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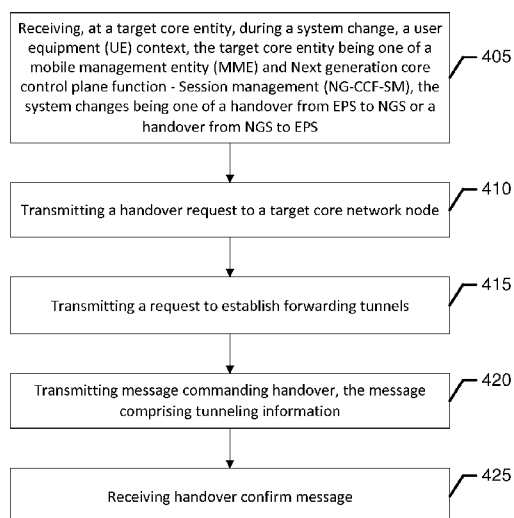


FIG. 4

(57) Abstract: Various methods are provided for allowing PDU sessions in a source system to be maintained in a target system by transferring UE context during a system change. One example method may comprise receiving, at a target core entity, during a system change, a user equipment context, the target core entity being one of an MME and a NG CCF-SM, the system changes being one of a handover from EPS to NGS or a handover from NGS to EPS, transmitting a handover request to a target core network node, transmitting a request to establish forwarding tunnels, transmitting a message commanding handover, the message comprising tunneling information, and receiving a handover confirm message.



METHOD AND APPARATUS FOR MAINTAINING SERVICE CONTINUITY DURING INTER-RAT MOBILITY UTILIZING CONTEXT TRANSFER

TECHNOLOGICAL FIELD

5 [0001] Embodiments of the present invention relate generally to providing an interworking mechanism between systems utilizing context transfer as well as a method, apparatus, and computer program product for maintaining service continuity during inter-RAT mobility.

BACKGROUND

10 [0002] While it is not expected that the service area of next generation systems (NGS), which includes the next generation radio access network (NG RAN) and next generation core (NGC), would replace the whole Evolved packet system (EPS) service area during early phases of NGS deployment, it is desired to prioritize the use of NGS over EPS in the NGS service area even where EPS is available in the area, in case a system change is required in the borderline of the NGS service
15 area since the NGS is considered to have benefits over EPS in terms of user experience and network management. In this regard, areas for improving known and existing systems have been identified. Through applied effort, ingenuity, and innovation, solutions to improve such systems have been realized and are described in connection with embodiments of the present invention.

BRIEF SUMMARY

20 [0003] In order to prevent user equipment (UE) from suffering service interruption due to the system change, embodiments of the present invention provide an NGS-EPS interworking mechanism to maintain service continuity.

[0004] In an exemplary embodiment, to support service continuity, embodiments of the present
25 invention may be configured to keep an entity in the UE's Protocol data unit (PDU) path unchanged even for the system change; in other words, assign a "PDU anchor." The invention allows the PDU session(s) in the source system to be maintained in the target system by transferring UE context from the source system to the target system. An inter-core interface is defined herein and used for the UE context transfer. The target system may choose the PDU anchor that has been used in the source
30 system based on the transferred UE context.

[0005] Furthermore, since frameworks (e.g., QoS framework, security framework) of EPS and NGS are different, the UE context exploited in the source system may be modified to adapt to the target system. The present invention provides a solution to convert UE context during the system change, i.e. inter-system handover.

35 [0006] Moreover, during the inter-system handover, the downlink PDUs delivered to the source RAN should be forwarded to the target RAN in order to support lossless handover. The invention provides a solution for the inter-system PDU forwarding.

[0007] A method, apparatus and computer program product are therefore provided according to an example embodiment of the present invention for allowing PDU sessions in a source system to be maintained in a target system by transferring UE context during a system change.

[0008] In some embodiments, a method may be provided, the method allowing Protocol data unit (PDU) sessions in a source system to be maintained in a target system by transferring user equipment (UE) context during a system change, the method comprising receiving, at a target core entity, during a system change, a UE context, the target core entity being one of a mobile management entity (MME) and Next generation core control plane function - Session management (NG CCF-SM), the system changes being one of a handover from EPS to NGS or a handover from NGS to EPS, transmitting a handover request to a target core network node, transmitting a request to establish forwarding tunnels, transmitting a message commanding handover, the message comprising tunneling information, and receiving a handover confirm message.

[0009] In some embodiments, the system change involves a UE being handed over from the source system, the source system being an Evolved Packet System (EPS) to the target system, the target system being a Next Generation System (NGS).

[0010] In some embodiments, the target core network node is a NG CCF-SM.

[0011] In some embodiments, the method further comprises receiving a forwarded relocation request, the forwarded relocation request originating at eNB and indicates that the UE is to be handed over to the NG RAN Node and includes IDs of bearers whose PDUs the eNB proposes to be forwarded.

[0012] In some embodiments, the UE context may include EPS bearer contexts and EMM context including EPS security context and a source to target transparent container

[0013] In some embodiments, the method further comprises causing transmission of a request to and receiving a response from a next generation Policy and Charging Rule Function (NG PCRF) for NG policy and charging information.

[0014] In some embodiments, the method further comprises, based on the NG policy and charging information, generating NG QoS rules for NG RAN and NGC UPF.

[0015] In some embodiments, the method further comprises obtaining QCI/GBR/MBR from the UE context.

[0016] In some embodiments, the handover request indicates a handover from NG CCF to a NG RAN, and includes the NG QoS rules and a source to target transparent container.

[0017] In some embodiments, the NG QoS rules for NG RAN includes a bearer ID for each of the FII values and QoS flow descriptors.

[0018] In some embodiments, the method further comprises receiving a response to the handover request.

[0019] In some embodiments, the response to the handover request comprises the FII values and/or QoS flow descriptors admitted by the NG RAN Node to be forwarded.

[0020] In some embodiments, the method further comprises preceding the message indicating the request to establish forwarding tunnels, based on the admitted FII values and/or QoS flow descriptors, confirming the list of bearers to be forwarded.

[0021] In some embodiments, the request, the message indicating the request to establish forwarding tunnels, includes the NG3 tunneling information and NG QoS rules for NGC UPF.

[0022] In some embodiments, the method further comprises receiving confirmation, from the NGC UPF, confirming an establishment of the tunnels, wherein the confirmation includes NGC UPF-side tunnelling information for interface NGy.

[0023] In some embodiments, the method further comprises responding to relocation request from the MME, the response comprising the tunnelling information and admitted bearer IDs for forwarding.

[0024] In some embodiments, the handover confirm message indicates that the UE is switched to the NG RAN, wherein the message includes the NG3 DL tunneling information.

[0025] In some embodiments, the method further comprises providing an indication that the relocation is complete to the MME and receiving an acknowledgement from the MME.

[0026] In some embodiments, the method further comprises providing an indication to the NG PCF/PCRF that the session is modified.

[0027] In some embodiments, the system change involves the handover of a UE from NGS to EPS.

[0028] In some embodiments, the target core network node is an eNB.

[0029] In some embodiments, the method further comprises receiving a forwarded relocation request, the forwarded relocation request originating at NG RAN and indicating that the UE is to be handed over to the eNB and includes FII values or QoS flow descriptors whose PDUs the NG RAN Node proposes to be forwarded.

[0030] In some embodiments, the method further comprises mapping the NG QoS rules into EPS bearer contexts.

[0031] In some embodiments, the method further comprises mapping the FII values and QoS flow descriptors into QCI values and bearers, and allocating EPS bearer IDs.

[0032] In some embodiments, the method further comprises selecting a SGW, sending a Create Session Request message, and receiving a response from the SGW, the response including SGW addresses and S1-U uplink TEIDs.

[0033] In some embodiments, the message requesting handover to the target eNB includes the bearer IDs converted from the proposed FII values and QoS flow descriptors by the NG RAN Node.

[0034] In some embodiments, the method further comprises receiving an acknowledgement, the acknowledgement including an admitted bearer ID list associated with S1 DL tunneling information.

[0035] In some embodiments, the request for the establishment of forwarding tunnels is directed towards the SGW and includes the list of admitted bearer IDs, receiving, from the SGW, a response to the request with SGW-side NGy tunnelling information per admitted bearer.

[0036] In some embodiments, the method further comprises sending a response message for the relocation request, the response message including SGW-side NGy tunneling information per admitted bearer, wherein each of the admitted bearers are associated with at least one of the FII values or QoS flow descriptors.

[0037] In some embodiments, subsequent to sending the response message, the NG CCF transmits a message commanding handover to the NG RAN Node, the message commanding handover comprising at least one of the admitted FII values or QoS descriptors for forwarding associated with the NG3 UL tunneling information, and the NG RAN Node sends a handover command message to the UE.

[0038] In some embodiments, subsequent to the NG RAN Node sending the handover command message to the UE, the UE sends a handover confirm message to the eNB, the method further comprising receiving, from the eNB, that the handover to the eNB is complete.

[0039] In some embodiments, the method further comprises sending a modify bearer request message to the SGW, and receiving an acknowledgement, wherein the SGW subsequently sends a modify bearer response message to the NG CCF and the NG CCF provides an indication to the NG PCF/PCRF that the session is modified.

[0040]

[0041] In some embodiments, then NG CCF subsequently provides traffic handling rules to the NGC UPF, the NGC UPF sends end marker PDUs with at least one a marking value subject to forwarding, and for each of the marking value of the end marker PDUs, the NG RAN sends the end marker PDUs with the marking value to the NGC UPF after the NG RAN is done with forwarding PDUs for the FII value.

[0042] In some embodiments, the NGC UPF sends the end marker PDUs removing the FII values via the NGy tunnels, wherein the end marker PDUs are delivered via a NGy tunnel after end marker PDUs of complete set of FII values subject to forwarding corresponding to the bearer are received.

[0043] In some embodiments, an apparatus allowing Protocol data unit (PDU) sessions in a source system to be maintained in a target system by transferring user equipment (UE) context during a system change may be provided, the 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 processor, cause the apparatus to at least receive, at a target core entity, during

a system change, a UE context, the target core entity being one of a mobile management entity (MME) and Next generation core control plane function - Session management (NG CCF-SM), the system changes being one of a handover from EPS to NGS or a handover from NGS to EPS, transmit a handover request to a target core network node, transmit a request to establish forwarding tunnels, transmit a message commanding handover, the message comprising tunneling information, and receive a handover confirm message.

[0044] In some embodiments, the system change involves a UE being handed over from the source system, the source system being an Evolved Packet System (EPS) to the target system, the target system being a Next Generation System (NGS).

[0045] In some embodiments, the target core network node is a NG CCF-SM.

[0046] In some embodiments, the apparatus further comprises receiving a forwarded relocation request, the forwarded relocation request originating at eNB and indicates that the UE is to be handed over to the NG RAN Node and includes IDs of bearers whose PDUs the eNB proposes to be forwarded.

[0047] In some embodiments, the UE context may include EPS bearer contexts and EMM context including EPS security context and a source to target transparent container

[0048] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to cause transmission of a request to and receiving a response from a next generation Policy and Charging Rule Function (NG PCRF) for NG policy and charging information.

[0049] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to based on the NG policy and charging information, generate NG QoS rules for NG RAN and NGC UPF.

[0050] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to obtain QCI/GBR/MBR from the UE context.

[0051] In some embodiments, the handover request indicates a handover from NG CCF to a NG RAN, and includes the NG QoS rules and a source to target transparent container.

[0052] In some embodiments, the NG QoS rules for NG RAN includes a bearer ID for each of the FII values and QoS flow descriptors.

[0053] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to receive a response to the handover request.

[0054] In some embodiments, the response to the handover request comprises the FII values and/or QoS flow descriptors admitted by the NG RAN Node to be forwarded.

[0055] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to precede the message indicating the request to establish forwarding tunnels, based on the admitted FII values or QoS flow descriptors, confirm the list of bearers to be forwarded.

5 [0056] In some embodiments, the request, the message indicating the request to establish forwarding tunnels, includes the NG3 tunneling information and NG QoS rules for NGC UPF.

[0057] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to receive confirmation, from the NGC UPF, confirming an establishment of the tunnels, wherein the confirmation includes NGC UPF-side
10 tunneling information for interface NGy.

[0058] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to respond to relocation request from the MME, the response comprising the tunneling information and admitted bearer IDs for forwarding.

