(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 December 2020 (17.12.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/249183 A1

(51) International Patent Classification:
H04W 36/00 (2009.01) *H04W 40/36* (2009.01)

(21) International Application Number:
PCT/EP2019/065111

(22) International Filing Date:
11 June 2019 (11.06.2019)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) Title: APPARATUS, METHOD AND COMPUTER PROGRAM

(57) Abstract: An apparatus comprising means for performing: sending, to a first session management function (211a), a first request to update information of a first protocol data unit session; sending, to a second session management function (211b), a second request to update information of a second protocol data unit session; receiving a first response to the first request before receiving a second response to the second request; sending a first acknowledgement message to a radio access network (215) before receiving the response to the second request; wherein the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

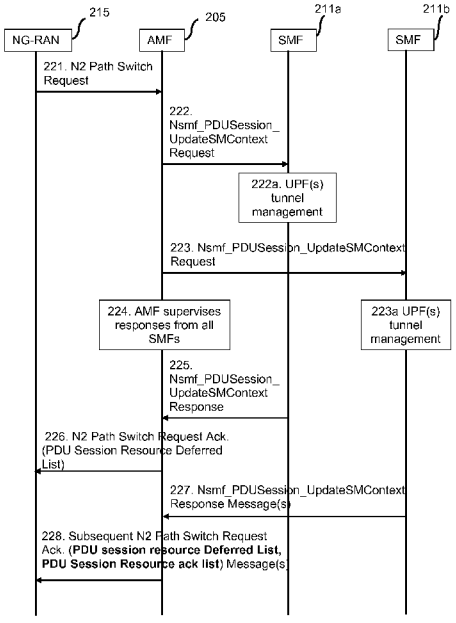

Fig. 2

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Apparatus, method and computer program

Field

This disclosure relates to wireless telecommunications. More particularly, the present disclosure relates to an apparatus, method and computer program for acknowledging changes in session information for Protocol Data Unit (PDU) sessions.

Background

In some telecommunications networks, for example in 5G networks, a User Equipment (UE) with multiple established PDU sessions may be served by different Session Management Functions (SMFs).

Statement of invention

According to a first aspect there is provided an apparatus comprising means for performing: sending, to a first session management function, a first request to update information of a first protocol data unit session; sending, to a second session management function, a second request to update information of a second protocol data unit session; receiving a first response to the first request before receiving a second response to the second request; sending a first acknowledgement message to a radio access network before receiving the response to the second request; wherein the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

According to some examples, the means are further configured to perform: receiving a path switch request from the radio access network before sending the first request and sending the second request.

According to some examples, the path switch request is an N2 path switch request.

According to some examples, the path switch request is sent from the radio access network during a handover of a user equipment from a source base station to a target base station in the radio access network.

According to some examples, the handover is an Xn handover.

According to some examples, the means are further configured to perform: receiving, subsequent to sending the first acknowledgement message to the radio access network, the second response; and sending a second acknowledgement message to the radio access network; wherein the second acknowledgement message comprises session information of the first protocol data unit session received in the first response and session information of the second protocol data unit session received in the second response.

According to some examples, the first protocol data unit session comprises Ultra Reliable Low Latency Communication data transmission.

According to some examples, the first session management function is located at an edge of the radio access network and the second session management function is not located at an edge of the radio access network.

According to some examples, the apparatus comprises an access and mobility management function.

According to a second aspect there is provided an 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 apparatus at least to perform: sending, to a first session management function, a first request to update information of a first protocol data unit session; sending, to a second session management function, a second request to update information of a second protocol data unit session; receiving a first response to the first request before receiving a second response to the second request; sending a first acknowledgement message to a radio access network before receiving the response to the second request; wherein the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

According to some examples, the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus

at least to perform: receiving a path switch request from the radio access network before sending the first request and sending the second request.

According to some examples, the path switch request is an N2 path switch request.

According to some examples, the path switch request is sent from the radio access network during a handover of a user equipment from a source base station to a target base station in the radio access network.

According to some examples, the handover is an Xn handover.

According to some examples, the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform: receiving, subsequent to sending the first acknowledgement message to the radio access network, the second response; and sending a second acknowledgement message to the radio access network; wherein the second acknowledgement message comprises session information of the first protocol data unit session received in the first response and session information of the second protocol data unit session received in the second response.

According to some examples, the first protocol data unit session comprises Ultra Reliable Low Latency Communication data transmission.

According to some examples, the first session management function is located at an edge of the radio access network and the second session management function is not located at an edge of the radio access network.

According to some examples, the apparatus comprises an access and mobility management function.

According to a third aspect there is provided an apparatus comprising: circuitry for sending, to a first session management function, a first request to update information of a first protocol data unit session; circuitry for sending, to a second session management function, a second request to update information of a second protocol data unit session; circuitry for receiving a first response to the first request before receiving a second response to the second request; and circuitry for sending a first acknowledgement message to a radio access network before receiving the response to the second request; wherein the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response

is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

According to a fourth aspect there is provided a method comprising: sending, to a first session management function, a first request to update information of a first protocol data unit session; sending, to a second session management function, a second request to update information of a second protocol data unit session; receiving a first response to the first request before receiving a second response to the second request; sending a first acknowledgement message to a radio access network before receiving the response to the second request; wherein the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

According to some examples, the method comprises: receiving a path switch request from the radio access network before sending the first request and sending the second request.

According to some examples, the path switch request is an N2 path switch request

According to some examples, the path switch request is sent from the radio access network during a handover of a user equipment from a source base station to a target base station in the radio access network.

According to some examples, the handover is an Xn handover.

According to some examples, the method comprises: receiving, subsequent to sending the first acknowledgement message to the radio access network, the second response; and sending a second acknowledgement message to the radio access network; wherein the second acknowledgement message comprises session information of the first protocol data unit session received in the first response and session information of the second protocol data unit session received in the second response.

According to some examples, the first protocol data unit session comprises Ultra Reliable Low Latency Communication data transmission.

According to some examples, the first session management function is located at an edge of the radio access network and the second session management function is not located at an edge of the radio access network.

According to some examples, the method is performed by an access and mobility management function.

