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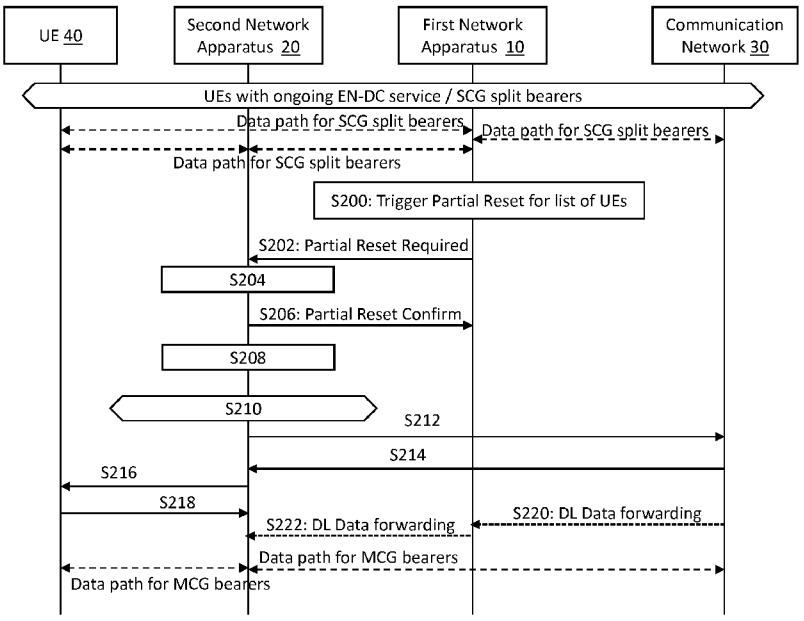

Fig. 5

(57) Abstract: A first network apparatus providing (S10) connectivity to a communication network via a first access technology using specific bearers that are served by the first network apparatus and by a second network apparatus for providing connectivity to the communication network via a second access technology, transmits (S14) a partial reset message which informs the second network apparatus that the specific bearers used for providing connectivity to the communication network for user equipments of a list are going to be released by said first network apparatus. The partial reset message comprises an identification of each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, and for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, an uplink count value of first missing uplink data to be received from the user equipments via the specific bearers, and a downlink count value of first missing downlink data

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PARTIAL RESET FOR UEs WITH DUAL CONNECTIVITY

TECHNICAL FIELD

At least some embodiments relate to partial reset for UEs with dual connectivity (DC).

BACKGROUND

Partial reset over X2 interface between master node and secondary node is a procedure currently explored in 3GPP.

For example, without a partial reset procedure, to cope with bulk UE releases in which the secondary node has to release a plurality of UEs served by the master node and the secondary node, the secondary node has to release the impacted UEs one-by-one, which will cause considerable additional performance load (message bursts) with the risk of causing overload situations in the secondary node and the master node.

CITATION LIST

[1] 3GPP TR 38.801 V14.0.0 (2017-03)

LIST OF ABBREVIATIONS

3GPP	third generation partnership project
5G	fifth generation
AP	application protocol
C-plane	control plane
CU	control unit
DC	dual connectivity
DL	downlink
DU	distributed unit
EN	E-UTRA NR
eNB	evolved Node B
EPC	evolved/enhanced packet core
E-RAB	evolved RAB

E-UTRA	evolved UMTS terrestrial radio access
gNB	5G Node B
GTP	gateway transfer protocol
HFN	hyper frame number
ID	identification
IE	information element
LTE	long term evolution
MAC	multiple access control
MCG	master cell group
MeNB	master eNB
NG	next generation
NR	new radio
PDCP	packet data convergence protocol
RAB	radio access bearer
RAN	radio access network
RLC	radio link control
SCG	secondary cell group
SDU	service data unit
SgNB	secondary gNB
SN	sequence number
UE	user equipment
UL	uplink
UMTS	universal mobile telecommunications system
U-plane	user plane

SUMMARY

At least some embodiments aim at providing a partial reset procedure e.g. over X2 interface so that it will be possible for the master node, e.g. an eNB, to take back impacted SCG split bearers and to continue an enhanced service, e.g. E-RAB service, with MCG bearers.

According to at least some embodiments, this is achieved by methods, apparatuses and non-transitory computer-readable storage media as defined in the appended claims.

Different from legacy reset scenarios occurring on S1 and legacy X2 interfaces, partial reset for EN-DC according to at least some embodiments can be handled in a way that allows to continue data transmission for impacted UEs without re-initialization of bearers/ data loss.

In the following example embodiments and example implementations will be described with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a schematic diagram illustrating a network architecture adoptable by at least some embodiments and a protocol structure for an SCG split bearer.

Fig. 2 shows a schematic block diagram illustrating a structure of control units in which example embodiments are implementable.

Fig. 3 shows flowcharts illustrating processes according to example embodiments.

Fig. 4 shows a signaling diagram illustrating an X2 partial reset procedure including a PDCP SN status option according to an example implementation.

Fig. 5 shows a signaling diagram illustrating an X2 partial reset procedure including PDCP SN status and data forwarding options according to an example implementation.

Fig. 6 shows a schematic block diagram illustrating an overview of a 5G NR architecture.

DESCRIPTION OF THE EMBODIMENTS

Fig. 1 illustrates a network architecture and protocol structure for EN-NR DC (also referred to as "EN-DC") according to option 3X as described e.g. in [1], which may be adopted by at least some embodiments.

A UE configured in EN-DC is served both by an eNB (LTE eNB) and by a 5G node (gNB) as follows. The eNB provides connectivity to the UE via LTE radio interface/ LTE cells. The 5G node 'en-gNB' provides connectivity to the UE via 5G radio interface/ New Radio cells.

The eNB and the en-gNB are connected via an X2 interface which is a logical interface between two NodeBs. Whilst logically representing a point-to-point link between NodeBs, the physical realization does not have to be a point-to-point link.

In EN-DC option 3X, an S1 U-plane connection is present between the eNB and an EPC and between the gNB and the EPC. However, an S1 C-plane connection to the EPC is only available for the eNB, which plays the role of the Master Node (MN), whereas the en-gNB has no C-plane connection to the EPC and it plays the role of the Secondary Node (SN). S1 defines a logical interface between a NodeB and an EPC, providing an interconnection point between the E-UTRAN and the EPC. It is also considered as a reference point.

The LTE eNB may establish for UEs an EN-DC eligible E-RAB, i.e. a Data Radio Bearer that can be served both by an eNB and by an en-gNB, a so called 'SCG split bearer' (in this application also referred to as 'special bearer'). Such E-RAB uniquely identifies the concatenation of an S1 Bearer and the corresponding Data Radio Bearer.

For SCG split bearers, the following configuration applies. Data transmission to/ from a UE for a respective E-RAB may go via New Radio cell(s) and/or via LTE cell(s). An NR PDCP (also referred to as 'upper layer protocol') entity for the SCG split bearer is located in the en-gNB.

In particular, the protocol structure adopted in the gNB comprises for each SCG or SCG split bearer: one NR MAC entity, one NR RLC entity and one NR PDCP entity.

The gNB-CU hosts the NR PDCP and terminates the S1-U and the X2-C interfaces as well as the air interface layer 3 protocol. The gNB-DU terminates the air interface layer 1 and Layer 2/RLC protocols.

The protocol structure adopted in the eNB comprises a MAC entity, RLC entities each for an MCG bearer and the SCG split bearer, and a PDCP entity for the MCG bearer.

At a given time, the eNB may serve multiple UEs with SCG split bearers and the en-gNB may decide to release a high number of the SCG split bearers/ UEs at the same time. A typical case for which this may happen are F1 link failures between CU and DU units of the en-gNB.