15 [0059] In some embodiments, the handover confirm message indicates that the UE is switched to the NG RAN, wherein the message includes the NG3 DL tunneling information.

[0060] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to provide an indication that the relocation is complete to the MME and receive an acknowledgement from the MME.

20 [0061] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to provide an indication to the NG PCF/PCRF that the session is modified.

[0062] In some embodiments, the system change involves the handover of a UE from NGS to EPS.

25 [0063] In some embodiments, the target core network node is an eNB.

[0064] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to receive a forwarded relocation request, the forwarded relocation request originating at NG RAN and indicating that the UE is to be handed over to the eNB and includes FII values or QoS flow descriptors whose PDUs the NG RAN
30 Node proposes to be forwarded.

[0065] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to map the NG QoS rules into EPS bearer contexts.

[0066] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to map the FII values and QoS flow descriptors into QCI values and bearers, and allocate EPS bearer IDs.
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[0067] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to select a SGW, sending a Create Session Request message, and receive a response from the SGW, the response including SGW addresses and S1-U uplink TEIDs.

5 [0068] In some embodiments, the message requesting handover to the target eNB includes the bearer IDs converted from the proposed FII values and QoS flow descriptors by the NG RAN Node.

[0069] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to receive an acknowledgement, the acknowledgement including an admitted bearer ID list associated with S1 DL tunneling information.

10 [0070] In some embodiments, the request for the establishment of forwarding tunnels is directed towards the SGW and includes the list of admitted bearer IDs, receiving, from the SGW, a response to the request with SGW-side NGy tunneling information per admitted bearer.

[0071] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to send a response message for the relocation request, the response message including SGW-side NGy tunneling information per admitted bearer, wherein each of the admitted bearers are associated with at least one of the FII values or QoS flow descriptors.

15 [0072] In some embodiments, subsequent to sending the response message, the NG CCF transmits a message commanding handover to the NG RAN Node, the message commanding handover comprising at least one of the admitted FII values or QoS descriptors for forwarding associated with the NG3 UL tunneling information, and the NG RAN Node sends a handover command message to the UE.

[0073] In some embodiments, subsequent to the NG RAN Node sending the handover command message to the UE, the UE sends a handover confirm message to the eNB, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to receive, from the eNB, that the handover to the eNB is complete.

25 [0074] In some embodiments, the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to send a modify bearer request message to the SGW, and receive an acknowledgement, wherein the SGW subsequently sends a modify bearer response message to the NG CCF and the NG CCF provides an indication to the NG PCF/PCRF that the session is modified.

[0075] In some embodiments, then NG CCF subsequently provides traffic handling rules to the NGC UPF, the NGC UPF sends end marker PDUs with at least one a marking value subject to forwarding, and for each of the marking value of the end marker PDUs, the NG RAN sends the end marker PDUs with the marking value to the NGC UPF after the NG RAN is done with forwarding PDUs for the FII value.

[0076] In some embodiments, the NGC UPF sends the end marker PDUs removing the FII values via the NGy tunnels, wherein the end marker PDUs are delivered via a NGy tunnel after end marker PDUs of complete set of FII values subject to forwarding corresponding to the bearer are received.

5 [0077] In some embodiments, a computer program product may be provided allowing Protocol data unit (PDU) sessions in a source system to be maintained in a target system by transferring user equipment (UE) context during a system change, the computer program product comprising at least one non-transitory computer-readable storage medium having computer-executable program code instructions stored therein, the computer-executable program code instructions comprising program
10 code instructions for receiving, at a target core entity, during a system change, a UE context, the target core entity being one of a mobile management entity (MME) and Next generation core control plane function - Session management (NG CCF-SM), the system changes being one of a handover from EPS to NGS or a handover from NGS to EPS, transmitting a handover request to a target core network node, transmitting a request to establish forwarding tunnels, transmitting a message
15 commanding handover, the message comprising tunneling information, and receiving a handover confirm message.

[0078] In some embodiments, the system change involves a UE being handed over from the source system, the source system being an Evolved Packet System (EPS) to the target system, the target system being a Next Generation System (NGS).

20 [0079] In some embodiments, the target core network node is a NG CCF-SM.

[0080] In some embodiments, the computer program product further comprises receiving a forwarded relocation request, the forwarded relocation request originating at eNB and indicates that the UE is to be handed over to the NG RAN Node and includes IDs of bearers whose PDUs the eNB proposes to be forwarded.

25 [0081] In some embodiments, the UE context may include EPS bearer contexts and EMM context including EPS security context and a source to target transparent container

[0082] In some embodiments, the computer-executable program code instructions further comprise program code instructions for causing transmission of a request to and receiving a response from a next generation Policy and Charging Rule Function (NG PCRF) for NG policy and charging
30 information.

[0083] In some embodiments, the computer-executable program code instructions further comprise program code instructions for based on the NG policy and charging information, generating NG QoS rules for NG RAN and NGC UPF.

[0084] In some embodiments, the computer-executable program code instructions further
35 comprise program code instructions for obtaining QCI/GBR/MBR from the UE context.

[0085] In some embodiments, the handover request indicates a handover from NG CCF to a NG RAN, and includes the NG QoS rules and a source to target transparent container.

[0086] In some embodiments, the NG QoS rules for NG RAN includes a bearer ID for each of the FII values and QoS flow descriptors.

5 [0087] In some embodiments, the computer-executable program code instructions further comprise program code instructions for receiving a response to the handover request.

[0088] In some embodiments, the response to the handover request comprises the FII values and/or QoS flow descriptors admitted by the NG RAN Node to be forwarded.

10 [0089] In some embodiments, the computer-executable program code instructions further comprise program code instructions for preceding the message indicating the request to establish forwarding tunnels, based on the admitted FII values and/or QoS flow descriptors, confirming the list of bearers to be forwarded.

[0090] In some embodiments, the request (the message indicating the request to establish forwarding tunnels) includes the NG3 tunneling information and NG QoS rules for NGC UPF.

15 [0091] In some embodiments, the computer-executable program code instructions further comprise program code instructions for receiving confirmation, from the NGC UPF, confirming an establishment of the tunnels, wherein the confirmation includes NGC UPF-side tunnelling information for interface NGy.

20 [0092] In some embodiments, the computer-executable program code instructions further comprise program code instructions for responding to relocation request from the MME, the response comprising the tunnelling information and admitted bearer IDs for forwarding.

[0093] In some embodiments, the handover confirm message indicates that the UE is switched to the NG RAN, wherein the message includes the NG3 DL tunneling information.

25 [0094] In some embodiments, the computer-executable program code instructions further comprise program code instructions for providing an indication that the relocation is complete to the MME and receiving an acknowledgement from the MME.

[0095] In some embodiments, the computer-executable program code instructions further comprise program code instructions for providing an indication to the NG PCF/PCRF that the session is modified.

30 [0096] In some embodiments, the system change involves the handover of a UE from NGS to EPS.

[0097] In some embodiments, the target core network node is an eNB.

35 [0098] In some embodiments, the computer-executable program code instructions further comprise program code instructions for receiving a forwarded relocation request, the forwarded relocation request originating at NG RAN and indicating that the UE is to be handed over to the eNB

and includes FII values or QoS flow descriptors whose PDUs the NG RAN Node proposes to be forwarded.

[0099] In some embodiments, the computer-executable program code instructions further comprise program code instructions for mapping the NG QoS rules into EPS bearer contexts.

5 [00100] In some embodiments, the computer-executable program code instructions further comprise program code instructions for mapping the FII values and QoS flow descriptors into QCI values and bearers, and allocating EPS bearer IDs.

[00101] In some embodiments, the computer-executable program code instructions further comprise program code instructions for selecting a SGW, sending a Create Session Request message,
10 and receiving a response from the SGW, the response including SGW addresses and S1-U uplink TEIDs.

[00102] In some embodiments, the message requesting handover to the target eNB includes the bearer IDs converted from the proposed FII values and QoS flow descriptors by the NG RAN Node.

[00103] In some embodiments, the computer-executable program code instructions further
15 comprise program code instructions for receiving an acknowledgement, the acknowledgement including an admitted bearer ID list associated with S1 DL tunneling information.

[00104] In some embodiments, the request for the establishment of forwarding tunnels is directed towards the SGW and includes the list of admitted bearer IDs, receiving, from the SGW, a response to the request with SGW-side NGy tunnelling information per admitted bearer.

20 [00105] In some embodiments, the computer-executable program code instructions further comprise program code instructions for sending a response message for the relocation request, the response message including SGW-side NGy tunneling information per admitted bearer, wherein each of the admitted bearers are associated with at least one of the FII values or QoS flow descriptors.

[00106] In some embodiments, subsequent to sending the response message, the NG CCF
25 transmits a message commanding handover to the NG RAN Node, the message commanding handover comprising at least one of the admitted FII values or QoS descriptors for forwarding associated with the NG3 UL tunneling information, and the NG RAN Node sends a handover command message to the UE.

[00107] In some embodiments, subsequent to the NG RAN Node sending the handover command
30 message to the UE, the UE sends a handover confirm message to the eNB, the computer program product wherein the computer-executable program code instructions further comprise program code instructions for receiving, from the eNB, that the handover to the eNB is complete.

[00108] In some embodiments, the computer-executable program code instructions further
35 comprise program code instructions for sending a modify bearer request message to the SGW, and receiving an acknowledgement, wherein the SGW subsequently sends a modify bearer response

message to the NG CCF and the NG CCF provides an indication to the NG PCF/PCRF that the session is modified.

[00109] In some embodiments, then NG CCF subsequently provides traffic handling rules to the NGC UPF, the NGC UPF sends end marker PDUs with at least one a marking value subject to forwarding, and for each of the marking value of the end marker PDUs, the NG RAN sends the end marker PDUs with the marking value to the NGC UPF after the NG RAN is done with forwarding PDUs for the FII value.

[00110] In some embodiments, the NGC UPF sends the end marker PDUs removing the FII values via the NGy tunnels, wherein the end marker PDUs are delivered via a NGy tunnel after end marker PDUs of complete set of FII values subject to forwarding corresponding to the bearer are received.

BRIEF DESCRIPTION OF THE DRAWINGS

[00111] Having thus described embodiments of the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

[00112] Figure 1 is block diagram of a system that may be specifically configured in accordance with an example embodiment of the present invention;

[00113] Figure 2 is block diagram of an apparatus that may be specifically configured in accordance with an example embodiment of the present invention;

[00114] Figure 3 is block diagram of a system that may be specifically configured in accordance with an example embodiment of the present invention;

[00115] Figure 4 is a flowchart showing an exemplary method of operating an example apparatus in accordance with an embodiment of the present invention;

[00116] Figure 5 is a data flow diagram showing an exemplary data flow process in accordance with an embodiment of the present invention; and

[00117] Figure 6 is a data flow diagram showing an exemplary data flow process in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

[00118] Some example embodiments will now be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments are shown. Indeed, the example embodiments may take many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like reference numerals refer to like elements throughout. The terms “data,” “content,” “information,” and similar terms may be used interchangeably, according to

some example embodiments, to refer to data capable of being transmitted, received, operated on, and/or stored. Moreover, the term “exemplary”, as may be used herein, is not provided to convey any qualitative assessment, but instead merely to convey an illustration of an example. Thus, use of any such terms should not be taken to limit the spirit and scope of embodiments of the present invention.

[00119] As used herein, the term “circuitry” refers to all of the following: (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry); (b) to combinations of circuits and software (and/or firmware), such as (as applicable): (i) to a combination of processor(s) or (ii) to portions of processor(s)/software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions); and (c) to circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present.

[00120] This definition of “circuitry” applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term ‘circuitry’ would also cover an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware. The term ‘circuitry’ would also cover, for example and if applicable to the particular claim element, a baseband integrated circuit or application specific integrated circuit for a mobile phone or a similar integrated circuit in a server, a cellular network device, or other network device.

System Architecture

[00121] Referring now to Figure 1, which illustrates an example system that supports communications between a plurality of stations 10 and one or more access points 12 (e.g., a high density system scenario where a plurality of access points may be deployed to a geographical area and may be operating on the same frequency channel), each access point may communicate with one or more stations and, in one embodiment, may communicate with a large number of stations, such as 6,000 or more stations. The access points may, in turn, communicate with a network 14. While the access points may communicate via an Long Term Evolution (LTE) or LTE-Advanced (LTE-A) network, other networks may support communications between the access points including those configured in accordance with wideband code division multiple access (W-CDMA), CDMA2000, global system for mobile communications (GSM), general packet radio service (GPRS), the IEEE 802.11 standard including, for example, the IEEE 802.11ah or 802.11ac standard or other newer amendments of the standard, wireless local access network (WLAN), Worldwide Interoperability for Microwave Access (WiMAX) protocols, universal mobile telecommunications systems (UMTS) terrestrial radio access network (UTRAN) and/or the like.