According to a fifth aspect there is provided a computer program comprising instructions for causing an apparatus to perform at least the following: sending, to a first session management function, a first request to update information of a first protocol data unit session; sending, to a second session management function, a second request to update information of a second protocol data unit session; receiving a first response to the first request before receiving a second response to the second request; sending a first acknowledgement message to a radio access network before receiving the response to the second request; wherein the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

According to a sixth aspect there is provided a computer program comprising instructions stored thereon for performing at least the following: sending, to a first session management function, a first request to update information of a first protocol data unit session; sending, to a second session management function, a second request to update information of a second protocol data unit session; receiving a first response to the first request before receiving a second response to the second request; sending a first acknowledgement message to a radio access network before receiving the response to the second request; wherein the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

According to a seventh aspect there is provided a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following: sending, to a first session management function, a first request to update information of a first protocol data unit session; sending, to a second session management function, a second request to update information of a second protocol data unit session; receiving a first response to the first request before receiving a second response to the second request; sending a first acknowledgement message to a radio access network before receiving the response to the second request;

wherein the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

According to an eighth aspect there is provided a non-transitory computer readable medium comprising program instructions stored thereon for performing at least the following: sending, to a first session management function, a first request to update information of a first protocol data unit session; sending, to a second session management function, a second request to update information of a second protocol data unit session; receiving a first response to the first request before receiving a second response to the second request; sending a first acknowledgement message to a radio access network before receiving the response to the second request; wherein the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

According to a ninth aspect there is provided an apparatus comprising means for performing: receiving a first acknowledgement message from an access and mobility management function; wherein the first acknowledgement message comprises information of a first protocol data unit session and a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information, wherein the list comprises a session identifier of a second protocol data unit session.

According to some examples, the means are further configured to perform: sending a path switch request to the access and mobility management function before receiving the first acknowledgement message from the access and mobility management function.

According to some examples, the path switch request is an N2 path switch request.

According to some examples, the path switch request is sent during a handover of a user equipment from a source base station to a target base station.

According to some examples, the handover is an Xn handover.

According to some examples, wherein the path switch request comprises an indication of whether or not the apparatus will accept a list of protocol data unit

sessions for which the access and mobility management function is waiting for updated information.

According to some examples, the means are further configured to perform: receiving, subsequent to receiving the first acknowledgement message from the access and mobility management function, a second acknowledgement message from the access and mobility management function; and wherein the second acknowledgement message comprises session information of the first protocol data unit session and session information of the second protocol data unit session.

According to some examples, the first protocol data unit session comprises Ultra Reliable Low Latency Communication data transmission.

According to some examples, the apparatus is a next generation radio access network node.

According to a tenth aspect there is provided an 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 apparatus at least to perform: receiving a first acknowledgement message from an access and mobility management function; wherein the first acknowledgement message comprises information of a first protocol data unit session and a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information, wherein the list comprises a session identifier of a second protocol data unit session.

According to some examples, the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform: sending a path switch request to the access and mobility management function before receiving the first acknowledgement message from the access and mobility management function.

According to some examples, the path switch request is an N2 path switch request.

According to some examples, the path switch request is sent during a handover of a user equipment from a source base station to a target base station.

According to some examples, the handover is an Xn handover.

According to some examples, the path switch request comprises an indication of whether or not the apparatus will accept a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information.

According to some examples, the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform: receiving, subsequent to receiving the first acknowledgement message from the access and mobility management function, a second acknowledgement message from the access and mobility management function; and wherein the second acknowledgement message comprises session information of the first protocol data unit session and session information of the second protocol data unit session.

According to some examples, the first protocol data unit session comprises Ultra Reliable Low Latency Communication data transmission.

According to some examples, the apparatus is a next generation radio access network node.

According to a eleventh aspect there is provided an apparatus comprising: circuitry for receiving a first acknowledgement message from an access and mobility management function; wherein the first acknowledgement message comprises information of a first protocol data unit session and a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information, wherein the list comprises a session identifier of a second protocol data unit session.

According to a twelfth aspect there is provided a method comprising: receiving a first acknowledgement message from an access and mobility management function; wherein the first acknowledgement message comprises information of a first protocol data unit session and a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information, wherein the list comprises a session identifier of a second protocol data unit session.

According to some examples, the method further comprises: sending a path switch request to the access and mobility management function before receiving the first acknowledgement message from the access and mobility management function.

According to some examples, the path switch request is an N2 path switch request.

According to some examples, the path switch request is sent during a handover of a user equipment from a source base station to a target base station.

According to some examples, the handover is an Xn handover.

According to some examples, the path switch request comprises an indication of whether or not the apparatus will accept a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information.

According to some examples, the method comprises: receiving, subsequent to receiving the first acknowledgement message from the access and mobility management function, a second acknowledgement message from the access and mobility management function; and wherein the second acknowledgement message comprises session information of the first protocol data unit session and session information of the second protocol data unit session.

According to some examples, the first protocol data unit session comprises Ultra Reliable Low Latency Communication data transmission.

According to some examples, the method is performed by a next generation radio access network node.

According to a thirteenth aspect there is provided a computer program comprising instructions for causing an apparatus to perform at least the following: receiving a first acknowledgement message from an access and mobility management function; wherein the first acknowledgement message comprises information of a first protocol data unit session and a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information, wherein the list comprises a session identifier of a second protocol data unit session.

According to a fourteenth aspect there is provided a computer program comprising instructions stored thereon for performing at least the following: receiving a first acknowledgement message from an access and mobility management function; wherein the first acknowledgement message comprises information of a first protocol data unit session and a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information, wherein the list comprises a session identifier of a second protocol data unit session.

According to a fifteenth aspect there is provided a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following: receiving a first acknowledgement message from an access and mobility management function; wherein the first acknowledgement message comprises information of a first protocol data unit session and a list of protocol data unit sessions for which the access and mobility management function is waiting for

updated information, wherein the list comprises a session identifier of a second protocol data unit session.

According to an sixteenth aspect there is provided a non-transitory computer readable medium comprising program instructions stored thereon for performing at least the following: receiving a first acknowledgement message from an access and mobility management function; wherein the first acknowledgement message comprises information of a first protocol data unit session and a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information, wherein the list comprises a session identifier of a second protocol data unit session.

Brief description of Figures

The invention will now be described in further detail, by way of example only, with reference to the following examples and accompanying drawings, in which:

Figure 1 shows a schematic representation of part of a network;

Figure 2 shows a schematic representation of a method for data transmission;

Figure 3 shows a schematic representation of an apparatus according to an example;

Figure 4 shows a schematic representation of an apparatus according to an example;

Figure 5 shows a flow diagram of a method according to an example; and

Figure 6 shows a flow diagram of a method according to an example.

Detailed description

The present disclosure relates to wireless communications. More particularly, some examples relate to an apparatus, method and computer program for acknowledging changes in session information for one or more PDU sessions in a network while deferring acknowledging changes in other PDU sessions in the network,

In some telecommunications networks such as 5G networks, a UE having two or more established PDU sessions may be served by different SMFs. A PDU session usually belongs to one specific network slice instance per Public Land Mobile Network (PLMN). This is discussed, for example, in 3GPP, TS 23.501; System Architecture for the 5G System; Stage 2; Sections 5.6.1 and 5.15.1.

In 5G, edge computing is supported by the 5G Core Network (5GC) selecting a User Plane Function (UPF) close to a UE. This selection could be for providing a Local Area Data Network (LADN) service, for example. Edge computing may be considered to comprise a method of bringing computer data storage closer to the location where it is needed. For example, in a telecommunications network, computer data storage could be brought closer to a UE than in a centralised telecommunications network. In such cases, functionality provided near a UE at a network edge may be able to respond more quickly to changes in the state of the UE than functionality provided at a network core.

