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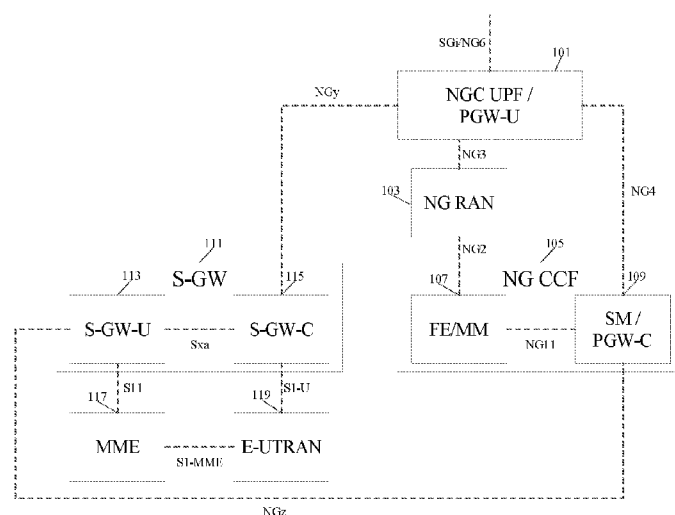


Figure 1

(57) Abstract: Using protocol data units as anchors for user equipment transitioning between a next generation system and evolved packet system may be useful in various communication systems. For example, user equipment may decision to transition between an evolved packet system and next generation system. The user equipment may send a request that causes a next generation core user plane function to begin buffering downlink protocol data units. The user equipment may then detach from the source system and attach to the target system.

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TITLE:

METHOD AND APPARATUS FOR INTERWORKING BETWEEN
SYSTEMS BASED ON SUSPENSION AND RESUMPTION INDICATIONS
FROM A TERMINAL

BACKGROUND:

Field:

[0001] Certain embodiments may relate to communication systems, and, for example, to network interworking.

Description of the Related Art:

[0002] During the early phase of a next generation system (NGS) deployment, it may be expected that any service area created by the NGS would not immediately replace any service area provided by an existing evolved packet system (EPS). Instead, there would be two service options for user equipment (UE) in overlapping NGS and EPS coverage areas. Since a NGS may be considered to have some benefits over a traditional EPS, for example, user experience and network management, it may be desired to prioritize the use of NGS over EPS for UE when both systems are available. However, service interruptions may arise when UE switches between these two systems, for example, when UE moves outside of a dual coverage area and into an EPS-only coverage area.

SUMMARY:

[0003] In accordance with an embodiment, there is a method that comprises determining, by a user equipment, that the user equipment should detach from a source system and attach to a target system. The method further comprises transmitting, by the user equipment, a mobility management request message to a network entity. The method further comprises detaching, by the user equipment, from the source system. The method further comprises attaching, by

the user equipment, to the target system.

[0004] In accordance with an embodiment, there is 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 are configured to, with the at least one processor, cause the apparatus to at least determine that the apparatus should detach from a source system and attach to a target system. The at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least transmit a mobility management request message to a network entity. The at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least receive a mobility management response message from the network entity. The at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least detach from the source system. The at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least attach to the target system.

[0005] In accordance with an embodiment, there is a method that comprises receiving, by a first network entity, a first session management request from a second network entity. The method further comprises buffering, by the first network entity, one or more downlink protocol data units for a user equipment and/or beginning, by the first network entity, a counter. The method further comprises transmitting, by the first network entity, a first session management response to the second network entity.

[0006] In accordance with an embodiment, there is 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 are configured to, with the at least one processor, cause the apparatus to at least receive a first session management request from a network entity. The at least one memory and the computer program code are further configured to, with the at least one

processor, cause the apparatus to at least buffer one or more downlink protocol data units for a user equipment and/or begin a counter. The at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least transmit a first session management response to the network entity.

[0007] In accordance with an embodiment, there is a method that comprises receiving, by a first network entity, a first request from a second network entity. The method further comprises transmitting, by the first network entity, a second request to a third network entity. The method further comprises receiving, by the first network entity, a first response from the third network entity. The method further comprises transmitting, by the first network entity, a second response to the second network entity.

[0008] In accordance with an embodiment, there is 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 are configured to, with the at least one processor, cause the apparatus to at least receive a first request from a first network entity. The at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least transmit a second request to a second network entity. The at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least receive a first response from the second network entity. The at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least transmit a second response to the first network entity.

[0009] In accordance with an embodiment, an apparatus can include means for determining that the apparatus should detach from a source system and attach to a target system. The apparatus can further include means for transmitting a mobility management request message to a network entity. The apparatus can further include means for detaching from the source system. The apparatus can

further include means for attaching to the target system.

[0010] In accordance with an embodiment, an apparatus can include means for receiving a first session management request from a network entity. The apparatus can further include means for buffering one or more downlink protocol data units for a user equipment and/or beginning a counter. The apparatus can further include means for transmitting a first session management response to the network entity.

[0011] In accordance with an embodiment, an apparatus can include means for receiving a first request from a first network entity. The apparatus can further include means for transmitting a second request to a second network entity. The method further comprises receiving a first response from the second network entity. The apparatus can further include means for transmitting a second response to the first network entity.

[0012] A non-transitory computer readable medium can, in certain embodiments, be encoded with instructions that, when executed in hardware, perform a process. The process can include a method according to any of the steps performed by any of the above discussed apparatuses.

[0013] A computer program product can, according to certain embodiments, encode instructions for performing a process. The process can include a method according to any of the steps performed by any of the above discussed apparatuses.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0014] For proper understanding of this disclosure, reference should be made to the accompanying drawings, wherein:

[0015] For proper understanding of this disclosure, reference should be made to the accompanying drawings, wherein:

[0016] Figure 1 illustrates an example of a system according to certain embodiments.

[0017] Figure 2 illustrates an example of a signal flow diagram according to certain embodiments.

[0018] Figure 3 illustrates another example of a signal flow diagram according to certain embodiments.

[0019] Figure 4 illustrates an example of a method performed by a user equipment according to certain embodiments.

[0020] Figure 5 illustrates another example of a method performed by a user equipment according to certain embodiments.

[0021] Figure 6 illustrates an example of a method performed by a network application function according to certain embodiments.

[0022] Figure 7 illustrates another example of a method performed by a network application function according to certain embodiments.

[0023] Figure 8 illustrates another example of a method performed by a network application function according to certain embodiments.

[0024] Figure 9 illustrates another example of a method performed by a network application function according to certain embodiments.

[0025] Figure 10 illustrates an example of a system according to certain embodiments.

[0026] Figure 11 illustrates an example of a system according to certain embodiments.

DETAILED DESCRIPTION:

[0027] The features, structures, or characteristics of certain embodiments described throughout this specification may be combined in any suitable manner in one or more embodiments. For example, the usage of the phrases “certain embodiments,” “some embodiments,” “other embodiments,” or other similar language, throughout this specification refers to the fact that a particular feature, structure, or characteristic described in connection with the embodiment may be included in at least one embodiment of the present invention. Thus, appearance

of the phrases “in certain embodiments,” “in some embodiments,” “in other embodiments,” or other similar language, throughout this specification does not necessarily refer to the same group of embodiments, and the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0028] For a UE capable of operating in both an EPS and a NGS, it may be assumed that the UE may not be registered in both systems simultaneously during normal operation to avoid inefficient use of network resources. During a transition, dual registration permits a UE to be registered simultaneously to both a NGS and an EPS, rather than requiring suspension in the source system and resumption in the target system. In dual registration, the UE session in the source system may be maintained until the session in the target system is established, which then triggers the release of the session in the target system. However, this presents a significant disadvantage in computer-related technology by consuming duplicative and unnecessary resources in both systems.

[0029] As discussed below, during the transition between EPS and NGS services, an NGS-EPS interworking mechanism may assist in providing service continuity. For example, during such a transition, a network entity may exist that serves as a protocol data unit (PDU) anchor in the path of the UE and remains unchanged throughout the transition. Thus, PDU sessions in the source system may be carried over into the target system.

[0030] Once the UE detaches from the source system, the target system may receive an indication that a particular PDU anchor should be selected, which the target system may select to continue the transition. This interworking between a source system and target system may be referred to as “loose interworking” because the system transition may be accomplished without any direct inter-core interaction for context transfer.

[0031] Thus, when a UE moves between the two systems, the UE may first detach locally from the source system, and then attach to the target system.

A brief time gap may occur between detaching from the source system and attaching to the target system, and issues may arise in delivering seamless service to the UE.

[0032] Thus, there is a need for a solution for supporting seamless service continuity when interworking between a source and target system which preserves the source system internet protocol (IP) address of a UE, while also avoiding the requirement of a control plane interface between the source system and the target system.

[0033] As will be discussed in detail below, during this time gap, a PDU anchor may serve to buffer downlink PDUs in order to deliver seamless service to the UE.

[0034] Certain embodiments may have various benefits and/or advantages. For example, certain embodiments may allow user equipment to transition between an EPS and a NGS without dual registration. Thus, certain embodiments are directed to improvements in computer-related technology, such as providing techniques to buffer downlink PDUs in order to deliver seamless service to the UE during a system transition. Furthermore, certain embodiments are directed to improvements in computer-related technology, such as minimizing waste of network and radio resources.

[0035] Figure 1 illustrates an example of a system according to certain embodiments. A system may include at least one or more of a next generation core user plane function/packet data network gateway-U (NGC UPF/PGW-U) 101, next generation radio access network (NG RAN) 103, next generation control plane function (NG CCF) 105, front end/mobility management (FE/MM) 107, session management/packet data network gateway-C (SM/PGW-C) 109, serving gateway (S-GW) 111, serving gateway-C (S-GW-C) 113, serving gateway-U (S-GW-U) 115, mobility management entity (MME) 117, and/or evolved universal mobile telecommunications system terrestrial radio access network (E-UTRAN) 119.

