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- (54) **Title:** METHOD AND APPARATUS FOR DOWNLINK TRANSMISSION IN A DUAL/MULTI-CONNECTIVITY ENABLED SYSTEM

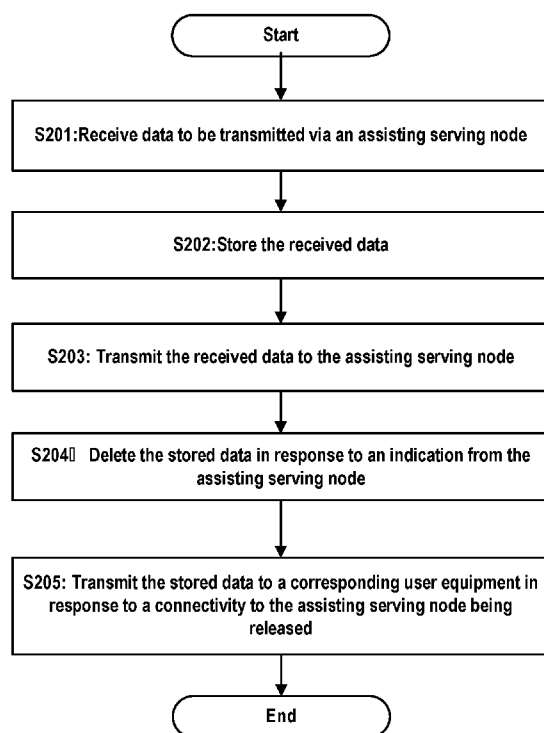


Fig. 2

- (57) **Abstract:** The present disclosure provides a method and apparatus for downlink transmission in a dual/multi-connectivity enabled system. In an embodiment according to the present disclosure, the method may comprise: receiving data to be transmitted via an assisting serving node; storing the received data; transmitting the received data to the assisting serving node; deleting the stored data in response to an indication from the assisting serving node; and transmitting the stored data to a corresponding user equipment in response to a connectivity to the assisting serving node being released. According to embodiments of the present disclosure, there is provided a mechanism for downlink transmission in a dual/multi-connectivity enabled system, wherein the anchor serving node and the assisting serving node may collaborate effectively to serve a user equipment, thereby reducing the system interruption time during switching from a dual/ multi-connectivity to a single connectivity.



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METHOD AND APPARATUS FOR DOWNLINK TRANSMISSION IN A DUAL/MULTI-CONNECTIVITY ENABLED SYSTEM

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FIELD OF THE INVENTION

[0001] Embodiments of the present disclosure relate to the field of wireless communication technologies, and more specifically, to a method and apparatus for downlink transmission in a dual/multi-connectivity enabled system.

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BACKGROUND OF THE INVENTION

[0002] With rapid development of the mobile market, expedite increase of users, and rocketing of mobile data services, the demand on system capacity and data rate has become increasingly high. In order to adapt this demand, a small cell technology has been proposed by far. Small cell is a low-power radio access point, which may work at an authorized or non-authorized spectrum and with coverage far less than the coverage of a macro cell, usually within a range between 10-200m.

[0003] Since usage of small cell may bring gains such as increasing the capacity and solving blind-point coverage, deployment and enhancement of small cells has attracted a great attention from researchers now. Moreover, in 3GPP Rel-12, a new study item “Small Cell Enhancements for E-UTRA and E-UTRAN – Higher-layer aspects” has been approved, wherein an important issue is to study architecture and protocol enhancement for dual connectivity to macro cell and small cell layers.

[0004] At present, the following options are present for splitting user-plane data:

Option 1: S1-U terminates in both a macro base station (MeNB) and a small base station (SeNB);

Option 2: S1-U only terminates in MeNB, no bearer split in a radio access network (RAN);

Option 3: S1-U only terminates in MeNB, bearer split in RAN.

Further, based on the options for bearer splitting and UP protocol stack, there are 9 alternative solutions in total, as specified below:

Architecture 1A: The S1-U terminates in both MeNB and SeNB, no bearer split in RAN, and there is an independent packet data convergence protocol (PDCP) layer at the SeNB;

Architecture 2A: S1-U only terminates in MeNB, no bearer split in RAN, and
5 there is an independent PDCP at SeNB;

Architecture 2B: S1-U only terminates in MeNB, no bearer split in RAN, adopting a master-slave PDCP pattern;

Architecture 2C: S1-U only terminates in MeNB, no bearer split in RAN, and there is an independent radio link control (RLC) layer at SeNB;

10 Architecture 2D: S1-U only terminates in MeNB, no bearer split in RAN, adopting a master-slave RLC pattern;

Architecture 3A: S1-U only terminates in MeNB, bearer split in RAN; and there is an independent PDCP for bearer splitting at SeNB;

Architecture 3B: S1-U only terminates in MeNB, bearer split in RAN,
15 adopting a master-slave PDCP pattern for bearer splitting;

Architecture 3C: S1-U only terminates in MeNB, bearer split in RAN; and there is an independent RLC for bearer splitting at SeNB; and

Architecture 3D: S1-U only terminates in MeNB, bearer split in RAN, adopting a master-slave RLC pattern for bearer splitting.

20 **[0005]** For option 2 and option 3 (including architecture 2A-2D and 3A-3D, respectively), the S1-U is only connected with the MeNB, which means the data offloaded to the SeNB must be first routed to the MeNB which then passes the data to the SeNB. However, in many scenarios such as channel quality deterioration of small cell, load congestion, and the like, it might be required to release the connectivity to the
25 small cell. When the user is switched from a dual-connectivity to macro cells and small cells to a single-connectivity only to the macro cell, it is required to re-allocate the radio bearer (RB) offloaded to the SeNB. In this case, the data that have been offloaded to the SeNB also need to be transmitted back to the MeNB. However, due to the unsatisfactory condition of the backhaul link, the switching will experience a large
30 latency, which will cause a longer system interruption time and consume limited resources for transmission between MeNB and SeNB. This is rather undesired.

[0006] In view of the above problem, it is desirable in the art to provide a

solution reducing latency when switching from a dual/multi-connectivity to a single connectivity.

SUMMARY OF THE INVENTION

5 **[0007]** In view of the above, the present disclosure provides a solution for downlink data transmission in a dual/multi-connectivity enabled system so as to overcome or alleviate at least a part of abovementioned drawbacks existing in the prior art.

10 **[0008]** According to a first aspect of the present disclosure, there is provided a method for downlink transmission in a dual/multi-connectivity enabled system. The method comprises: receiving data to be transmitted from an assisting serving node; storing the received data; transmitting the received data to the assisting serving node; deleting the stored data in response to an indication from the assisting serving node; and transmitting the stored data to a corresponding user equipment in response to a
15 connectivity to the assisting serving node being released.

20 **[0009]** According to a second aspect of the present disclosure, there is provided a method for downlink data transmission in a dual/multi-connectivity enabled system. The method comprises: receiving data from an anchor serving node; transmitting the received data; and transmitting an indication of deleting the data to the anchor serving node.

25 **[0010]** According to a third aspect of the present disclosure, there is provided an apparatus for downlink data transmission in a dual/multi-connectivity enabled system. The apparatus comprises: a data receiving unit configured to receive data to be transmitted from an assisting serving node; a data storing unit configured to store the received data; a data transmission unit configured to transmit the received data to the assisting serving node; a data deletion unit configured to delete the stored data in response to an indication from the assisting serving node; and a switch processing unit configured to transmit the stored data to a corresponding user equipment in response to a connectivity to the assisting serving node being released,.

30 **[0011]** According to a fourth aspect of the present disclosure, there is provided an apparatus for downlink data transmission in a dual/multi-connectivity enabled system. The apparatus comprises: a data receiving unit configured to receive data

from an anchor serving node; a data transmission unit configured to transmit the received data; and an indication transmission unit configured to transmit an indication of deleting the data to the anchor serving node.

[0012] According to a fifth aspect of the present disclosure, there is provided a computer program product having program code embodied thereon, the computer program code configured to, when executed on a processor, cause the processor to execute a method according to a first aspect of the present disclosure.

[0013] According to a sixth aspect of the present disclosure, there is provided a computer program product having program code embodied thereon, the computer program code configured to, when executed on a processor, cause the processor to execute a method according to a second aspect of the present disclosure.

[0014] According to a seventh aspect of the present disclosure, there is provided an apparatus, comprising a processor and at least one memory storing program code thereon, the computer program code configured to, when executed on the processor, cause the processor to execute a method according to a first aspect of the present disclosure.

[0015] According to an eighth aspect of the present disclosure, there is provided an apparatus, comprising a processor and at least one memory storing program code thereon, the computer program code configured to, when executed on the processor, cause the processor to execute a method according to a second aspect of the present disclosure.