In some examples, other 5GC functions such as a SMF and Access and Mobility Management Function (AMF) could also be deployed close to a UE. The deployment of a SMF and AMF may depend on the expected UE mobility pattern.

In 5G, Ultra Reliable Low Latency Communication (URLLC) is a Slice/Service Type (SST). This is discussed, for example, in 3GPP, TS 23.501; System Architecture for the 5G System; Stage 2; Section 5.15.2.2. A URLLC transmission can be considered to be a latency critical transmission.

Figure 1 shows an example of part of a telecommunication network 100. In some examples, the network 100 is a 5G network. It will be understood that network 100 may also comprise various other components.

The network 100 may comprise a UE 101. The UE 101 may be connectable to gNBs 104a and 104b. Such a connection may be made over either interface 103a or interface 103b, for example. In some examples, interface 103a and/or interface 103b may be an air interface.

An interface 107 may be provided between gNB 104a and gNB 104b. In some examples, interface 107 may be an Xn interface. In some examples, a UE in the network may be connected to source gNB 104a and then handed over to target gNB 104b in a handover procedure. The handover procedure may comprise an Xn handover in some examples.

Each gNB 104a and 104b may be connected to an Access and Mobility Management Function (AMF) 105 via interfaces 113a and 113b. In some examples, interface 113a is an N2 interface. In some examples, interface 113b is an N2 interface.

As shown in Figure 1, Session Management Function (SMF) 111 may be connected to AMF 105. SMF 111 may also be connected to User Plane Function (UPF) 109. The network may comprise one or more other SMFs. In some examples, one or more SMFs in the network may be located at a network edge while one or more other SMFs in the network are not located at the network edge. In some examples, each PDU session for UE 101 may be managed by a different SMF.

UPF 109 may be connected to Radio Access Network (RAN) 115. As shown in the example of Figure 1, RAN 115 may comprise gNB 104a and gNB 104b.

Figure 2 shows an example message flow. Prior to step 221, a UE or other device may be connected to NG-RAN 215. NG-RAN 215 may comprise a target gNB and a source gNB for the handover of a device. For the purpose of explanation, a UE will be used as an example of a device connected to NG-RAN 215 in the following example, however it will be understood that in other examples a different device could be used.

In some examples, the UE connected to NG-RAN 215 will be served by a different SMF for each PDU session established for the UE. In the following example, it is assumed that the UE is served by SMF 211a for a first PDU session and by SMF 211b for a second PDU session. It will be understood, however, that the UE could have one or more PDU sessions established and could be served by a respective one or more SMFs, where the UE is served by a different SMF for each PDU session.

In some examples, the first PDU session comprises a latency critical PDU session. The first PDU session may comprise URLLC data transmissions. In some examples, SMF 211a is located at a network edge close to the UE.

In some examples, the second PDU session comprises a PDU session in which latency is not critical. The second PDU session may, in some examples, comprise non-URLLC data transmissions. In some examples, SMF 211b is located at a central site of a network, i.e. SMF 211b may not be located at the network edge.

At 221, NG-RAN 215 sends a path switch request to AMF 205. The path switch request may be sent as described in 3GPP TS 38.413, 3GPP TS 23.501 and 3GPP TS 23.502, for example. The path switch request may be caused by a UE handover between two or more base stations. The handover may be over an Xn interface from

a source gNB to a target gNB, such that the handover is an Xn handover. The two or more base stations may comprise one or more gNBs. In some examples, the path switch request comprises an N2 path switch request i.e. a request to switch from one N2 path to another N2 path. In some examples, NG-RAN 215 comprises one or more base stations. In some examples, NG-RAN 215 comprises one or more gNBs.

At step 222, AMF 205 sends a first PDU session update request for the first PDU session to SMF 211a. The first PDU session update request may comprise a Nsmf_PDUSession_UpdateSMContext Request as described in 3GPP TS 23.501 and 3GPP TS 23.502.

At step 222a, SMF 211a performs session modification and UPF tunnel management for the first PDU session. Example methods of session modification and UPF tunnel management are given in 3GPP TS 23.501 and 3GPP TS 23.502. SMF 211a may select a new UPF(s) for the first PDU session during this session modification.

At step 223, AMF 205 sends a second PDU session update request for the second PDU session to SMF 211b. AMF 205 may send the second PDU session update request at approximately the same time as the first PDU session update request. The second PDU session update request may comprise a Nsmf_PDUSession_UpdateSMContext Request as described in 3GPP TS 23.501 and 3GPP TS 23.502. The requests sent at steps 222 and 223 may, in some examples, be sent simultaneously or approximately simultaneously.

At step 223a, SMF 211b performs session modification and UPF tunnel management for the second PDU session. Example methods of session modification and UPF tunnel management are given in 3GPP TS 23.501 and 3GPP TS 23.502. SMF 211b may select a new UPF(s) for the second PDU session during this session modification.

At step 224, AMF 205 monitors for responses from SMFs 211a and 211b for the context request messages sent at 222 and 223. In some examples, AMF 205 monitors for Nsmf_PDUSession_UpdateSMContext Responses.

At step 225, AMF 205 receives a response to the request sent at 222. The response is received from SMF 211a. The response may comprise information regarding the first PDU session. The response may comprise a Nsmf_PDUSession_UpdateSMContext Response message for the first PDU session. The response sent at 225 may be received before the response sent at 227 because,

for example, SMF 211a may be located at a network edge while SMF 211b may be located at a central site (non-edge) site of a network.

At step 226, AMF 205 sends an acknowledgement to NG-RAN 215 for the path switch request sent at 221. In some examples, the acknowledgment may comprise an N2 Path Switch Request acknowledgement. In some examples, the acknowledgment is sent as soon as AMF 205 receives the response sent at step 225.

The acknowledgement may be sent to a target gNB of an Xn handover in NG-RAN 215.

The acknowledgement sent at 226 may comprise session information received at AMF 205 from SMF 211a for the first PDU session. The session information may be sent in a list. The list may be comprise a PDU Session Resource Switched List. In some examples, the PDU Session Resource Switched List may be considered as a PDU Session Resource Acknowledged List. The list may comprise session information for all PDU sessions for which the AMF 205 has received a PDU session update request response for.

The acknowledgment may also comprise a “PDU Session Resource Deferred List”. The PDU Session Resource Deferred List may comprise one or more PDU Session identifiers (IDs) for PDU sessions for which a response has not yet been received to the one or more PDU session update requests sent at 222 and 223. PDU sessions for which a response has not yet been received to the one or more PDU session update requests sent at 222 and 223, for example, can be considered to be “deferred” PDU sessions.

When receiving an acknowledgement comprising a PDU Session Resource Deferred List, NG-RAN 215 can prepare to wait for further acknowledgment messages to arrive. In some examples, a target gNB in NG-RAN 215 can preserve Xn user plane tunnelling via a source gNB of an Xn handover for a PDU session marked as deferred in the PDU Resource Deferred List.