[0036] NGC UPF/PGW-U 101 may be in communication with SM/PGW-C 109

via a NG4 interface. NGC UPF/PGW-U 101 may also be in communication with S-GW-U 115 via inter-core interface NGy. Inter-core interface NGy may correspond to a S5/S8-U, with possible modifications, or a newly defined interface. NGC UPF/PGW-U 101 may also be in communication with NG RAN 103 via a NG3 interface. NGC UPF/PGW-U 101 may also communicate over a SGi/NG6 interface to a data network, such as the Internet. IP packets and/or PDUs may be transferred over a SGi/NG6 interface.

[0037] NG RAN 103 may also be in communication with FE/MM 107 via a NG2 interface. FE/MM 107 may also be in communication with SM/PGW-C 109 via a NG11 interface.

[0038] SM/PGW-C 109 may also be in communication with S-GW-C 113 via inter-core interface NGz. Inter-core interface NGz may correspond to a S5/S8-C, with possible modifications, or a newly defined interface. S-GW-C 113 may also communicate with S-GW-U 115 via a Sxa interface, as well as MME 117 via a S11 interface. E-UTRAN 119 may be in communication with MME 117 via S1-MME, as well as S-GW-U 115 via a S1-U interface.

[0039] In a transition from EPS to NGS, a UE may provide notification to NGC UPF/PGW-U 101 of the transition with a suspension notification passing from the UE to MME 117. MME 117 may pass the suspension notification to SGW 111, and SGW 111 may pass the suspension notification to NG CCF-SM/PGW-C 109. NG CCF-SM/PGW-C 109 may pass the suspension notification to NGC UPF/PGW-U 101. Upon receipt of the suspension notification, NGC UPF/PGW-U 101 may begin to buffer downlink PDUs for the UE, which suspends the PDU session of the UE.

[0040] Once the UE attaches to the NGS, the UE may provide NG CCF-FE/MM 107 with information regarding the NGC-SM 109 and NGC UPF/PGW-U 101 corresponding to the current UE session. This may result in NG CCF-SM 109 and NGC UPF/PGW-U 101 being selected after previously serving the UE. Additionally or alternatively, NGC UPF/PGW-U 101 may be notified of the resumption of a PDU session for the UE, and the buffered

downlink PDUs may be delivered to the UE via the target system. This resumption notification may be passed through the UE, NG CCF-SM 109, and then NGC UPF/PGW-U 101.

[0041] In a transition from NGS to EPS, a UE may provide notification to NGC UPF/PGW-U 101 of the transition with a suspension notification passing from the UE to NG CCF-SM 109. NG CCF-SM 109 may pass the suspension notification to NGC UPF/PGW-U 101. Upon receipt of the suspension notification, NGC UPF/PGW-U 101 may begin to buffer downlink PDUs for the UE, which may suspend the PDU session of the UE.

[0042] Once the UE attaches to the EPS, the UE may provide MME 117 information regarding the corresponding NGC-SM 109 and NGC UPF/PGW-U 101. This may result in NG CCF-SM 109 and NGC UPF/PGW-U 101 being selected after previously serving the UE. Additionally or alternatively, NGC UPF/PGW-U 101 may be notified of the resumption of a PDU session for the UE, and the buffered downlink PDUs may be delivered to the UE via the target system. This resumption notification may be passed through the UE, MME 117, SGW 111, NG CCF-SM 109, and NGC UPF/PGW-U 101.

[0043] Figure 2 illustrates an example of a signal flow diagram according to certain embodiments. For example, Figure 2 illustrates a NG CCF/PGW-C facilitating a call flow for handover from a next generation system (NGS) to an evolved packet system (EPS).

[0044] In step 201, a UE 230 may decide to change the serving system from a NGS to an EPS. In an embodiment, UE 230 may decide to change the serving system based on measurements related to an E-UTRAN 240, an evolved E-UTRAN (not shown), and/or a New Generation Radio Access Network 250.

[0045] In step 203, UE 230 may transmit a mobility management (MM) request message to a NG CCF-MM 260. The MM request message may include a suspension indication, which may be forwarded to NG CCF-SM 260. In step 205, NG CCF-SM 260 may transmit a Session Management

(SM) request message to NGC UPF/PGW-U 280. In an embodiment, NG CCF-SM 260 may also send the suspension indication received from UE 230 together with the SM Request message, or may send the suspension indication to NGC UPF/PGW-U 280, separately.

[0046] In step 207, if NGC UPF/PGW-U 280 receives one or more downlink protocol data unit (DL PDUs) from a data network, and the DL PDUs are determined to belong to the packet data network (PDN) connection and/or PDU session that may be transferred to the NGC, NGC UPF/PGW-U 280 may begin buffering downlink protocol data units (PDUs) for UE 230 while the PDU session for UE 230 is suspended. NGC UPF/PGW-U 280 may also begin a timer, countdown, and/or clock. NGC UPF/PGW-U 280 may resume the suspended UE session upon receiving a session resumption request or the timer expiring (not shown). If the SM request message received in step 205 includes a session deletion request, the session may be deleted if NGC UPF/PGW-U 280 does not receive a session resumption request and/or the timer expires (not shown).

[0047] In step 209, NGC UPF/PGW-U 280 may transmit a SM response message to NG CCF-MM 260. In an embodiment, the SM response message may include a timer expiration value corresponding to the timer begun by the NGC UPF/PGW-U 280. In step 211, NG CCF-SM 260 may transmit a MM response message to UE 230. In an embodiment, the MM response message may include a timer expiration value corresponding to the timer begun by the NGC UPF/PGW-U 280. In step 213, UE 230 may detach from the NGS. In step 215, UE 230 may transmit an attach/TAU request to MME 270. The attach/TAU request may include a handover indication.

[0048] If the attach/TAU request includes a handover indication, MME 270 may retrieve NG CCF-SM information from a HSS/NG-SDM (not shown) that allows the NG CCF-SM that has been serving UE 230 to be selected.

[0049] In step 217, MME 270 may transmit a SM request message to SGW 290 that includes NG CCF-SM information and/or a handover indication. In

step 219, SGW 290 may transmit a SM request message to NG CCF-SM 260. In an embodiment, the SM request message may include a handover indication. In step 221, NG CCF-SM 260 may determine whether the SM request message transmitted in step 219 includes a resumption indication. If NG CCF-SM 260 determines that a SM request message includes a resumption notification, NG CCF-SM 260 may retrieve session information of UE 230 and/or may modify the session information to comply with the NG quality of service (QoS) policy framework.

[0050] In step 223, NG CCF-SM 260 may retrieve information of NGC UPF/PGW-U 280 and send to NGC UPF/PGW-U 280 a SM request message that includes the resumption indication. NGC UPF/PGW-U 280 may also begin to send buffered downlink PDUs to NG RAN 250 (not shown).

[0051] In step 225, NGC UPF/PGW-U 280 may transmit a SM response message to NG CCF-SM 260. In step 227, NG CCF-SM 260 may transmit a SM response message to SGW 290. In step 229, SGW 290 may transmit a SM response message to MME 270. In step 231, MME 270 may transmit a MM Response message to UE 230. The MM response may include attach/TAU accept indications.

[0052] Figure 3 illustrates an example of a signal flow diagram according to certain embodiments. For example, Figure 3 illustrates a NG CCF/PGW-C facilitating a call flow for handover from an EPS to a NGS.

[0053] In step 301, a UE 330 may decide to change the serving system from an EPS to a NGS. For example, UE 330 may decide to change the serving system based on measurements related to an E-UTRAN 340, an evolved E-UTRAN (not pictured), and/or a New Radio 350. In step 303, UE 330 may transmit a mobility management (MM) request message to a MME 360. For example, the MM request message may include a tracking area update (TAU) request message. In an embodiment, the MM request message may include a suspension indication, an indication that U-plane connectivity should be preserved, and/or an indication that UE 330 will transition to

NGS.

[0054] Additionally or alternatively, UE 330 may utilize a UE-initiated detach procedure to provide a suspension notification to NGC UPF/PGW-U 390.

[0055] In step 305, MME 360 may transmit a session management (SM) request message to a serving gateway (SGW) 370. In an embodiment, the SM request message may be a SM message defined to deliver one or more indications of suspension and/or a modify bearer request message. Alternatively, if UE 330 utilized a UE-initiated detach procedure in step 303, the SM request message may be a delete session request message.

[0056] In step 307, SGW 370 may transmit the SM request message to a new generation control plane function (NG CCF)/packet data network gateway-C (PGW-C) 380. Alternatively, if UE 330 utilized a UE-initiated detach procedure in step 303, the SM request message may be a delete session request message.

[0057] In step 309, NG CCF/PGW-C 380 may transmit a notification to a next generation core user plane function (NGC UPF)/packet data network gateway-U (PGW-U) 390. In step 311, if NGC UPF/PGW-U 390 receives one or more DL PDUs from a data network, and the DL PDUs are determined to belong to the packet data network (PDN) connection and/or PDU session that may be transferred to the NGC, NGC UPF/PGW-U 390 may begin buffering DL PDUs for UE 330, while the PDU session for UE 330 is suspended. NGC UPF/PGW-U 390 may also begin a timer, countdown, and/or clock. NGC UPF/PGW-U 390 may resume the suspended UE session upon receiving a session resumption request or the timer expiring (not shown). However, if the MM request message of step 303 includes a detach request and/or the SM request messages of steps 305, 307, and/or 309 contain a delete session request, the session may be deleted if NGC UPF/PGW-U 390 does not receive a session resumption request and/or the timer expires (not shown).

[0058] In step 313, NGC UPF/PGW-U 390 may transmit a SM response

message to NG CCF/PGW-C 380. The SM response message may include a timer expiration value corresponding to the timer begun by the NGC UPF/PGW-U 390. Alternatively, if UE 330 utilized a UE-initiated detach procedure in step 303, the SM response message may be a delete session response message.

[0059] In step 315, NG CCF/PGW-C 380 may transmit the SM response message to SGW 370. Alternatively, if UE 330 utilized a UE-initiated detach procedure in step 303, the SM response message may be a delete session response message.