In order to avoid that the en-gNB has to release for such cases every impacted UE one-by-one, a new X2AP procedure has to be introduced, the Partial Reset for X2.

For a normal SCG split bearer release triggered by en-gNB, e.g. via the SgNB initiated SgNB Release procedure or SgNB initiated SgNB Modification procedure, the en-gNB may send buffered data not yet delivered to UE via a forwarding tunnel to eNB. In addition, the en-gNB transmits the status of NR PDCP via an 'SN Status Transfer' message (including essentially the last PDCP Sequence Numbers used), which allows the eNB to take the SCG split bearer back as MCG bearer, i.e. as bearer served by the eNB only, and to continue the data transmission for the respective E-RAB starting with the appropriate PDCP Sequence Number (PDCP SN), i.e. with a PDCP SN that follows the last one used for the SCG split bearer and therefore does not lead to packet discarding or packet confusion/repetition in the UE.

In case the eNB has no information about the last PDCP Sequence Numbers used on en-gNB side, the eNB does not know from which PDCP SN to resume data transmission from the MCG bearer and therefore it has no other choice than to release the E-RABs of the impacted UEs or to newly establish bearers, loosing not yet delivered data and/or retransmitting already delivered ones.

In other words, even if all resources and information for reconfiguration of SCG split bearers to MCG are available, but cannot be notified to the eNB, X2 partial reset will lead to a loss of all impacted E-RABs, i.e. all SCG split bearers that the eNB should take back as MCG bearers, of all impacted UEs. For the above indicated trigger for X2 partial reset, namely F1 link failure, it is highly probable that all needed resources for a continuation of the E-RAB are available.

At least some embodiments provide for an X2 partial reset procedure enabling the eNB to take back the impacted SCG split bearers and to continue the E-RAB service with MCG bearers without any degradation.

As a preliminary matter before exploring details of various implementations, reference is made to Fig. 2 for illustrating a simplified block diagram of various electronic devices that are suitable for use in practicing example embodiments.

Fig. 2 illustrates structures of control units 100, 200. According to an example implementation, the control unit 100 is part of and/or used by a first network apparatus, e.g. a gNB, and the control unit 200 is part of and/or used by a second network apparatus, e.g. an eNB.

The control units 100, 200 comprise processing resources (e.g. processing circuitry) 101, 201, memory resources (e.g. memory circuitry) 102, 202 that may store programs, and interfaces (e.g. interface circuitry) 102, 203.

The processing resources 101, 201, memory resources 102, 202 and interfaces 102, 203 are coupled via connections (e.g. buses) 104, 204. The control units 100, 200 are coupled via a connection 123, e.g. an X2 interface.

The interfaces 103, 203 may include a suitable radio frequency (RF) transceiver coupled to one or more antennas for bidirectional wireless communications over one or more wireless links with UEs.

The terms "connected," "coupled," or any variant thereof, mean any connection or coupling, either direct or indirect, between two or more elements, and may encompass the presence of one or more intermediate elements between two elements that are "connected" or "coupled" together. The coupling or connection between the elements can be physical, logical, or a combination thereof. As employed herein two elements may be considered to be "connected" or "coupled" together by the use of one or more wires, cables and printed electrical connections, as well as by the use of electromagnetic energy, such as electromagnetic energy having wavelengths in the radio frequency region, the microwave region and the optical (both visible and invisible) region, as non-limiting examples.

Further, as used in this application, the term "circuitry" refers to one or more or all of the following:
(a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and
(b) to combinations of circuits and software (and/or firmware), such as (as applicable): (i) to a combination of processor(s) or (ii) to portions of processor(s)/software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and
(c) to circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present.

This definition of "circuitry" applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term "circuitry" would also cover an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware. The term "circuitry" would also cover, for example and if applicable to the particular claim element, a baseband integrated circuit or applications processor integrated circuit for a mobile phone or a similar integrated circuit in server, a cellular network device, or other network device.

The programs stored in the memory resources 102, 202 are assumed to include program instructions that, when executed by the associated processing resources 101, 201, enable the electronic device to operate in accordance with example embodiment, as detailed below.

In general, example embodiments may be implemented by computer software stored in the memory resources 102, 202 and executable by the processing resources 101, 201, or by hardware, or by a combination of software and/or firmware and hardware in any or all of the devices shown.

According to a first example embodiment for a partial reset procedure, optionally for each impacted E-RAB of each impacted UE, a PDCP Sequence Number (PDCP SN) and a Hyper Frame Number (HFN) of the first missing Uplink (UL) and DownLink (DL) PDCP Service Data Unit (PDCP SDU) as well as a Receive status of the UL and DL PDCP SDUs are provided, which may be conveyed for legacy 3GPP implementations via an X2AP SN STATUS TRANSFER message.

The first example embodiment provides for additional IEs to ensure that EN-DC partial reset can also be adopted when PDCP SNs are not/ no longer available.

With knowledge of PDCP SNs, the eNB will be able to take back SCG split bearers and to establish MCG bearers instead. With this proposal, the eNB can continue data transmission from the impacted E-RABs after they are taken back as MCG bearers without losing the synchronization with the UE, i.e. re-establishing the PDCP without data loss or data repetition.

Fig. 3 illustrates flowcharts of processes 1, 2 according to example embodiments. Process 1 may be executed by a first network apparatus, e.g. a gNB, and process 2 may be executed by a second network apparatus, e.g. an eNB.

In process 1, S10, connectivity to a communication network (e.g. EPC) is provided via a first access technology (e.g. 5G radio interface/new radio cells) using specific bearers (e.g. SCG split bearers) that are served by a first network apparatus (e.g. gNB) and by a second network apparatus (e.g. eNB) for providing connectivity to the communication network via a second access technology (e.g. LTE radio interface/LTE cells) according to EN-DC option 3X.

In S12, a partial reset for a list of user equipments is initiated (e.g. triggered) for which the first network apparatus provides connectivity to the communication network using the specific bearers.

In S14, a partial reset message is transmitted which requests the second network apparatus to take back the specific bearers used for providing connectivity to the communication network for the user equipments of the list. In other words, a partial reset message is transmitted which informs the second network apparatus that the specific bearers used for providing connectivity to the communication network for the user equipments of the list are going to be released by said first network apparatus. The partial reset message comprises an identification of each of the specific bearers (e.g. E-RAB ID) used for providing connectivity to the communication network for the user equipments of the list. The partial reset message

further comprises, for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, an uplink count value (e.g. UL COUNT Value) of first missing uplink data to be received from the user equipments via the specific bearers, and a downlink count value (e.g. DL COUNT Value) of first missing downlink data to be transmitted to the user equipments via the specific bearers.

In process 2, S20, connectivity to a communication network (e.g. EPC) via a second access technology (e.g. LTE radio interface/LTE cells) using specific bearers (e.g. SCG split bearers) that are served by a second network apparatus (e.g. eNB) and by a first network apparatus (e.g. gNB) for providing connectivity to the communication network via a first access technology (e.g. 5G radio interface/new radio cells).

In S22, a partial reset message is received which requests the second network apparatus to take back the specific bearers used for providing connectivity to the communication network for a list of user equipments. In other words, a partial reset message is received which informs the second network apparatus that the specific bearers used for providing connectivity to the communication network for a list of user equipments are going to be released by said first network apparatus. The partial reset message comprises an identification (e.g. E-RAB ID) of each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, and for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, an uplink count value (e.g. UL COUNT Value) of first missing uplink data to be received from the user equipments via the specific bearers, and a downlink count value (e.g. DL COUNT Value) of first missing downlink data to be transmitted to the user equipments via the specific bearers.