A target gNB of an N2 handover may use a Security Context Information Element included in an N2 Path Switch Request Acknowledge message sent at 226 as defined in “3GPP TS 33.501; System Architecture and procedures for the 5G System; Stage 2”.

In the example of Figure 2, the PDU Session Resource Deferred List sent at 226 would comprise a session ID for a PDU session managed by SMF 211b. By sending a path switch request acknowledgment at 226 comprising session information

of the first PDU session, which may be a latency critical data session and/or a URLLC data transmission, it is not necessary to wait for a response for the second PDU session which may be non-latency critical and/or a non-URLLC data transmission.

After step 226, at 227 AMF 205 receives a subsequent response to the request sent at 223. The response may comprise information about the second PDU session. Although in the example of Figure 2 only SMF 211a and SMF 211b are shown, it will be understood that further SMFs other than SMF 211b may send responses after step 226.

After receiving the response at 227, AMF 205 may update the PDU Session Resource Switched List to include session information received from SMF 211b. AMF 205 may also update the PDU Session Resource Deferred List to remove the Session ID of the second PDU session.

At step 228, AMF 205 sends a second path switch request acknowledgement to NG-RAN 215. Step 228 may take place after one response subsequent to the response at received at 225 is received from a SMF (such as SMF 211b) in the network. Step 228 may take place after responses from all SMFs in a network are received. Step 228 may take place after a threshold number of responses from SMFs in the network are received.

The second patch switch request acknowledgement message may comprise an updated PDU Session Resource Deferred List and updated PDU Session Resource Switched List. The PDU Session Resource Switched List may comprise session information for the first and second PDU session. The PDU Session Resource Deferred List comprises PDU Session ID(s) for one or more PDU sessions for which AMF is still waiting for a response from. When AMF 205 has received a response from all SMFs in the network and/or when a response has been received for all PDU sessions for the NG-RAN 215, the PDU Session Resource Deferred List may comprise no session IDs.

Similarly to the first path switch request acknowledgement message sent at 226, the second path switch request acknowledgement message may comprise a Security Context Information Element that can be used by a target gNB of NG-RAN 215. In examples, the content of the Security Context Information element for the acknowledgement message sent at 228 is the same as the content of the Security Context Information element for the acknowledgement message sent at 226.

Upon receiving the second path switch request acknowledgement message at 228, wherein the second path switch request acknowledgement message comprises PDU Session Resource Switched List, the target gNB may check the PDU Session ID with a UE context that is maintained by the target gNB. In some examples, when the PDU Session Resource Switched List is included the target gNB will continue to use the Security Context received in the first path switch request acknowledgement message sent at 226. A security context included in the message sent by the AMF 205 at 226 may be the same as a security context sent by the AMF 205 at 228. The Security Context may be used as specified in 3GPP, TS 33.501. The Security Context can be used to derive (calculate) a security key at the target gNB.

Therefore, in some examples, when receiving subsequent path switch request acknowledgement messages after the first path switch request acknowledgement message received at 226, the security context from the first path switch request acknowledgement can be used to derive the security key at NG-RAN 215 for the subsequent path switch request acknowledgement messages. For example, the security context received at the NG-RAN 215 in step 226 could be used by a target gNB at step 228. This can prevent changes in Security Context such that the amount of computation at NG-RAN 215 in deriving security keys can be reduced.

In some examples, a security mode control procedure can be used after a final path switch is sent in order to change a security key. In some examples the final path switch may be an N2 path switch.

In some examples, NG-RAN 215 may indicate in a N2 Path Switch Request message sent at 221 that NG-RAN 215 will accept deferred PDU sessions by including an information element “Deferred PDU session capabilities”. In some examples, NG-RAN 215 may indicate in “Deferred PDU session capabilities” that it will not accept deferred PDU sessions. AMF 205 may use the absence of “Deferred PDU session capabilities” in N2 Path Switch Request message to detect that NG-RAN 215 either does not accept deferred PDU sessions or does not support “Deferred PDU session capabilities”. Alternatively, NG-RAN 215 may indicate its node level capability to support processing deferred PDU sessions to AMF 205 using a New Generation (NG) Setup Request message (as described in 3GPP; TS 38.413).

According to some examples described above, an AMF is provided with a mechanism in which the AMF can send acknowledgements to a NG-RAN node of

tunnel modifications made by a network edge SMF before acknowledging tunnel modifications made by a central SMF.

A possible wireless communication device will now be described in more detail with reference to Figure 3 showing a schematic, partially sectioned view of a communication device 300. Such a communication device is often referred to as user equipment (UE) or terminal. An appropriate mobile communication device may be provided by any device capable of sending and receiving radio signals. Non-limiting examples comprise a mobile station (MS) or mobile device such as a mobile phone or what is known as a 'smart phone', a computer provided with a wireless interface card or other wireless interface facility (e.g., USB dongle), personal data assistant (PDA) or a tablet provided with wireless communication capabilities, or any combinations of these or the like. A mobile communication device may provide, for example, communication of data for carrying communications such as voice, electronic mail (email), text message, multimedia and so on. Users may thus be offered and provided numerous services via their communication devices. Non-limiting examples of these services comprise two-way or multi-way calls, data communication or multimedia services or simply an access to a data communications network system, such as the Internet. Users may also be provided broadcast or multicast data. Non-limiting examples of the content comprise downloads, television and radio programs, videos, advertisements, various alerts and other information.

A wireless communication device may be for example a mobile device, that is, a device not fixed to a particular location, or it may be a stationary device. The wireless device may need human interaction for communication, or may not need human interaction for communication. In the present teachings the terms UE or "user" are used to refer to any type of wireless communication device.

The wireless device 300 may receive signals over an air or radio interface 307 via appropriate apparatus for receiving and may transmit signals via appropriate apparatus for transmitting radio signals. In Figure 3 transceiver apparatus is designated schematically by block 306. The transceiver apparatus 306 may be provided for example by means of a radio part and associated antenna arrangement. The antenna arrangement may be arranged internally or externally to the wireless device.

A wireless device is typically provided with at least one data processing entity 301, at least one memory 302 and other possible components 303 for use in software

and hardware aided execution of tasks it is designed to perform, including control of access to and communications with access systems and other communication devices. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. This feature is denoted by reference 304. The user may control the operation of the wireless device by means of a suitable user interface such as key pad 305, voice commands, touch sensitive screen or pad, combinations thereof or the like. A display 308, a speaker and a microphone can be also provided. Furthermore, a wireless communication device may comprise appropriate connectors (either wired or wireless) to other devices and/or for connecting external accessories, for example hands-free equipment, thereto. The communication devices 302, 304, 305 may access the communication system based on various access techniques.