[0060] In step 317, SGW 370 may transmit the SM response message to MME 360. In step 319, MME 360 may transmit a MM response message to UE 330. In an embodiment, the MM response message may include the timer expiration value that indicates the time that the source system will maintain the U-plane connection, the timer begun by NGC UPF/PGW-U 390, and/or buffer the downlink packets.

[0061] In step 321, UE 330 may detach from the EPS. UE 330 may also select NR access and/or an evolved E-UTRAN. In some embodiments, UE 330 may select NR access and/or an evolved E-UTRAN based upon measurement results, access restriction status, and/or other criteria. In step 323, UE 330 may send a MM request message to NG CCF/PGW-C 380, which may include a registration request, an attach request, and/or a handover indication. In an embodiment, UE 330 may also send a SM request message to NG CCF/PGW-C 380, which may include a resumption indication. The SM request message may be sent together with the MM request message, or the SM request message may be sent separately from the MM request message.

[0062] In step 325, NG CCF/PGW-C 380 may determine whether a MM request message includes a handover indication. If NG CCF/PGW-C 380 determines that a MM request message includes a handover notification, NG CCF/PGW-C 380 may retrieve NG CCF SM information from a home subscriber server (HSS)/NG-subscriber data management (SDM) (not

shown) that allows the NG CCF-MM that has been serving UE 330 to be selected.

[0063] In the case of home-routed roaming, the NG CCF-MM may forward visited public land mobile network (VPLMN) NG CCF-SM information received from the HSS/NG-SDM to the NG CCF-SM in home public land mobile network (HPLMN). The NG CCF-SM in HPLMN may select the NG CCF-SM in VPLMN that has been servicing UE 330.

[0064] In step 327, NG CCF-SM may retrieve information of NG UPF/PGW-C 380. NG CCF-SM may also transmit a SM request message to NGC UPF/PGW-U 390. In step 329, NGC UPF/PGW-U 390 may determine whether the SM request message includes a resumption indication. If NGC UPF/PGW-U 390 determines that the SM request message includes a resumption indication, NGC UPF/CCF-SM (not shown) may retrieve session information for UE 330, and/or may modify the session information to comply with the NG quality of service (QoS) policy framework. NGC UPF/CCF-SM may retrieve information of NGC UPF/PGW-U 390 and send to NGC UPF/PGW-U 390 a SM request message that includes the resumption indication. NGC UPF/PGW-U 390 may also begin to send buffered downlink PDUs to NG RAN 350 (not shown). In step 331, NGC UPF/PGW-U 390 may send a SM response to SGW 370. In step 333, SGW 370 may transmit a MM response message and/or a SM response message to UE 330.

[0065] Figure 4 illustrates an example method of a UE transitioning from a NGS to an EPS. In step 401, a UE 430 may decide to change the serving system from a NGS to an EPS. UE 430 may decide to change the serving system based on measurements related to an E-UTRAN, an evolved E-UTRAN, and/or a New Radio. In step 403, UE 430 may transmit a mobility management (MM) request message to a NG CCF-MM 460. The MM request message may include a suspension indication, which may also be forwarded to CCF-SM.

[0066] In step 405, UE 430 may receive a MM response message from NG CCF 460. The MM response message may include a timer expiration value corresponding to a timer begun by NGC UPF/PGW-U 480. In step 407, UE 430 may detach from the NGS. In step 409, UE 430 may transmit an attach/TAU request to MME 470. The attach/TAU request may include a handover indication. In step 411, UE 430 may receive an MM response message from MME 470. The MM response may include attach/TAU accept indications.

[0067] Figure 5 illustrates an example method of a UE transitioning from an EPS to NGS. In step 501, a UE 530 may decide to change the serving system from an EPS to a NGS. UE 530 may decide to change the serving system based on measurements related to an E-UTRAN, an evolved E-UTRAN, and/or a New Radio. In step 503, UE 530 may transmit a MM request message to a MME 560. The MM request message may include a tracking area update (TAU) request message, a suspension indication, an indication that U-plane connectivity should be preserved, and/or an indication that UE 530 may transition to NGS. Additionally or alternatively, UE 530 may utilize a UE-initiated detach procedure to provide a suspension notification to NGC UPF/PGW-U 590.

[0068] In step 505, UE 530 may receive a MM response message from MME 560. The MM response message may include a timer expiration value that indicates the time that the source system will maintain the U-plane connection, the timer begun by a NGC UPF/PGW-U 590, and/or a time that NGC UPF/PGW-U 590 may begin to buffer downlink packets.

[0069] In step 507, UE 330 may detach from the EPS. UE 530 may also select NR access and/or an evolved E-UTRAN. In some embodiments, UE 530 may select NR access and/or an evolved E-UTRAN based upon measurement results, access restriction status, and/or other criteria. In step 509, UE 530 may send a MM request message to NG CCF/PGW-C 580, which may include a tracking area update (TAU) request message, a registration request, an attach

request, and/or a handover indication. UE 530 may also send a SM request message to NG CCF/PGW-C 580, which may include a resumption indication. The SM request message may be sent together with the MM request message, or the SM request message may be sent separately from the MM request message. In step 509, UE 530 may receive a MM response message and/or SM response message from SGW 570.

[0070] Figure 6 illustrates an example method of a next generation user plane function buffering downlink protocol data units. In step 601, NGC UPF/PGW-U 680 may receive a session management request message from NG CCF-SM 650. NGC UPF/PGW-U 680 may also receive suspension indication corresponding to UE 630 together with the SM request message, or may receive the suspension indication from NG CCF-SM 650 separately.

[0071] In step 603, if NGC UPF/PGW-U 680 receives one or more DL PDUs from a data network, and the DL PDUs are determined to belong to the packet data network (PDN) connection and/or PDU session that may be transferred to the NGC, NGC UPF/PGW-U 680 may begin buffering downlink PDUs for UE 630 while the PDU session for UE 630 is suspended. NGC UPF/PGW-U 680 may also begin a timer, countdown, and/or clock. NGC UPF/PGW-U 680 may resume the suspended UE session upon receiving a session resumption request or the timer expiring.

[0072] If the SM request message received in step 601 includes a session deletion request, the session may be deleted if NGC UPF/PGW-U 680 does not receive a session resumption request and/or the timer expires (not shown).

[0073] In step 605, NGC UPF/PGW-U 680 may transmit a SM response message to NG CCF-MM 660. The SM response message may include a timer expiration value corresponding to the timer begun by the NGC UPF/PGW-U 680.

[0074] In step 607, NGC UPF/PGW-U 680 may receive a SM request message that includes a resumption indication from NG CCF-SM 660. NGC

UPF/PGW-U 680 may also begin to send buffered downlink PDUs to NG RAN 650 (not shown). The buffered DL PDUs may be sent to NG RAN 650. In step 609, NGC UPF/PGW-U 680 may transmit a SM response message to NG CCF-SM 660.

[0075] Figure 7 illustrates an example method of a next generation user plane function buffering downlink protocol data units. In step 701, a next generation core user plane function (NGC UPF)/packet data network gateway-U (PGW-U) 790 may receive a message from NG CCF/PGW-C 780. The notification may include a session management request message. In step 703, if NGC UPF/PGW-U 790 receives one or more DL PDUs from a data network, and the DL PDUs are determined to belong to the packet data network (PDN) connection and/or PDU session that may be transferred to the NGC, NGC UPF/PGW-U 790 may begin buffering downlink protocol data units (PDUs) for UE 730, while the PDU session for UE 730 is suspended. NGC UPF/PGW-U 790 may also begin a timer, countdown, and/or clock. NGC UPF/PGW-U 790 may resume a suspended UE session upon receiving a session resumption request or the timer expiring (not shown). However, if the request message of step 701 includes a detach request and/or a delete session request, the session may be deleted if NGC UPF/PGW-U 790 does not receive a session resumption request and/or the timer expires (not shown).

[0076] In step 705, NGC UPF/PGW-U 790 may transmit a SM response message to NG CCF/PGW-C 780. The SM response message may include a timer expiration value corresponding to the timer begun by the NGC UPF/PGW-U 790. Alternatively, if the message in step 701 included a UE-initiated detach procedure, the SM response message may be a delete session response message.

[0077] In step 707, NGC UPF/PGW-U 790 may receive a second SM request message from NG CCF-SM. In step 709, NGC UPF/PGW-U 790 may determine whether the second SM request message includes a resumption indication. In step 711, If NGC UPF/PGW-U 790 determines that the second

SM request message includes a resumption indication, NGC UPF/PGW-U 790 may retrieve session information for UE 730, and/or may modify the session information to comply with the NG quality of service (QoS) policy framework. NGC UPF/PGW-U 790 may receive a SM request message that includes the resumption indication. NGC UPF/PGW-U 790 may also begin to send buffered downlink PDUs to NG RAN 750 (not shown).

[0078] In step 713, NGC UPF/PGW-U 790 may send a SM response to SGW 370.

[0079] Figure 8 illustrates an example method of a next generation control plane function retrieving user equipment session information.

[0080] In step 801, NG CCF 860 may receive a mobility management (MM) request message from UE 830. The MM request message may include a suspension indication, which may be forwarded to CCF-SM.

[0081] In step 803, NG CCF 860 may transmit a session management (SM) request message to NGC UPF/PGW-U 880. NG CCF 860 may also send the suspension indication received from UE 830 together with the SM request message, or may send the suspension indication to NGC UPF/PGW-U 880 separately.

[0082] In step 805, NG CCF 860 may receive a SM response message from NGC UPF/PGW-U 880. The SM response message may include a timer expiration value corresponding to the timer begun by NGC UPF/PGW-U 880.

[0083] In step 807, NG CCF 860 may transmit a MM response message to UE 830. The MM response message may include a timer expiration value corresponding to the timer begun by the NGC UPF/PGW-U 880.

[0084] In step 809, NG CCF 860 may receive a SM request message from SGW 890. The SM request message may include a handover indication. In step 811, NG CCF-SM 860 may determine whether the SM request message includes a resumption indication. If NG CCF 860 determines that a SM request message includes a resumption notification, NG CCF 860 may retrieve session

information of UE 830 and/or may modify the session information to comply with the NG QoS policy framework.