In S24, the specific bearers used for providing connectivity to the communication network for the user equipments of the list are taken back

and master bearers (e.g. MCG bearers) are established for providing connectivity to the communication network via the second access technology for the specific bearers which were taken back. In other words, the specific bearers used for providing connectivity to the communication network for the user equipments of the list are taken back as bearers served by the second access technology only for providing connectivity to the communication network using the received above mentioned uplink and downlink count values for continuing uplink and downlink data transmission without PDCP sequence number discontinuity.

Optionally, the partial reset message further comprises a status indication which indicates a receive status of uplink data units according to an upper layer protocol (e.g. NR PDCP) of the first access technology for at least one of the specific bearers used for providing connectivity to the communication network for the user equipments of the list.

Optionally, the partial reset message further comprises an uplink sequence number (e.g. UL PDCP SN) of a first missing uplink data unit (e.g. UL SDU) on the at least one specific bearer according to the upper layer protocol of the first access technology, and a downlink sequence number (e.g. DL PDCP SN) of a first missing downlink data unit (e.g. DL SDU) on the at least one specific bearer according to the upper layer protocol of the first access technology.

Optionally, the partial reset message further comprises an uplink hyper frame number (e.g. UL HFN) of the first missing uplink data unit and a downlink hyper frame number (e.g. DL HFN) of the first missing downlink data unit.

According to a second example embodiment, in addition to the information described in the first example embodiment, for each impacted E-RAB of each impacted UE new IEs are provided, which allow the establishment of data forwarding tunnels for transmission of data buffered in en-gNB to eNB.

With this option, it will be possible to continue the E-RAB without data loss.

If the first example embodiment is applied without the extension according to the second example embodiment, data which are stored in the en-gNB can be recovered by the application level, however the subsequent data can be successfully delivered.

According to the second example embodiment, the partial reset message transmitted in S14 and received in S22 further comprises a data forwarding indication which indicates support of data forwarding for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list.

According to the second example embodiment, the procedure in S24 further comprises transmitting a confirmation message indicating, for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, a downlink tunnel endpoint and an uplink tunnel endpoint to be used for the data forwarding.

The confirmation message is received in response to the partial reset message transmitted in S14, and for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, the downlink tunnel endpoint and the uplink tunnel endpoint are used for forwarding, to the second network apparatus, uplink data received from the user equipments via the specific bearers, and downlink data which is received from the communication network and is to be transmitted to the user equipments via the specific bearers

At the second network apparatus, forwarding tunnels are prepared for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list. Then, over the forwarding tunnels, from the first network apparatus, uplink data can be received,

which the first network apparatus received from the user equipments via the specific bearers, and downlink data can be received, which the first network apparatus received from the communication network and which had to be transmitted to the user equipments via the specific bearers.

According to a third example embodiment, the partial reset procedure of the first and second example embodiments is applied to (LTE) Dual Connectivity scenarios. For example, the first and second network apparatuses each comprise an eNB and the first and second access technologies each comprise at least one of a long term evolution radio interface and long term evolution cells.

According to a fourth example embodiment, the partial reset procedure of the first and second example embodiments is applied to NG-RAN. For example, the first and second network apparatuses each comprises a base station of a next generation radio access network and the first and second access technologies each comprises at least one of a next generation radio interface and next generation radio cells.

According to a fifth example embodiment, the partial reset procedure of the first and second example embodiments is applied to LTE/5G scenarios, where the master node is a gNB and the secondary node is e.g. an eNB which triggers Partial Reset over an Xn-C interface. In this case, the second network apparatus comprises a 5G node, e.g. a gNB, the second access technology comprises at least one of a 5G radio interface and new radio cells, the first network apparatus comprises e.g. an eNB and the first access technology comprises e.g. at least one of a long term evolution radio interface and long term evolution cells. Instead of EPC, a 5GC is involved.

Fig. 6 shows a schematic block diagram illustrating an overview of a 5G NR architecture in which the fifth example embodiment is implementable.

The 5G NR architecture shown in Fig. 6 comprises an NG-RAN 610 and a 5GC 620. The NG-RAN comprises an gNB 630 as master node and an eNB 640 as secondary node, which are connected via an Xn-C interface 634 used for coordination using XnAP procedures. The gNB 630 and the eNB 640 are connected to the 5GC 620 via NG interfaces 623, 624.

According to the fifth example embodiment, the above-described second network apparatus comprises an NG control plane connection and an NG user plane connection with the communication network (5GC), and the first network apparatus comprises an NG user plane connection with the communication network but does not comprise an NG control plane connection with the communication network.

Now reference is made to Fig. 4 showing a signaling diagram illustrating an example implementation of the first example embodiment.

Fig. 4 illustrates signaling between a first network apparatus (e.g. gNB) 10 (e.g. using control unit 100 shown in Fig. 2 and/or executing process 1 shown in Fig. 3), a second network apparatus (e.g. eNB) 20 (e.g. using control unit 200 shown in Fig. 2 and/or executing process 2 shown in Fig. 3), a communication network 30 (e.g. EPC), and a UE 40 which is one of UEs with ongoing EN-DC service / SCG split bearers.

In Fig. 4 data paths for SCG split bearers are indicated by broken line arrows.

In S100, the first network apparats 10 triggers a partial reset for a list of UEs. In S102, the first network apparatus 10 transmits a partial reset required message towards the second network apparatus 20.

The partial reset required message comprises an UEs to be reset list which is a list of UEs for which SCG split bearers have to be released, an MeNB UE X2AP ID, an SgNB UE X2AP ID, an E-RABs subject to status transfer list

comprising an E-RAB ID per E-RAB item, an UL COUNT Value per E-RAB item, and a DL COUNT Value per E-RAB item.

Optionally, the E-RABs subject to status transfer list further comprises a list of E-RABs for which PDCP SN status is provided, and a receive status of UL PDCP SDUs per E-RAB item.

In S104, the second network apparatus 20 releases X2AP ID resources.

In S106, the second network apparatus 20 transmits a partial reset confirm message to the first network apparatus 10. The partial reset confirm message comprises a UEs admitted to be reset list which is a list of UEs for which SCG split bearers are accepted to be released, an MeNB UE X2AP ID and an SgNB UE X2AP ID.

In S108, the second network apparatus 20 triggers taking back of SCG split bearers for all UEs/E-RABs for which PDCP SN status has been received.

In S110, the second network apparatus 20 decides to take back SCG split bearers.

In S112, the second network apparatus 20 transmits an E-RAB modification indication message to the communication network 30.

In S114, the second network apparatus 20 receives an E-RAB modification confirm message from the communication network 30.

In S116, the second network apparatus 20 transmits an RRC connection reconfiguration message to the UE 40.

In S118, the second network apparatus 20 receives an RRC connection reconfiguration complete message from the UE 40.

Data paths for MCG bearers are indicated by broken line arrows.

Now reference is made to Fig. 5 showing a signaling diagram illustrating an example implementation of the second example embodiment.

Fig. 5 illustrates signaling between a first network apparatus (e.g. gNB) 10 (e.g. using control unit 100 shown in Fig. 2 and/or executing process 1 shown in Fig. 3), a second network apparatus (e.g. eNB) 20 (e.g. using control unit 200 shown in Fig. 2 and/or executing process 2 shown in Fig. 3), a communication network 30 (e.g. EPC), and a UE 40 which is one of UEs with ongoing EN-DC service / SCG split bearers.

In Fig. 5 data paths for SCG split bearers are indicated by broken line arrows.