[00122] The access points 12 and the stations 10 may communicate via wireline communications, but most commonly communicate via wireless communications. For example, the access points and the stations may communicate in a sub 1 GHz band as defined by IEEE 802.11ah standard or in a 5GHz band, which may be defined by, for example, IEEE 802.11ac standard. The access point may be embodied by any of a variety of network entities, such as an access point, a base station, a Node B, an evolved Node B (eNB), a radio network controller (RNC), a mobile device / a station (e.g., mobile telephones, smart phones, portable digital assistants (PDAs), pagers, laptop computers, tablet computers or any of numerous other hand held or portable communication devices, computation devices, content generation devices, content consumption devices, or combinations thereof), or the like. The stations may also be embodied by a variety of devices, such as sensors, meters or the like. The sensors and meters may be deployed in a variety of different applications including in utility applications to serve as a gas meter, a water meter, a power meter or the like, in environmental and/or agricultural monitoring applications, in industrial process automation applications, in healthcare and fitness applications, in building automation and control applications and/or in temperature sensing applications. Stations that are embodied by sensors or meters may be utilized in some embodiments to backhaul sensor and meter data. Alternatively, the stations may be embodied by mobile terminals or user equipment(s) (UE), such as mobile communication devices, e.g., mobile telephones, smart phones, portable digital assistants (PDAs), pagers, laptop computers, tablet computers or any of numerous other hand held or portable communication devices, computation devices, content generation devices, content consumption devices, or combinations thereof. In an embodiment in which the station is embodied by a mobile terminal, the communication between an access point and the station may serve to extend the range of wi-fi or another wireless local area network (WLAN), such as by extending the range of a hotspot, and to offload traffic that otherwise would be carried by a cellular or other network.

[00123] The access point 12 and/or the station 10 may be embodied as or otherwise include an apparatus 20 that is specifically configured to perform the functions of the respective device, as generically represented by the block diagram of Figure 2. While the apparatus may be employed, for example, by an access point or a station, it should be noted that the components, devices or elements described below may not be mandatory and thus some may be omitted in certain embodiments. Additionally, some embodiments may include further or different components, devices or elements beyond those shown and described herein.

Apparatus Architecture

[00124] Regardless of the type of device that embodies the station 10, the station 10 may include or be associated with an apparatus 20 as shown in Figure 2. In this regard, the apparatus may include or otherwise be in communication with a processor 22, a memory device 24, a communication

interface 26 and a user interface 28. As such, in some embodiments, although devices or elements are shown as being in communication with each other, hereinafter such devices or elements should be considered to be capable of being embodied within the same device or element and thus, devices or elements shown in communication should be understood to alternatively be portions of the same device or element.

[00125] In some embodiments, the processor 22 (and/or co-processors or any other processing circuitry assisting or otherwise associated with the processor) may be in communication with the memory device 24 via a bus for passing information among components of the apparatus. The memory device may include, for example, one or more volatile and/or non-volatile memories. In other words, for example, the memory device may be an electronic storage device (e.g., a computer readable storage medium) comprising gates configured to store data (e.g., bits) that may be retrievable by a machine (e.g., a computing device like the processor). The memory device may be configured to store information, data, content, applications, instructions, or the like for enabling the apparatus 20 to carry out various functions in accordance with an example embodiment of the present invention. For example, the memory device could be configured to buffer input data for processing by the processor. Additionally or alternatively, the memory device could be configured to store instructions for execution by the processor.

[00126] As noted above, the apparatus 20 may be embodied by a computing device 10 configured to employ an example embodiment of the present invention. However, in some embodiments, the apparatus may be embodied as a chip or chip set. In other words, the apparatus may comprise one or more physical packages (e.g., chips) including materials, components and/or wires on a structural assembly (e.g., a baseboard). The structural assembly may provide physical strength, conservation of size, and/or limitation of electrical interaction for component circuitry included thereon. The apparatus may therefore, in some cases, be configured to implement an embodiment of the present invention on a single chip or as a single “system on a chip.” As such, in some cases, a chip or chipset may constitute means for performing one or more operations for providing the functionalities described herein.

[00127] The processor 22 may be embodied in a number of different ways. For example, the processor may be embodied as one or more of various hardware processing means such as a coprocessor, a microprocessor, a controller, a digital signal processor (DSP), a processing element with or without an accompanying DSP, or various other processing circuitry including integrated circuits such as, for example, an ASIC (application specific integrated circuit), an FPGA (field programmable gate array), a microcontroller unit (MCU), a hardware accelerator, a special-purpose computer chip, or the like. As such, in some embodiments, the processor may include one or more processing cores configured to perform independently. A multi-core processor may enable multiprocessing within a single physical package. Additionally or alternatively, the processor may

include one or more processors configured in tandem via the bus to enable independent execution of instructions, pipelining and/or multithreading.

[00128] In an example embodiment, the processor 22 may be configured to execute instructions stored in the memory device 24 or otherwise accessible to the processor. Alternatively or additionally, the processor may be configured to execute hard coded functionality. As such, whether configured by hardware or software methods, or by a combination thereof, the processor may represent an entity (e.g., physically embodied in circuitry) capable of performing operations according to an embodiment of the present invention while configured accordingly. Thus, for example, when the processor is embodied as an ASIC, FPGA or the like, the processor may be specifically configured hardware for conducting the operations described herein. Alternatively, as another example, when the processor is embodied as an executor of software instructions, the instructions may specifically configure the processor to perform the algorithms and/or operations described herein when the instructions are executed. However, in some cases, the processor may be a processor of a specific device (e.g., a head mounted display) configured to employ an embodiment of the present invention by further configuration of the processor by instructions for performing the algorithms and/or operations described herein. The processor may include, among other things, a clock, an arithmetic logic unit (ALU) and logic gates configured to support operation of the processor. In one embodiment, the processor may also include user interface circuitry configured to control at least some functions of one or more elements of the user interface 28.

[00129] Meanwhile, the communication interface 26 may be any means such as a device or circuitry embodied in either hardware or a combination of hardware and software that is configured to receive and/or transmit data between the computing device 10 and a server 12. In this regard, the communication interface 26 may include, for example, an antenna (or multiple antennas) and supporting hardware and/or software for enabling communications wirelessly. Additionally or alternatively, the communication interface may include the circuitry for interacting with the antenna(s) to cause transmission of signals via the antenna(s) or to handle receipt of signals received via the antenna(s). For example, the communications interface may be configured to communicate wirelessly with the head mounted displays 10, such as via Wi-Fi, Bluetooth or other wireless communications techniques. In some instances, the communication interface may alternatively or also support wired communication. As such, for example, the communication interface may include a communication modem and/or other hardware/software for supporting communication via cable, digital subscriber line (DSL), universal serial bus (USB) or other mechanisms. For example, the communication interface may be configured to communicate via wired communication with other components of the computing device.

[00130] The user interface 28 may be in communication with the processor 22, such as the user interface circuitry, to receive an indication of a user input and/or to provide an audible, visual,

mechanical, or other output to a user. As such, the user interface may include, for example, a keyboard, a mouse, a joystick, a display, a touch screen display, a microphone, a speaker, and/or other input/output mechanisms. In some embodiments, a display may refer to display on a screen, on a wall, on glasses (e.g., near-eye-display), in the air, etc. The user interface may also be in communication with the memory 24 and/or the communication interface 26, such as via a bus.

Overview

[00131] Disclosed is a method to provide Next Generation System (NGS) - Evolved Packet System (EPS) interworking to maintain service continuity by transferring a context of User Equipment (UE) (e.g., such as bearer context, security, etc.) adaptable to target Radio Access Network (RAN) system during system change. In case of handover from EPS to NGS, NG Core Control Function-Session Management (NG CCF-SM) receives the UE context from Mobility Management Entity (MME) via NGx interface. NG-CCF-SM then interacts with NG PCRF (Policy and Charging Rule Function) and receives NG policy and charging information. NG CCF-SM then creates NG Quality of Service (QoS) policy from the received PCRF information and provides it to target NG-Radio Access Network (NG-RAN) and NGC User Plane Function (NGC UPF) which convert the UE context adaptable to NG-RAN without impacting UE's actual charging. After UE switches to the NG RAN, the NG PCRF is updated regarding the path switch and new NG policy and charging information.

[00132] As a further alternative, interaction with NG PCRF can be avoided if the NG CCF contains the mapping rule between QoS Class identifier (QCI)/Guaranteed Bit Ratio (GBR)/downlink templates and tagging rules/ flow descriptors.

[00133] Similar process follows when handover takes place from NGS to EPS but in addition to above, MME may need to allocate new EPS bearer IDs for the PDU sessions which further needs synchronization with UE. Furthermore, Packet Data Unit (PDUs) are forwarded from source to target RAN to maintain the continuity. If EPS is the source then NGC UPF marks the PDUs subjected to forwarding according to QoS rules and if NG RAN is the source then it unmarks the PDUs to map them to the respective bearers in GPRS Tunneling Protocol (GTP-U) tunnels. Moreover, the target RAN buffers non-forwarded downlink PDUs subject to forwarding until the end marker PDUs are received whereas PDUs not subject to forwarding are delivered without buffering.

[00134] Features include a system configured to provide NGS - EPS interworking to maintain service continuity by transferring UE's context adaptable (or convertible) to target RAN system during system change.

[00135] If EPS is the source then NGC UPF marks the PDUs subjected to forwarding according to QoS rules and if NG RAN is the source then it unmarks the PDUs to map them to the respective bearers in GPRS Tunneling Protocol (GTP-U) tunnels.

[00136] The target RAN buffers non-forwarded downlink PDUs subject to forwarding until the end marker PDUs are received whereas PDUs not subject to forwarding are delivered without buffering.

Architecture

5 [00137] As described with reference to Figure 3, the high level architecture associated with exemplary embodiment of the present invention is provided. The NGx, NGy, and NGz interfaces are inter-core interfaces. They may correspond to S10, S5/S8-U, and S5/S8-U interfaces, respectively, with possible modifications. Or they can be newly defined interfaces.

Context Conversion

10 [00138] The UE context is delivered via the NGx interface 305 between the MME 310 and NG CCF-MM 315 and the delivered UE context is adapted in the target core entity (MME 310 or NG CCF-SM 320).

[00139] In an instance of a handover from the EPS to NGS, as the NG CCF-MM 315 receives the UE context from the MME 310, the NG CCF-SM 320 may interact with the NG PCF/PCRF and receive NG policy and charging information from the NG PCF/PCRF. Based on the NG policy and charging information and other available information, the NG CCF-SM 320 creates the NG QoS rules for NG RAN 325 and NGC UPF 330. As an alternative, the involvement of the NF PCF/PCRF can be avoided, if the NG CCF has the mapping rule between the QCI/GBR/MBR/downlink templates and FII tagging rules/flow descriptors with guaranteed flow bit rate/maximum flow bit rate.

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[00140] The created NG QoS rules may be provided to NG RAN 330 and NGC UPF 325 while requesting handover to the NG RAN 330 and creating and/or modifying sessions in the NGC UPF 325. After the UE is switched to the NG RAN 330, the NG PCF/PCRF 325 is updated about the path switch, in case the NG PCF/PCRF 325 requires such a notification. If there are RAN specific policies, the new NG policy and charging information applicable for NG RAN 330 becomes effective from then.

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[00141] In case of handover from the NGS to EPS, the MME 310 receives the UE context from the NG CCF-MM 315. Based on the received UE context and other available information, the MME 310 creates EPS UE context including the EPS bearer contexts. MME 310 may need to allocate new EPS bearer IDs for the PDU sessions that were moved from NGS to EPS and this needs synchronization with the UE.

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PDU Forwarding

[00142] The downlink PDUs received by the source RAN after the UE is switched to the target RAN may be forwarded to the target RAN.

35 [00143] In case the source RAN is the E-UTRAN 335, the E-UTRAN 335 forwards the PDUs subject to forwarding. The PDUs subject to forwarding is negotiated between the E-UTRAN 335,

NG RAN 330 and possibly core entities. The SGW 340 forwards the PDUs via a GTP-U tunnel established per bearer subject to PDU forwarding to the NGC UPF 325. The NGC UPF 325 marks the PDUs according to the NG QoS rules.