[0085] In step 813, NG CCF 860 may retrieve information of NGC UPF/PGW-U 880. In step 815, NG CCF 860 may send to NGC UPF/PGW-U 880 a SM request message that includes the resumption indication. In step 817, NG CCF 860 may receive a SM response message from NGC UPF/PGW-U 880. In step 819, NG CCF 860 may transmit a SM response message to SGW 890.

[0086] Figure 9 illustrates an example method of a next generation control plane function retrieving next generation control plane information. In step 901, a new generation control plane function (NG CCF)/packet data network gateway-C (PGW-C) 980 may receive a SM request message from SGW 970. Alternatively, if UE 930 utilized a UE-initiated detach procedure, the SM request message may be a delete session request message. In step 903, NG CCF/PGW-C 980 may transmit a notification to a next generation core user plane function (NGC UPF)/packet data network gateway-U (PGW-U) 990.

[0087] In step 905, NG CCF/PGW-C 980 may receive a SM response message from NGC UPF/PGW-U 990. The SM response message may include a timer expiration value corresponding to the timer begun by the NGC UPF/PGW-U 990. Alternatively, if UE 930 utilized a UE-initiated detach procedure, the SM response message may be a delete session response message.

[0088] In step 907, NG CCF/PGW-C 980 may transmit the SM response message to SGW 970. Alternatively, if UE 930 utilized a UE-initiated detach procedure, the SM response message may be a delete session response message.

[0089] In step 909, UE 930 may send a MM request message to NG CCF/PGW-C 980, which may include a registration request, an attach request, and/or a handover indication. NG CCF/PGW-C 980 may also receive a SM request message, which may include a resumption indication. The SM request message may be sent together with the MM request message, or the SM request message may be sent separately from the MM

request message.

[0090] In step 911, NG CCF/PGW-C 980 may determine whether a MM request message includes a handover indication. If NG CCF/PGW-C 980 determines that a MM request message includes a handover notification, NG CCF/PGW-C 980 may retrieve NG CCF SM information from a home subscriber server (HSS)/NG-subscriber data management (SDM) that allows the NG CCF-MM that has been serving UE 930 to be selected. In the case of home-routed roaming, the NG CCF-MM may forward visited public land mobile network (VPLMN) NG CCF-SM information received from the HSS/NG-SDM to the NG CCF-SM in home public land mobile network (HPLMN). The NG CCF-SM in HPLMN may select the NG CCF-SM in VPLMN that has been servicing UE 930.

[0091] In step 913, NG CCF 980 may retrieve NG CCF SM information. NG CCF 980 may also transmit a SM request message to NGC UPF/PGW-U 990.

[0092] Figure 10 illustrates a system according to certain embodiments. In one embodiment, a system may include multiple devices, such as, for example, network entity 1010. Network entity 1010 may include one or more of evolved universal mobile telecommunications system terrestrial radio access network (E-UTRAN), next generation radio access network (NG RAN), mobility management entity (MME), serving gateway (SGW), next generation control plane function-CM/packet data network gateway-C (NG CCF-CM/PGW-C), next generation control plane function-mobility management/packet data network gateway-C (NG CCF-MM/PGW-C), and/or next generation core user plane function/packet data network gateway-U (NGC UPF/PGW-U). A network entity may also include a base station, such as an evolved node B (eNB), a server, and/or other access node.

[0093] One or more of these devices may include at least one processor, respectively indicated as 1011. At least one memory may be provided in one or more of devices indicated at 1012. The memory may be fixed or removable.

The memory may include computer program instructions or computer code contained therein. Processor 1011 and memory 1012, or a subset thereof, may be configured to provide means corresponding to the various blocks of Figures 1 through 9. Although not shown, the devices may also include positioning hardware, such as global positioning system (GPS) or micro electrical mechanical system (MEMS) hardware, which may be used to determine a location of the device. Other sensors are also permitted and may be included to determine location, elevation, orientation, and so forth, such as barometers, compasses, and the like.

[0094] As shown in Figure 10, transceiver 1013 may be provided, and one or more devices may also include at least one antenna, respectively illustrated as 1014. The device may have many antennas, such as an array of antennas configured for multiple input multiple output (MIMO) communications, or multiple antennas for multiple radio access technologies. Other configurations of these devices, for example, may be provided.

[0095] Transceiver 1013 may be a transmitter, a receiver, or both a transmitter and a receiver, or a unit or device that may be configured both for transmission and reception.

[0096] Processor 1011 may be embodied by any computational or data processing device, such as a central processing unit (CPU), application specific integrated circuit (ASIC), or comparable device. The processors may be implemented as a single controller, or a plurality of controllers or processors.

[0097] Memory 1012 may independently be any suitable storage device, such as a non-transitory computer-readable medium. A hard disk drive (HDD), random access memory (RAM), flash memory, or other suitable memory may be used. The memories may be combined on a single integrated circuit as the processor, or may be separate from the one or more processors. Furthermore, the computer program instructions stored in the memory and which may be processed by the processors may be any suitable form of computer program code, for example, a compiled or interpreted

computer program written in any suitable programming language.

[0098] The memory and the computer program instructions may be configured, with the processor for the particular device, to cause a hardware apparatus such as E-UTRAN, NG RAN, MME, SGW, NG CCF-CM/PGW-C, NG CCF-MM/PGW-C, and NGC UPF/PGW-C, to perform any of the processes described below (see, for example, Figures 1-9). Therefore, in certain embodiments, a non-transitory computer-readable medium may be encoded with computer instructions that, when executed in hardware, perform a process such as one of the processes described herein. Alternatively, certain embodiments may be performed entirely in hardware.

[0099] Figure 11 illustrates a system according to certain embodiments. In one embodiment, a system may include multiple devices, such as, for example, user equipment 1110. User equipment 1110 may include at least one processor, respectively indicated as 1111. At least one memory may be provided in one or more of user equipment indicated at 1112. The memory may be fixed or removable. The memory may include computer program instructions or computer code contained therein. Processor 1111 and memory 1112, or a subset thereof, may be configured to provide means corresponding to the various blocks of Figures 1 through 9. Although not shown, user equipment may also include positioning hardware, such as global positioning system (GPS) or micro electrical mechanical system (MEMS) hardware, which may be used to determine a location of the device. Other sensors are also permitted and may be included to determine location, elevation, orientation, and so forth, such as barometers, compasses, and the like.

[0100] As shown in Figure 11, transceiver 1113 may be provided, and user equipment may also include at least one antenna, respectively illustrated as 1114. User equipment may have many antennas, such as an array of antennas configured for multiple input multiple output (MIMO) communications, or multiple antennas for multiple radio access technologies. Other configurations of user equipment, for example, may be provided.

[0101] Transceiver 1113 may be a transmitter, a receiver, or both a transmitter and a receiver, or a unit or device that may be configured both for transmission and reception.

[0102] Processor 1111 may be embodied by any computational or data processing device, such as a central processing unit (CPU), application specific integrated circuit (ASIC), or comparable device. The processors may be implemented as a single controller, or a plurality of controllers or processors.

[0103] Memory 1112 may independently be any suitable storage device, such as a non-transitory computer-readable medium. A hard disk drive (HDD), random access memory (RAM), flash memory, or other suitable memory may be used. The memories may be combined on a single integrated circuit as the processor, or may be separate from the one or more processors. Furthermore, the computer program instructions stored in the memory and which may be processed by the processors may be any suitable form of computer program code, for example, a compiled or interpreted computer program written in any suitable programming language.

[0104] The memory and the computer program instructions may be configured, with the processor for the particular device, to cause a hardware apparatus such as user equipment to perform any of the processes described above (see, for example, Figures 1-9). Therefore, in certain embodiments, a non-transitory computer-readable medium may be encoded with computer instructions that, when executed in hardware, perform a process such as one of the processes described herein. Alternatively, certain embodiments may be performed entirely in hardware.

[0105] One having ordinary skill in the art will readily understand that certain embodiments discussed above may be practiced with steps in a different order, and/or with hardware elements in configurations which are different than those which are disclosed. Therefore, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope

of the invention. In order to determine the metes and bounds of the invention, therefore, reference should be made to the appended claims.

[0106] Partial Glossary

[0107]	RFC	Request for Comments
[0108]	3GPP	3rd Generation Partnership Project
[0109]	4G	Fourth Generation
[0110]	5G	Fifth Generation
[0111]	CCF	Control Plane Function
[0112]	DL	Downlink
[0113]	EMM	Evolved Packet System Mobility Management
[0114]	EPC	Evolved Packet Core
[0115]	EPS	Evolved Packet System
[0116]	E-UTRAN	Evolved Universal Mobile Telecommunications System Terrestrial Radio Access Network
[0117]	FE	Front End
[0118]	GPRS	General Packet Radio Service
[0119]	HPLMN	Home Public Land Mobile Network
[0120]	HSS	Home Subscriber Server
[0121]	IMS	IP Multimedia Subsystem
[0122]	IP	Internet Protocol
[0123]	LTE	Long-Term Evolution
[0124]	MM	Mobility Management
[0125]	MME	Mobility Management Entity
[0126]	NAS	Non-Access Stratum
[0127]	NG	Next Generation
[0128]	NGC	Next Generation Core
[0129]	NGS	Next Generation System
[0130]	NG-SDM	New Generation Subscriber Data Management
[0131]	NGy	Inter-core interface between NGC UPF/PGW-U and U

[0132]	NGz	Inter-core interface between SM/PGW-C and C
[0133]	NR	New Radio
[0134]	PDN	Packet Data Network
[0135]	PDU	Protocol Data Unit
[0136]	PGW	Packet Data Network Gateway
[0137]	PGW-C	Protocol Data Network Gateway Control Plane Function
[0138]	PGW-U	Protocol Data Network Gateway User Plane Function
[0139]	PLMN	Public Land Mobile Network
[0140]	QoS	Quality of Service
[0141]	RAN	Radio Access Network
[0142]	SDM	Subscriber Data Management
[0143]	SGi	Reference point between Packet Data Network Gateway and Packet Data Network
[0144]	SGW	Serving Gateway
[0145]	SM	Session Management
[0146]	TAU	Tracking Area Update
[0147]	UE	User Equipment
[0148]	UMTS	Universal Mobile Telecommunications System
[0149]	UPF	User Plane Function
[0150]	VPLMN	Visited Public Land Mobile Network

WE CLAIM:

1. A method, comprising:

determining, by a user equipment, that the user equipment should detach from a source system and attach to a target system;

transmitting, by the user equipment, a mobility management request message to a network entity;

receiving, by the user equipment, a mobility management response message from the network entity;

detaching, by the user equipment, from the source system; and

attaching, by the user equipment, to the target system.