In S200, the first network apparatus 10 triggers a partial reset for a list of UEs. In S202, the first network apparatus 10 transmits a partial reset required message towards the second network apparatus 20.

The partial reset required message comprises an UEs to be reset list which is a list of UEs for which SCG split bearers have to be released, an MeNB UE X2AP ID, an SgNB UE X2AP ID, an E-RABs subject to status transfer list comprising an E-RAB ID per E-RAB item, an UL COUNT Value per E-RAB item, and a DL COUNT Value per E-RAB item.

Optionally, the E-RABs subject to status transfer list further comprises a list of E-RABs for which PDCP SN status is provided, and a receive status of UL PDCP SDUs per E-RAB item.

Optionally, the E-RABs subject to status transfer list further comprises a data forwarding indication which indicates data forwarding support for E-RAB.

In S204, the second network apparatus 20 releases X2AP ID resources.

In S206, the second network apparatus 20 transmits a partial reset confirm message to the first network apparatus 10. The partial reset confirm message comprises a UEs admitted to be reset list which is a list of UEs for which SCG split bearers are accepted to be released, an MeNB UE X2AP ID and an SgNB UE X2AP ID.

Optionally, the partial reset confirm message includes an E-RABs subject to data forwarding list that includes E-RABs of UE for data forwarding, a DL forwarding GTP tunnel endpoint and a UL forwarding GTP tunnel endpoint.

In S208, the second network apparatus 20 triggers taking back of SCG split bearers for all UEs/E-RABs for which PDCP SN status has been received and prepares forwarding tunnels.

In S210, the second network apparatus 20 decides to take back SCG split bearers with data forwarding.

In S212, the second network apparatus 20 transmits an E-RAB modification indication message to the communication network 30.

In S214, the second network apparatus 20 receives an E-RAB modification confirm message from the communication network 30.

In S216, the second network apparatus 20 transmits an RRC connection reconfiguration message to the UE 40.

In S218, the second network apparatus 20 receives an RRC connection reconfiguration complete message from the UE 40.

In S220, the first network apparatus 10 receives DL data from the communication network 30 and, in S222, forwards the DL data to the second network apparatus 20 via the forwarding tunnels.

Data paths for MCG bearers are indicated by broken line arrows.

According to an example embodiment, a first network apparatus comprises means for providing connectivity to a communication network via a first access technology using specific bearers that are served by the first network apparatus and by a second network apparatus for providing connectivity to the communication network via a second access technology, means for initiating a partial reset for a list of user equipments for which the first network apparatus provides connectivity to the communication network using the specific bearers, and means for transmitting a partial reset message which informs the second network apparatus that the specific bearers used for providing connectivity to the communication network for the user equipments of the list are going to be released by said first network apparatus. The partial reset message comprises an identification of each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, and for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, an uplink count value of first missing uplink data to be received from the user equipments via the specific bearers, and a downlink count value of first missing downlink data to be transmitted to the user equipments via the specific bearers.

According to an example implementation, the first network apparatus comprises control unit 100.

According to an example implementation, the partial reset message further comprises, for at least one of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, an uplink sequence number of a first missing uplink data unit on the at least one specific bearer according to an upper layer protocol of the first access technology, and a downlink sequence number of a first missing downlink data unit on the at least one specific bearer according to the upper layer protocol of the first access technology.

According to an example implementation, the partial reset message further comprises an uplink hyper frame number of the first missing uplink data unit and a downlink hyper frame number of the first missing downlink data unit.

According to an example implementation, the partial reset message further comprises a status indication which indicates a receive status of uplink data units according to the upper layer protocol of the first access technology for the at least one of the specific bearers.

According to an example implementation, the partial reset message further comprises a data forwarding indication which indicates support of data forwarding for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list.

According to an example implementation, the first network apparatus further comprises means for receiving, from the second network apparatus, a confirmation message indicating, for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, a downlink tunnel endpoint and an uplink tunnel endpoint to be used for the data forwarding, and means for, for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, using the downlink tunnel endpoint and the uplink tunnel endpoint for forwarding, to the second network apparatus, uplink data received from the user equipments via the specific bearers, and downlink data which is received from the communication network and is to be transmitted to the user equipments via the specific bearers.

According to an example embodiment, a second network apparatus comprises means for providing connectivity to a communication network via a second access technology using specific bearers that are served by the

second network apparatus and by a first network apparatus for providing connectivity to the communication network via a first access technology, means for receiving by the first network apparatus a partial reset message which informs the second network apparatus that the specific bearers used for providing connectivity to the communication network for a list of user equipments are going to be released by said first network apparatus, wherein the partial reset message comprises an identification of each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, and for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, an uplink count value of first missing uplink data to be received from the user equipments via the specific bearers, and a downlink count value of first missing downlink data to be transmitted to the user equipments via the specific bearers, and means for taking back the specific bearers used for providing connectivity to the communication network for the user equipments of the list as bearers served by the second access technology only for providing connectivity to the communication network using the received uplink and downlink count values for continuing uplink and downlink data transmission.

According to an example implementation, the second network apparatus comprises control unit 200.

According to an example implementation, the partial reset message further comprises a data forwarding indication which indicates support of data forwarding for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list.

According to an example implementation, the second network apparatus further comprises means for transmitting to the first network apparatus a confirmation message indicating, for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, a downlink tunnel endpoint and an uplink tunnel

endpoint to be used for the data forwarding, means for preparing forwarding tunnels for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, and means for receiving, over the forwarding tunnels, from the first network apparatus, uplink data which the first network apparatus received from the user equipments via the specific bearers, and downlink data which the first network apparatus received from the communication network and which had to be transmitted to the user equipments via the specific bearers.

According to an example implementation, the above-described partial reset message further comprises the list of the user equipments, an identification of the first network apparatus and an identification of the second network apparatus.

According to an example implementation, the above-described first network apparatus comprises a 5G node, the first access technology comprises at least one of a 5G radio interface and new radio cells, the second network apparatus comprises an eNB and the second access technology comprises at least one of a long term evolution radio interface and long term evolution cells.

According to an alternative example implementation, the above-described second network apparatus comprises a 5G node, the second access technology comprises at least one of a 5G radio interface and new radio cells, the first network apparatus comprises an eNB and the first access technology comprises at least one of a long term evolution radio interface and long term evolution cells.

According to an alternative example implementation, the above-described first and second network apparatuses each comprise an eNB and the first and second access technologies each comprise at least one of a long term evolution radio interface and long term evolution cells.

According to an alternative example implementation, the above-described first and second network apparatuses each comprises a base station of a next generation radio access network and the first and second access technologies each comprises at least one of a next generation radio interface and next generation radio cells.

According to an example implementation, the above-described first and second network apparatuses communicate over an X2 interface.

According to another example implementation, the above-described first and second network apparatuses communicate over an Xn-C interface.

According to an example implementation, the above-described second network apparatus comprises an S1 control plane connection and an S1 user plane connection with the communication network, and the first network apparatus comprises an S1 user plane connection with the communication network but does not comprise an S1 control plane connection with the communication network.

According to another example embodiment, the above-described second network apparatus comprises an NG control plane connection and an NG user plane connection with the communication network, and the first network apparatus comprises an NG user plane connection with the communication network but does not comprise an NG control plane connection with the communication network.

According to an example implementation, the above-described communication network comprises an enhanced packet core.

According to another example implementation, the above-described communication network comprises a 5G core.

According to an example implementation, the above-described higher layer protocol comprises a packet data convergence protocol.

According to an example implementation, the above-described specific bearers are secondary cell group split bearers.