[0016] According to embodiments of the present invention, there is provided a mechanism for downlink transmission in a dual/multi-connectivity enabled system, wherein the anchor serving node and the assisting serving node may effectively collaborate to serve a user equipment, thereby reducing system interruption time during switching from a dual/multi-connectivity to a single connectivity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Features, advantages, and other aspects of various embodiments of the present disclosure will become more apparent through the following detailed description with reference to the following drawings, wherein:

[0018] Fig. 1 schematically illustrates an exemplary diagram of a

communication system in which embodiments of the present disclosure can be implemented;

[0019] Fig. 2 schematically shows a flow chart of a method for downlink transmission in a dual/multi-connectivity enabled system according to an embodiment of the present disclosure;

[0020] Fig. 3 schematically illustrates a diagram of an exemplary solution for downlink transmission in a dual/multi-connectivity enabled system under Architecture 2A;

[0021] Fig. 4 schematically illustrates a diagram of an exemplary solution for downlink transmission in a dual/multi-connectivity enabled system under Architecture 3A;

[0022] Figs. 5A-5F briefly illustrate a diagram of an exemplary solution for downlink transmission in a dual/multi-connectivity enabled system under Architectures 2B- 2D and 3B-3D;

[0023] Fig. 6 schematically illustrates a diagram of an exemplary structure of a super packet used in an embodiment of the present disclosure;

[0024] Fig. 7 schematically shows a flow chart of a method for downlink transmission in a dual/multi-connectivity enabled system according to another embodiment of the present disclosure;

[0025] Fig. 8 schematically shows a block diagram of an apparatus for downlink transmission in a dual/multi-connectivity enabled system according to an embodiment of the present disclosure; and

[0026] Fig. 9 schematically shows a block diagram of an apparatus for downlink transmission in a dual/multi-connectivity enabled system according to another embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0027] Hereinafter, respective exemplary embodiments of the present disclosure will be described in detail with reference to the drawings. It should be noted that these figures and description only relate to several exemplary preferred embodiments. It should be pointed out that based on the subsequent description, the skilled in the art will readily conceive alternative embodiments of the structures and

methods disclosed herein, and these alternative embodiments may be used without departing from the anchor of the disclosure as claimed.

[0028] It should be understood that these embodiments are provided only to enable those skilled in the art to better understand and in turn implement the present disclosure, not intended for limiting the scope of the present disclosure in any manner. Besides, in the drawings, for the sake of illustration, optional steps, modules, and units and the like are shown in dotted-line blocks.

[0029] Next, reference is made to Fig. 1 to describe an exemplary schematic diagram of a communication system in which embodiments of the present disclosure can be implemented. The communication system shown in Fig. 1 is a dual/multi-connectivity enabled communication system, wherein an S1-U interface is only connected to an anchor serving node. As shown in the figure, a user equipment UE 130 may be connected to both serving nodes 110 and 120, so as to transmit data over the radio bearer to the UE through the serving node 110 and the serving node 120. In embodiments of the present disclosure, the two serving nodes 110 and 120 serving the UE 130 may play roles of an anchor serving 110 and an assisting serving node 120, respectively. Herein, the anchor serving node 110 is for example a macro base station MeNB; the assisting serving node is for example a small base station SeNB, such as micro eNB, femto eNB, pico eNB, and remote radio frequency unit RHH, etc. As shown in the figure, the anchor serving node 110 is connected to a mobility management network element (MME) 140 via an S1-MME interface in an S1AP protocol to control transmission of signaling, and connected to a serving gateway S-GW 150 via an S1-U interface in a GTP-U protocol to transmit user data. Specifically, the anchor serving node 110 may receive an evolved packet system (EPS) bearer 1 and an EPS bearer 2 from the S-GW 150. Herein, the EPS bearer 1 is directly sent to the UE through the anchor serving node 110. However, all or a part of the EPS bearer 2 is transmitted to the UE through the assisting serving node 120, which depends on specific selection of the user-plane data splitting solution (i.e., option 2 or option 3). There is no any connection between the assisting serving node 120 and the S-GW 150; instead, the assisting serving node 120 is connected to the anchor serving node 110 via an X2/Xn interface. The data of the bearer 2 to be transmitted via the assisting serving node 120 need to be first transmitted to the anchor serving node 110, then transmitted to the

assisting serving node 120 via the X2/Xn interface, and in turn is transmitted to the UE via the assisting serving node 120.

[0030] It is known that in the LTE system, a user usually has one serving cell. Although there are a plurality of serving cells in the case of carrier convergence, those
5 cells are located in the same base station and, these serving cells are also handled at the same base station. All protocol stacks of the user plane and control plane are located on the same serving node, while the serving node is directly connected to the S-GW. However, in dual/multi-connectivity, particularly for option 2 and option 3 of user-plane data partition, the small cell is not connected to S-GW via the S1, and all data
10 transmitted by the small cell will be routed via the macro cell. The data offloaded to the small cell will be transmitted from the macro cell to the small cell and buffered in the small to wait for being transmitted to the user. If the small cell link is released and it is decided to turn over the data offloaded to the small cell to the macro cell, the data already passed to the small cell need to be retransmitted back to the macro cell, which
15 means these data will experience two backhaul links, thereby causing a greater latency. In turn, this will cause a longer switch interruption time. In the prior art, there is no any solution about how to avoid or reduce interruption so as to support such a user plane architecture with dual/multi-connectivity. To this end, the present disclosure provides a technical solution for downlink transmission with respect to the system, so as
20 to transmit data rapidly and reduce the interruption time during switching.

[0031] Hereinafter, operations performed at the anchor serving node such as MeNB will be described with reference to Fig. 2, which schematically shows a flow chart of a method for downlink transmission in a dual/multi-connectivity enabled system according to an embodiment of the present disclosure.

[0032] As shown in Fig. 2, first, at step S201, data to be transmitted via an
25 assisting serving node are received at an anchor serving node. In the present disclosure, since the switch latency mainly involves the data transmitted via the assisting serving node, these data will be processed specially at the anchor serving node.

[0033] Next, at step S202, the received data are stored. For example, the data
30 to be transmitted via the assisting serving node may be replicated and stored in a buffer of the anchor serving node.

[0034] Herein, storing the data offloaded to the assisting serving node is to use

upon accidental occurrence of switch. However, if the data have already been transmitted via the assisting serving node, they will be deleted from the buffer. This means the assisting serving node will provide an indication to the anchor serving node subsequently. It may be understood that a deletion indication from the assisting serving node should designate the data packet to be deleted. In order to lower the processing complexity, preferably, the data received at the anchor serving node and to be transmitted via the assisting serving node may be stored at a protocol layer corresponding to the protocol layer where the assisting serving node performs data offloading. For example, if the assisting serving node will perform data offloading on the PDCP, then the anchor serving node will store the data to be transmitted via the assisted serving node on the PDCP.

[0035] Fig. 3 schematically illustrates a diagram of an exemplary solution for downlink transmission in a dual/multi-connectivity enabled system under Architecture 2A. As shown in Fig. 3, under the architecture 2A, no radio bearer splitting is performed (i.e., the data of radio bearer #2 are all transmitted to the user equipment via an assisting serving node such as SeNB) and, in the anchor serving node such as MeNB, there is no communication protocol layer corresponding to the assisting serving node (which is shown in dotted-line block in Fig. 3, indicating that these protocol layer entities are only existent in a case of switching from dual connectivity to single connectivity and the data on radio bearer #2 being transmitted by the MeNB). In this case, at the anchor serving node MeNB and assisting serving node SeNB, the buffer layer for storing data may be set at the PDCP layer.

[0036] Fig. 4 schematically illustrates a diagram of an exemplary solution for downlink transmission in a dual/multi-connectivity enabled system under Architecture 3A. Fig. 4 shows the scenario of architecture 3A, which differs from architecture 2A shown in Fig. 2 in that it performs bearer splitting. However, for the data to be transmitted by the assisting serving node SeNB, the processing performed at the anchor serving node MeNB and the assisting serving node SeNB is identical to what is shown in Fig. 2. Besides, the buffer layer is also set at the PDCP layer.

[0037] In addition, for the sake of illustration, Figs. 5A-5B briefly show diagrams of exemplary solutions of downlink transmission under architectures 2B, 3B, 2C, 3C, 2D and 3D. As shown in Figs. 5A and 5B, for architectures 2B and 3B which

adopt a master-slave PDCP manner (wherein the anchor PDCP is shown in a solid-line block, while the slave PDCP is shown in dotted-line block), the buffer layer is arranged at or below the anchor PDCP layer at the anchor serving node MeNB side, while at the assisting serving node SeNB side, it is disposed at or above the slave PDCP layer.

5 Besides, as shown in Figs. 5C and 5D, for architectures 2C and 3C in which the assisting serving node performs data splitting at the RLC layer, the buffer layer is disposed on the RLC layer at both the MeNB side and the SeNB side. Similarly, for architectures 2D and 3D which adopt a master-slave RLC manner (wherein the anchor RLC is shown in solid-line block, while the slave RLC is shown in dotted-line block) as shown in Figs. 5E and 5F, at the MeNB side, the buffer layer is disposed at or below the anchor RLC layer, while at the SeNB side, the buffer layer is disposed at or above the RLC layer.

[0038] Continue to refer to Fig. 2, at step S203, the anchor serving node transmits the received data to the assisting serving node so as to transmit the data to the corresponding user equipment via the assisting serving node. The anchor serving node, for example, may transmit the data to the assisting serving node via an X2/Xn interface. The assisting serving node will perform a series of operations after receiving the data. The operations about the assisting serving node will be described in detail hereinafter with reference to Fig. 7, which will not be detailed here.

20 [0039] Afterwards, at step S204, the stored data are deleted in response to an indication from the assisting serving node. For example, after the assisting serving node has transmitted the data, the assisting serving node may transmit an indication of deleting corresponding data to the anchor serving node. After receiving the indication, the anchor serving node may delete the corresponding data based on the indication.

25 [0040] The indication from the assisting serving node may indicate deleting a data packet. In this case, the indication may include an indicator for indicating the data packet, e.g., a sequence indicator, a time indicator, or other indicator. Besides, the indication may also indicate deleting a plurality of data packets. In the case of indicating deleting a plurality of data packets, the indication may include a plurality of indicators corresponding to a plurality of data packets to be deleted. Alternatively, when the indication may include a time indicator or a sequence indicator, the indication may also include a time indicator or a sequence indicator indicating the latest time or

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sequence in the plurality of packets. Thus, the anchor serving node may delete the data, among the stored data, whose time or sequence is no later than the time or sequence indicated by the time indicator or sequence indicator. In this way, the data amount that needs to be returned to the anchor serving node may be lowered significantly.