2. The method according to claim 1, wherein the source system is an evolved packet system, the target system is a next generation system, and the network entity is a mobility management entity.

3. The method according to claim 1, wherein the source system is a next generation system, the target system is an evolved packet system, and the network entity is a next generation control plane function with packet data network gateway.

4. The method according to any of claims 1-3, wherein determining that the user equipment should detach from the source system and attach to the target system is based, at least, upon measurements related to an E-UTRAN,

measurements related to an evolved E-UTRAN, and/or measurements related to a new radio access network.

5. The method according to any of claims 1-4, wherein the mobility management request message includes one or more of a tracking area update request message, a suspension indication, an indication that U-plane connectivity should be preserved, and/or an indication that the user equipment will transition to the target system.

6. The method according to any of claims 1-5, wherein the user equipment transmits a user equipment-initiated detach procedure to the network entity to provide a suspension notification to the network entity.

7. The method according to any of claims 1-6, wherein the mobility management response message includes one or more of an expiration time value that indicates the time that the source system will maintain the U-plane connection, a counter begun by a next generation core user plane function, and/or a time that a next generation core user plane function will buffer downlink packets.

8. The method according to any of claims 1-2 or 4-7, wherein the user equipment transmits a second mobility management request message and/or a

session management request message to a next generation control plane function.

9. The method according to any of claims 1 or 3-8, wherein the user equipment transmits a second mobility management request message to a mobility management entity, wherein the second mobility management request message includes one or more of a registration request, an attach request, a tracking area update request, and/or a handover indication.

10. An apparatus, comprising:

at least one processor; and

at least one memory including computer program code,

wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to at least:

determine that the apparatus should detach from a source system and attach to a target system;

transmit a mobility management request message to a network entity;

receive a mobility management response message from the network entity;

detach from the source system; and

attach to the target system.

11. The apparatus according to claim 10, wherein the source system is an evolved packet system, the target system is a next generation system, and the network entity is a mobility management entity.

12. The apparatus according to claim 10, wherein the source system is a next generation system, the target system is an evolved packet system, and the network entity is a next generation control plane function with packet data network gateway.

13. The apparatus according to any of claims 10-12, wherein determining that the apparatus should detach from the source system and attach to the target system is based, at least, upon measurements related to an E-UTRAN, measurements related to an evolved E-UTRAN, and/or measurements related to a new radio access network.

14. The apparatus according to any of claims 10-13, wherein the mobility management request message includes one or more of a tracking area update request message, a suspension indication, an indication that U-plane connectivity should be preserved, and/or an indication that the apparatus will transition to the target system.

15. The apparatus according to any of claims 10-14, wherein the at least

one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least:

transmit an apparatus-initiated detach procedure to the network entity to provide a suspension notification to the network entity.

16. The apparatus according to any of claims 10-15, wherein the mobility management response message includes one or more of an expiration time value that indicates the time that the source system will maintain the U-plane connection, a counter begun by a next generation core user plane function, and/or a time that a next generation core user plane function will buffer downlink packets.

17. The apparatus according to any of claims 10-11 or 13-16, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least:

transmits a second mobility management request message, wherein the second mobility management request message includes one or more of a registration request, an attach request, and/or a handover indication.

18. The apparatus according to any of claims 10 or 12-17, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least:

transmit a second mobility management request message to a mobility management entity, wherein the second mobility management request message includes one or more of a registration request, an attach request, a tracking area update request, and/or a handover indication.

19. A method, comprising:

receiving, by a first network entity, a first session management request from a second network entity;

buffering, by the first network entity, one or more downlink protocol data units for a user equipment and/or beginning, by the first network entity, a counter; and

transmitting, by the first network entity, a first session management response to the second network entity.

20. The method according to claim 19, wherein the first network entity is a next generation user plane function, and the second network entity is a next generation control plane function.

21. The method according to any of claims 19-20, wherein the first session management response includes an indication of the counter.

22. The method according to any of claims 19-21, wherein the counter is

at least one of a timer, a countdown, and/or a clock.

23. The method according to any of claims 19-22, further comprising:

receiving, by the first network entity, a second session management request from the second network entity;

determining, by the first network entity, whether the second session management request contains a resumption indication; and

in response to the first network entity determining that the second session management request contains a resumption indication, retrieving, by the first network entity, session information relating to one or more user equipment.

24. The method according to any of claims 19-23, wherein the first network entity transmits a second session management response to a serving gateway.

25. The method according to any of claims 19-24, wherein the first network entity transmits a second session management response to the second network entity.

26. An apparatus, comprising:

at least one processor; and

at least one memory including computer program code,

wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to at least:

receive a first session management request from a network entity;

buffer one or more downlink protocol data units for a user equipment and/or begin a counter; and

transmit a first session management response to the network entity.

27. The apparatus according to claim 26, wherein the apparatus is a next generation user plane function, and the network entity is a next generation control plane function.

28. The apparatus according to any of claims 26-27, wherein the first session management response includes an indication of the counter.

29. The apparatus according to any of claims 26-28, wherein the counter is at least one of a timer, a countdown, and/or a clock.

30. The apparatus according to any of claims 26-29, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least:

receive a second session management request from the network entity;

determine whether the second session management request contains a

resumption indication; and

in response to the apparatus determining that the second session management request contains a resumption indication, retrieve session information relating to one or more user equipment.

31. The apparatus according to any of claims 26-30, wherein the apparatus transmits a second session management response to a serving gateway.

32. The apparatus according to any of claims 26-31, wherein the apparatus transmits a second session management response to the network entity.

33. A method, comprising:

receiving, by a first network entity, a first request from a second network entity;

transmitting, by the first network entity, a second request to a third network entity;

receiving, by the first network entity, a first response from the third network entity; and

transmitting, by the first network entity, a second response to the second network entity.

34. The method according to claim 33, wherein the first network entity is a next generation control plane function, the second network entity is a serving gateway, the third network entity is a next generation user plane function, the first request is a session management request, and the first response is a session management response.

35. The method according to claim 33, wherein the first network entity is a next generation control plane function, the second network entity is a user equipment, the third network entity is a next generation user plane function, the first request is a mobility management request, the second request is a session management request, the first response is a session management response, and the second response is a mobility management response.

36. The method according to any of claims 33-34, further comprising:

receiving, by the next generation control plane function, in response to transmitting the first response to the serving gateway, a mobility management request message and/or a session management request message from a user equipment;

determining, by the next generation control plane function, whether the mobility management request contains a handover indication;

in response to the next generation control plane function determining that

the mobility management request contains a handover indication, retrieving, by the next generation control plane function, next generation control plane function session management information; and

transmitting, by the next generation control plane function, a second session management request to the next generation user plane function.

37. The method according to any of claims 33-34 or 36, wherein the next generation control plane function session management information is retrieved from a home subscriber server.

38. The method according to any of claims 33 or 35, further comprising:

receiving, by the next generation control plane function, in response to transmitting the second response, a second session management request from a serving gateway;

determining, by the next generation control plane function, whether the second session management request contains a resumption indication;

in response to the next generation control plane function determining that the second session management request contains a resumption indication, retrieving, by the next generation control plane function, user equipment session information; and

transmitting, by the next generation control plane function, the second session management request to the next generation user plane function.

39. The method according to any of claims 33, 35, or 38, wherein the user equipment session information is retrieved from a home subscriber server.

40. An apparatus, comprising:
at least one processor; and
at least one memory including computer program code,
wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to at least:
receive a first request from a first network entity;
transmit a second request to a second network entity;
receive a first response from the second network entity; and
transmit a second response to the first network entity.

41. The apparatus according to claim 40, wherein the apparatus is a next generation control plane function, the first network entity is a serving gateway, the second network entity is a next generation user plane function, the first request and second request are session management requests, and the first response and second response are session management responses.

42. The apparatus according to claim 40, wherein the apparatus is a next generation control plane function, the first network entity is a user equipment,

the second network entity is a next generation user plane function, the first request is a mobility management request, the second request is a session management request, the first response is a session management response, and the second response is a mobility management response.

43. The apparatus according to any of claims 40-41, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least:

in response to transmitting the second response to the serving gateway, receive a mobility management request message and/or a session management request message from a user equipment;

determine whether the mobility management request contains a handover indication;

in response to the next generation control plane function determining that the mobility management request contains a handover indication, retrieve next generation control plane function session management information; and

transmit a second session management request to the next generation user plane function.

44. The apparatus according to any of claims 40-41 or 43, wherein the next generation control plane function session management information is retrieved from a home subscriber server.

45. The apparatus according to any of claims 40 or 42, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to at least:

in response to transmitting the second response, receive a second session management request from a serving gateway;

determine whether the second session management request contains a resumption indication;

in response to the next generation control plane function determining that the second session management request contains a resumption indication, retrieve user equipment session information; and

transmit the second session management request to the next generation user plane function.

46. The apparatus according to any of claims 40, 42, or 45, wherein the user equipment session information is retrieved from a home subscriber server.

47. A non-transitory computer-readable medium encoding instructions that, when executed in hardware, perform a process according to any of claims 1-46.

48. An apparatus comprising means for performing a process

according to any of claims 1-46.

49. A computer program product encoding instructions for performing a process according to any of claims 1-46.

50. A computer program product embodied in a non-transitory computer-readable medium and encoding instructions that, when executed in hardware, perform a process, the process according to claim 1-46.

