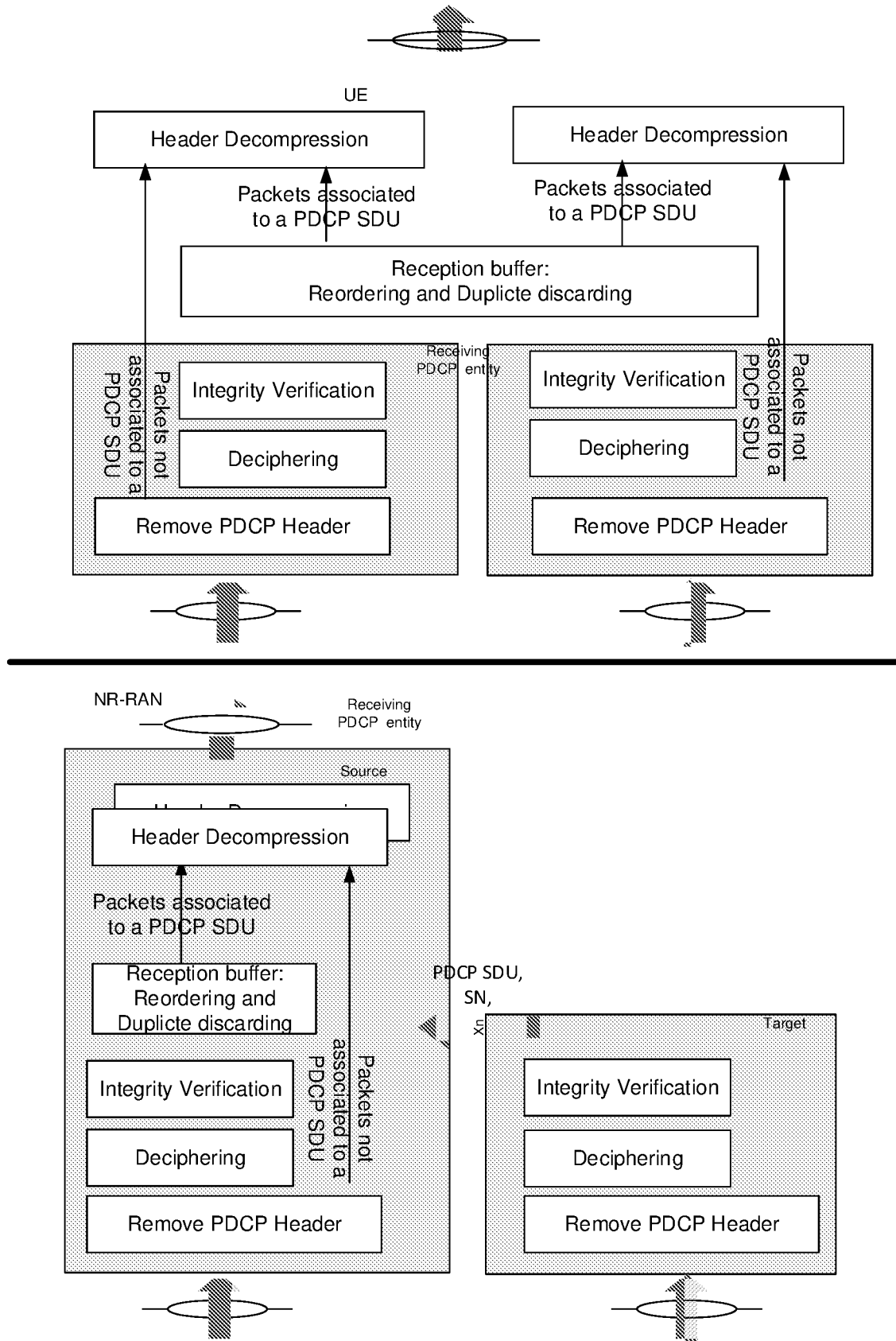


Fig. 8

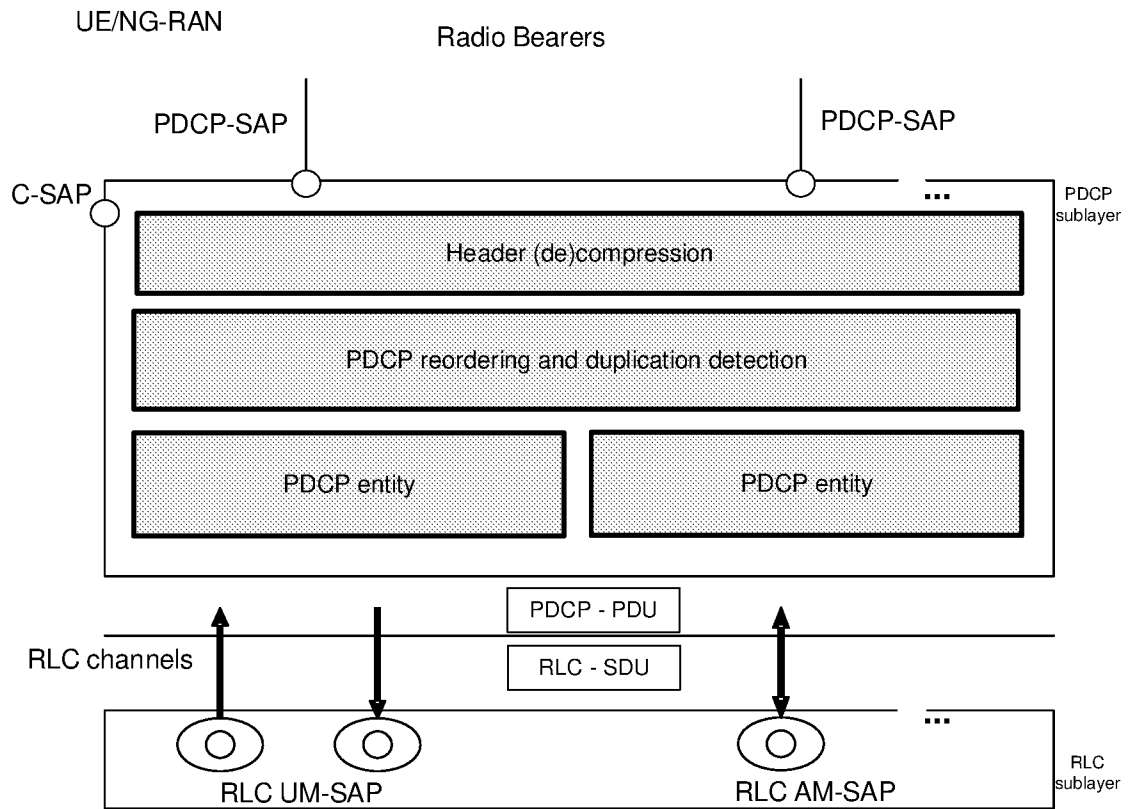


Fig. 9

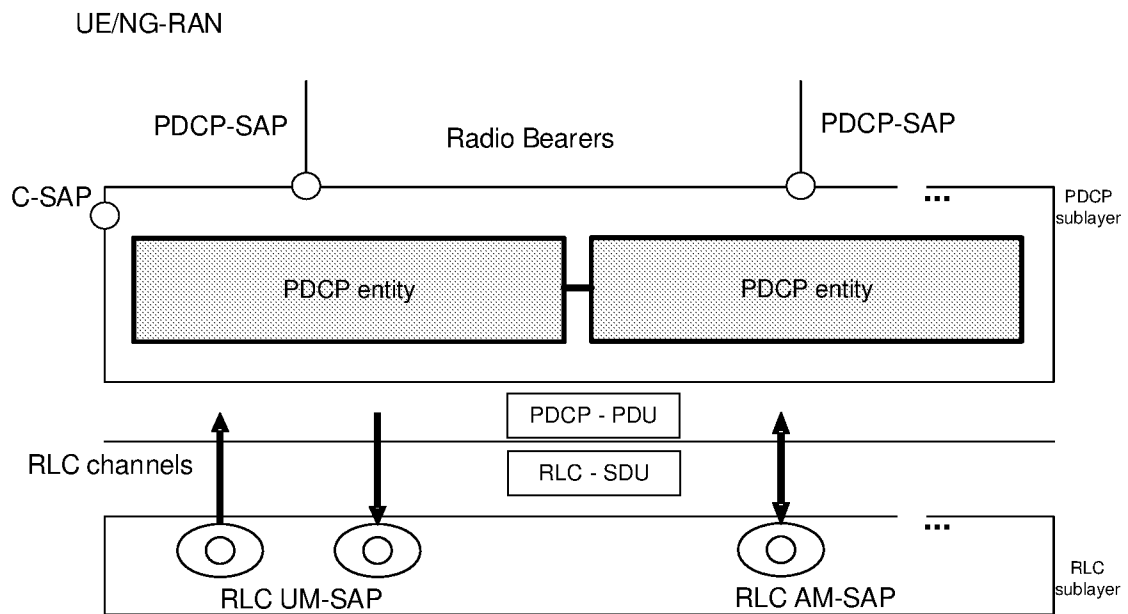


Fig. 10

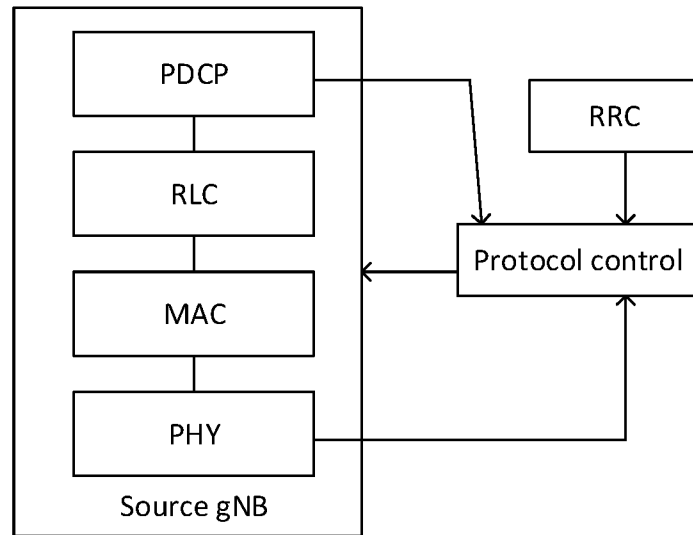


Fig.11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2019/073178

A. CLASSIFICATION OF SUBJECT MATTER

H04W 36/02(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)

H04W; H04Q; H04L

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)

CNABS, CNTXT, CNKI, VEN, USTXT, WOTXT, EPTXT, IEEE, 3GPP: PDCP SDU, entity, HO handover, handoff, upper layer, compression, security key, dual

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2018092146 A1 (KT CORP) 29 March 2018 (2018-03-29) description, paragraphs [0056], [0109] - [0299]	1-17
A	US 2018013685 A1 (QUALCOMM INC) 11 January 2018 (2018-01-11) th whole document	1-17
A	US 2018376386 A1 (LG ELECTRONICS INC) 27 December 2018 (2018-12-27) th whole document	1-17
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A	US 2016212661 A1 (BASU MALLICK PRATEEKET AL.) 21 July 2016 (2016-07-21) th whole document	1-17

☐ 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

08 October 2019

Date of mailing of the international search report

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Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2019/073178

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