[0041] Next, if at step S205, it is determined that the connectivity to the assisting serving node will be released, then the anchor serving node may directly transmit its stored data to the corresponding user equipment. If it is necessary to switch from a dual/multi-connectivity mode to a single connectivity mode of only being connected to the anchor serving node due to reasons such as channel quality deterioration and load congestion, the data stored in the buffer at this point are just the data that have been offloaded to the assisting serving node but not transmitted yet. Therefore, upon reconfiguration of the radio bearer, the stored data may be directly taken out and transmitted to the corresponding user equipment by the anchor serving node, without transmitting from the assisting serving node back to the data.

[0042] In embodiments of the present disclosure, the indication from the assisting serving node may be issued when starting data transmission at a corresponding protocol layer. Therefore, when it is needed to release the link to the assisting serving node, it is likely that a part of data have not been actually transmitted to the user yet. In this case, the assisting serving node may return that part of data that have not been transmitted to the user equipment back to the anchor serving node. Therefore, the anchor serving node might also receive from the assisting serving node that part of data having not been transmitted to the assisting serving node yet. In this case, the anchor serving node may transmit that part of data to the user equipment so as to realize lossless data transmission. However, those skilled in the art should understand that in this case, this part of data may also be neglected, but there will be a data loss.

[0043] Besides, the solution of transmitting a data delete indication from the assisting serving node to the anchor serving node will significantly increase the data amount transmitted to the anchor serving node; particularly in the case of frequently transmitting the indication, it will occupy many transmission resources. Due to this reason, it may be considered to form a super packet at the anchor serving node based on the data to be transmitted through the assisting serving node. Here, the super packet

refers to a large packet including indicators such as time indicator or sequence indicator and a plurality of data packets. The super packet may have a fixed number of data packets or a variable number of packets. For the sake of simplifying the processing, the super packet is preferably formed on a protocol layer corresponding to the protocol layer where the assisting serving node performs the data offloading.

[0044] According to an embodiment of the present disclosure, by means of a PDU packet, a super packet may be generated for the bearer downloaded to the assisting serving node SeNB. This super packet includes a time tag or a serial number to indicate time or sequence of these data packets. Fig. 6 schematically shows a diagram of an exemplary structure of a super packet. As shown in Fig. 6, the super packet comprises a serial number SN and packet 1 to packet N. For the data to be transmitted by the assisting serving node, the anchor service node MeNB will form a super packet in the form as illustrated in Fig. 6, stores the super packet into a duplicate buffer, and meanwhile transmits the super packet to the SeNB, rather than storing and transmitting individual data packets respectively. At the assisting serving node SeNB, a stripping processing will be executed so as to strip a time or sequence indicator such as SN to obtain data packets 1-N and store them into the buffer to wait for transmission.

[0045] The operations at the anchor serving node have been first described with reference to Figs. 2 to 5F. Next, the operations executed at the assisting serving node will be described with further reference to Fig. 7, which schematically illustrates a method for downlink transmission in a dual/multi-connectivity enabled system according to another embodiment of the present invention.

[0046] As shown in Fig. 7, first at step S701, data from the anchor serving node are received. The assisting serving node receives the data from the anchor serving node via for example the X2/Xn interface, and buffers, after receiving the data, the data on the protocol layer where the offloading is executed, to wait for transmission.

[0047] Next, at step S702, the assisting serving node transmits the received data. When the data transmission can be performed, the assisting serving node will deliver the data from the protocol layer where the offloading is executed to lower layers for transmission.

[0048] Next, at step S703, an indication of deleting the data is transmitted to the anchor serving node.

[0049] According to embodiments of the present disclosure, the assisting serving node may transmit the indication of deleting the data to the anchor serving node at a plurality of time points. Hereinafter, it will be described in detail.

[0050] According to an embodiment of the present disclosure, the assisting
5 serving node may transmit an indication of deleting data to the anchor serving node when starting data transmission on the protocol layer where the data offloading is performed. For example, in the architecture 2A, if the PDCP layer entity first starts making an attempt to transmit a PDCP PDU, an indication of deleting data and carrying an indicator of the data packet may be transmitted to indicate to delete the data packet.
10 At this time point, the data transmission already starts. Therefore, after receiving the indication, the anchor serving node may delete corresponding data from the buffer.

[0051] However, since this mechanism transmits an indication when a corresponding protocol layer starts data transmission, there might be a possibility that the assisting serving node does not transmit data to the user equipment. With
15 architecture 2A as an example, the assisting serving node will perform the data offloading on a PDCP (Packet Data Convergence Protocol) layer; when the PDCP layer of the assisting serving node starts data transmission, it notifies the anchor serving node to delete its stored data packet. However, upon bearer reconfiguration, the data packet might be still stored on other layer (e.g., RLC layer) of the assisting serving node and
20 has not been transmitted yet. At this point, the data packet that has not been transmitted yet may be transmitted back to the anchor serving node. This method can support lossless data transmission, but needs to transmit back the data packet to the anchor serving node.

[0052] Besides, the indication of deleting data packets may also be transmitted
25 to the anchor serving node when the PDCP PDU is transmitted from the PDCP layer to the RLC layer. However, it likely occurs that upon radio bearer reconfiguration, the data are still stored in the RLC buffer and have not been transmitted yet; at this point, data will be lost.

[0053] Further, according to another embodiment of the present disclosure, the
30 indication of deleting the data may be transmitted to the anchor serving node after the assisting serving node transmits the data to the user equipment.

[0054] As stated above, after receiving the data packet from the anchor serving

node, the indicator of the data packet is first stripped. The data packet may enter into the PDCP layer and processed by the PDCP entity, such as numbering in sequence, header compression, encryption, etc., and then form a PDCP PDU to be transmitted the RLC layer. Through the above processing, generally for the super packet, it is already
5 hard to know which data belong to which super packet. Therefore, additional functionalities need to be added.

[0055] For the RLC UM mode, when the assisting serving node starts data transmission at the RLC layer, it is regarded that packets have already been transmitted to the user, such that it is unnecessary for the anchor serving node to transmit it again.

10 Therefore, for the RLC UM mode, when the PDU is transmitted to the MAC layer from the RLC layer, it is regarded that the assisting serving node has transmitted the data to the user. At this point, a delete indication may be transmitted to the anchor serving node so as to delete corresponding data stored in the buffer of the anchor serving node. For example, the function of the RLC layer entity may be modified such that when RLC
15 PDU including a PDCP PDU is transmitted, the RLC layer entity may read the SN of the PDCP PDU and return the PDCP SN to the upper layer. The buffer layer in the assisting serving node may match the PDSP SN with the indicator of the original data. Moreover, the indication returned to the anchor serving node includes the matched indicator. However, when the data is received in the form of super packet, an indicator
20 of deleting the super packet may be returned to the anchor serving node when all data in the super packet are transmitted. In this way, an indicator may represent a plurality of data packets; therefore, the indication transmission times may be reduced, and system overheads may be decreased.

[0056] For the RLC AM mode, only when an acknowledgement response ACK
25 of data transmission success at the RLC layer, can it be regarded that the data has been transmitted to the user equipment. Therefore, in the RLC AM mode, an indication of deleting the data may be transmitted to the anchor serving node when receiving the ACK. Identical to the RLC UM mode, it is also unknown which data the transmitted back ACK is directed to; therefore, the functionalities of the RLC layer entity may be
30 modified such that when the RLC PDU including one PDCP PDU is successfully transmitted to the user, the corresponding PDCP SN is obtained, and returned to the upper-layer entity so as to perform matching.

[0057] It should be noted that in the solution proposed in the present disclosure, since it likely occurs that data have been successfully transmitted at the assisting serving node but the anchor serving node has not received the delete indication yet, the user equipment might receive two copies of the data. Therefore, the user equipment may delete one extra data after identifying the same data.

[0058] Besides, in the case of indicating deletion of multiple data packets, the indicator returned to the anchor serving node may include a time indicator or sequence indicator indicating the latest time or sequence in the multiple packets. It is likewise applicable for the case of deleting a plurality of super packets.

[0059] Besides, as stated above, the data from the anchor serving node may be in a manner of a super packet including a time indicator or sequence indicator and a plurality of data packets. In this case, after receiving the super packet, the assisting serving node will first strip off the time indicator or sequence indicator in the super packet to obtain the data packets included therein. Then, the assisting serving node will store the data packets to wait for being transmitted.

[0060] It should be noted that when the anchor serving node does not have a function of adding a serial number to a data packet, it needs to attach an indicator for each data packet, e.g., for architecture 2A and 3A. However, if the anchor serving node per se has a function of attaching a serial number to the data packet, it is unnecessary to additionally attach the indicator, e.g., for architecture 2C and 3C. Besides, for architectures 2B, 2D, 3B, and 3D, for example, whether it is necessary to attach an indicator is determined based on the functions division between the corresponding anchor and slave functional entities of the anchor serving node and the assisting serving node. If the anchor serving node has a function of adding a serial number, it does not need to additionally attach an indicator; otherwise, it needs to attach an indicator. Besides, it should be further noted that in the case of forming a super packet, it needs to attach an indicator to the super packet so as to collectively indicate how many packets are included therein, regardless of whether the anchor serving node has a function of adding a serial number.

[0061] Additionally, it should also be noted that although many embodiments of the present invention of the present invention are described in conjunction with the super packet, the super packet is only a preferred embodiment for implementing the

present invention, and the present invention may also be implemented without forming a super packet.