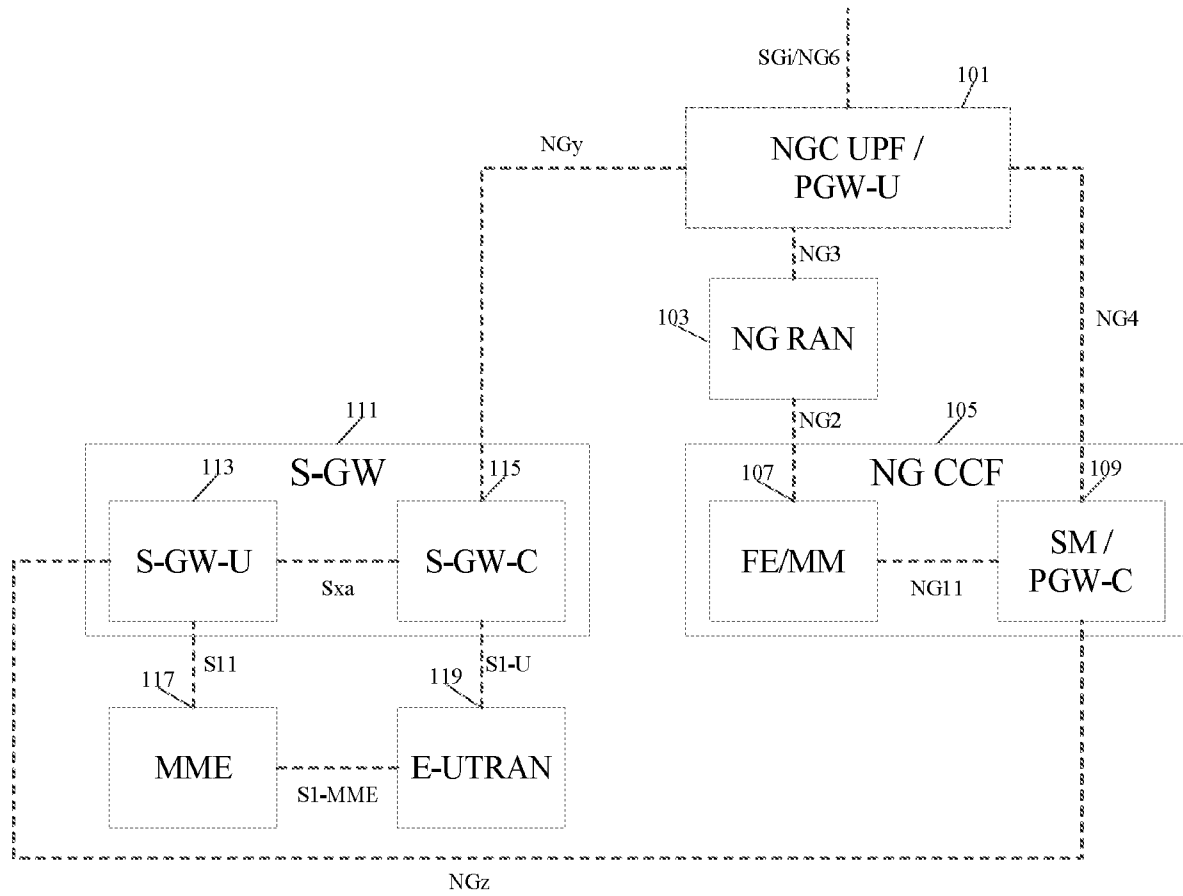


Figure 1

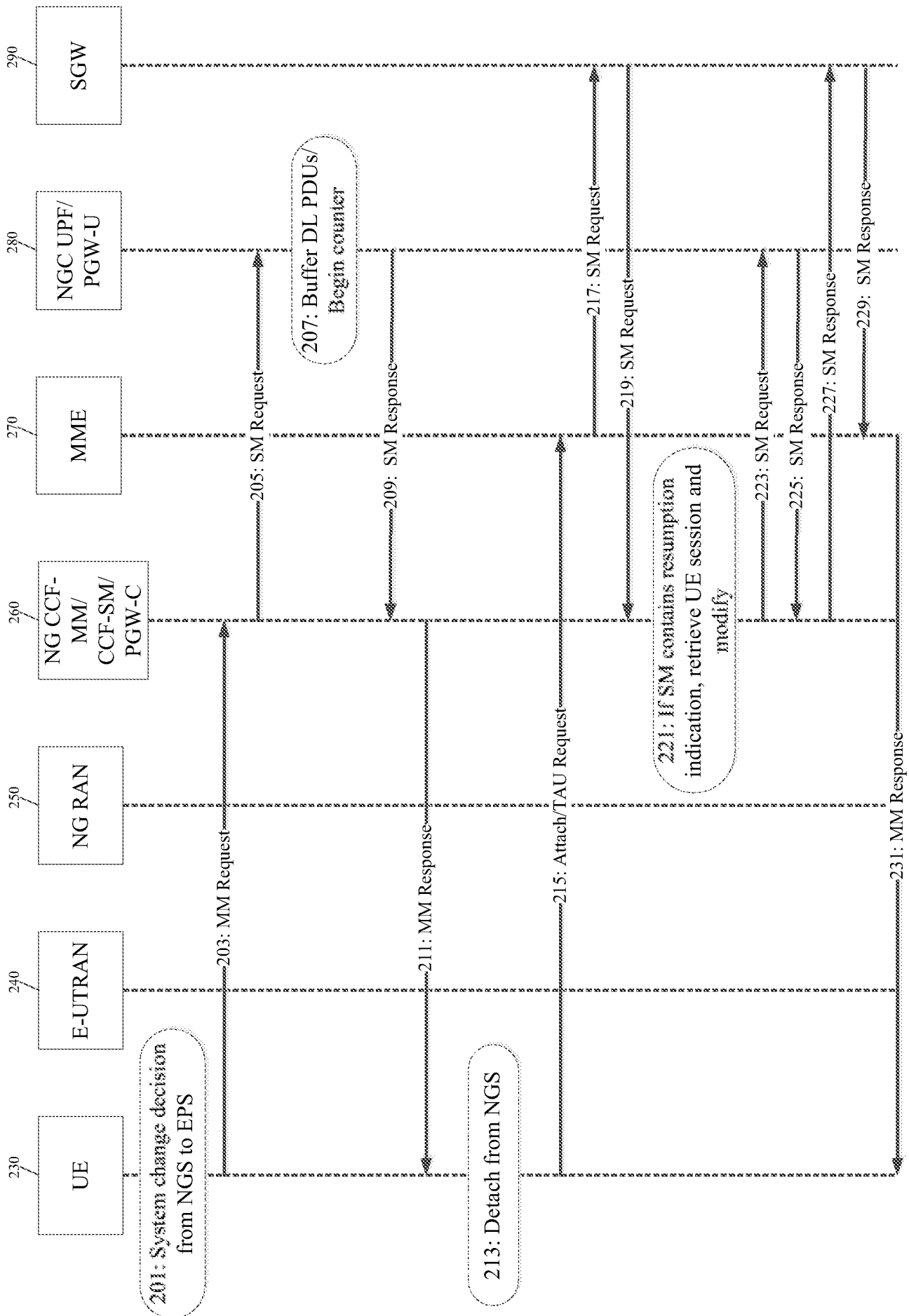


Figure 2

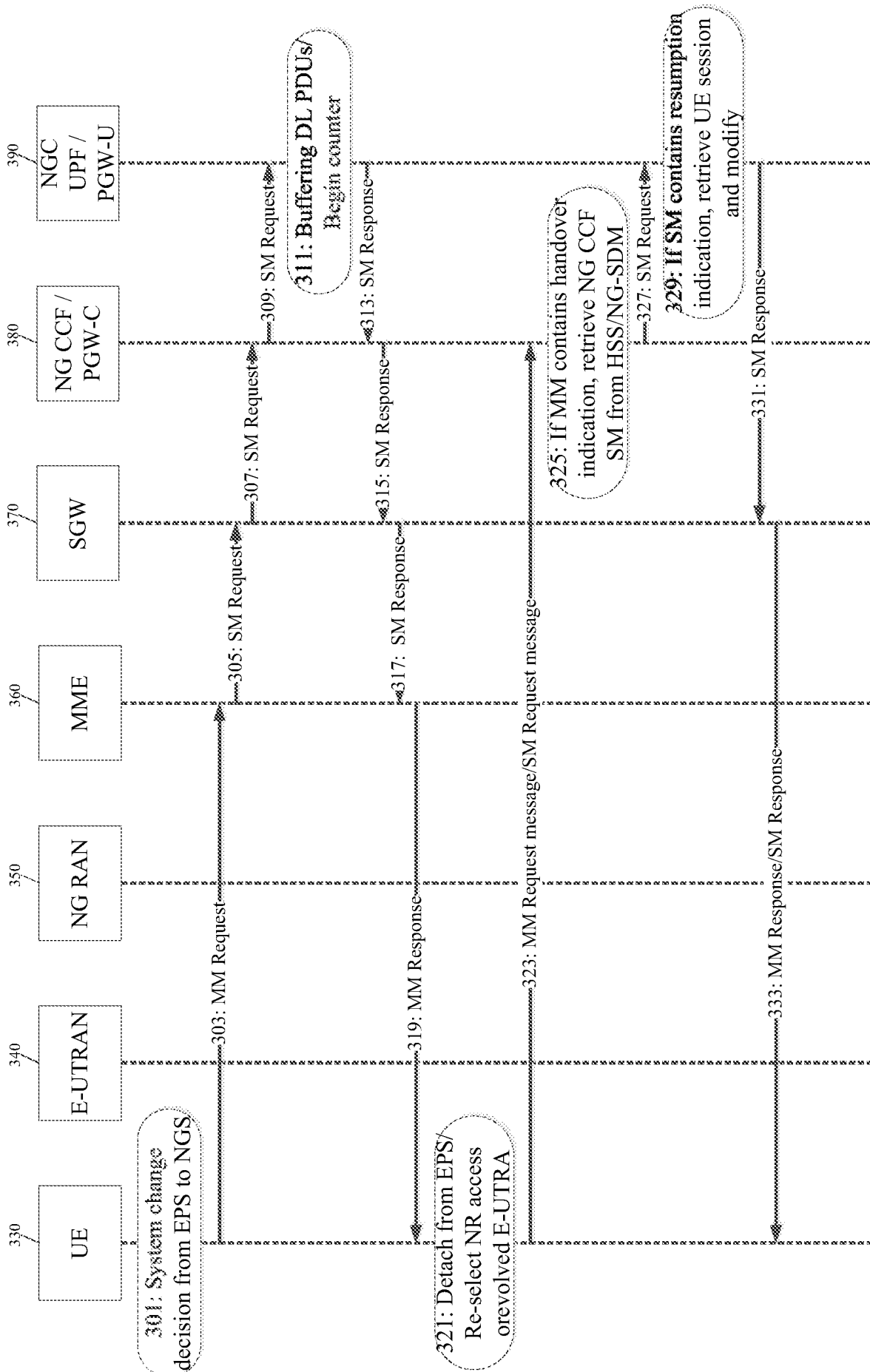


Figure 3

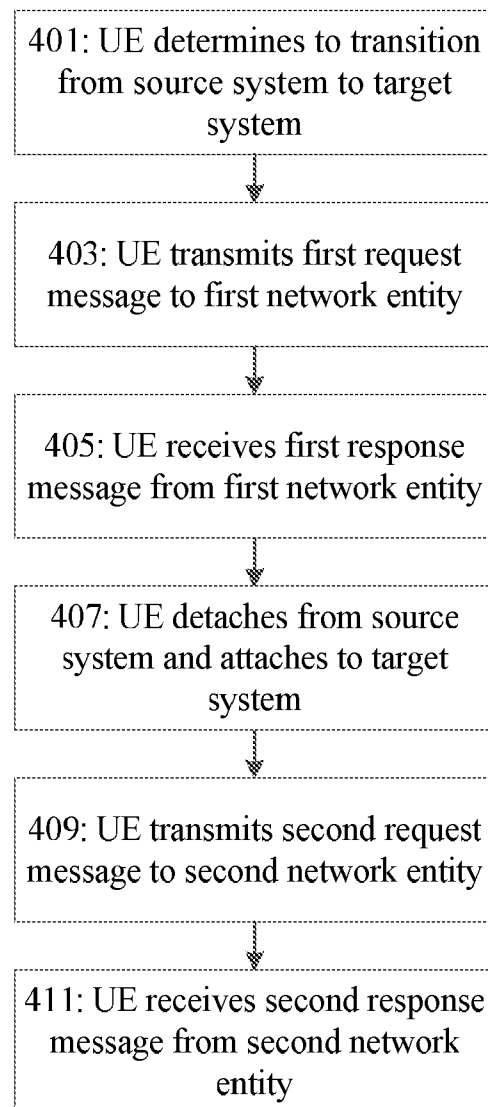


Figure 4

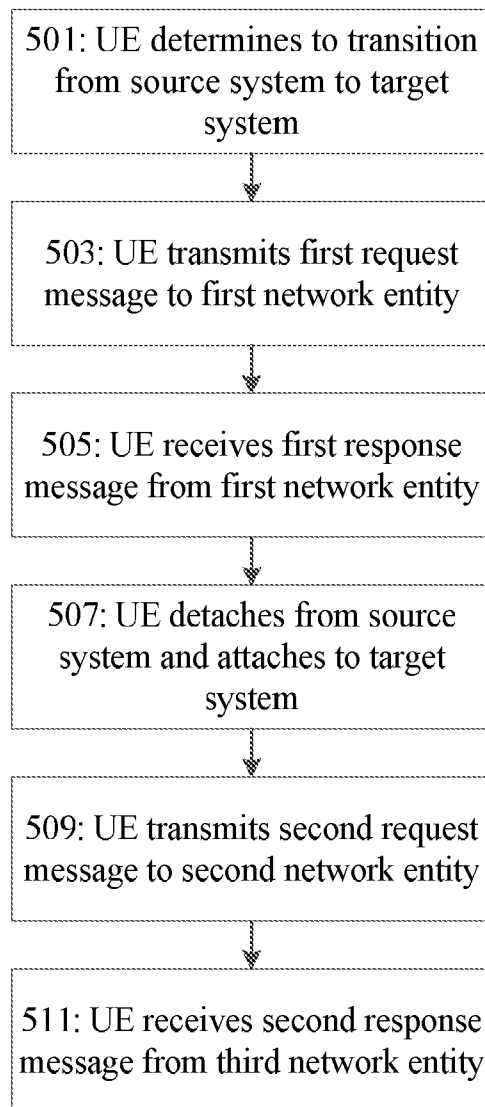


Figure 5

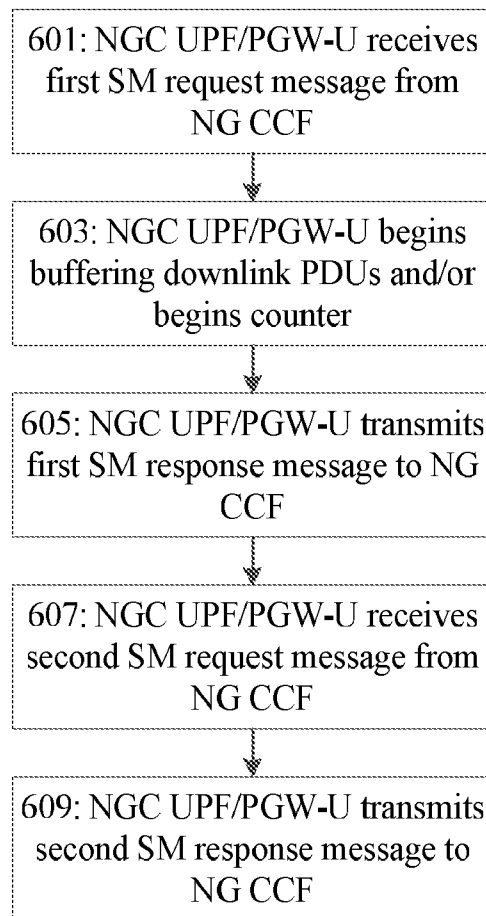


Figure 6

7/11

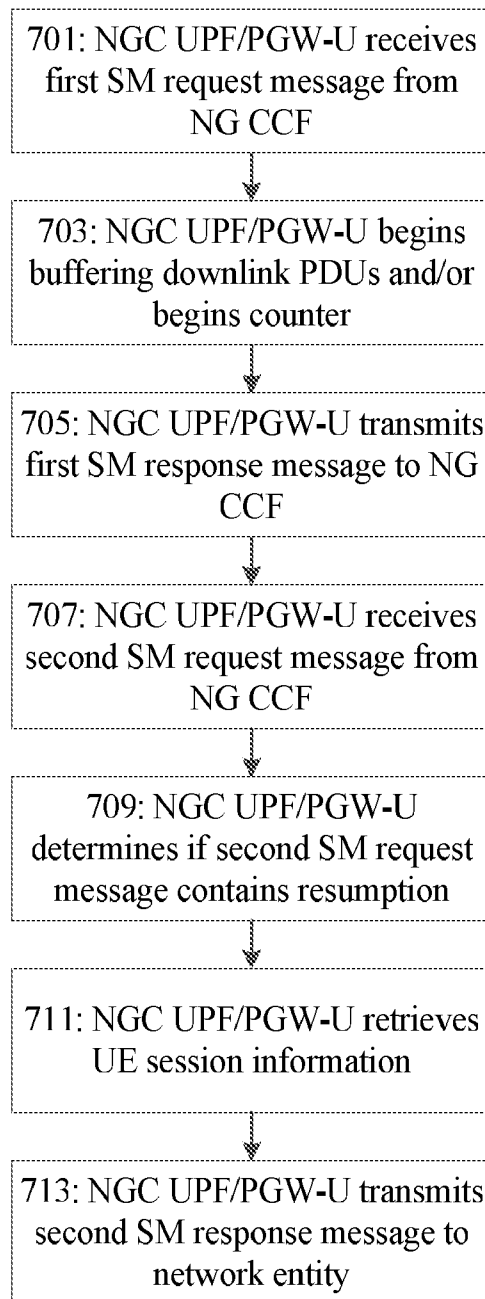


Figure 7

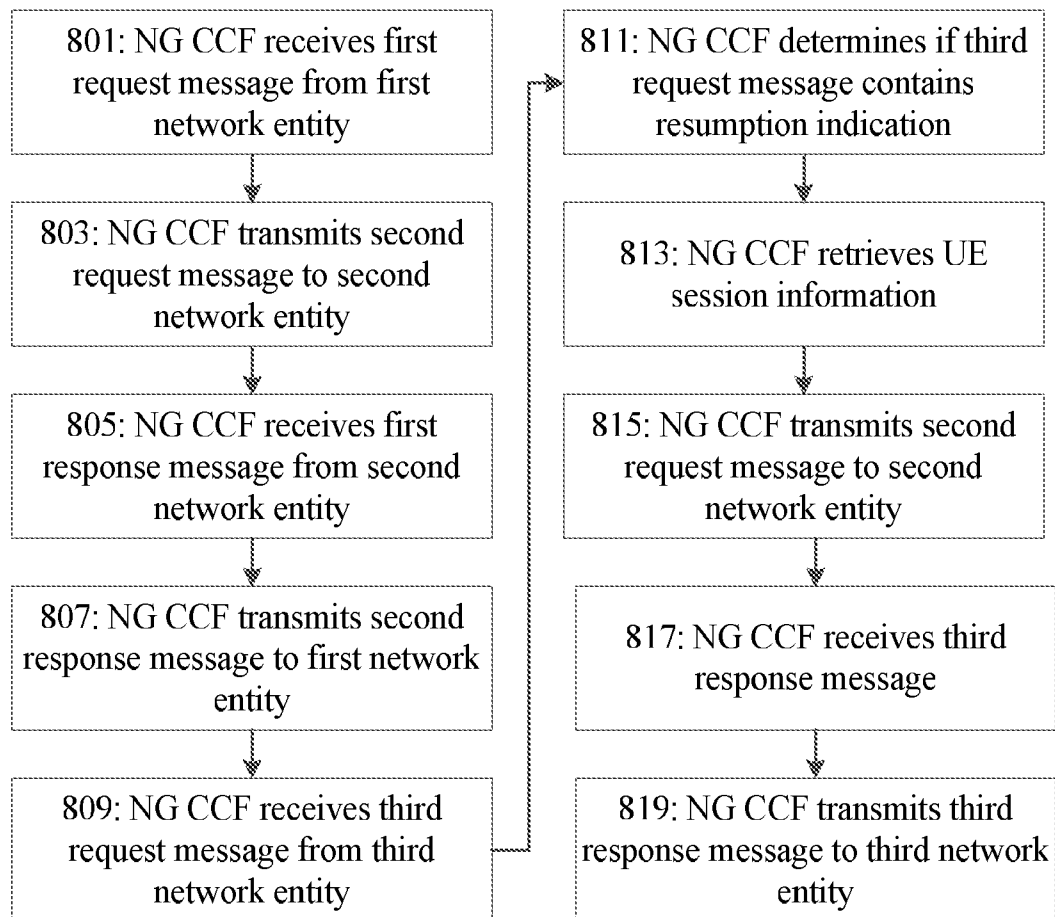


Figure 8

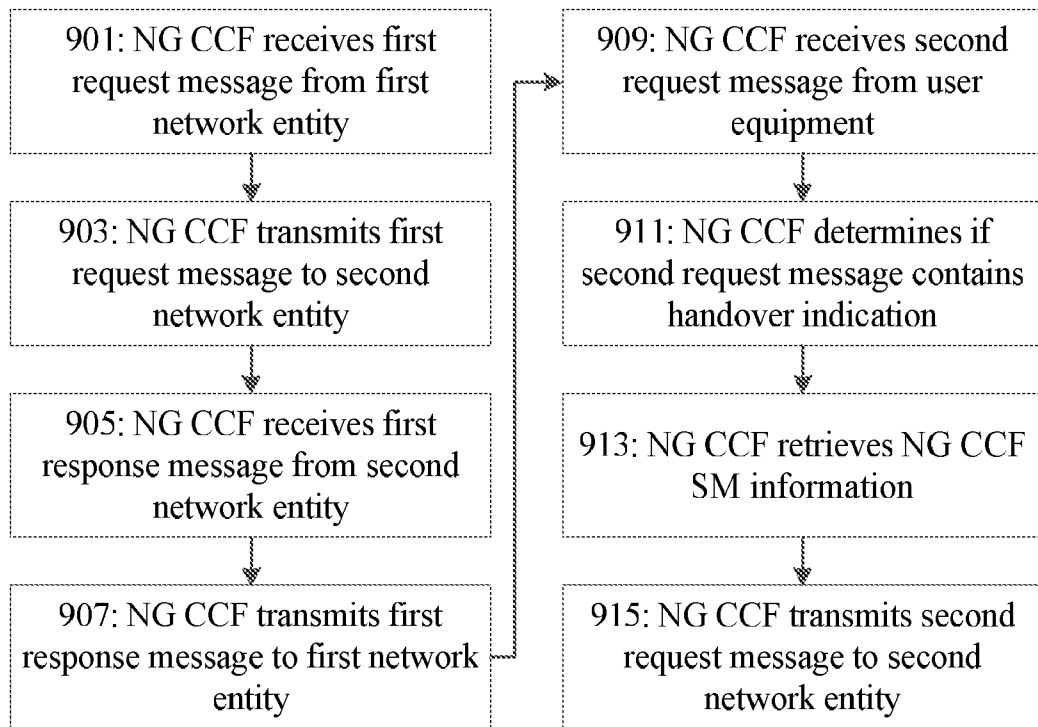


Figure 9

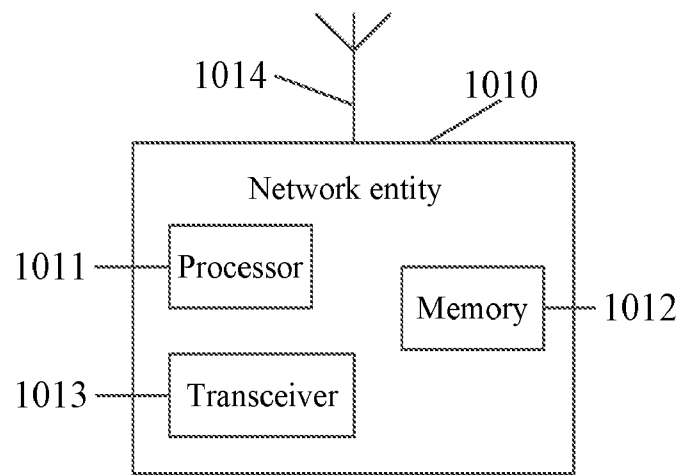


Figure 10

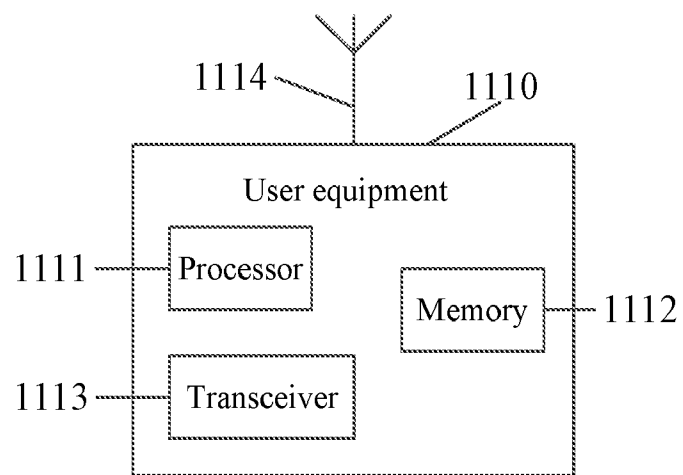


Figure 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 17/29823

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 5-9, 14-18, 22-25, 29-32, 37, 44 and 46-50
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-4 and 10-13 are directed to a method and apparatus for conditionally detaching a user equipment from a first system and attaching to a second system.

Group II: Claims 19-21 and 26-28 are directed to a method and apparatus for processing a session management request.

Group III: Claims 33-36, 38-43 and 45 are directed to a method and apparatus for relying network request and responses between devices.

--- (See Continuation in Supplemental Box) ---

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-4 and 10-13

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 17/29823

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H04W 36/14 (2017.01), H04W 88/06 (2017.01), H04W 36/22 (2017.01)
CPC - H04W36/14, H04W84/12, H04W36/22, H04W36/0066, H04W88/06

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)

See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2015/0334622 A1 (Broadcom Corporation), 19 November 2015 (19.11.2015), entire document, especially Abstract; Para [0050], [0051], [0064]	1 and 10 ----- 2-4 and 11-13
Y	US 2007/0021120 A1 (Flore et al.), 25 January 2007 (25.01.2007), entire document, especially Abstract; Para [0008], [0026]-[0030], [0032]-[0034]	2-4 and 11-13