[00144] In case the source RAN is the NG RAN 330, the NG RAN 330 forwards the PDUs subject to forwarding. The NG QoS rules in the NG RAN 330 may be used to select PDUs subject to forwarding. The NGC UPF 325 un-marks the forwarded PDUs if they are marked. The un-marked PDUs are forwarded to the SGW 340 via the GTP-U tunnels for forwarding. The NGC UPF 325 uses the downlink templates (SDF templates and/or downlink TFTs) and the mapping relationship between the GTP-U tunnels for downlink and forwarding to map the forwarded PDUs to the GTP-U tunnels for forwarding, i.e. first find out to which bearer a forwarded PDU belongs (GTP-U tunnel for downlink) and find which GTP-U tunnel corresponds to the bearer.

[00145] The target RAN buffers non-forwarded downlink PDUs of a bearer/flow subject to forwarding until the end marker PDUs for the bearer/flow are received. PDUs not subject to forwarding, e.g. PDUs requiring low latency but not requiring high reliability, are delivered without buffering.

[00146] In case the source RAN is the E-UTRAN 335, the NGC UPF 325 sends the end marker PDUs via bearers subject to forwarding after path switch. For each of the bearers, the E-UTRAN 335 sends the end marker PDUs if the E-UTRAN 335 is finished with forwarding PDUs. The NGC UPF 325 marks the end marker according to the mapping relationship of a FII-marking value and a GTP-U tunnel for forwarding (the mapping relationship may be derived from the downlink templates used while the UE is served by EPS, EPS bearer contexts, and NG QoS rules). As the NG RAN 330 receives one or more end marker PDUs with a specific FII marking value, the NG RAN 330 may start to send buffered PDUs with the FII marking value. The NG RAN 330 may only buffer PDUs that were marked with the FII value(s) with which forwarded PDUs are marked.

[00147] In case the source RAN is the NG RAN 330, after path switch, the NGC UPF 325 sends the end marker PDUs with FII marking values or a different marking value with which PDUs require forwarding. For each of the FII marking values of the end marker PDUs, the NG RAN 330 sends the end marker PDUs with the FII marking value to the NGC UPF 325 after the NG RAN 330 is done with forwarding PDUs. The NGC UPF 325 sends the end marker PDUs removing the FII marking value(s) via the GTP-U tunnels. The forwarded PDUs are mapped to the GTP-U tunnels for forwarding according to the DL TFTs.

Operation

[00148] In an example embodiment of the present invention, an apparatus or computer program product may be provided to implement or execute a method, process, or algorithm for allowing PDU sessions in a source system to be maintained in a target system by transferring UE context

during a system change. Figure 4 is a flowchart showing an exemplary method of operating an example apparatus in accordance with an embodiment of the present invention.

[00149] As such, as shown in block 405 of Figure 4, an apparatus, such as apparatus 20 embodied by the computing device 10, may be configured to receive, at a target core entity, during a system change, a user equipment (UE) context, the target core entity being one of a mobile management entity (MME) and next generation core control plane function - Session management (NG CCF-SM), the system changes being one of a handover from EPS to NGS or a handover from NGS to EPS. The apparatus embodied by computing device 10 may therefore include means, such as the processor 22, the communication interface 26 or the like, for receiving, at a target core entity, during a system change, a user equipment (UE) context, the target core entity being one of a mobile management entity (MME) and Next generation core control plane function - Session management (NG CCF-SM), the system changes being one of a handover from EPS to NGS or a handover from NGS to EPS.

[00150] As shown in block 410 of Figure 4, an apparatus, such as apparatus 20 embodied by the computing device 10, may be configured to transmit a handover request to a target core network node. The apparatus embodied by computing device 10 may therefore include means, such as the processor 22, the communication interface 26 or the like, for transmitting a handover request to a target core network node.

[00151] As shown in block 415 of Figure 4, an apparatus, such as apparatus 20 embodied by the computing device 10, may be configured to transmit a request to establish forwarding tunnels. The apparatus embodied by computing device 10 may therefore include means, such as the processor 22, the communication interface 26 or the like, for transmitting a request to establish forwarding tunnels.

[00152] As shown in block 420 of Figure 4, an apparatus, such as apparatus 20 embodied by the computing device 10, may be configured to transmit a message commanding handover. The apparatus embodied by computing device 10 may therefore include means, such as the processor 22, the communication interface 26 or the like, for transmitting a message commanding handover. In some embodiments, the message may comprise tunneling information.

[00153] As shown in block 425 of Figure 4, an apparatus, such as apparatus 20 embodied by the computing device 10, may be configured to receive a handover confirm message. The apparatus embodied by computing device 10 may therefore include means, such as the processor 22, the communication interface 26 or the like, for receiving a handover confirm message.

[00154] Figure 5 depicts a data flow diagram showing an exemplary implementation of the invention, for example, mobility from the EPS to the NGS is considered. Though the steps are described in a particular order below, the order may be changed.

[00155] At step 505, the eNB may inform the MME that the UE should be handed over to the NG RAN Node. The eNB may include IDs of bearers whose PDUs the eNB proposes to be forwarded. These bearer IDs may be encapsulated in the source to target transparent container.

[00156] The bearer IDs may not necessarily be delivered via the source to target transparent container. In this case, the bearer IDs are transferred via one or more dedicated information elements in the S1 message and NGx message. The NG CCF may convert the bearer IDs into FII values and/or QoS flows descriptors, for example, using UE context and downlink templates or interacting with the NG PCF/PCRF. The converted FII values and/or QoS flow descriptors may be provided to the NG RAN Node and the NG RAN Node may respond with the admitted FII values and QoS flow descriptors for forwarding; or the NGC UPF is indicated of the FII values and/or QoS flow descriptors and marks PDUs corresponding to the FII values and/or QoS flow descriptors with the specific value(s) from which the NG RAN Node understands that FII values and/or QoS flow descriptors corresponding to the PDUs with the specific value(s) are subject to forwarding. In the latter case, for each of the specific values, the NG RAN Node may forward PDUs with the specific value coming from the NG3 tunnel(s) for forwarding first and buffers PDUs with the specific value coming from the NG3 tunnel(s) not relevant for forwarding until the end marker PDUs for the specific value is received.

[00157] At step 510, The MME may select the target core network node (e.g., NG CCF-MM) and transmit a message indicative of a relocation request to the NG CCF-MM. The message may include the UE context (e.g. EPS bearer contexts and EMM context including EPS security context) and source to target transparent container.

[00158] At step 515, The NG CCF-SM may request NG policy and charging information to the NG PCF/PCRF as the UE is about to be handed over to NG RAN.

[00159] The NG PCF/PCRF may provide the NG policy and charging information to the NG CCF. The NG policy and charging information may be created based on the EPS PCC rules. From the NG policy and charging information (and other available information), the NG CCF-SM may create the NG QoS rules for NG RAN and NGC UPF.

[00160] The NG PCF/PCRF may understand that this step is to derive the NG QoS rules and thus may not let the UE's actual charging (and other policy control) impacted since the PDU path for the UE is still traversing through the EPS entities (SGW and E-UTRAN). The NG PCF/PCRF may be indicated that the UE's actual charging (and other policy control) should not be impacted by this step e.g. implicitly by the message type used in this step or explicitly by an indicator.

[00161] The signaling between the NG CCF and NG PCF/PCRF can be optional. If the NG CCF is capable of mapping QCI/GBR/MBR/downlink template to FII tagging rules/QoS flow descriptors without interacting with the NG PCF/PCRF, the signaling between the NG CCF-SM and NG PCF/PCRF is not necessary. The QCI/GBR/MBR can be obtained from the UE context. In some

embodiments, the downlink templates and, in some embodiments, the QCI/GBR/MBR as well, have been available since the NG CCF-SM has not been changed.

[00162] In this case, the NG CCF may derive FII tagging rules and QoS flow descriptors as follows:

5 [00163] - FII value and FII tagging rule: Downlink template/QCI value corresponding to each non-GBR bearer in the EPS bearer contexts are used to generate FII tagging rules associated with FII values.

[00164] - QoS flow descriptor with GBR/MBR: Downlink template/QCI value corresponding to GBR bearer in the EPS bearer contexts are used to generate QoS flow descriptors associated with
10 GBR/MBR.

[00165] This may not be the case if the PDU anchor (NG CCF-SM/NGC UPF) locates in the HPLMN. The NG CCF-SM in the VPLMN does not possess the downlink templates. In this case, the UE context delivered to the NG CCF in the VPLMN should include downlink templates. In order to make this possible, the MME stores the downlink templates of bearers, which the MME may
15 receive from the PGW/NG CCF-SM in HPLMN via the SGW.

[00166] At step 520, The NG CCF may request handover towards the NG RAN. The request may include the NG QoS rules, and in some embodiments, a source to target transparent container. In the case of inter-system handover, the NG QoS rules for NG RAN may additionally include a bearer ID for each of the FII values and/or QoS flow descriptors. The NG CCF may additionally indicate the
20 FII values, QoS flow descriptors that are not possible to be forwarded.

[00167] From the source to target transparent container, the NG RAN Node may recognize which bearers are proposed to be forwarded by the source eNB. Among the FII values and/or QoS flow descriptors corresponding to the proposed bearers, the NG RAN may select the FII values and/or QoS flow descriptors that the NG RAN Nodes admits the PDU forwarding taking into account the
25 FII values, and QoS flow descriptors that are not possible to be forwarded that are indicated by the NG CCF.

[00168] The NG RAN may then respond to the handover request. The response message may contain the FII values and/or QoS flow descriptors admitted by the NG RAN Node to be forwarded, possibly associated with NG3 DL tunneling information.

30 [00169] At step 525, from the admitted FII values and/or QoS flow descriptors, the NG CCF may confirm the list of bearers to be forwarded. The NG CCF then sends a request to the NGC UPF to establish the forwarding tunnels. The request includes the NG3 tunneling information and NG QoS rules for NGC UPF. An NGy tunnel is established per bearer. The NG CCF or NGC UPF generates the NGC UPF side NGy tunneling information (TEID, transport layer address). The NG QoS rules
35 may be used when delivering forwarded PDUs from the SGW towards the NG RAN Node.

[00170] The NGC UPF may then respond to the NG CCF confirming the successful establishment of tunnels. The response may include the NGC UPF-side tunneling information for NGy. In case of home-routed roaming, the NG CCF-SM in VPLMN may need to request for session creation towards the NGC UPF in VPLMN. The request may include NG QoS rules for the NGC UPF. The request may further include the tunneling information for NG3 uplink if the network is configured to perform tunneling information allocation in the CP function. If the network is configured to perform tunneling information allocation in the UP function, the NGC UPF allocates tunneling information for NG3 uplink. The tunneling information may include IP address(es) and/or tunneling ID(s). The NGC UPF responds to the NG CCF confirming the successful creation of the session. The response may include the tunneling information for NG3 uplink.

[00171] At step 530, the NG CCF may now respond to the relocation request from the MME. The response may include the NGy tunneling information and admitted bearer IDs for forwarding. At step 535, the MME may request the SGW to establish forwarding tunnels. The request may include the NGC UPF-side NGy tunneling information per admitted bearer. The response from the SGW may include the S1 UL tunneling information.

[00172] At step 540, the MME may send a handover command message including the admitted bearer IDs associated with S1 UL tunneling information. The eNB commands handover to the UE.

[00173] At this point, the downlink PDU path (after the eNB receives the DL PDUs) may be described as follows: eNB → SGW → NGC UPF → NG RAN Node. The eNB may forward the PDUs subject to forwarding. The SGW forwards the PDUs via the NGy tunnels to the NGC UPF. The NGC UPF marks the PDUs according to the NG QoS rules as necessary. The NG RAN processes the forwarded PDUs according to the NG QoS rules.

[00174] At step 545, the UE sends a handover confirm message to the NG RAN Node. The NG RAN Node notifies the NG CCF that the UE is switched to the NG RAN. The notification message may include the NG3 DL tunneling information. At step 550, the NG CCF may indicate that the relocation is complete to the MME. The MME may subsequently acknowledge the indication.