[0062] Further, the present disclosure further provides apparatuses for downlink transmission in a dual/multi-connectivity enabled system. Hereinafter, description will be made with reference to Fig. 8 and Fig. 9.

[0063] First, reference is made to Fig. 8, which illustrates a block diagram of an apparatus for downlink transmission in a dual/multi-connectivity enabled connection according to an embodiment of the present disclosure. The apparatus 800 as shown in Fig. 8 may be applied to an anchor serving node such as MeNB. As shown in Fig. 8, the apparatus 800 may comprise: a data receiving unit 810, a data storing unit 820, a data transmission unit 830, a data deletion unit 840, and a switch processing unit 850. The data receiving unit 810 may be configured to receive data to be transmitted via the assisting serving node. The data storing unit 820 may be configured to store the received data. The data transmission unit 830 may be configured to transmit the received data to the assisting serving node. The data deletion unit 840 may be configured to delete the stored data in response to an indication from the assisting serving node. The switch processing unit 850 may be configured to transmit the stored data to the corresponding user equipment in response to connectivity to the assisting serving node being released.

[0064] In an embodiment of the present disclosure, the data storing unit 820 may be further configured to store the received data in a protocol layer corresponding to the protocol layer where the assisting serving node performs data offloading.

[0065] In another embodiment of the present disclosure, the apparatus 800 may further include a non-transmitted data receiving unit 860. The non-transmitted data receiving unit 860 may be configured to receive the non-transmitted data from the assisting serving node, and the switch processing unit 850 may be further configured to transmit the non-transmitted data to the user equipment.

[0066] According to a still embodiment of the present disclosure, the indication from the assisting serving node may include a time indicator or a sequence indicator, and the data deletion unit 840 may be configured to delete the data, among the stored data, whose time or sequence is no later than the time or sequence indicated by the time indicator or sequence indicator in response to the indication.

[0067] In a still further embodiment of the present disclosure, the apparatus 800 may further include a super packet forming unit 870 that may be configured to form a super packet based on the data to be transmitted through the assisting serving node, which super packet including a time indicator or sequence indication and a plurality of data packets. The received data may be stored in a form of the super packet, and the received data may be transmitted to the assisting serving node in a form of the super packet. Moreover, the super packet may be formed at the protocol layer corresponding to the protocol layer where the assisting serving node performs data offloading.

[0068] Next, an apparatus 900 for an assisting serving node will be described with reference to Fig. 9. As shown in Fig. 9, the apparatus 900 comprises: a data receiving unit 910, a data transmission unit 920, and an indication transmission unit 930. The data receiving unit 910 may be configured to receive data from the anchor serving node. The data transmission unit 920 may be configured to transmit the received data. The indication transmission unit 930 may be configured to transmit an indication of deleting the data to the anchor serving node.

[0069] In an embodiment according to the present invention, the indication transmission unit 930 may be further configured to transmit an indication of deleting the data to the anchor serving node in response to starting data transmission at the protocol layer where the assisting serving node performs data offloading.

[0070] In an embodiment according to the present invention, the apparatus 900 may further comprise: non-transmitted data transmission unit 940 configured to transmit, to the anchor serving node, data having not been transmitted to the user equipment by the assisting serving node.

[0071] In an embodiment according to the present invention, the indication transmission unit 930 may be further configured to transmit an indication of deleting the data to the anchor serving node in response to transmitting the data from the packet data convergence protocol to the radio link control layer.

[0072] In an embodiment according to the present invention, the indication transmission unit 930 may be further configured to transmit an indication of deleting the data to the anchor serving node in response to the assisting serving node transmitting the data to a user equipment.

[0073] In an embodiment according to the present invention, the indication

transmission unit 930 may be further configured to transmit an indication of deleting the data to the anchor serving node in response to transmitting the data from the radio link control layer to a medium access control layer.

[0074] In an embodiment according to the present invention, the indication
5 transmission unit 930 may be further configured to transmit an indication of deleting the data to the anchor serving node in response to the radio link control layer receiving an acknowledgement response of data transmission success.

[0075] In an embodiment according to the present invention, the data from the
10 anchor serving node is in a form of super packet. The super packet includes a time indicator or a sequence indicator and a plurality of data packets.

[0076] In an embodiment according to the present invention, the apparatus 900
further comprises: an indicator stripping unit 950 configured to strip off the time
indicator or sequence indicator in the super packet so as to obtain data packets included
therein; and a packet storing unit 960 configured to store the data packet for
15 transmission.

[0077] In an embodiment according to present invention, in the case of
indicating deletion of a plurality of data packets, the indication may include a time
indicator or a sequence indicator indicating the latest time or sequence in the plurality of
packets.

[0078] It should be noted that the operations of respective components of the
20 apparatuses 800 and 900 as described above with reference to Figs. 8 and 9 substantially
correspond to the operations in respective steps of the methods described above.
Therefore, for details about the specific operations of these components, they may refer
to the above specific description of the methods of the present disclosure with reference
25 to Figs. 1 – 7.

[0079] According to embodiments of the present disclosure, there is provided a
mechanism for downlink transmission in a dual/multi-connectivity enabled system,
wherein the anchor serving node and the assisting serving node may collaborate
effectively to serve a user equipment, thereby reducing the system interruption time
30 when switching from a dual/ multi-connectivity to a single connectivity.

[0080] It should be noted that the present disclosure may be implemented in
software or a combination of software and hardware; for example, it may be

implemented by a dedicated integrated circuit (ASIC), a general-purpose computer, or any other similar hardware device. In an embodiment, the software program of the present disclosure may be executed by a processor so as to implement the above steps or functions. Likewise, the software program of the present disclosure (including
5 relevant data structure) may be stored in a computer readable recording medium, for example, a RAM memory, a magnetic or optical driver, or a floppy disk, and similar devices. Besides, some steps of functions of the present disclosure may be implemented by hardware, for example, a circuit cooperating with the processor to execute various functions or steps.

10 **[0081]** Further, a portion of the present disclosure may be applied as a computer program product, for example, a computer program instruction, which, when executed by the computer, may invoke or provide a method and/or technical solution according to the present disclosure through operations of the computer. Further, the program instruction invoking the method of the present disclosure may be stored in a
15 fixed or mobile recording medium, and/or transmitted through broadcast or data flow in other signal bearer media, and/or stored in a working memory of a computer device which operates based on the program instruction. Here, in an embodiment according to the present disclosure, an apparatus comprises a memory for storing a computer program instruction and a processor for executing the program instruction, wherein
20 when the computer program instruction is executed by the processor, the apparatus is triggered to run the methods and/or technical solutions according to a plurality of embodiments of the present disclosure.

25 **[0082]** To those skilled in the art, it is apparent that the present disclosure is not limited to the details of the above exemplary embodiments, and the present disclosure may be implemented with other forms without departing from the spirit or basic features of the present disclosure. Thus, in any way, the embodiments should be regarded as exemplary, not limitative; the scope of the present disclosure is limited by the appended claims, instead of the above depiction. Thus, all variations intended to fall into the meaning and scope of equivalent elements of the claims should be covered
30 within the present disclosure. No reference signs in the claims should be regarded as limiting the involved claims. Besides, it is apparent that the term “comprise/comprising/include/including” does not exclude other units or steps, and

singularity does not exclude plurality. A plurality of units or means stated in the apparatus claims may also be implemented by a single unit or means through software or hardware. Terms such as the first and the second are used to indicate names, but do not indicate any particular sequence.

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WHAT IS CLAIMED IS:

1. A method for downlink data transmission in a dual/multi-connectivity enabled system, comprising:

- 5 receiving data to be transmitted via an assisting serving node;
storing the received data;
transmitting the received data to the assisting serving node;
deleting the stored data in response to an indication from the assisting serving node; and
10 transmitting the stored data to a corresponding user equipment in response to a connectivity to the assisting serving node being released.

2. The method according to claim 1, wherein the received data are stored at a protocol layer corresponding to a protocol layer where the assisting serving node
15 performs data offloading.

3. The method according to claim 1 or 2, further comprising:
receiving non-transmitted data from the assisting serving node, and
transmitting the non-transmitted data to the user equipment.
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4. The method according to claim 1 or 2, wherein the indication from the assisting serving node includes a time indicator or a sequence indicator, and wherein, in response to the indication, the data, among the stored data, whose time or sequence is no later than the time or sequence indicated by the time indicator or
25 sequence indicator, are deleted.

5. The method according to claim 1 or 2, further comprising:
forming a super packet based on data to be transmitted via the assisting serving node, which super packet includes a time indicator or sequence indicator
30 and a plurality of data packets,
wherein the received data are stored in a form of super packet, and the received data are transmitted to the assisting serving node in a form of super packet.

6. The method according to claim 5, wherein the super packet is formed at a protocol layer corresponding to a protocol layer where the assisting serving node performs data offloading.

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7. The method according to claim 5, wherein the super packet has a predefined length.

8. The method according to claim 5, wherein the super packet has a variable length.

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9. A method for downlink data transmission in a dual/multi-connectivity enabled system, comprising:

receiving data from an anchor serving node;

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transmitting the received data; and

transmitting an indication of deleting the data to the anchor serving node.

10. The method according to claim 9, wherein the indication of deleting the data is transmitted to the anchor serving node in response to starting data transmission on the protocol layer where the assisting serving node performs data offloading,.

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11. The method according to claim 10, further comprising:
transmitting, to the anchor serving node, data that have not been transmitted to a user equipment by the assisting serving node.

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12. The method according to claim 10, wherein the indication of the data is transmitted to the anchor serving node in response to transmitting the data from a packet data convergence protocol layer to a radio link control layer,.