It is to be understood that the above description is illustrative and is not to be construed as limiting the disclosure. Various modifications and applications may occur to those skilled in the art without departing from the true spirit and scope as defined by the appended claims.

CLAIMS

1. A method for use by a first network apparatus, the method comprising:

providing connectivity to a communication network via a first access technology using specific bearers that are served by the first network apparatus and by a second network apparatus for providing connectivity to the communication network via a second access technology;

initiating a partial reset for a list of user equipments for which the first network apparatus provides connectivity to the communication network using the specific bearers; and

transmitting a partial reset message which informs the second network apparatus that the specific bearers used for providing connectivity to the communication network for the user equipments of the list are going to be released by said first network apparatus,

wherein the partial reset message comprises

an identification of each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, and

for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list,

an uplink count value of first missing uplink data to be received from the user equipments via the specific bearers, and

a downlink count value of first missing downlink data to be transmitted to the user equipments via the specific bearers.

2. The method of claim 1, wherein the partial reset message further comprises, for at least one of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, an uplink sequence number of a first missing uplink data unit on the at least one specific bearer according to an upper layer protocol of the first access technology, and a downlink sequence number of a first missing downlink data unit on the at least one specific bearer according to the upper layer protocol of the first access technology.

3. The method of claim 2, wherein the partial reset message further comprises an uplink hyper frame number of the first missing uplink data unit and a downlink hyper frame number of the first missing downlink data unit.

4. The method of claim 2 or 3, wherein the partial reset message further comprises a status indication which indicates a receive status of uplink data units according to the upper layer protocol of the first access technology for the at least one of the specific bearers.

5. The method of any one of claims 1 to 4, wherein the partial reset message further comprises a data forwarding indication which indicates support of data forwarding for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list.

6. The method of claim 5, further comprising:

receiving from the second network apparatus a confirmation message indicating, for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, a downlink tunnel endpoint and an uplink tunnel endpoint to be used for the data forwarding; and

for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, using the downlink tunnel endpoint and the uplink tunnel endpoint for forwarding, to the second network apparatus, uplink data received from the user equipments via the specific bearers, and downlink data which is received from the communication network and is to be transmitted to the user equipments via the specific bearers.

7. A method for use by a second network apparatus, the method comprising:

providing connectivity to a communication network via a second access technology using specific bearers that are served by the second network apparatus and by a first network apparatus for providing connectivity to the communication network via a first access technology;

receiving by the first network apparatus a partial reset message which informs the second network apparatus that the specific bearers used for providing connectivity to the communication network for a list of user equipments are going to be released by said first network apparatus,

wherein the partial reset message comprises

an identification of each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, and

for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list,

an uplink count value of first missing uplink data to be received from the user equipments via the specific bearers, and

a downlink count value of first missing downlink data to be transmitted to the user equipments via the specific bearers; and

taking back the specific bearers used for providing connectivity to the communication network for the user equipments of the list as bearers served by the second access technology only for providing connectivity to the communication network using the received uplink and downlink count values for continuing uplink and downlink data transmission.

8. The method of claim 7, wherein the partial reset message further comprises a data forwarding indication which indicates support of data forwarding for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list.

9. The method of claim 8, further comprising:

transmitting to the first network apparatus a confirmation message indicating, for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, a downlink

tunnel endpoint and an uplink tunnel endpoint to be used for the data forwarding;

preparing forwarding tunnels for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list; and

receiving, over the forwarding tunnels, from the first network apparatus, uplink data which the first network apparatus received from the user equipments via the specific bearers, and downlink data which the first network apparatus received from the communication network and which had to be transmitted to the user equipments via the specific bearers.

10. The method of any one of claims 1 to 9, wherein

the partial reset message further comprises the list of the user equipments, an identification of the first network apparatus and an identification of the second network apparatus, and/or

the first network apparatus comprises a 5G node, the first access technology comprises at least one of a 5G radio interface and new radio cells, the second network apparatus comprises an eNB and the second access technology comprises at least one of a long term evolution radio interface and long term evolution cells, or

the second network apparatus comprises a 5G node, the second access technology comprises at least one of a 5G radio interface and new radio cells, the first network apparatus comprises an eNB and the first access technology comprises at least one of a long term evolution radio interface and long term evolution cells, or

the first and second network apparatuses each comprise an eNB and the first and second access technologies each comprise at least one of a long term evolution radio interface and long term evolution cells, or

the first and second network apparatuses each comprises a base station of a next generation radio access network and the first and second access technologies each comprises at least one of a next generation radio interface and next generation radio cells, and/or

the first and second network apparatuses communicate over an X2 interface, or

the first and second network apparatuses communicate over an Xn-C interface, and/or

the second network apparatus comprises an S1 control plane connection and an S1 user plane connection with the communication network, and the first network apparatus comprises an S1 user plane connection with the communication network but does not comprise an S1 control plane connection with the communication network, or

the second network apparatus comprises an NG control plane connection and an NG user plane connection with the communication network, and the first network apparatus comprises an NG user plane connection with the communication network but does not comprise an NG control plane connection with the communication network, and/or

the communication network comprises an enhanced packet core, or

the communication network comprises a fifth generation core, and/or

the higher layer protocol comprises a packet data convergence protocol, and/or

the specific bearers are secondary cell group split bearers.

11. A first network apparatus comprising at least one processor and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the first network apparatus at least to perform:

providing connectivity to a communication network via a first access technology using specific bearers that are served by the first network apparatus and by a second network apparatus for providing connectivity to the communication network via a second access technology;

initiating a partial reset for a list of user equipments for which the first network apparatus provides connectivity to the communication network using the specific bearers; and

transmitting a partial reset message which informs the second network apparatus that the specific bearers used for providing connectivity

to the communication network for the user equipments of the list are going to be released by said first network apparatus,

wherein the partial reset message comprises

an identification of each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, and

for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list,

an uplink count value of first missing uplink data to be received from the user equipments via the specific bearers, and

a downlink count value of first missing downlink data to be transmitted to the user equipments via the specific bearers.

12. The first network apparatus of claim 11, wherein the partial reset message further comprises, for at least one of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, an uplink sequence number of a first missing uplink data unit on the at least one specific bearer according to an upper layer protocol of the first access technology, and a downlink sequence number of a first missing downlink data unit on the at least one specific bearer according to the upper layer protocol of the first access technology.

13. The first network apparatus of claim 12, wherein the partial reset message further comprises an uplink hyper frame number of the first missing uplink data unit and a downlink hyper frame number of the first missing downlink data unit.

14. The first network apparatus of claim 12 or 13, wherein the partial reset message further comprises a status indication which indicates a receive status of uplink data units according to the upper layer protocol of the first access technology for the at least one of the specific bearers.

15. The first network apparatus of any one of claims 11 to 14, wherein the partial reset message further comprises a data forwarding indication which indicates support of data forwarding for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list.

16. The first network apparatus of claim 15, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the first network apparatus to further perform:

receiving from the second network apparatus a confirmation message indicating, for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, a downlink tunnel endpoint and an uplink tunnel endpoint to be used for the data forwarding; and

for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, using the downlink tunnel endpoint and the uplink tunnel endpoint for forwarding, to the second network apparatus, uplink data received from the user equipments via the specific bearers, and downlink data which is received from the communication network and is to be transmitted to the user equipments via the specific bearers.