[00175] At step 555, the NG CCF may provide an indication to the NG PCF/PCRF that the session is modified. This may impact the UE's charging (and other policy control) due to path switch. The NG PCF/PCRF may provide the NG policy and charging information to the NG CCF if the modification is needed. If the NG policy and charging information is received, the NG CCF modifies the NG QoS rules based on the NG policy and charging information and updates the NG QoS rules to the NG RAN and NGC UPF. The NG QoS rules for NGC UPF may be provided to the NGC UPF and the NG QoS rules for NG RAN may be delivered to the NG RAN via a dedicated message (not shown in the figure).

[00176] At step 560, the NG CCF may forward the NG3 downlink tunneling information to the NGC UPF and the NGC UPF may then acknowledge the session modification. Additionally the NG CCF may send the NG QoS rules to the NGC UPF, if modified.

[00177] In some embodiments, the NGC UPF may send one or more end marker PDUs towards the SGW and E-UTRAN via bearers subject to PDU forwarding. For each of the bearers, the E-UTRAN may send the end marker PDUs if the E-UTRAN is done with forwarding PDUs of the bearer. If the end marker PDUs are received by the NGC UPF through a NGy tunnel corresponding to the bearer, the NGC UPF tags the end marker PDUs with one or more FII values according to the mapping relationship of the bearer and the FII value(s).

[00178] As the NG RAN receives one or more end marker PDUs with a specific FII value, the NG RAN may start to send buffered PDUs with the FII value. The NG RAN may only buffer PDUs that were marked with the FII value(s) that the NG RAN admitted forwarding. In some embodiments, QoS flows corresponding to the QoS flow descriptors admitted for forwarding may not support in-sequence delivery as the end marker PDUs for the QoS flows do not include information to be identified by the QoS flow descriptors.

[00179] Figure 6 depicts a data flow diagram showing an exemplary implementation of the invention, for example, mobility from the NGS to the EPS. Though the steps are described in a particular order below, the order may be changed.

[00180] At step 605, the NG RAN Node may provide an indication to the NG CCF-MM that the UE should be handed over to the eNB. The NG RAN Node may include FII values and/or QoS flow descriptors whose PDUs the NG RAN Node proposes to be forwarded.

[00181] At step 610, the NG CCF may select the target core network node (MME) and send a forward relocation request message to the MME. The forward relocation request message may include the UE context (e.g. NG QoS rules and NGMM context including NGS security context) and proposed FII values and/or QoS flow descriptors for PDU forwarding.

[00182] The MME may map the NG QoS rules into EPS bearer contexts. In some embodiments, the MME may map the FII values and QoS flow descriptors into QCI values and thus bearers, and subsequently allocate EPS bearer IDs. In the event that the GBR/MBR are associated with the FII values and QoS flow descriptors, the corresponding QCI values may also be associated with the GBR/MBR. The proposed FII values and QoS flow descriptors may also be mapped to the bearers.

[00183] At step 615, the MME may select the SGW and send a create session request message. The SGW may then respond to the MME. The response may include the SGW addresses and S1-U uplink TEIDs. In some embodiments, the NGC UPF may act as an S-GW.

[00184] At step 620, the MME may send a message requesting handover to the target eNB. The message may include the bearer IDs converted from the proposed FII values and QoS flow descriptors by the NG RAN Node. In some embodiments, the MME may exclude IDs of bearers that

are not allowed for PDU forwarding. The eNB may then acknowledge the request and include the admitted bearer ID list associated with S1 DL tunneling information in the acknowledgement to the MME.

[00185] At step 625, the MME may request establishment of forwarding tunnels towards the SGW including the list of admitted bearer IDs. The SGW may then respond to the request with SGW-side NGy tunneling information per admitted bearer.

[00186] At step 630, the MME may send a response message for the relocation request including the SGW-side NGy tunneling information per admitted bearer. Each of the admitted bearers may be associated with the FII values and/or QoS flow descriptors.

[00187] At step 635, the NG CCF may interact with the NGC UPF to establish PDU forwarding tunnel(s). The NG CCF may then provide the NGC UPF with the SGW-side NGy tunneling information. The NGC UPF may provide the NG3 UL tunneling information.

[00188] At step 640, the NG CCF may provide a message commanding handover to the NG RAN Node. The message commanding handover may include the admitted FII values and/or QoS descriptors for forwarding associated with the NG3 UL tunneling information. The NG RAN Node may send a handover command message to the UE.

[00189] At this point, the downlink PDU path (after the NG RAN Node receives DL PDUs) may be described as follows: NG RAN Node → NGC UPF → SGW → eNB. The NG RAN Node may forward the PDUs subject to forwarding. The NGC UPF may un-tag the forwarded PDUs if they are tagged. The un-tagged PDUs may then be forwarded to the SGW via the NGy tunnels for forwarding. The NGC UPF may use the mapping information from the FII values and/or QoS flow descriptors into corresponding bearers, in order to map the flows to corresponding bearers.

[00190] At step 645, the UE may send a handover confirm message to the eNB. The eNB may then notify the MME that the handover to the eNB is complete. The MME may send a forward relocation complete notification message. The NG CCF may then provide an acknowledgement to the message. The MME may send a modify bearer request message to the SGW. The SGW may then provide an acknowledgement of the session modification. The SGW may then send a modify bearer response message to the NG CCF. The message may include the S5/8 downlink TEIDs and SGW addresses. The NG CCF may provide an indication to the NG PCF/PCRF that the session is modified. This may impact the UE's charging (and other policy) due to path switch. The NG PCF/PCRF may provide the EPS PCC rules to the NG CCF if the modification is required. The NG CCF may modify EPS bearer contexts based on the EPS PCC rules and creates dedicated bearer as necessary. The NG CCF indicates S5/8 downlink TEIDs and SGW addresses to the NGC UPF. The NG CCF may provide the traffic handling rules to the NGC UPF.

[00191] At this point, the user plane path between the UE and a data network includes eNB, SGW, and NGC UPF. The NGC UPF may send the end marker PDUs with FII or certain marking

values subject to forwarding. For each of the marking value of the end marker PDUs, the NG RAN may send the end marker PDUs with the marking value to the NGC UPF after the NG RAN is done with forwarding PDUs for the FII value. The NGC UPF may then send the end marker PDUs removing the FII values via the NGy tunnels. The end marker PDUs may then be delivered via a NGy tunnel after end marker PDUs of complete set of FII values (subject to forwarding) corresponding to the bearer are received.

[00192] Figures 4-6 show flowcharts of the exemplary operations performed by a method, apparatus and computer program product in accordance with an embodiment of the present invention. It will be understood that each block of the flowcharts, and combinations of blocks in the flowcharts, may be implemented by various means, such as hardware, firmware, processor, circuitry and/or other device associated with execution of software including one or more computer program instructions. For example, one or more of the procedures described above may be embodied by computer program instructions. In this regard, the computer program instructions which embody the procedures described above may be stored by a memory 26 of an apparatus employing an embodiment of the present invention and executed by a processor 24 in the apparatus. As will be appreciated, any such computer program instructions may be loaded onto a computer or other programmable apparatus (e.g., hardware) to produce a machine, such that the resulting computer or other programmable apparatus provides for implementation of the functions specified in the flowchart block(s). These computer program instructions may also be stored in a non-transitory computer-readable storage memory that may direct a computer or other programmable apparatus to function in a particular manner, such that the instructions stored in the computer-readable storage memory produce an article of manufacture, the execution of which implements the function specified in the flowchart block(s). The computer program instructions may also be loaded onto a computer or other programmable apparatus to cause a series of operations to be performed on the computer or other programmable apparatus to produce a computer-implemented process such that the instructions which execute on the computer or other programmable apparatus provide operations for implementing the functions specified in the flowchart block(s). As such, the operations of Figures 4-6 when executed, convert a computer or processing circuitry into a particular machine configured to perform an example embodiment of the present invention. Accordingly, the operations of Figures 4-6 define an algorithm for configuring a computer or processing to perform an example embodiment. In some cases, a general purpose computer may be provided with an instance of the processor which performs the algorithms of Figures 4-6 to transform the general purpose computer into a particular machine configured to perform an example embodiment.

[00193] Accordingly, blocks of the flowchart support combinations of means for performing the specified functions and combinations of operations for performing the specified functions. It will also be understood that one or more blocks of the flowcharts, and combinations of blocks in the

flowcharts, can be implemented by special purpose hardware-based computer systems which perform the specified functions, or combinations of special purpose hardware and computer instructions.

[00194] In some embodiments, certain ones of the operations herein may be modified or further amplified as described below. Moreover, in some embodiments additional optional operations may also be included as shown by the blocks having a dashed outline in Figures 4-6. It should be appreciated that each of the modifications, optional additions or amplifications below may be included with the operations above either alone or in combination with any others among the features described herein.

[00195] Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Moreover, although the foregoing descriptions and the associated drawings describe example embodiments in the context of certain example combinations of elements and/or functions, it should be appreciated that different combinations of elements and/or functions may be provided by alternative embodiments without departing from the scope of the appended claims. In this regard, for example, different combinations of elements and/or functions than those explicitly described above are also contemplated as may be set forth in some of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

What is claimed is:

1. A method for allowing Protocol data unit (PDU) sessions in a source system to be maintained in a target system by transferring user equipment (UE) context during a system change, the method comprising:

5 receiving, at a target core entity, during a system change, a UE context, the target core entity being one of a mobile management entity (MME) and Next generation core control plane function - Session management (NG CCF-SM), the system changes being one of a handover from EPS to NGS or a handover from NGS to EPS;

transmitting a handover request to a target core network node;

10 transmitting a request to establish forwarding tunnels;

transmitting a message commanding handover, the message comprising tunneling information; and

receiving a handover confirm message.

15 2. The method according to Claim 1, wherein the system change involves a UE being handed over from the source system, the source system being an Evolved Packet System (EPS) to the target system, the target system being a Next Generation System (NGS).

3. The method according to claim 2, wherein the target core network node is a NG CCF-SM.

20 4. The method according to Claim 3, wherein the method further comprises: receiving a forwarded relocation request, the forwarded relocation request originating at eNB and indicates that the UE is to be handed over to the NG RAN Node and includes IDs of bearers whose PDUs the eNB proposes to be forwarded.

25 5. The method according to any of Claims 3 or 4, wherein the UE context may include EPS bearer contexts and EMM context including EPS security context and a source to target transparent container

30 6. The method according to any of Claim 3 to 5, further comprising: causing transmission of a request to and receiving a response from a next generation Policy and Charging Rule Function (NG PCRF) for NG policy and charging information.

35 7. The method according to Claim 6, further comprising: based on the NG policy and charging information, generating NG QoS rules for NG RAN and NGC UPF.

8. The method according to Claim 6, further comprising: obtaining QCI/GBR/MBR from the UE context.

9. The method according to any of Claims 3 to 8, wherein the handover request indicates a handover from NG CCF to a NG RAN, and includes the NG QoS rules and a source to target transparent container.

10. The method according to Claim 9, wherein the NG QoS rules for NG RAN includes a bearer ID for each of the FII values and QoS flow descriptors.

11. The method according to any of Claims 3 to 9, further comprising: receiving a response to the handover request.

12. The method according to Claim 11, wherein the response to the handover request comprises the FII values and/or QoS flow descriptors admitted by the NG RAN Node to be forwarded.

13. The method according to any of Claims 3 to 12, further comprising: preceding the message indicating the request to establish forwarding tunnels, based on the admitted FII values and/or QoS flow descriptors, confirming the list of bearers to be forwarded.

14. The method according to any of Claims 3 to 13, wherein the request, the message indicating the request to establish forwarding tunnels, includes the NG3 tunneling information and NG QoS rules for NGC UPF.

15. The method according to any of Claims 3 to 14, further comprising: receiving confirmation, from the NGC UPF, confirming an establishment of the tunnels, wherein the confirmation includes NGC UPF-side tunnelling information for interface NGy.

16. The method according to any of Claims 3 to 14, further comprising: responding to relocation request from the MME, the response comprising the tunnelling information and admitted bearer IDs for forwarding.

17. The method according to any of Claims 3 to 16, wherein the handover confirm message indicates that the UE is switched to the NG RAN, wherein the message includes the NG3 DL tunneling information.

18. The method according to any of Claims 3 to 17, further comprising: providing an indication that the relocation is complete to the MME and receiving an acknowledgement from the MME.

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19. The method according to any of Claims 3 to 18, further comprising: providing an indication to the NG PCF/PCRF that the session is modified.