A	US 2012/0014356 A1 (Mutikainen et al.), 19 January 2012 (19.01.2012), entire document	1-4 and 10-13
A	US 2013/0279470 A1 (Sen et al.), 24 October 2013 (24.10.2013), entire document	1-4 and 10-13
A	US 2013/0294410 A1 (Huawei Technologies Co., LTD.), 07 November 2013 (07.11.2013), entire document	1-4 and 10-13
A	US 2017/0086115 A1 (Google Inc.), 23 March 2017 (23.03.2017), entire document	1-4 and 10-13

☐ 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

20 August 2017

Date of mailing of the international search report

19 OCT 2017

Name and mailing address of the ISA/US

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PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 17/29823

Continuation of:

Box III. Observations where unity of invention is lacking

The inventions listed as Groups I-III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special Technical Features:

The invention of Group I included the features of determining, by a user equipment, that the user equipment should detach from a source system and attach to a target system; transmitting, by the user equipment, a mobility management request message to a network entity; receiving, by the user equipment, a mobility management response message from the network entity; detaching, by the user equipment, from the source system; and attaching, by the user equipment, to the target system, not required by any other groups.

The invention of Group II included the features of receiving, by a first network entity, a first session management request from a second network entity; buffering, by the first network entity, one or more downlink protocol data units for a user equipment and/or beginning, by the first network entity, a counter; and transmitting, by the first network entity, a first session management response to the second network entity, not required by any other groups.