17. A second network apparatus comprising at least one processor and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the second network apparatus at least to perform:

providing connectivity to a communication network via a second access technology using specific bearers that are served by the second network apparatus and by a first network apparatus for providing connectivity to the communication network via a first access technology;

receiving by the first network apparatus a partial reset message which informs the second network apparatus that the specific bearers used

for providing connectivity to the communication network for a list of user equipments are going to be released by said first network apparatus,

wherein the partial reset message comprises

an identification of each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, and

for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list,

an uplink count value of first missing uplink data to be received from the user equipments via the specific bearers, and

a downlink count value of first missing downlink data to be transmitted to the user equipments via the specific bearers; and

taking back the specific bearers used for providing connectivity to the communication network for the user equipments of the list as bearers served by the second access technology only for providing connectivity to the communication network using the received uplink and downlink count values for continuing uplink and downlink data transmission.

18. The second network apparatus of claim 17, wherein the partial reset message further comprises a data forwarding indication which indicates support of data forwarding for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list.

19. The second network apparatus of claim 18, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the second network apparatus to further perform:

transmitting to the first network apparatus a confirmation message indicating, for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, a downlink tunnel endpoint and an uplink tunnel endpoint to be used for the data forwarding;

preparing forwarding tunnels for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list; and

receiving, over the forwarding tunnels, from the first network apparatus, uplink data which the first network apparatus received from the user equipments via the specific bearers, and downlink data which the first network apparatus received from the communication network and which had to be transmitted to the user equipments via the specific bearers.

20. A non-transitory computer-readable storage medium storing a program comprising software code portions that, when executed by a computer of a first apparatus, cause the first network apparatus to perform:

providing connectivity to a communication network via a first access technology using specific bearers that are served by the first network apparatus and by a second network apparatus for providing connectivity to the communication network via a second access technology;

initiating a partial reset for a list of user equipments for which the first network apparatus provides connectivity to the communication network using the specific bearers; and

transmitting a partial reset message which informs the second network apparatus that the specific bearers used for providing connectivity to the communication network for the user equipments of the list are going to be released by said first network apparatus,

wherein the partial reset message comprises

an identification of each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, and

for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list,

an uplink count value of first missing uplink data to be received from the user equipments via the specific bearers, and

a downlink count value of first missing downlink data to be transmitted to the user equipments via the specific bearers.

21. A non-transitory computer-readable storage medium storing a program comprising software code portions that, when executed by a computer of a second network apparatus, cause the second network apparatus to perform:

providing connectivity to a communication network via a second access technology using specific bearers that are served by the second network apparatus and by a first network apparatus for providing connectivity to the communication network via a first access technology;

receiving by the first network apparatus a partial reset message which informs the second network apparatus that the specific bearers used for providing connectivity to the communication network for a list of user equipments are going to be released by said first network apparatus,

wherein the partial reset message comprises

an identification of each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list, and

for each of the specific bearers used for providing connectivity to the communication network for the user equipments of the list,

an uplink count value of first missing uplink data to be received from the user equipments via the specific bearers, and

a downlink count value of first missing downlink data to be transmitted to the user equipments via the specific bearers; and

taking back the specific bearers used for providing connectivity to the communication network for the user equipments of the list as bearers served by the second access technology only for providing connectivity to the communication network using the received uplink and downlink count values for continuing uplink and downlink data transmission.

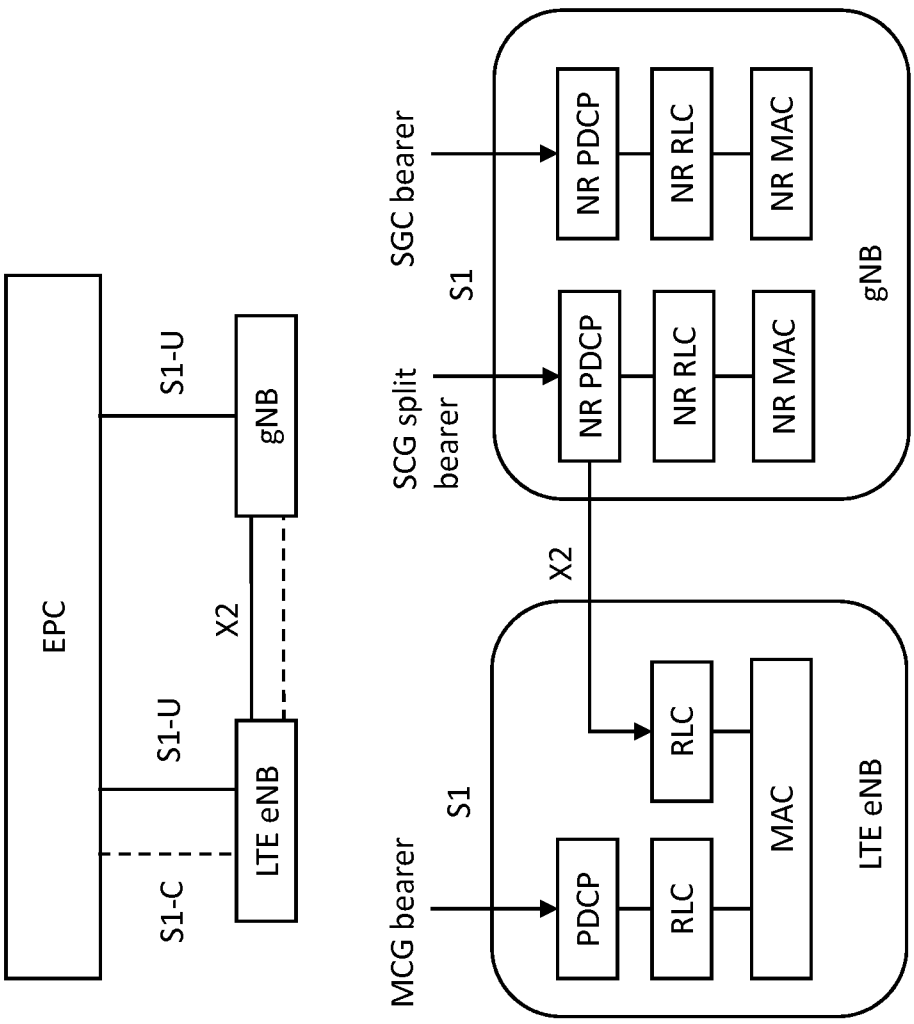
EPC
S1-U
S1-U
S1-C
X2
gNB
LTE eNB
MCG bearer
SCG split bearer
SGC bearer
S1
S1
X2
PDCP
RLC
MAC
RLC
NR PDCP
NR RLC
NR MAC
NR PDCP
NR RLC
NR MAC
LTE eNB
gNB

Fig. 1

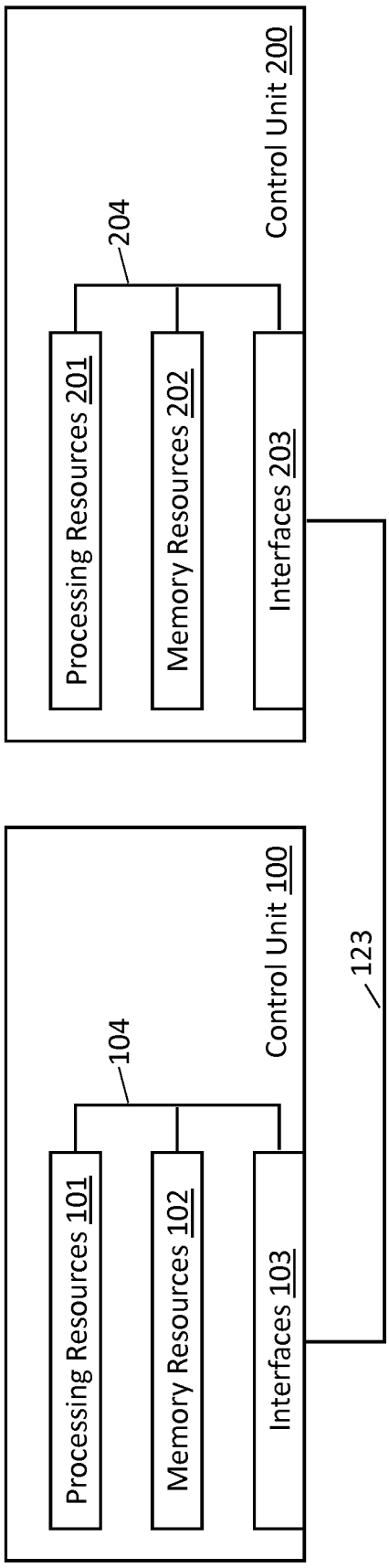
Control Unit 100
Processing Resources 101
Memory Resources 102
Interfaces 103
104
123
Control Unit 200
Processing Resources 201
Memory Resources 202
Interfaces 203
204