20. The method according to Claim 1, wherein the system change involves the handover of a UE from NGS to EPS.

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21. The method according to any of Claim 1 or 20, wherein the target core network node is an eNB.

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22. The method according to any of Claims 20 or 21, further comprising: receiving a forwarded relocation request, the forwarded relocation request originating at NG RAN and indicating that the UE is to be handed over to the eNB and includes FII values or QoS flow descriptors whose PDUs the NG RAN Node proposes to be forwarded.

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23. The method according to any of Claim 20 to 22, further comprising: mapping the NG QoS rules into EPS bearer contexts.

24. The method according to any of Claim 20 to 22, further comprising: mapping the FII values and QoS flow descriptors into QCI values and bearers; and allocating EPS bearer IDs.

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25. The method according to any of Claim 20 to 24, further comprising: selecting a SGW; sending a Create Session Request message; and receiving a response from the SGW, the response including SGW addresses and S1-U uplink TEIDs.

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26. The method according to any of Claim 20 to 25, wherein the message requesting handover to the target eNB includes the bearer IDs converted from the proposed FII values and QoS flow descriptors by the NG RAN Node.

27. The method according to any of Claim 20 to 26, further comprising: receiving an acknowledgement, the acknowledgement including an admitted bearer ID list associated with S1 DL tunneling information.

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28. The method according to any of Claim 20 to 27, wherein the request for the establishment of forwarding tunnels is directed towards the SGW and includes the list of admitted bearer IDs; receiving, from the SGW, a response to the request with SGW-side NGy tunnelling information per admitted bearer.

29. The method according to any of Claim 20 to 28, further comprising: sending a response message for the relocation request, the response message including SGW-side NGy tunneling information per admitted bearer, wherein each of the admitted bearers are associated with at least one of the FII values or QoS flow descriptors.

30. The method according to Claim 29, wherein subsequent to sending the response message, the NG CCF transmits a message commanding handover to the NG RAN Node, the message commanding handover comprising at least one of the admitted FII values or QoS descriptors for forwarding associated with the NG3 UL tunneling information; and the NG RAN Node sends a handover command message to the UE.

31. The method according to Claim 30, wherein subsequent to the NG RAN Node sending the handover command message to the UE, the UE sends a handover confirm message to the eNB, the method further comprising: receiving, from the eNB, that the handover to the eNB is complete.

32. The method according to any of Claim 20 to 31, further comprising: sending a modify bearer request message to the SGW; and receiving an acknowledgement, wherein the SGW subsequently sends a modify bearer response message to the NG CCF and the NG CCF provides an indication to the NG PCF/PCRF that the session is modified.

33. The method according to Claim 32, wherein then NG CCF subsequently provides traffic handling rules to the NGC UPF, the NGC UPF sends end marker PDUs with at least one a marking value subject to forwarding, and for each of the marking value of the end marker PDUs, the NG RAN sends the end marker PDUs with the marking value to the NGC UPF after the NG RAN is done with forwarding PDUs for the FII value.

34. The method according to Claim 33, wherein the NGC UPF sends the end marker PDUs removing the FII values via the NGy tunnels, wherein the end marker PDUs are delivered via a NGy tunnel after end marker PDUs of complete set of FII values subject to forwarding corresponding to the bearer are received.

35. An apparatus for allowing Protocol data unit (PDU) sessions in a source system to be maintained in a target system by transferring user equipment (UE) context during a system change, the 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 processor, cause the apparatus to at least:

receive, at a target core entity, during a system change, a UE context, the target core entity being one of a mobile management entity (MME) and Next generation core control plane function - Session management (NG CCF-SM), the system changes being one of a handover from EPS to NGS or a handover from NGS to EPS;

transmit a handover request to a target core network node;

transmit a request to establish forwarding tunnels;

transmit a message commanding handover, the message comprising tunneling information; and

receive a handover confirm message.

36. The apparatus according to Claim 35, wherein the system change involves a UE being handed over from the source system, the source system being an Evolved Packet System (EPS) to the target system, the target system being a Next Generation System (NGS).

37. The apparatus according to claim 36, wherein the target core network node is a NG CCF-SM.

38. The apparatus according to Claim 37, wherein the apparatus further comprises: receiving a forwarded relocation request, the forwarded relocation request originating at eNB and indicates that the UE is to be handed over to the NG RAN Node and includes IDs of bearers whose PDUs the eNB proposes to be forwarded.

39. The apparatus according to any of Claims 37 or 38, wherein the UE context may include EPS bearer contexts and EMM context including EPS security context and a source to target transparent container

40. The apparatus according to any of Claim 37 to 39, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: cause transmission of a request to and receiving a response from a next generation Policy and Charging Rule Function (NG PCRF) for NG policy and charging information.

41. The apparatus according to Claim 40, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: based on the NG policy and charging information, generate NG QoS rules for NG RAN and NGC UPF.

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42. The apparatus according to Claim 40, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: obtain QCI/GBR/MBR from the UE context.

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43. The apparatus according to any of Claims 37 to 42, wherein the handover request indicates a handover from NG CCF to a NG RAN, and includes the NG QoS rules and a source to target transparent container.

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44. The apparatus according to Claim 43, wherein the NG QoS rules for NG RAN includes a bearer ID for each of the FII values and QoS flow descriptors.

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45. The apparatus according to any of Claims 37 to 44, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: receive a response to the handover request.

46. The apparatus according to Claim 45, wherein the response to the handover request comprises the FII values and/or QoS flow descriptors admitted by the NG RAN Node to be forwarded.

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47. The apparatus according to any of Claims 37 to 46, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: preceding the message indicating the request to establish forwarding tunnels, based on the admitted FII values or QoS flow descriptors, confirm the list of bearers to be forwarded.

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48. The apparatus according to any of Claims 37 to 47, wherein the request, the message indicating the request to establish forwarding tunnels, includes the NG3 tunneling information and NG QoS rules for NGC UPF.

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49. The apparatus according to any of Claims 37 to 48, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to:

receive confirmation, from the NGC UPF, confirming an establishment of the tunnels, wherein the confirmation includes NGC UPF-side tunneling information for interface NGy.

50. The apparatus according to any of Claims 37 to 48, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: respond to relocation request from the MME, the response comprising the tunneling information and admitted bearer IDs for forwarding.

51. The apparatus according to any of Claims 37 to 50, wherein the handover confirm message indicates that the UE is switched to the NG RAN, wherein the message includes the NG3 DL tunneling information.

52. The apparatus according to any of Claims 37 to 51, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: provide an indication that the relocation is complete to the MME and receive an acknowledgement from the MME.

53. The apparatus according to any of Claims 37 to 52, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: provide an indication to the NG PCF/PCRF that the session is modified.

54. The apparatus according to Claim 35, wherein the system change involves the handover of a UE from NGS to EPS.

55. The apparatus according to any of Claim 35 or 54, wherein the target core network node is an eNB.

56. The apparatus according to any of Claims 35 or 55, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: receive a forwarded relocation request, the forwarded relocation request originating at NG RAN and indicating that the UE is to be handed over to the eNB and includes FQI values or QoS flow descriptors whose PDUs the NG RAN Node proposes to be forwarded.

57. The apparatus according to any of Claim 54 to 56, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: mapping the NG QoS rules into EPS bearer contexts.

58. The apparatus according to any of Claim 54 to 56, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: map the FII values and QoS flow descriptors into QCI values and bearers; and allocate EPS bearer IDs.

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59. The apparatus according to any of Claim 54 to 58, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: select a SGW; sending a Create Session Request message; and receive a response from the SGW, the response including SGW addresses and S1-U uplink TEIDs.

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60. The apparatus according to any of Claim 54 to 59, wherein the message requesting handover to the target eNB includes the bearer IDs converted from the proposed FII values and QoS flow descriptors by the NG RAN Node.

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61. The apparatus according to any of Claim 54 to 60, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: receive an acknowledgement, the acknowledgement including an admitted bearer ID list associated with S1 DL tunneling information.

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62. The apparatus according to any of Claim 54 to 61, wherein the request for the establishment of forwarding tunnels is directed towards the SGW and includes the list of admitted bearer IDs; receiving, from the SGW, a response to the request with SGW-side NGy tunnelling information per admitted bearer.

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63. The apparatus according to any of Claim 54 to 62, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: send a response message for the relocation request, the response message including SGW-side NGy tunneling information per admitted bearer, wherein each of the admitted bearers are associated with at least one of the FII values or QoS flow descriptors.

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64. The apparatus according to Claim 63, wherein subsequent to sending the response message, the NG CCF transmits a message commanding handover to the NG RAN Node, the message commanding handover comprising at least one of the admitted FII values or QoS descriptors for forwarding associated with the NG3 UL tunneling information; and the NG RAN Node sends a handover command message to the UE.

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65. The apparatus according to Claim 64, wherein subsequent to the NG RAN Node sending the handover command message to the UE, the UE sends a handover confirm message to the eNB, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: receive, from the eNB, that the handover to the eNB is complete.

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66. The apparatus according to any of Claim 54 to 65, wherein the at least one memory and the computer program code are further configured to, with the processor, cause the apparatus to: send a modify bearer request message to the SGW; and receive an acknowledgement, wherein the SGW subsequently sends a modify bearer response message to the NG CCF and the NG CCF provides an indication to the NG PCF/PCRF that the session is modified.

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67. The apparatus according to Claim 66, wherein then NG CCF subsequently provides traffic handling rules to the NGC UPF, the NGC UPF sends end marker PDUs with at least one a marking value subject to forwarding, and for each of the marking value of the end marker PDUs, the NG RAN sends the end marker PDUs with the marking value to the NGC UPF after the NG RAN is done with forwarding PDUs for the FII value.

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68. The apparatus according to Claim 67, wherein the NGC UPF sends the end marker PDUs removing the FII values via the NGy tunnels, wherein the end marker PDUs are delivered via a NGy tunnel after end marker PDUs of complete set of FII values subject to forwarding corresponding to the bearer are received.

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69. (1.) A computer program product for allowing Protocol data unit (PDU) sessions in a source system to be maintained in a target system by transferring user equipment (UE) context during a system change, the computer program product comprising at least one non-transitory computer-readable storage medium having computer-executable program code instructions stored therein, the computer-executable program code instructions comprising program code instructions for:

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receiving, at a target core entity, during a system change, a UE context, the target core entity being one of a mobile management entity (MME) and Next generation core control plane function - Session management (NG CCF-SM), the system changes being one of a handover from EPS to NGS or a handover from NGS to EPS;

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transmitting a handover request to a target core network node;

transmitting a request to establish forwarding tunnels;

transmitting a message commanding handover, the message comprising tunneling information; and

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receiving a handover confirm message.

70. 2. The computer program product according to Claim 69, wherein the system change involves a UE being handed over from the source system, the source system being an Evolved Packet System (EPS) to the target system, the target system being a Next Generation System (NGS).

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71. The computer program product according to claim 70, wherein the target core network node is a NG CCF-SM.

72. The computer program product according to Claim 71, wherein the computer program product further comprises: receiving a forwarded relocation request, the forwarded relocation request originating at eNB and indicates that the UE is to be handed over to the NG RAN Node and includes IDs of bearers whose PDUs the eNB proposes to be forwarded.

73. The computer program product according to any of Claims 71 or 72, wherein the UE context may include EPS bearer contexts and EMM context including EPS security context and a source to target transparent container

74. 6. The computer program product according to any of Claim 71 to 73, wherein the computer-executable program code instructions further comprise program code instructions for: causing transmission of a request to and receiving a response from a next generation Policy and Charging Rule Function (NG PCRF) for NG policy and charging information.

75. The computer program product according to Claim 74, wherein the computer-executable program code instructions further comprise program code instructions for: based on the NG policy and charging information, generating NG QoS rules for NG RAN and NGC UPF.

76. The computer program product according to Claim 74, wherein the computer-executable program code instructions further comprise program code instructions for: obtaining QCI/GBR/MBR from the UE context.

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77. The computer program product according to any of Claims 71 to 76, wherein the handover request indicates a handover from NG CCF to a NG RAN, and includes the NG QoS rules and a source to target transparent container.

78. The computer program product according to Claim 77, wherein the NG QoS rules for NG RAN includes a bearer ID for each of the FII values and QoS flow descriptors.

79. The computer program product according to any of Claims 71 to 78, wherein the computer-executable program code instructions further comprise program code instructions for: receiving a response to the handover request.