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13. The method according to claim 9, wherein the indication of the data is transmitted to the anchor serving node in response to the assisting serving node

transmitting the data to the user equipment.

14. The method according to claim 13, wherein the indication of the data is transmitted to the anchor serving node in response to transmitting the data from a radio link control layer to a medium access control layer.

15. The method according to claim 13, wherein the indication of the data is transmitted to the anchor serving node in response to the radio link control layer receiving an acknowledgement response of data transmission success.

16. The method according to claim 9, wherein the data from the anchor serving node is in a form of super packet, which super packet includes a time indicator or a sequence indicator and a plurality of data packets.

17. The method according to claim 16, further comprising:
stripping off the time indicator or sequence indicator in the super packet so as to obtain data packets included therein;
storing the data packets for transmission.

18. The method according to claim 9, wherein in the case of indicating deletion of a plurality of data packets, the indication includes a time indicator or a sequence indicator indicating the latest time or sequence in the plurality of packets.

19. An apparatus for downlink data transmission in a dual/multi-connectivity enabled system, comprising:

a data receiving unit configured to receive data to be transmitted via an assisting serving node;

a data storing unit configured to store the received data;

a data transmission unit configured to transmit the received data to the assisting serving node;

a data deletion unit configured to delete the stored data in response to an indication from the assisting serving node;

a switch processing unit configured to transmit the stored data to a corresponding user equipment in response to a connectivity to the assisting serving node being released.

5 20. The apparatus according to claim 19, wherein the data storing unit is further configured to store the received data at a protocol layer corresponding to the protocol layer where the assisting serving node performs data offloading.

21. The apparatus according to claim 19 or 20, further comprising:
10 an non-transmitted data receiving unit configured to receive non-transmitted data from the assisting serving node, and
 wherein the switch processing unit is further configured transmit the non-transmitted data to the user equipment.

15 22. The apparatus according to claim 19 or 20, wherein the indication from the assisting serving node includes a time indicator or a sequence indicator, and wherein the data deletion unit is configured to, in response to the indication, delete the data, among the stored data, whose time or sequence is no later than the time or sequence indicated by the time indicator or sequence indicator.

20 23. The apparatus according to claim 19 or 20, further comprising:
 a super packet forming unit configured to form a super packet based on data to be transmitted via the assisting serving node, which super packet includes a time indicator or a sequence indicator and a plurality of data packets.

25 wherein the received data are stored in a form of super packet, and the received data are transmitted to the assisting serving node in a form of super packet.

24. The apparatus according to claim 23, wherein the super packet is formed in a protocol layer corresponding to a protocol layer where the assisting serving
30 node performs data offloading.

25. An apparatus for downlink data transmission in a

dual/multi-connectivity enabled system, comprising:

a data receiving unit configured to receive data transmitted from an anchor serving node;

a data transmission unit configured to transmit the received data; and

5 an indication transmission unit configured to transmit an indication of deleting the data to the anchor serving node.

26. The apparatus according to claim 25, wherein the indication transmission unit is further configured to transmit an indication of deleting the data to the anchor serving node in response to starting data transmission at the protocol layer where the assisting serving node performs data offloading.

27. The apparatus according to claim 26, further comprising:

15 non-transmitted data transmitting unit configured to transmit, to the anchor serving node, data that have not been transmitted to a user equipment by the assisting serving node.

28. The apparatus according to claim 26, wherein the indication transmission unit 930 is further configured to transmit an indication of deleting the data to the anchor serving node in response to transmitting the data from the packet data convergence protocol to the radio link control layer.

29. The apparatus according to claim 25, wherein the indication transmission unit is further configured to transmit an indication of deleting the data to the anchor serving node in response to the assisting serving node transmitting the data to a user equipment.

30. The apparatus according to claim 29, wherein the indication transmission unit is further configured to transmit an indication of deleting the data to the anchor serving node in response to transmitting the data from a radio link control layer to a medium access control layer.

31. The apparatus according to claim 29, wherein the indication transmission unit is further configured to transmit an indication of deleting the data to the anchor serving node in response to the radio link control layer receiving an acknowledgement response of data transmission success.

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32. The apparatus according to claim 25, wherein the data from the anchor serving node is in a form of super packet, which super packet includes a time indicator or a sequence indicator and a plurality of data packets.

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33. The apparatus according to claim 32, further comprising:
an indicator stripping unit configured to strip off the time indicator or sequence indicator in the super packet so as to obtain data packets included therein;
a packet storing unit configured to store the data packet for transmission.

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34. The apparatus according to claim 25, wherein in the case of indicating deletion of a plurality of data packets, the indication includes a time indicator or a sequence indicator indicating the latest time or sequence in the plurality of packets.