Fig. 2

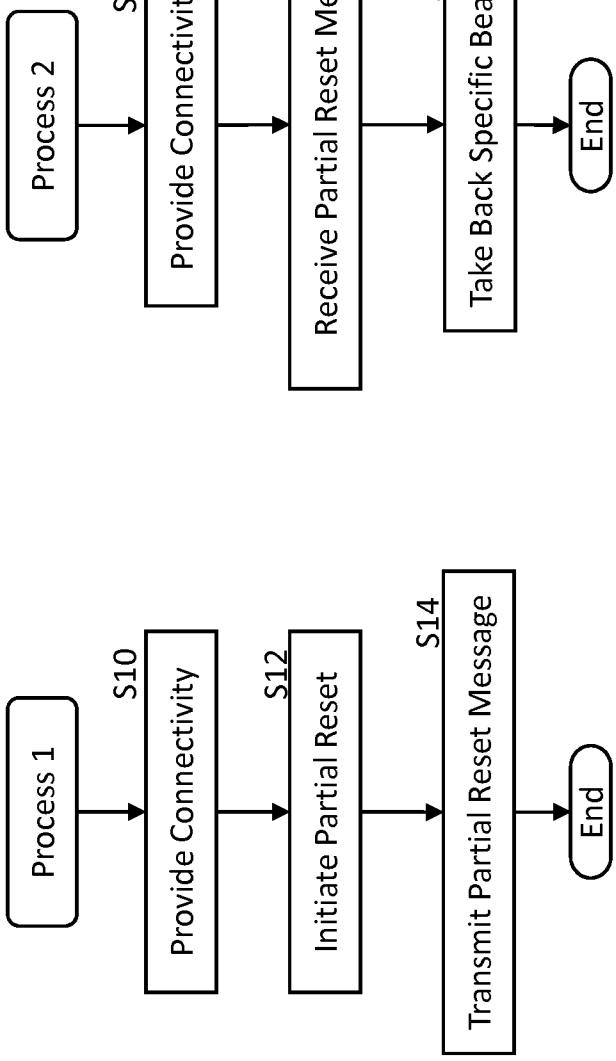
Process 1
S10
Provide Connectivity
S12
Initiate Partial Reset
S14
Transmit Partial Reset Message
End
Process 2
S20
Provide Connectivity
S22
Receive Partial Reset Message
S24
Take Back Specific Bearers
End

Fig. 3

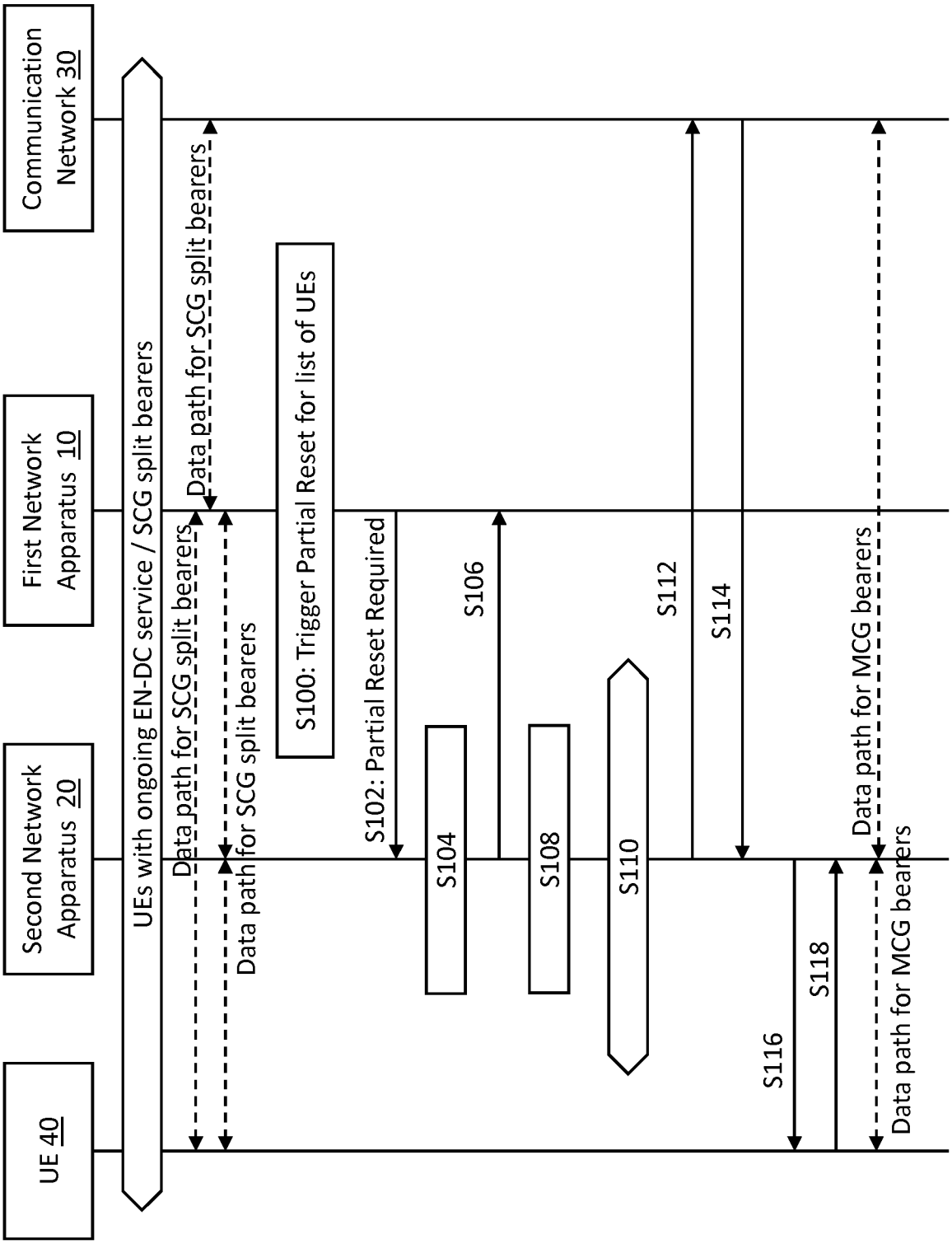
UE 40
Second Network Apparatus 20
First Network Apparatus 10
Communication Network 30
UEs with ongoing EN-DC service / SCG split bearers
Data path for SCG split bearers
Data path for SCG split bearers
Data path for SCG split bearers
S100: Trigger Partial Reset for list of UEs
S102: Partial Reset Required
S104
S106
S108
S110
S112
S114
S116
S118
Data path for MCG bearers
Data path for MCG bearers