Figure 4 shows an example of a control apparatus 400 for a communication system, for example to be coupled to and/or for controlling a station of an access system, such as a RAN node, e.g. a base station, gNB, a central unit of a cloud architecture or a node of a core network such as an MME or S-GW, a scheduling entity such as a spectrum management entity, or a server or host, or an IAB or relay node. Furthermore, the apparatus may be coupled to or be integrated with an AMF and/or SMF. The apparatus 400 may be coupled to an NG-RAN node, or to a part of a UPF. The control apparatus may be integrated with or external to a node or module of a core network or RAN. In some example embodiments, base stations comprise a separate control apparatus unit or module. In other example embodiments, the control apparatus can be another network element such as a radio network controller or a spectrum controller. In some example embodiments, each base station may have such a control apparatus as well as a control apparatus being provided in a radio network controller. The control apparatus 400 can be arranged to provide control on communications in the service area of the system. The control apparatus 400 comprises at least one memory 401, at least one data processing unit 402, 403 and an input/output interface 404. Via the interface the control apparatus can be coupled to a receiver and a transmitter of the base station. The receiver and/or the transmitter may be implemented as a radio front end or a remote radio head. For example the control apparatus 400 or processor 401 can be configured to execute an appropriate software code to provide the control functions.

Figure 5 is a flow chart of a method according to an example. The flow chart of Figure 5 is viewed from the perspective of an apparatus such as AMF 205, for example.

S501 comprises sending, to a first session management function, a first request to update information of a first protocol data unit session.

S502 comprises sending, to a second session management function, a second request to update information of a second protocol data unit session.

S503 comprises receiving a first response to the first request before receiving a second response to the second request.

S504 comprises sending a first acknowledgement message to a radio access network before receiving the response to the second request.

According to some examples of Figure 5, the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

Figure 6 is a flow chart of a method according to an example. The flow chart of Figure 6 is viewed from the perspective of an apparatus such as NG-RAN 215, for example. S601 comprises receiving a first acknowledgement message from an access and mobility management function. According to some examples, the first acknowledgement message comprises information of a first protocol data unit session and a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information, wherein the list comprises a session identifier of a second protocol data unit session.

In general, the various example embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects of the invention may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software,

firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

As used in this application, the term “circuitry” may refer 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) combinations of hardware circuits and software, such as (as applicable): (i) a combination of analog and/or digital hardware circuit(s) with software/firmware and (ii) any portions of hardware processor(s) with 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) hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor(s), that requires software (e.g., firmware) for operation, but the software may not be present when it is not needed for operation. 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 also covers an implementation of merely a hardware circuit or processor (or multiple processors) or portion of a hardware circuit or processor and its (or their) accompanying software and/or firmware. The term circuitry also covers, for example and if applicable to the particular claim element, a baseband integrated circuit or processor integrated circuit for a mobile device or a similar integrated circuit in server, a cellular network device, or other computing or network device.

The example embodiments of this invention may be implemented by computer software executable by a data processor of the mobile device, such as in the processor entity, or by hardware, or by a combination of software and hardware. Computer software or program, also called program product, including software routines, applets and/or macros, may be stored in any apparatus-readable data storage medium and they comprise program instructions to perform particular tasks. A computer program product may comprise one or more computer-executable components which, when the program is run, are configured to carry out example embodiments. The one or more computer-executable components may be at least one software code or portions of it.

Further in this regard it should be noted that any blocks of the logic flow as in the Figures may represent program steps, or interconnected logic circuits, blocks and functions, or a combination of program steps and logic circuits, blocks and functions. The software may be stored on such physical media as memory chips, or memory

blocks implemented within the processor, magnetic media such as hard disk or floppy disks, and optical media such as for example DVD and the data variants thereof, CD. The physical media is a non-transitory media.

The memory may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The data processors may be of any type suitable to the local technical environment, and may comprise one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs), application specific integrated circuits (ASIC), FPGA, gate level circuits and processors based on multi core processor architecture, as non-limiting examples.

Example embodiments of the inventions may be practiced in various components such as integrated circuit modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

The foregoing description has provided by way of non-limiting examples a full and informative description of the exemplary embodiment of this invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. However, all such and similar modifications of the teachings of this invention will still fall within the scope of this invention as defined in the appended claims. Indeed there is a further exemplary embodiments comprising a combination of one or more exemplary embodiments with any of the other exemplary embodiments previously discussed.

Claims

1. An apparatus comprising means for performing:

sending, to a first session management function, a first request to update information of a first protocol data unit session;

sending, to a second session management function, a second request to update information of a second protocol data unit session;

receiving a first response to the first request before receiving a second response to the second request;

sending a first acknowledgement message to a radio access network before receiving the response to the second request;

wherein the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

2. An apparatus according to any preceding claim, wherein the means are further configured to perform: receiving a path switch request from the radio access network before sending the first request and sending the second request.

3. An apparatus according to claim 2, wherein the path switch request is sent from the radio access network during a handover of a user equipment from a source base station to a target base station in the radio access network.

4. An apparatus according to any preceding claim, wherein the means are further configured to perform:

receiving, subsequent to sending the first acknowledgement message to the radio access network, the second response; and

sending a second acknowledgement message to the radio access network;

wherein the second acknowledgement message comprises session information of the first protocol data unit session received in the first response and session information of the second protocol data unit session received in the second response.

5. An apparatus according to any preceding claim, wherein the first protocol data unit session comprises Ultra Reliable Low Latency Communication data transmission.

6. An apparatus according to any preceding claim, wherein the first session management function is located at an edge of the radio access network and the second session management function is not located at an edge of the radio access network.

7. An apparatus according to any preceding claim, wherein the apparatus comprises an access and mobility management function.

8. An apparatus according to any of claims 1 to 7, wherein the means comprises:

at least one processor; and

at least one memory including computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the performances of the apparatus.

9. An apparatus comprising means for performing:

receiving a first acknowledgement message from an access and mobility management function;

wherein the first acknowledgement message comprises information of a first protocol data unit session and a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information, wherein the list comprises a session identifier of a second protocol data unit session.

10. An apparatus according to claim 9, wherein the means are further configured to perform: sending a path switch request to the access and mobility management function before receiving the first acknowledgement message from the access and mobility management function.

11. An apparatus according to claim 10, wherein the path switch request is sent during a handover of a user equipment from a source base station to a target base station.

12. An apparatus according to claim 10 or claim 11, wherein the path switch request comprises an indication of whether or not the apparatus will accept a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information.

13. An apparatus according to any of claims 9 to 12, wherein the means are further configured to perform:

receiving, subsequent to receiving the first acknowledgement message from the access and mobility management function, a second acknowledgement message from the access and mobility management function; and

wherein the second acknowledgement message comprises session information of the first protocol data unit session and session information of the second protocol data unit session.

14. An apparatus according to any of claims 9 to 13, wherein the first protocol data unit session comprises Ultra Reliable Low Latency Communication data transmission.