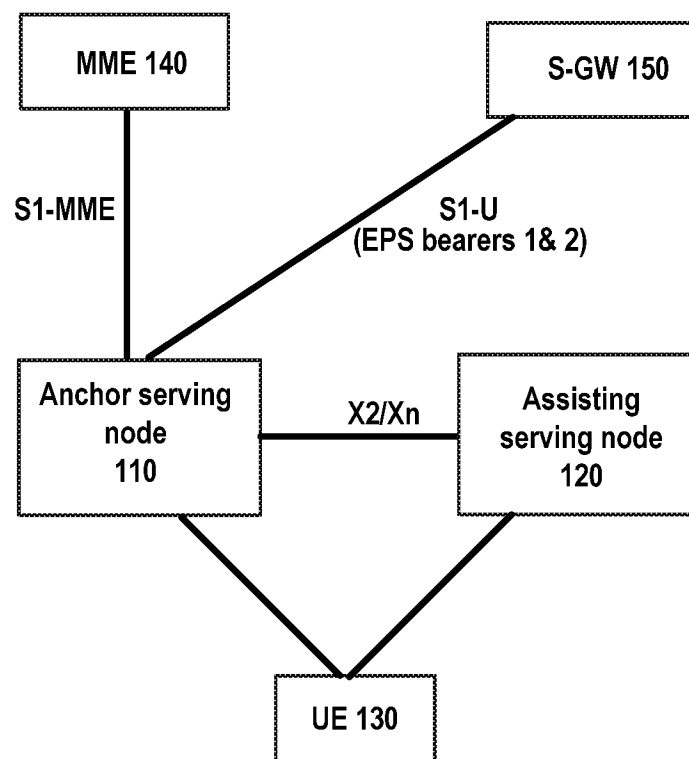


Fig. 1

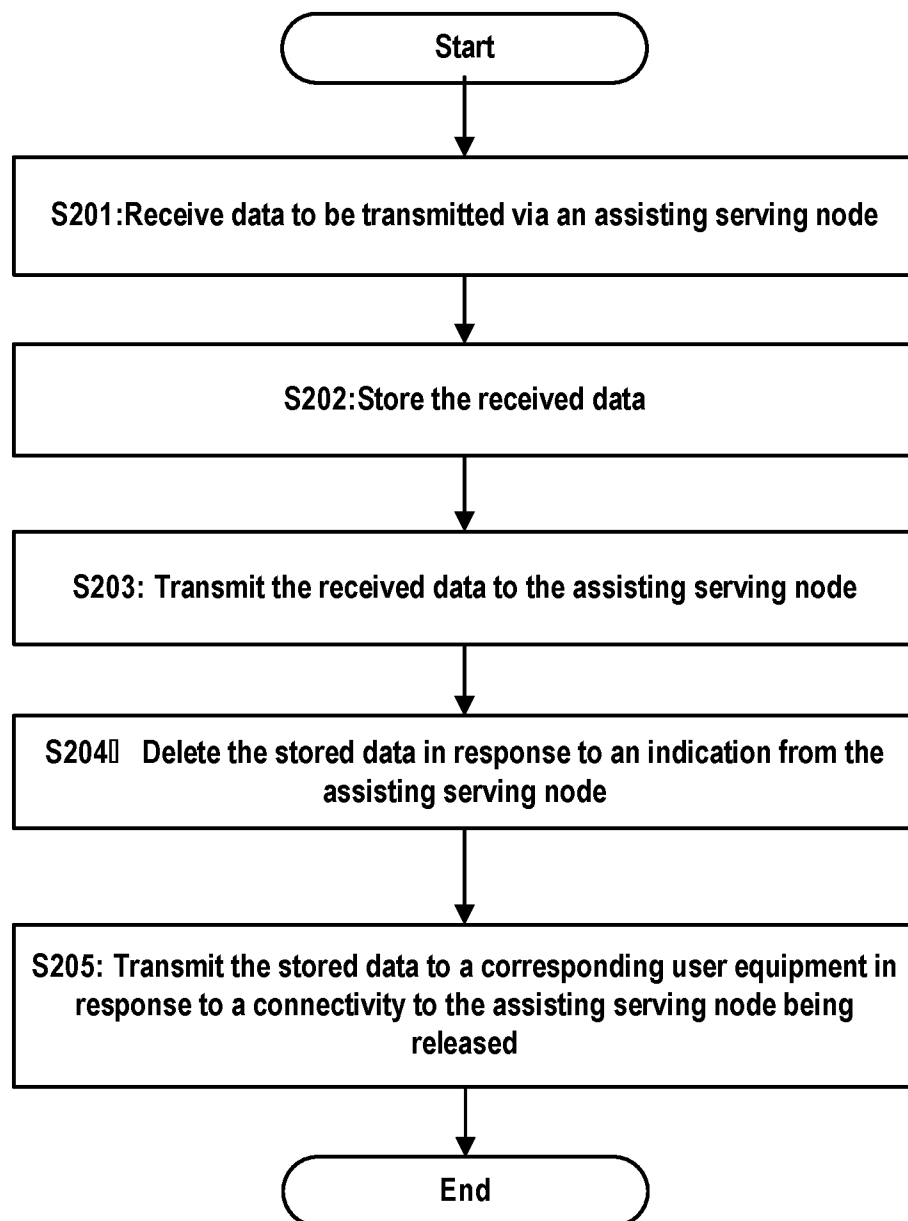


Fig. 2

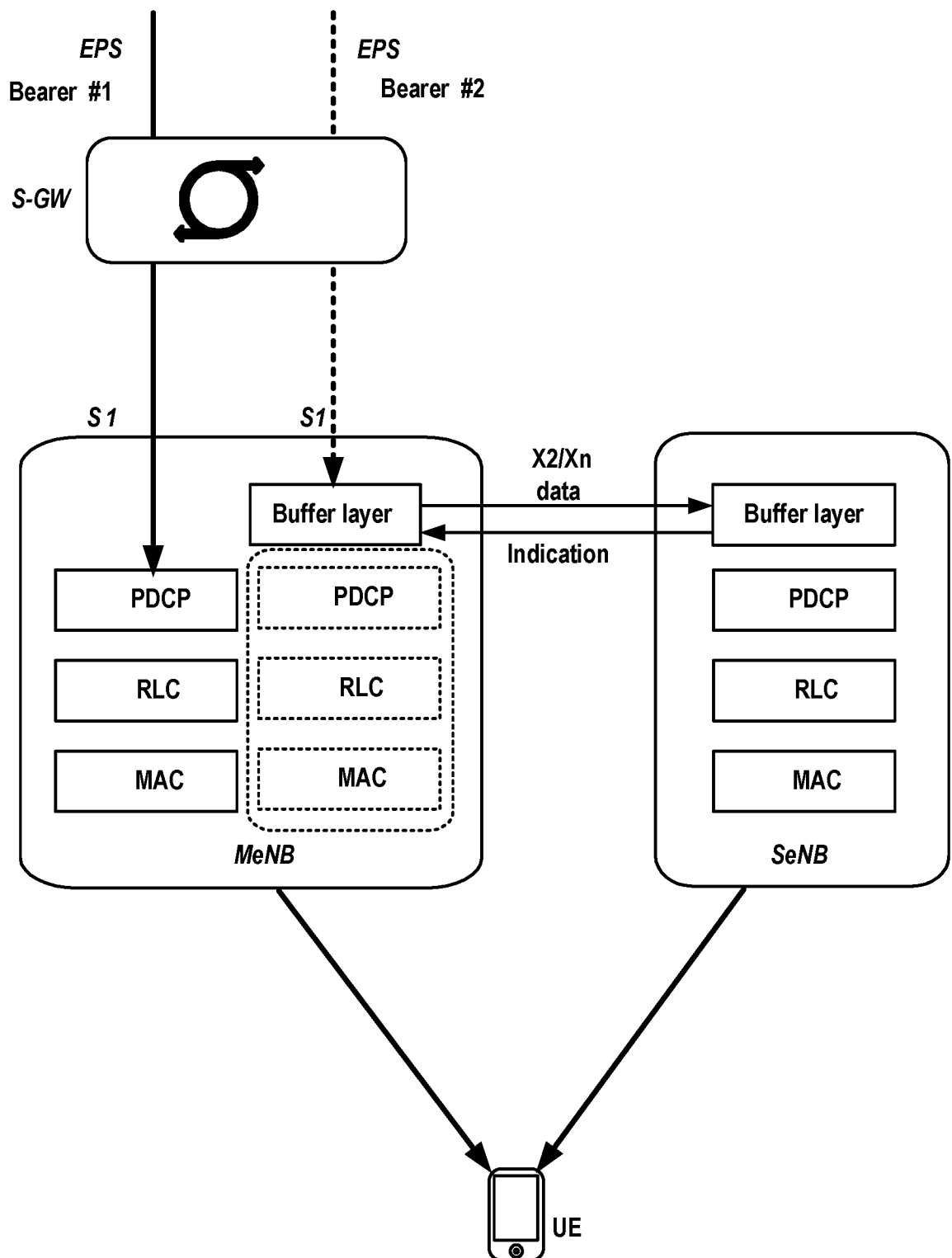


Fig. 3

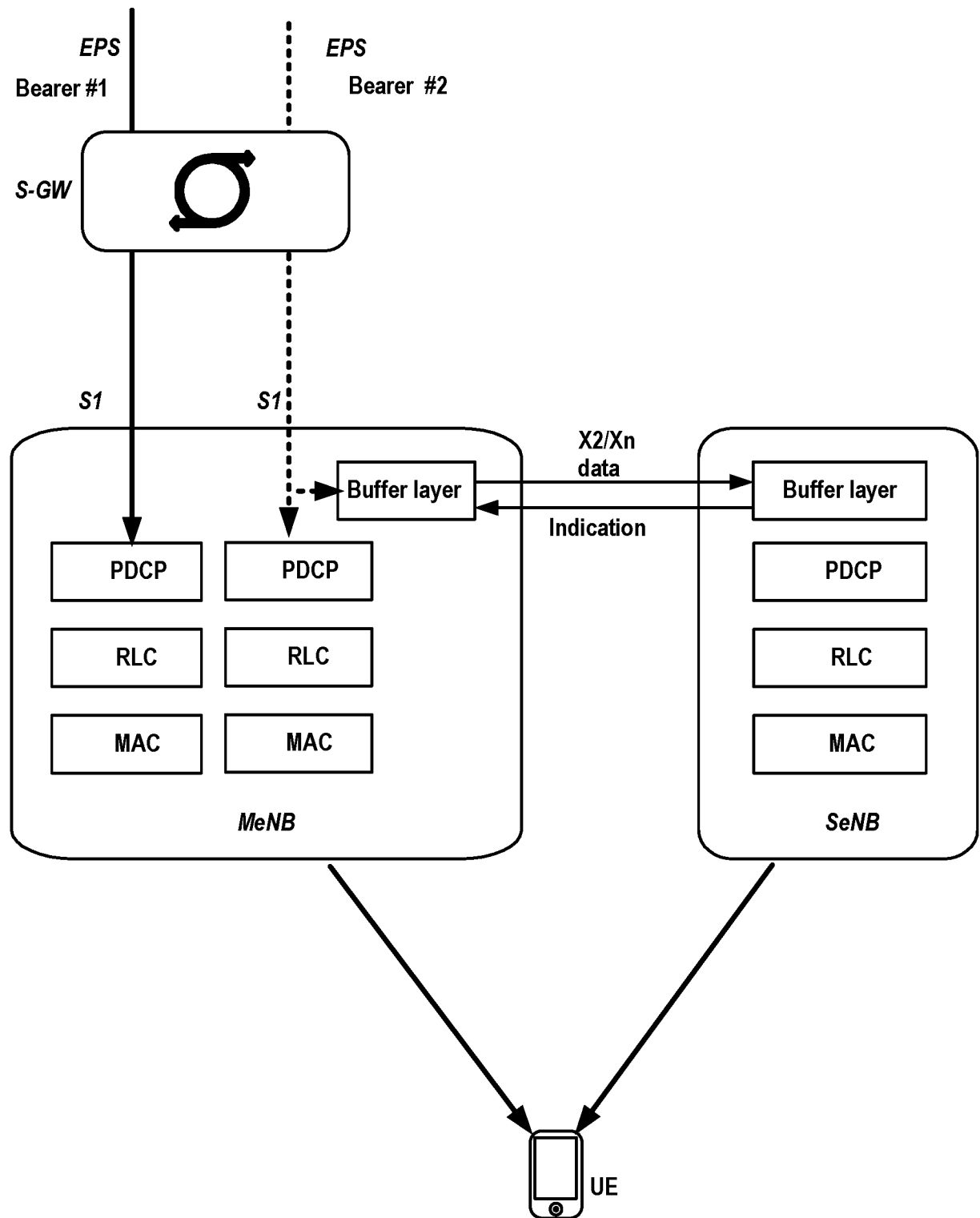


Fig. 4

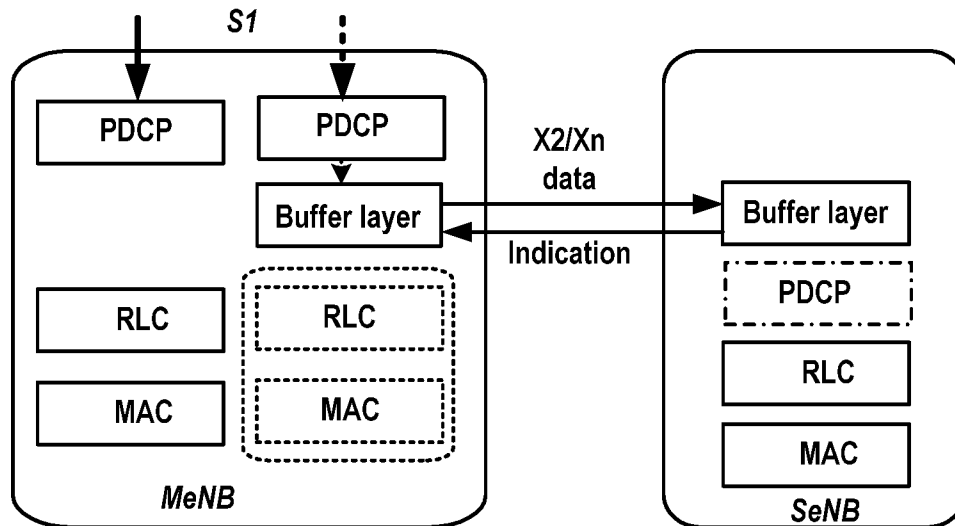