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80. The computer program product according to Claim 79, wherein the response to the handover request comprises the FII values and/or QoS flow descriptors admitted by the NG RAN Node to be forwarded.

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81. The computer program product according to any of Claims 71 to 80, wherein the computer-executable program code instructions further comprise program code instructions for: preceding the message indicating the request to establish forwarding tunnels, based on the admitted FII values and/or QoS flow descriptors, confirming the list of bearers to be forwarded.

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82. The computer program product according to any of Claims 71 to 81, wherein the request (the message indicating the request to establish forwarding tunnels) includes the NG3 tunneling information and NG QoS rules for NGC UPF.

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83. The computer program product according to any of Claims 71 to 82, wherein the computer-executable program code instructions further comprise program code instructions for: receiving confirmation, from the NGC UPF, confirming an establishment of the tunnels, wherein the confirmation includes NGC UPF-side tunnelling information for interface NGy.

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84. The computer program product according to any of Claims 71 to 82, wherein the computer-executable program code instructions further comprise program code instructions for: responding to relocation request from the MME, the response comprising the tunnelling information and admitted bearer IDs for forwarding.

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85. The computer program product according to any of Claims 71 to 84, wherein the handover confirm message indicates that the UE is switched to the NG RAN, wherein the message includes the NG3 DL tunneling information.

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86. The computer program product according to any of Claims 71 to 85, wherein the computer-executable program code instructions further comprise program code instructions for: providing an indication that the relocation is complete to the MME and receiving an acknowledgement from the MME.

87. The computer program product according to any of Claims 71 to 86, wherein the computer-executable program code instructions further comprise program code instructions for: providing an indication to the NG PCF/PCRF that the session is modified.

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88. The computer program product according to Claim 69, wherein the system change involves the handover of a UE from NGS to EPS.

89. The computer program product according to any of Claim 69 or 88, wherein the target
10 core network node is an eNB.

90. The computer program product according to any of Claims 88 or 89, wherein the computer-executable program code instructions further comprise program code instructions for: receiving a forwarded relocation request, the forwarded relocation request originating at NG RAN
15 and indicating that the UE is to be handed over to the eNB and includes FII values or QoS flow descriptors whose PDUs the NG RAN Node proposes to be forwarded.

91. The computer program product according to any of Claim 88 to 90, wherein the computer-executable program code instructions further comprise program code instructions for:
20 mapping the NG QoS rules into EPS bearer contexts.

92. The computer program product according to any of Claim 88 to 90, wherein the computer-executable program code instructions further comprise program code instructions for: mapping the FII values and QoS flow descriptors into QCI values and bearers; and allocating EPS
25 bearer IDs.

93. The computer program product according to any of Claim 88 to 92, wherein the computer-executable program code instructions further comprise program code instructions for: selecting a SGW; sending a Create Session Request message; and receiving a response from the
30 SGW, the response including SGW addresses and S1-U uplink TEIDs.

94. The computer program product according to any of Claim 88 to 93 (25), wherein the message requesting handover to the target eNB includes the bearer IDs converted from the proposed FII values and QoS flow descriptors by the NG RAN Node.

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95. The computer program product according to any of Claim 88 to 94, wherein the computer-executable program code instructions further comprise program code instructions for: receiving an acknowledgement, the acknowledgement including an admitted bearer ID list associated with S1 DL tunneling information.

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96. The computer program product according to any of Claim 88 to 95, wherein the request for the establishment of forwarding tunnels is directed towards the SGW and includes the list of admitted bearer IDs; receiving, from the SGW, a response to the request with SGW-side NGy tunnelling information per admitted bearer.

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97. The computer program product according to any of Claim 88 to 96, wherein the computer-executable program code instructions further comprise program code instructions for: sending a response message for the relocation request, the response message including SGW-side NGy tunneling information per admitted bearer, wherein each of the admitted bearers are associated with at least one of the FII values or QoS flow descriptors.

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98. The computer program product according to Claim 97, wherein subsequent to sending the response message, the NG CCF transmits a message commanding handover to the NG RAN Node, the message commanding handover comprising at least one of the admitted FII values or QoS descriptors for forwarding associated with the NG3 UL tunneling information; and the NG RAN Node sends a handover command message to the UE.

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99. The computer program product according to Claim 98, wherein subsequent to the NG RAN Node sending the handover command message to the UE, the UE sends a handover confirm message to the eNB, the computer program product wherein the computer-executable program code instructions further comprise program code instructions for: receiving, from the eNB, that the handover to the eNB is complete.

25

100. The computer program product according to any of Claim 88 to 99, wherein the computer-executable program code instructions further comprise program code instructions for: sending a modify bearer request message to the SGW; and receiving an acknowledgement, wherein the SGW subsequently sends a modify bearer response message to the NG CCF and the NG CCF provides an indication to the NG PCF/PCRF that the session is modified.

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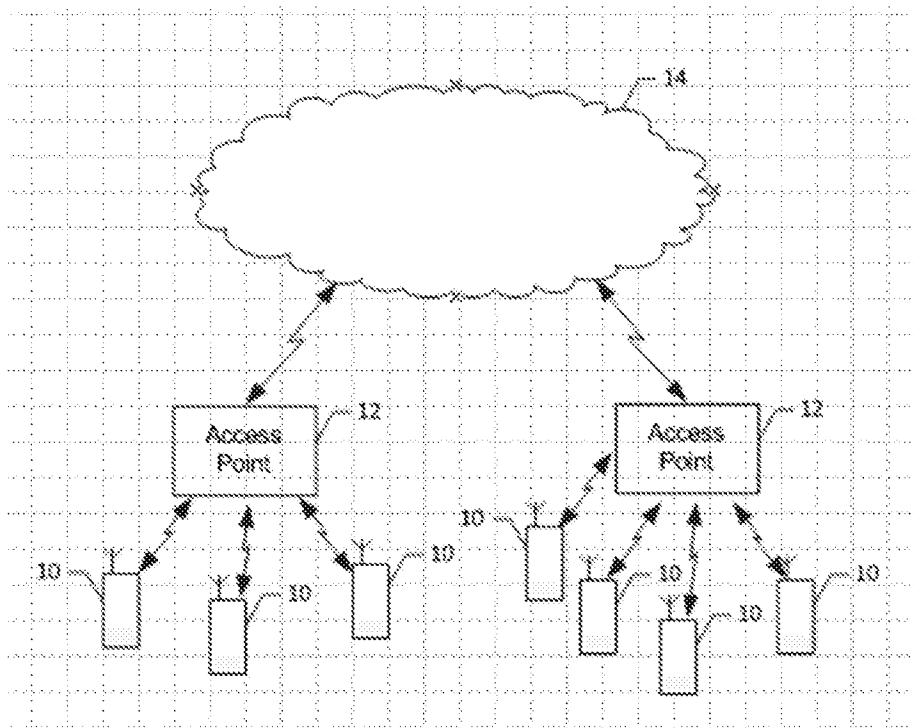
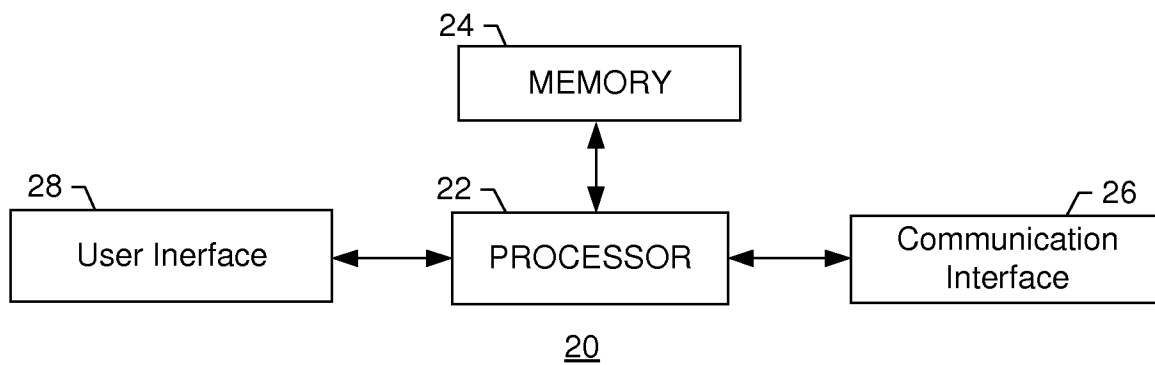
101. The computer program product according to Claim 100, wherein then NG CCF subsequently provides traffic handling rules to the NGC UPF, the NGC UPF sends end marker PDUs

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with at least one a marking value subject to forwarding, and for each of the marking value of the end marker PDUs, the NG RAN sends the end marker PDUs with the marking value to the NGC UPF after the NG RAN is done with forwarding PDUs for the FII value.

- 5 102. The computer program product according to Claim 101, wherein the NGC UPF sends the end marker PDUs removing the FII values via the NGy tunnels, wherein the end marker PDUs are delivered via a NGy tunnel after end marker PDUs of complete set of FII values subject to forwarding corresponding to the bearer are received.

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**FIG. 1****FIG. 2**

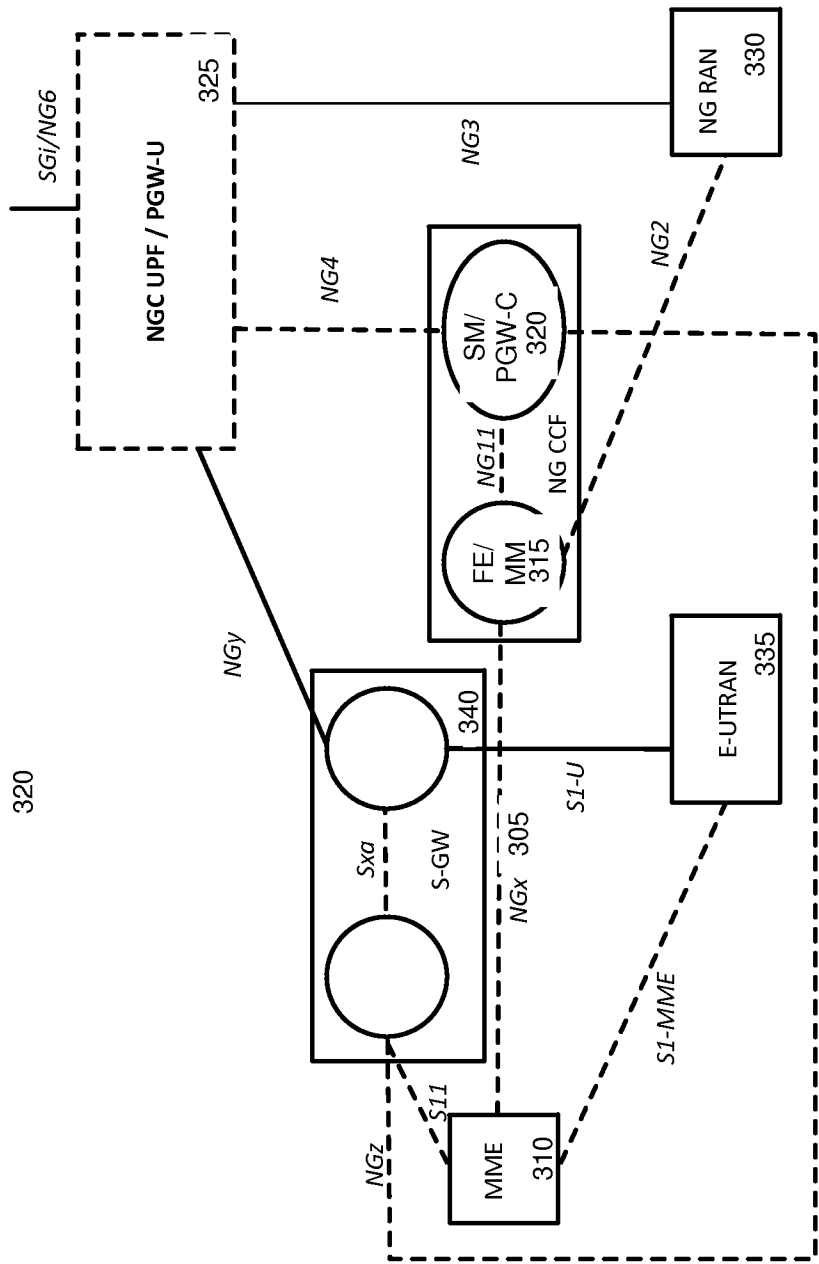
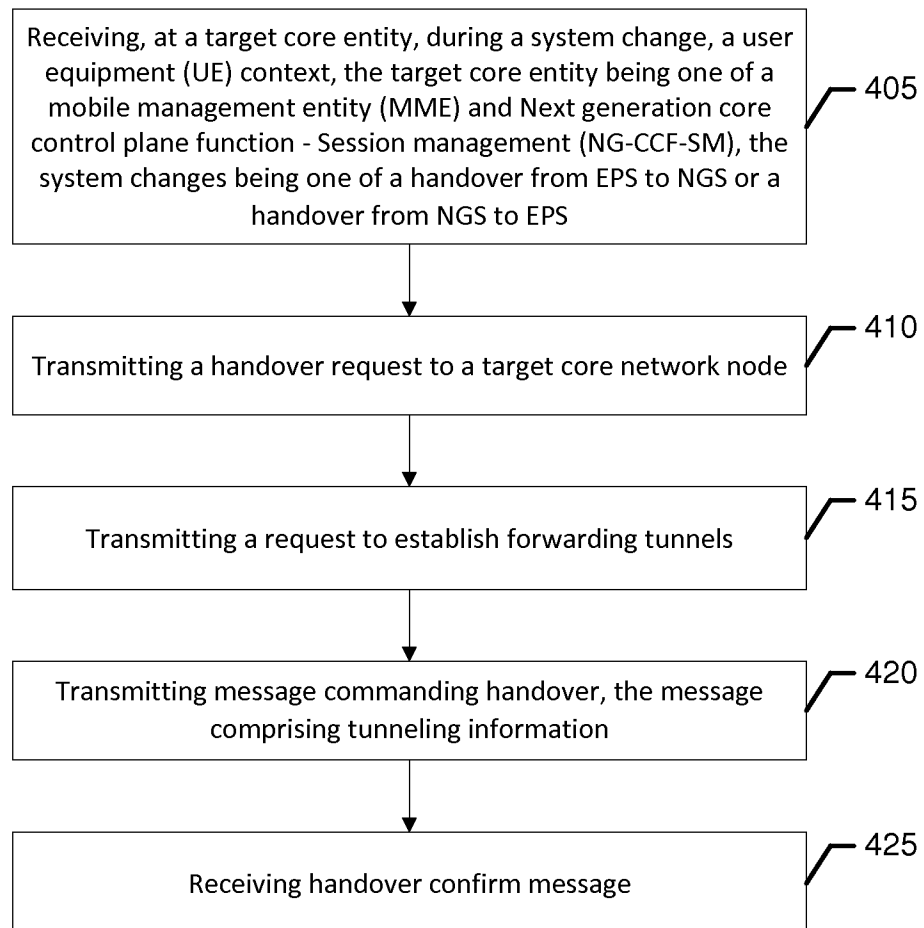