The invention of Group III included the features of receiving, by a first network entity, a first request from a second network entity; transmitting, by the first network entity, a second request to a third network entity; receiving, by the first network entity, a first response from the third network entity; and transmitting, by the first network entity, a second response to the second network entity, not required by any other groups.

Common Technical Features

Groups I-III share the technical features of at least one processor; and at least one memory including computer program code, wherein the at least one memory and the computer program code are configured to, with the at least one processor; network entities; user equipments.

However, the shared technical features does not represent a contribution over prior art as being anticipated by US 2012/0014356 A1 to Mutikainen et al. (hereinafter 'Mutikainen'), 19 January 2012 (19.01.2012).

Mutikainen teaches at least one processor (Para [0010]- processor); and at least one memory including computer program code, wherein the at least one memory and the computer program code are configured to, with the at least one processor (Para [0010]- memory storing executable instructions that when executed by the processor cause the apparatus to determine that a user equipment device being handed over from a packet switched network to a circuit switched network); network entities (Para [0009]- network entity on the circuit switched network); user equipments (Para [0009]- user equipment device).

As the common features were known in the art at the time of the invention, this cannot be considered a common technical feature that would otherwise unify the groups. Therefore, Groups I-III lack unity under PCT Rule 13.

Item 4 (Contd.): Claims 5-9, 14-18, 22-25, 29-32, 37, 44 and 46-50 are held unsearchable, since they are not drafted in accordance with the second and third sentences of Rule 6.4(a).