Fig. 5A

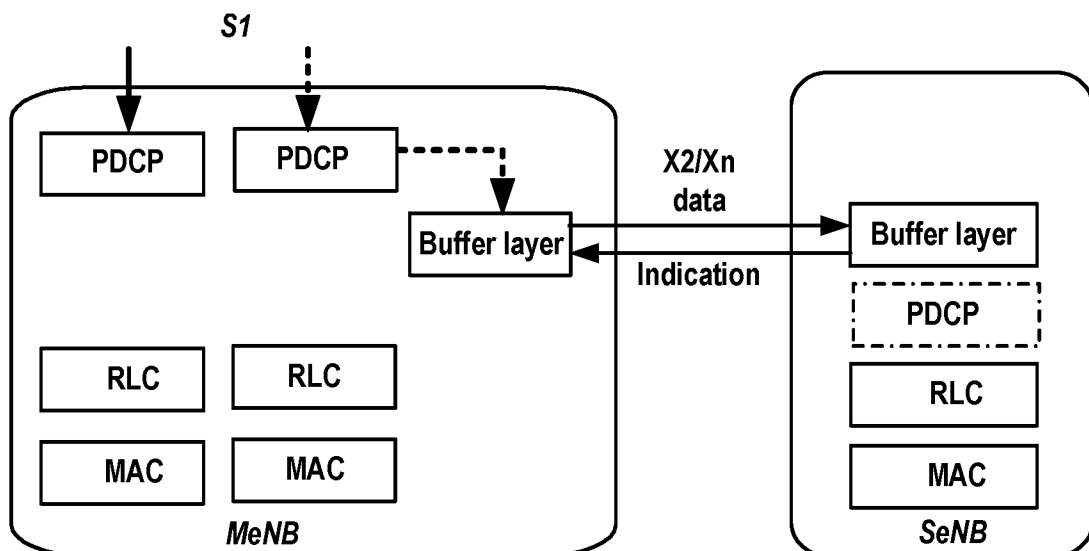


Fig. 5B

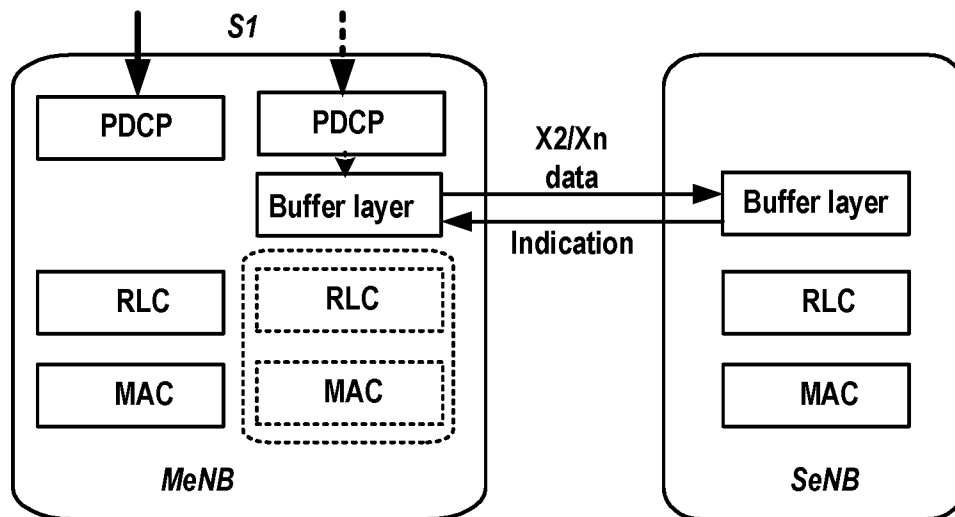


Fig. 5C

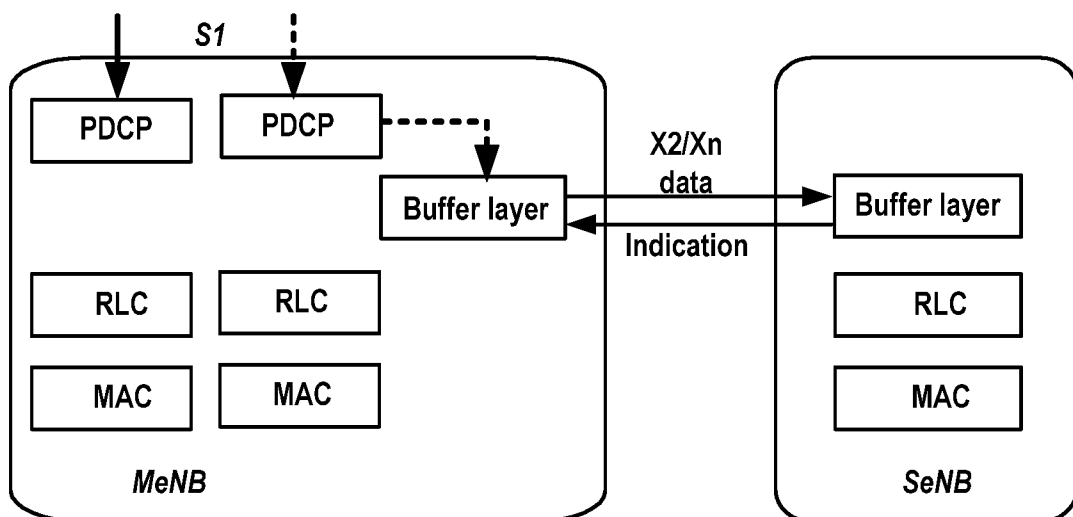


Fig. 5D

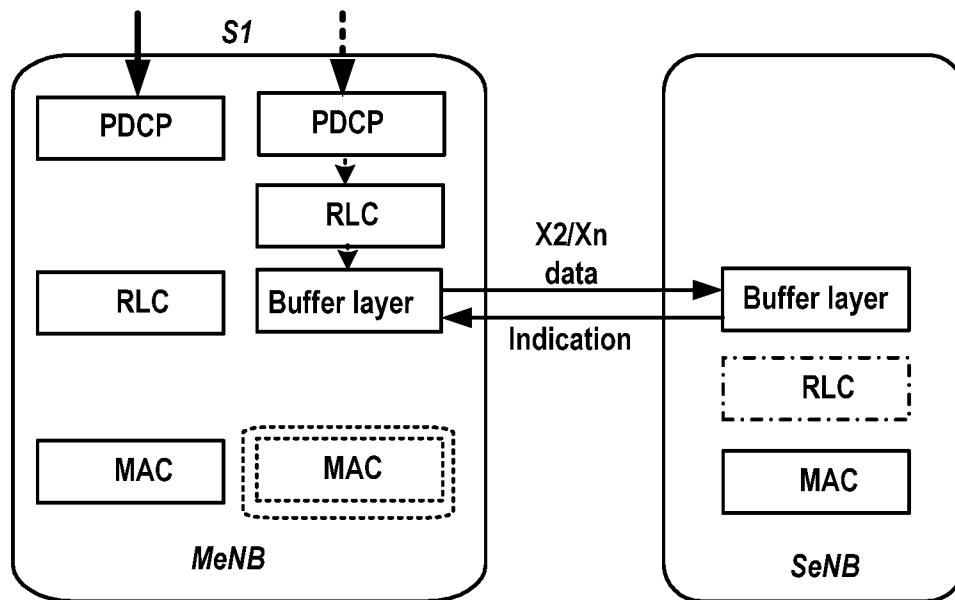