FIG. 3

**FIG. 4**

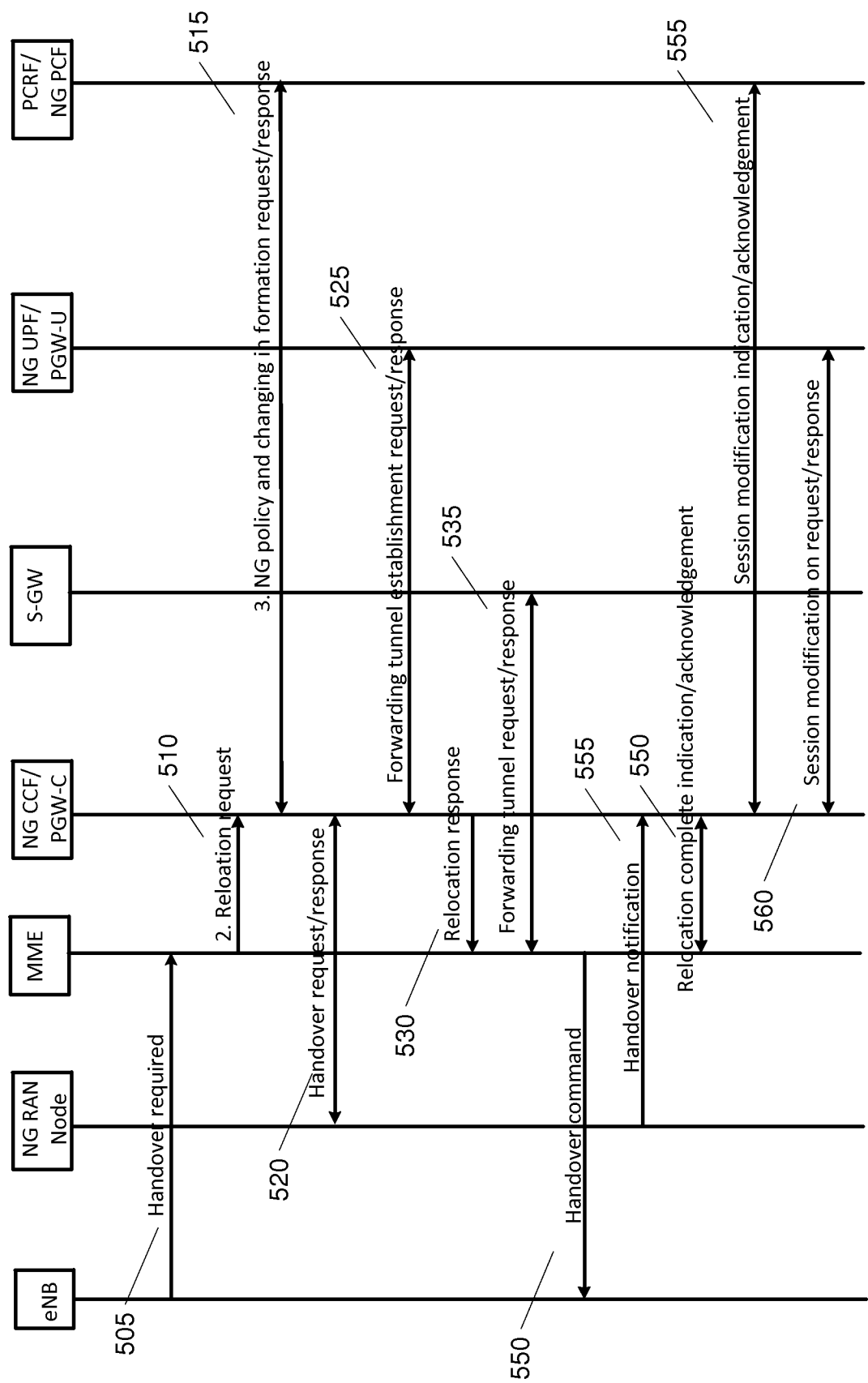


FIG. 5

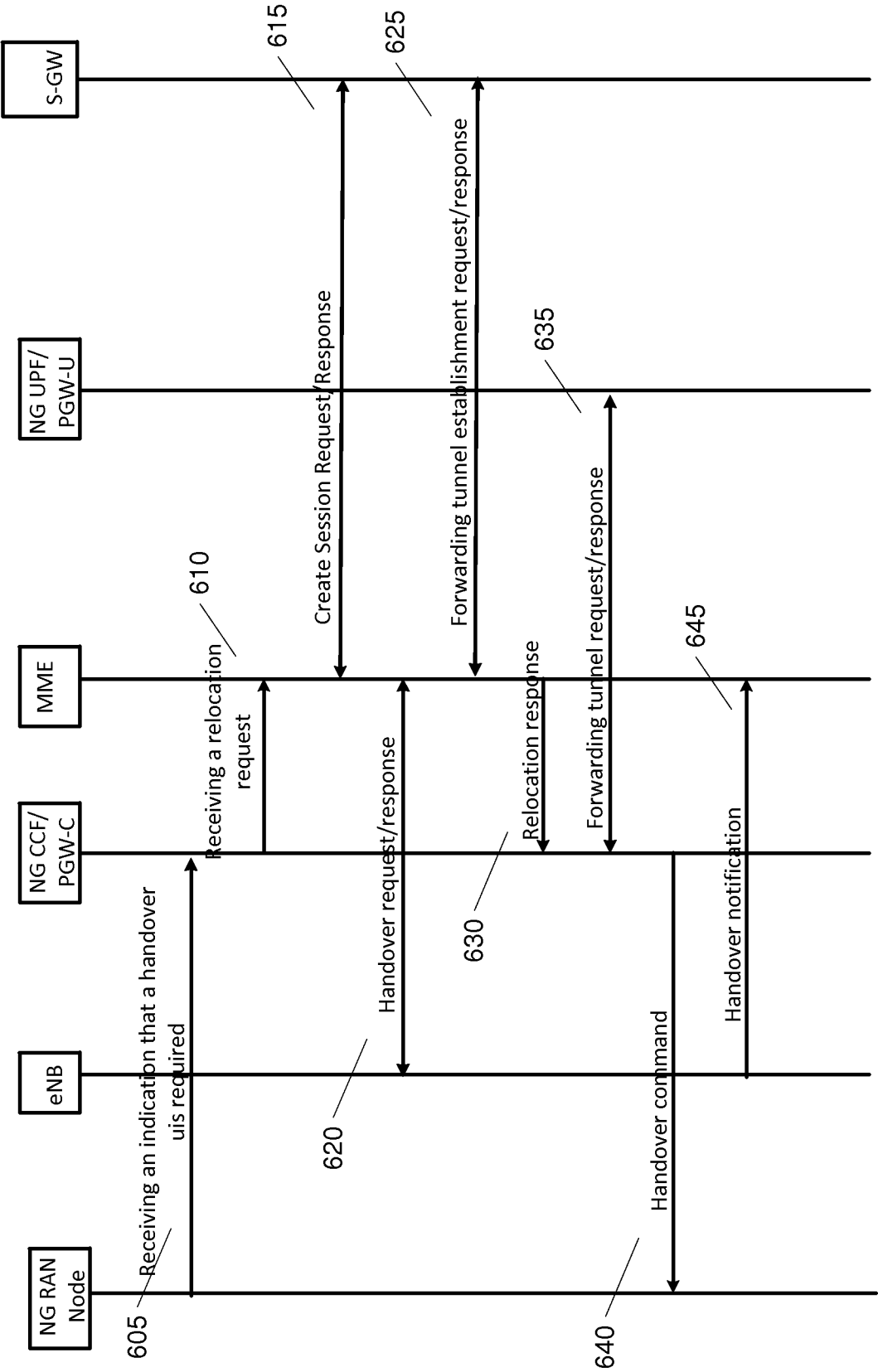


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2017/050835

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: H04W, H04L

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

FI, SE, NO, DK

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

EPODOC, EPO-Internal full-text databases

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Nokia: Solution for KI 18: Interworking of NGS and EPS based on inter-core context transfer, 3GPP SA WG2 Meeting #116BIS, S2-164395, 29 August - 2 September 2016, Sanya, P.R China. The whole document	1-102
Y	WO 2016047374 A1 (SHARP KK [JP]) 31 March 2016 (31.03.2016) & abstract [online] EPOQUENET EPODOC & machine translation into English by EPO [online] EPOQUENET PATENW, the whole document	1-102
A	US 9301229 B2 (ZHOU NA [CN] et al.) 29 March 2016 (29.03.2016) abstract	1-102
P, A	US 2017339609 A1 (YOUN MYUNGJUNE [KR] et al.) 23 November 2017 (23.11.2017)	1-102

☒ Further documents are listed in the continuation of Box C.
☒ See patent family annex.

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search

28 March 2018 (28.03.2018)

Date of mailing of the international search report

29 March 2018 (29.03.2018)

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2017/050835

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	WO 2018029933 A1 (NEC CORP [JP]) 15 February 2018 (15.02.2018) & abstract [online] EPOQUENET EPODOC & machine translation into English by EPO [online] EPOQUENET PATENW	1-102

INTERNATIONAL SEARCH REPORT
Information on Patent Family Members

International application No.
PCT/FI2017/050835

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
WO 2016047374 A1	31/03/2016	WO 2016047374	06/07/2017
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		CN 102196402 B	15/06/2016
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		KR 101410836 B1	24/06/2014
		WO 2011110025 A1	15/09/2011
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US 2017339609 A1	23/11/2017	None	
.....			
WO 2018029933 A1	15/02/2018	None	
.....			

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2017/050835

CLASSIFICATION OF SUBJECT MATTER

IPC

H04W 36/14 (2009.01)

H04W 36/38 (2009.01)

H04W 76/12 (2018.01)