15. An apparatus according to any of claims 9 to 14, wherein the apparatus is a next generation radio access network node.

16. An apparatus according to any of claims 9 to 15, wherein the means comprises:

at least one processor; and

at least one memory including computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the performances of the apparatus.

17. A method comprising:

sending, to a first session management function, a first request to update information of a first protocol data unit session;

sending, to a second session management function, a second request to update information of a second protocol data unit session;

receiving a first response to the first request before receiving a second response to the second request;

sending a first acknowledgement message to a radio access network before receiving the response to the second request;

wherein the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

18. A method according to claim 17, wherein the method comprises: receiving a path switch request from the radio access network before sending the first request and sending the second request.

19. A method according to claim 18, wherein the path switch request is sent from the radio access network during a handover of a user equipment from a source base station to a target base station in the radio access network.

20. A method according to any of claims 17 to 19, wherein the method comprises:

receiving, subsequent to sending the first acknowledgement message to the radio access network, the second response; and

sending a second acknowledgement message to the radio access network;

wherein the second acknowledgement message comprises session information of the first protocol data unit session received in the first response and session information of the second protocol data unit session received in the second response.

21. A method according to any of claims 17 to 20, wherein the first protocol data unit session comprises Ultra Reliable Low Latency Communication data transmission.

22. A method according to any of claims 17 to 21, wherein the first session management function is located at an edge of the radio access network and the second session management function is not located at an edge of the radio access network.

23. A method according to any of claims 17 to 22, wherein the method is performed by an access and mobility management function.

24. A method comprising:

receiving a first acknowledgement message from an access and mobility management function;

wherein the first acknowledgement message comprises information of a first protocol data unit session and a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information, wherein the list comprises a session identifier of a second protocol data unit session.

25. A method according to claim 24, wherein the method further comprises: sending a path switch request to the access and mobility management function before receiving the first acknowledgement message from the access and mobility management function.

26. A method according to claim 25, wherein the path switch request is sent during a handover of a user equipment from a source base station to a target base station.

27. A method according to claim 25 or claim 26, wherein the path switch request comprises an indication of whether or not the apparatus will accept a list of protocol

data unit sessions for which the access and mobility management function is waiting for updated information.

28. A method according to any of claims 24 to 27, wherein the method comprises:

receiving, subsequent to receiving the first acknowledgement message from the access and mobility management function, a second acknowledgement message from the access and mobility management function; and

wherein the second acknowledgement message comprises session information of the first protocol data unit session and session information of the second protocol data unit session.

29. A method according to any of claims 24 to 28, wherein the first protocol data unit session comprises Ultra Reliable Low Latency Communication data transmission.

30. A method according to any of claims 24 to 29, wherein the method is performed by a next generation radio access network node.

31. A computer program comprising instructions for causing an apparatus to perform at least the following:

sending, to a first session management function, a first request to update information of a first protocol data unit session;

sending, to a second session management function, a second request to update information of a second protocol data unit session;

receiving a first response to the first request before receiving a second response to the second request;

sending a first acknowledgement message to a radio access network before receiving the response to the second request;

wherein the first acknowledgement message comprises session information of the first protocol data unit session received in the first response and a list of one or more protocol data unit sessions for which a response is yet to be received, wherein the list comprises a session identifier of the second protocol data unit session.

32. A computer program comprising instructions for causing an apparatus to perform at least the following:

receiving a first acknowledgement message from an access and mobility management function;

wherein the first acknowledgement message comprises information of a first protocol data unit session and a list of protocol data unit sessions for which the access and mobility management function is waiting for updated information, wherein the list comprises a session identifier of a second protocol data unit session.

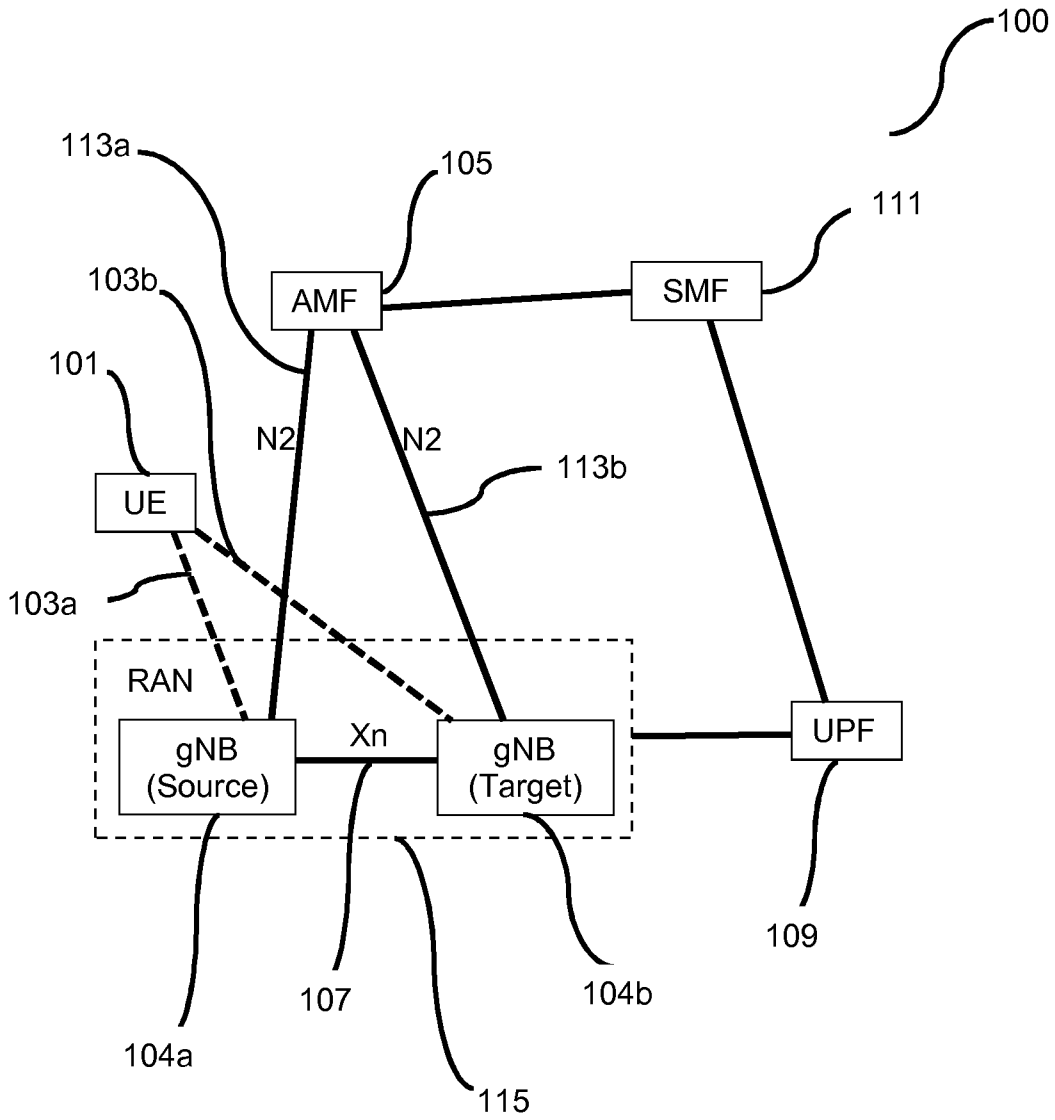
100
113a
105
111
103b
AMF
SMF
101
N2
N2
113b
UE
103a
RAN
gNB
(Source)
Xn
gNB
(Target)
UPF
109
104b
107
104a
115