Fig. 4

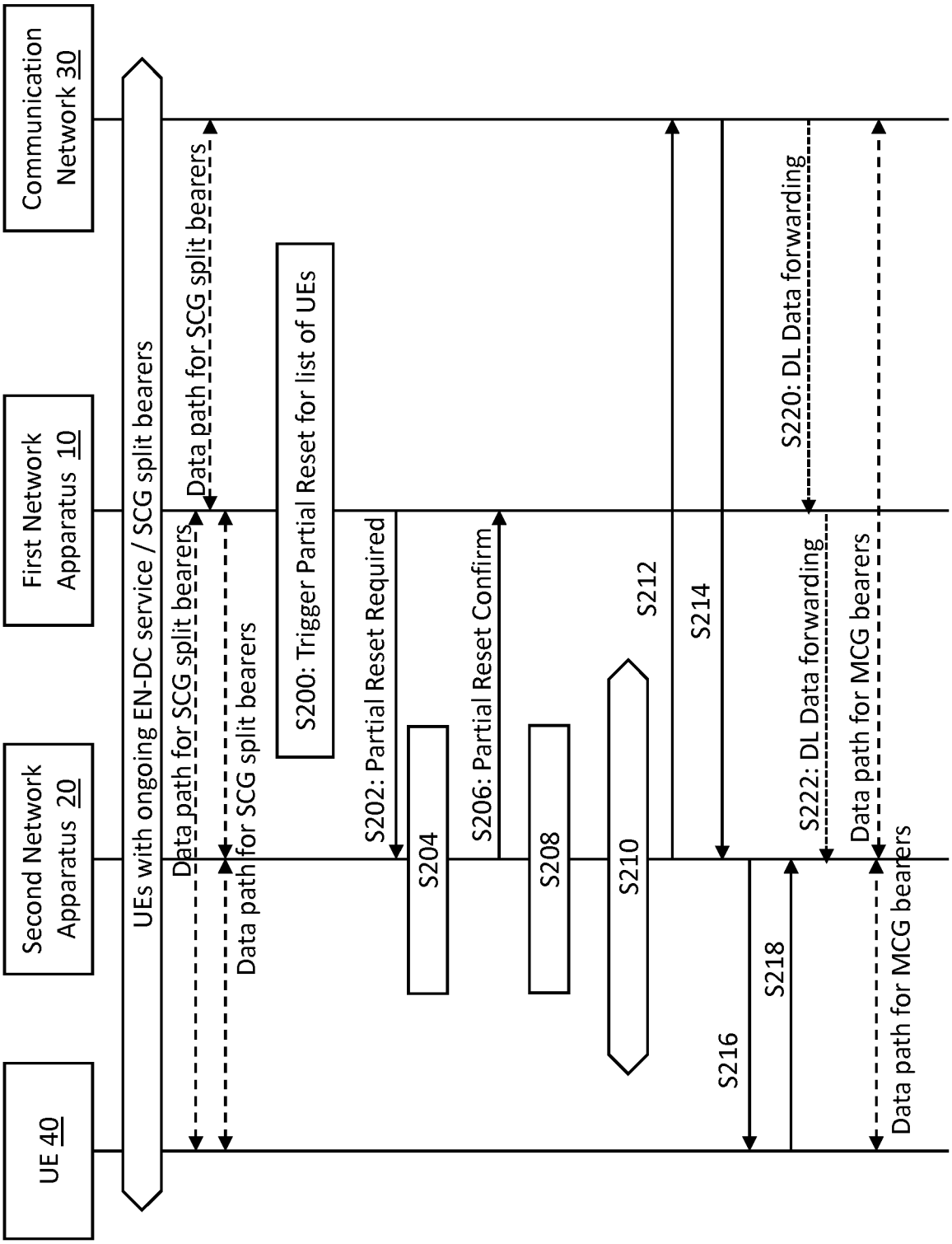
UE 40
Second Network Apparatus 20
First Network Apparatus 10
Communication Network 30
UEs with ongoing EN-DC service / SCG split bearers
Data path for SCG split bearers
Data path for SCG split bearers
Data path for SCG split bearers
S200: Trigger Partial Reset for list of UEs
S202: Partial Reset Required
S204
S206: Partial Reset Confirm
S208
S210
S212
S214
S216
S218
S220: DL Data forwarding
S222: DL Data forwarding
Data path for MCG bearers
Data path for MCG bearers

Fig. 5

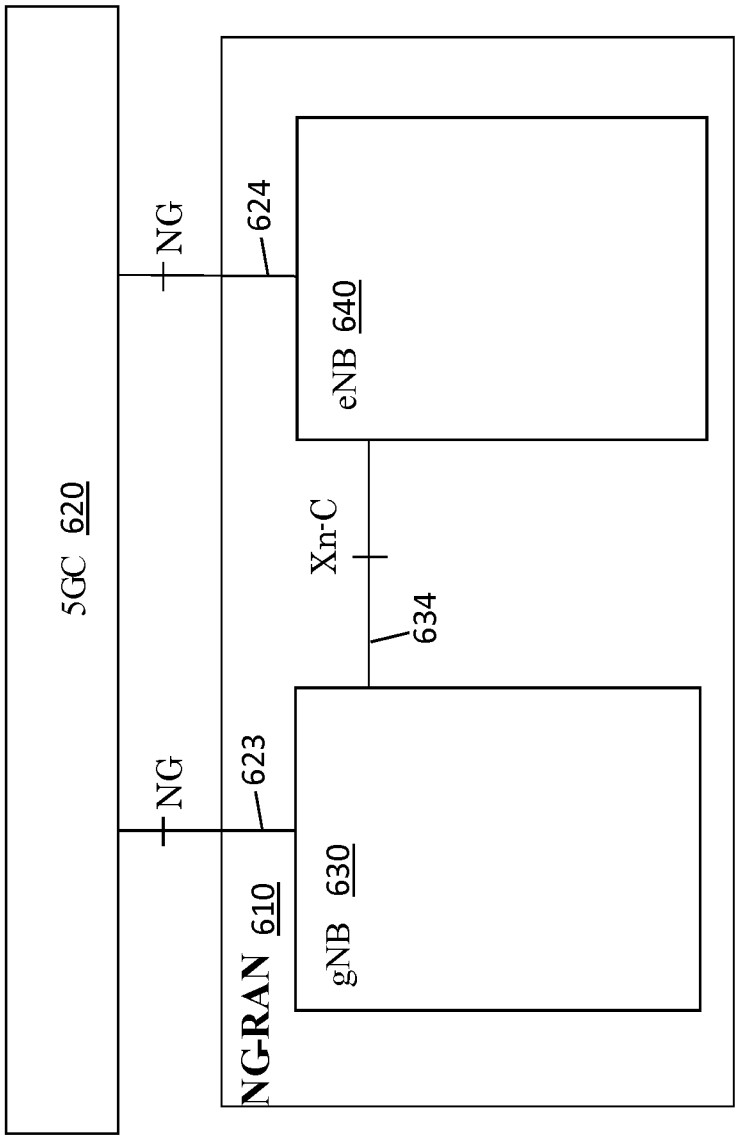

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/077757

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W76/34
ADD. H04W88/06 H04W76/15

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

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); X2 application protocol (X2AP) (Release 15)", 3GPP STANDARD; TECHNICAL SPECIFICATION; 3GPP TS 36.423, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG3, no. V15.3.0, 25 September 2018 (2018-09-25), pages 1-401, XP051487384, [retrieved on 2018-09-25] Section 8.7.14, 9.1.4.22, 9.1.4.23 -----	1-21

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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	Date of mailing of the international search report
3 July 2019	11/07/2019

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Siebel, Christian

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