Fig. 5E

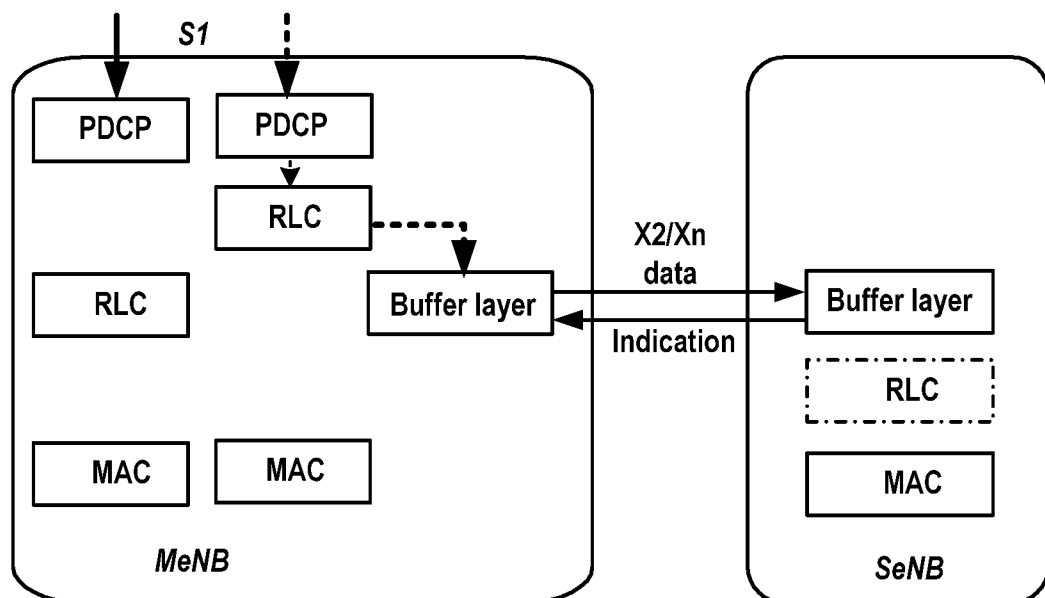


Fig. 5F



Fig. 6

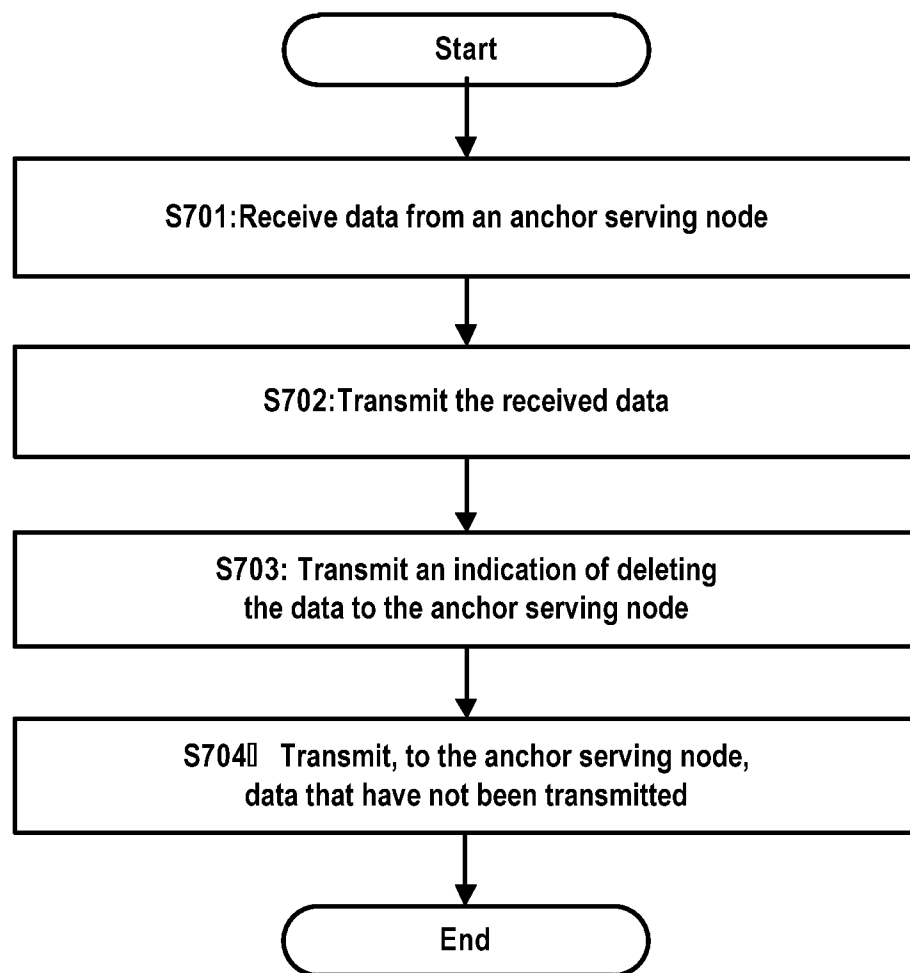


Fig. 7

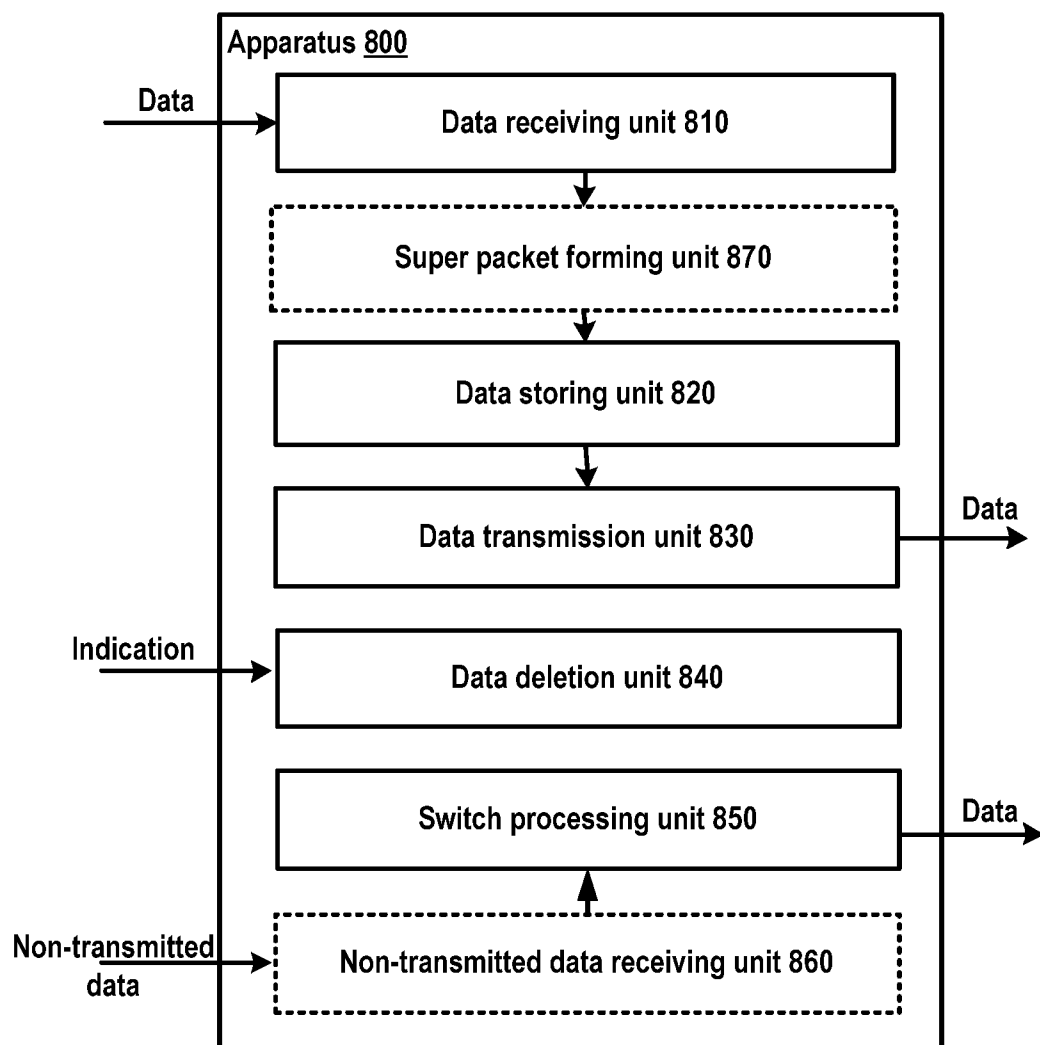


Fig. 8

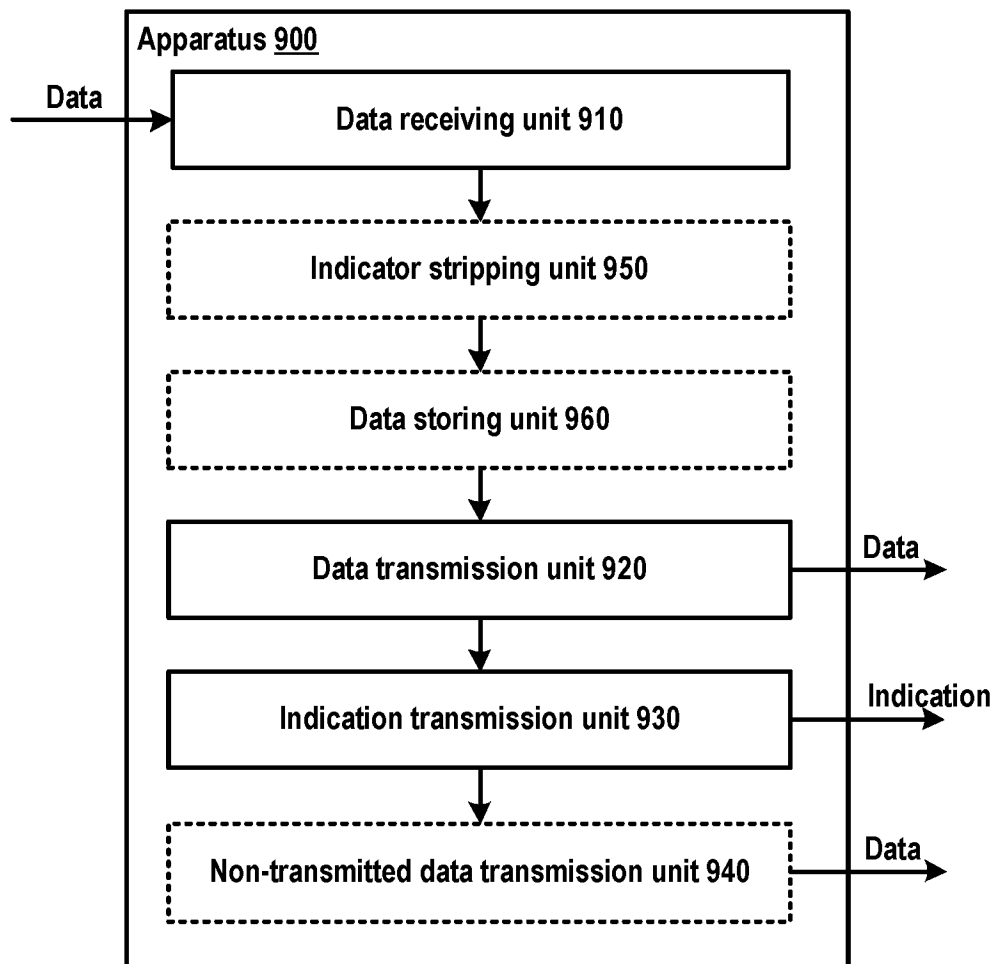


Fig. 9