Fig. 1

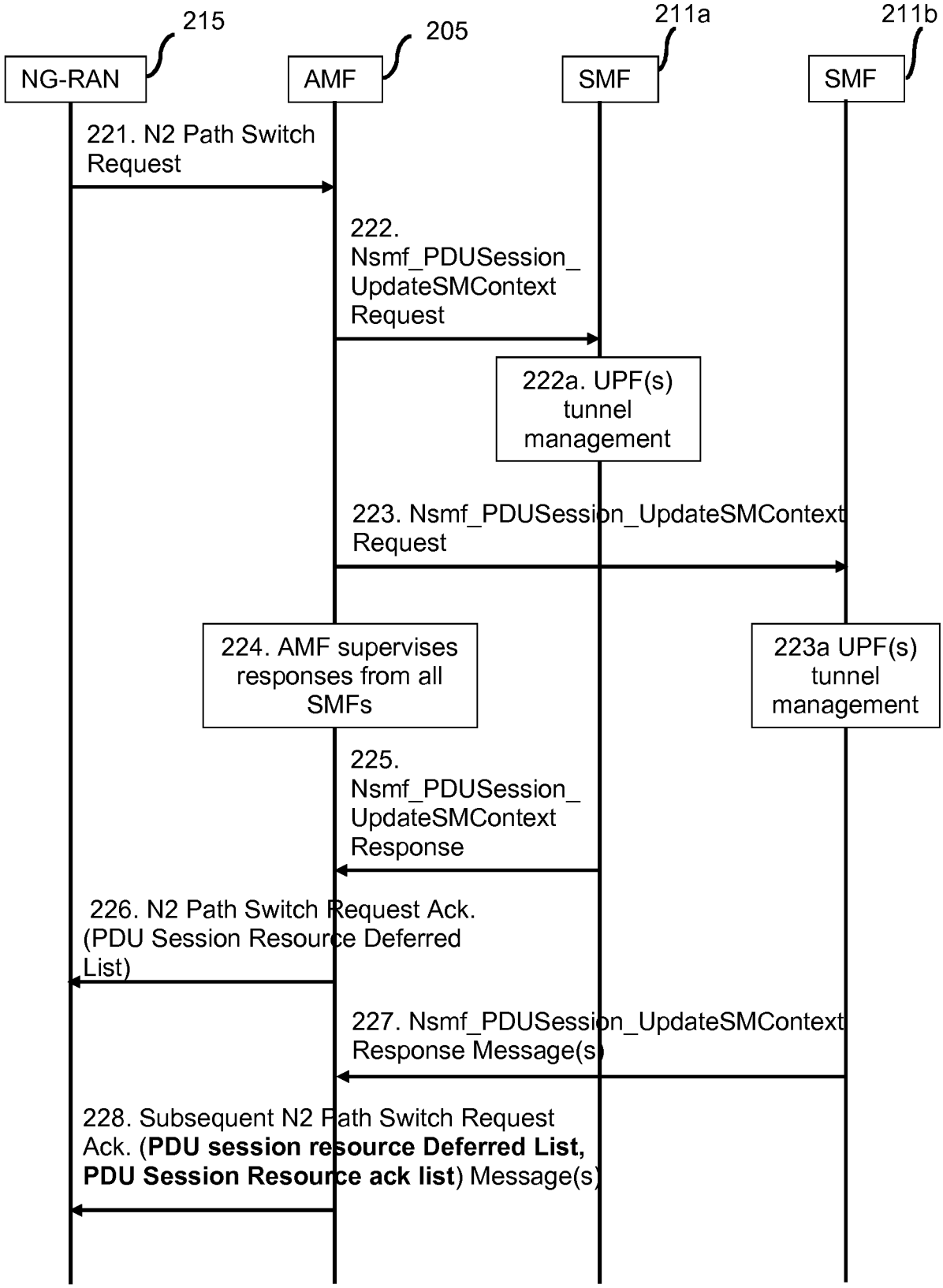
215
205
211a
211b
NG-RAN
AMF
SMF
SMF
221. N2 Path Switch Request
222. Nsmf_PDUSession_UpdateSMContext Request
222a. UPF(s) tunnel management
223. Nsmf_PDUSession_UpdateSMContext Request
224. AMF supervises responses from all SMFs
223a UPF(s) tunnel management
225. Nsmf_PDUSession_UpdateSMContext Response
226. N2 Path Switch Request Ack. (PDU Session Resource Deferred List)
227. Nsmf_PDUSession_UpdateSMContext Response Message(s)
228. Subsequent N2 Path Switch Request Ack. (**PDU session resource Deferred List, PDU Session Resource ack list**) Message(s)

Fig. 2

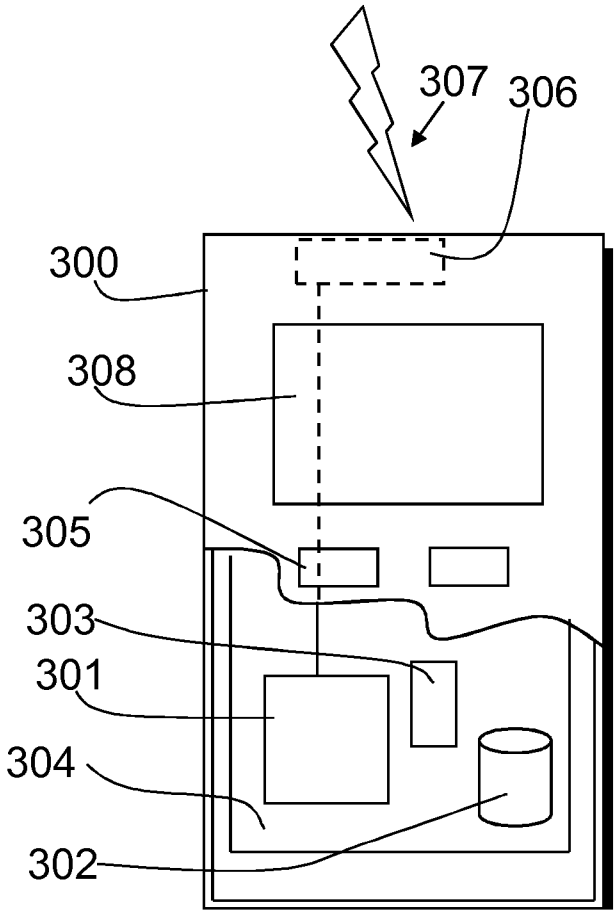

Figure 3

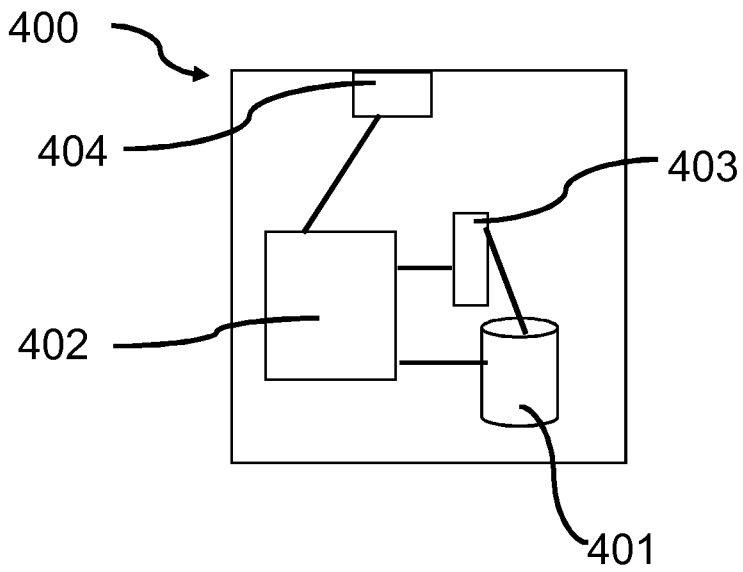

Figure 4

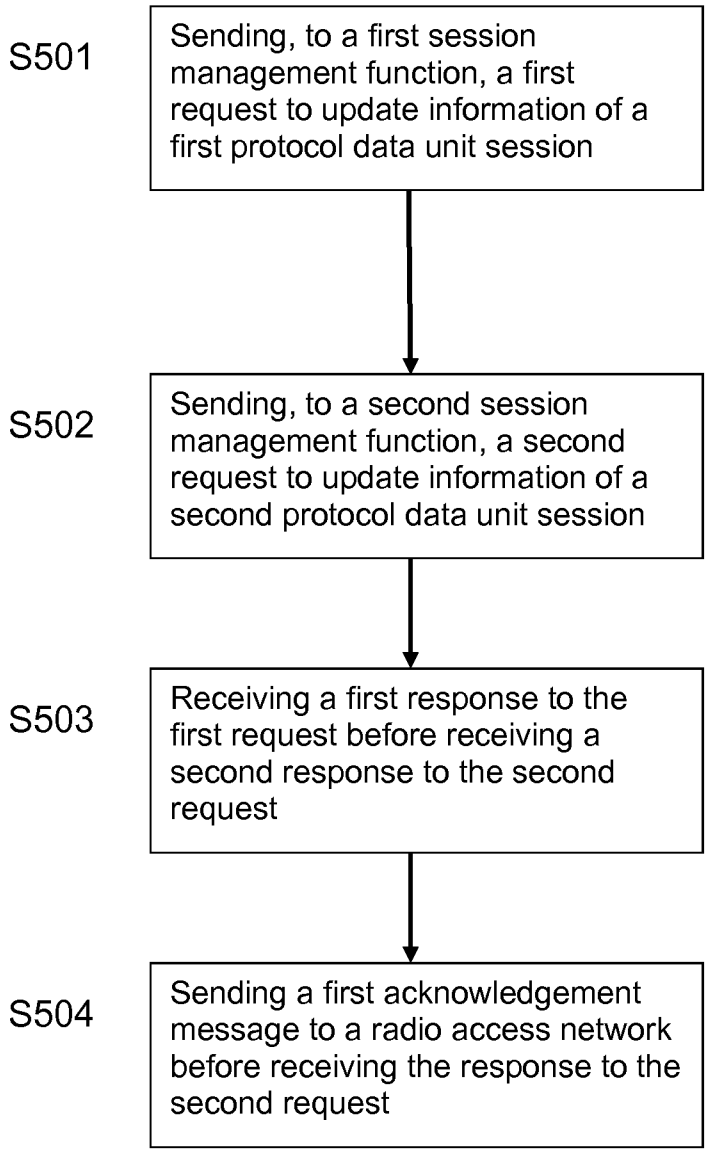
S501
Sending, to a first session management function, a first request to update information of a first protocol data unit session
S502
Sending, to a second session management function, a second request to update information of a second protocol data unit session
S503
Receiving a first response to the first request before receiving a second response to the second request
S504
Sending a first acknowledgement message to a radio access network before receiving the response to the second request

Figure 5

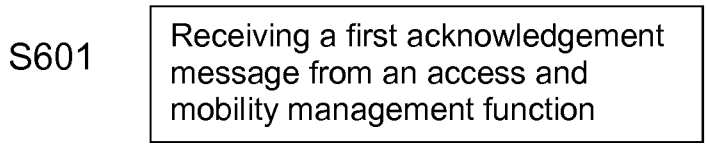
S601
Receiving a first acknowledgement message from an access and mobility management function

Figure 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/065111

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W36/00 H04W40/36
ADD.

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.
X Y	WO 2018/171916 A1 (ERICSSON TELEFON AB L M [SE]) 27 September 2018 (2018-09-27) page 10, line 5 - page 17, line 30; figures 3a,3b,3c	1,9,17, 24,31,32 2,3,5-8, 10,11, 14-16, 18,19, 21-23, 25,26, 29,30
A		4,12,13, 20,27,28

-/--

[X] Further documents are listed in the continuation of Box C.

[X] 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
17 July 2019	25/07/2019

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	Allot, Corentin

2

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Procedures for the 5G System; Stage 2 (Release 16)", 3GPP DRAFT; 23502-G02_MCC_CORRECTIONS, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. SA WG2 1 April 2019 (2019-04-01), XP051751807, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg%5Fsa/WG2%5FArch/Latest%5FSA2%5FSpecs/DRAFT%5FINTERIM/Archive/23502%2Dg02%5FMCC%5FCorrections%2Ezip [retrieved on 2019-04-01]	2,3,5-8, 10,11, 14-16, 18,19, 21-23, 25,26, 29,30
A	page 131 - page 140	1,4,9, 12,13, 17,20, 24,27, 28,31,32

A	US 2018/098251 A1 (LI XU [CA] ET AL) 5 April 2018 (2018-04-05) paragraphs [0142] - [0159]; figure 11	1-32

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2019/065111

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2018171916 A1	27-09-2018	NONE	
US 2018098251 A1	05-04-2018	CN 109792663 A	21-05-2019
		EP 3510809 A1	17-07-2019
		US 2018098251 A1	05-04-2018
		WO 2018059560 A1	05-04-2018