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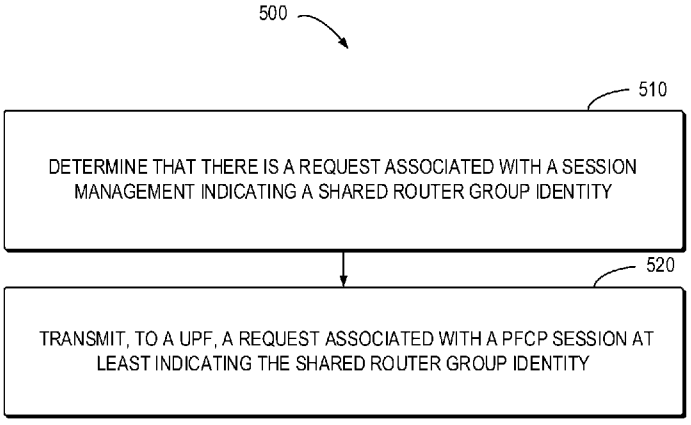

FIG. 5

(57) Abstract: Various example embodiments described herein relate to devices, methods, apparatuses and computer readable storage media of user equipment (UE) virtual network group management. For example, the method may comprise determining, at a session management function (SMF), that there is a request associated with session management indicating a shared router group identity, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity; and transmitting, to a user plane function (UPF), a request associated with a packet forwarding control protocol (PFCP) session at least indicating the shared router group identity.

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USER EQUIPMENT VIRTUAL NETWORK GROUP MANAGEMENT

TECHNICAL FIELD

[0001] Various example embodiments of this subject disclosure generally relate to the field of telecommunication, and more particularly to devices, methods, apparatuses and computer readable storage media relating to user equipment (UE) virtual network group management.

BACKGROUND

[0002] Examples of mobile or wireless telecommunication systems may include the Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (UTRAN), LTE Evolved UTRAN (E-UTRAN), LTE-Advanced (LTE-A), MulteFire, LTE-A Pro, Fifth Generation Mobile Communication Technology (5G) radio access technology or 5G New Radio (NR) access technology, and/or 5G-Advanced. 5G wireless systems refer to the next generation (NG) of radio systems and network architecture. 5G network technology is mostly based on NR technology, but the 5G (or NG) network can also build on E-UTRAN radio. It is estimated that NR may provide bitrates on the order of 10-20 Gbit/s or higher, and may support at least enhanced mobile broadband (eMBB) and ultra-reliable low-latency communication (URLLC) as well as massive machine-type communication (mMTC). NR is expected to deliver extreme broadband and ultra-robust, low-latency connectivity and massive networking to support the IoT.

SUMMARY

[0003] Some example embodiments of the subject disclosure will be described with respect to certain aspects. These aspects are not intended to indicate key or essential features of the various example embodiments, nor are they intended to be used to otherwise limit the scope of the subject disclosure. Other features, aspects and elements will be readily apparent to a person skilled in the art in view of the subject disclosure.

[0004] In a first aspect, there is provided an apparatus. The apparatus comprises at least one processor; and at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to: determine that there is a request associated with session management indicating a shared router group identity, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the

virtual network share a same shared router group identity; and transmit, to a user plane function (UPF), a request associated with a packet forwarding control protocol (PFCP) session at least indicating the shared router group identity.

[0005] In a second aspect, there is provided an apparatus. The apparatus comprises at least one processor; and at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to: receive, from a session management function (SMF), a request associated with a PFCP session at least indicating a shared router group identity associated with a terminal device router, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity; and perform an operation associated with the PFCP session at least based on the shared router group identity.

[0006] In a third aspect, there is provided an apparatus. The apparatus comprises at least one processor; and at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to: transmit, to SMF, a request associated with session management indicating a shared router group identity, wherein the apparatus belongs to a virtual network and one or more apparatuses belonging to the virtual network share a same shared router group identity.

[0007] In a fourth aspect, there is provided a method. The method comprises determining, at a SMF, that there is a request associated with session management indicating a shared router group identity, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity; and transmitting, to a UPF, a request associated with a PFCP session at least indicating the shared router group identity.

[0008] In a fifth aspect, there is provided a method. The method comprises receiving, at a UPF and from a SMF, a request associated with a PFCP session at least indicating a shared router group identity associated with a terminal device router, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity; and performing an operation associated with the PFCP session at least based on the shared router group identity.

[0009] In a sixth aspect, there is provided a method. The method comprises transmitting, from a terminal device router and to an SMF, a request associated with session management indicating a shared router group identity, wherein the terminal device router belongs to a

virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity.

[0010] In a seventh aspect, there is provided an apparatus comprising means for determining that there is a request associated with session management indicating a shared router group identity, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity; and means for transmitting, to a UPF, a request associated with a PFCP session at least indicating the shared router group identity.

[0011] In an eighth aspect, there is provided an apparatus comprising means for receiving from a SMF, a request associated with a PFCP session at least indicating a shared router group identity associated with a terminal device router, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity; and means for performing an operation associated with the PFCP session at least based on the shared router group identity.

[0012] In a ninth aspect, there is provided an apparatus comprising means for transmitting, to a SMF, a request associated with session management indicating a shared router group identity, wherein the apparatus belongs to a virtual network and one or more apparatuses belonging to the virtual network share a same shared router group identity.

[0013] In a tenth aspect, there is provided a computer readable medium having a computer program stored thereon which, when executed by at least one processor of an apparatus, causes the apparatus to carry out the method according to the fourth aspect, the fifth aspect or the sixth aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Some example embodiments of the subject disclosure will now be described with reference to the accompanying drawings.

[0015] FIG. 1 illustrates an example environment in which example embodiments of the subject disclosure may be implemented;

[0016] FIG. 2 shows a signaling chart illustrating an example of a process according to some example embodiments of the subject disclosure;

[0017] FIG. 3 shows an example of a UE's session management subscription model according to some example embodiments of the subject disclosure;

[0018] FIG. 4 shows an example of an implementation of a 2-step Packet Detection Rule (PDR) and Forwarding Action Rule (FAR) rule according to some example embodiments of the subject disclosure;

[0019] FIG. 5 shows a flowchart of an example method of a UE virtual network group management according to some example embodiments of the subject disclosure;

[0020] FIG. 6 shows a flowchart of an example method of a UE virtual network group management according to some example embodiments of the subject disclosure;

[0021] FIG. 7 shows a flowchart of an example method of a UE virtual network group management according to some example embodiments of the subject disclosure;

[0022] FIG. 8 shows a simplified block diagram of a device that is suitable for implementing example embodiments of the subject disclosure; and

[0023] FIG. 9 shows a block diagram of an example computer readable medium in accordance with some embodiments of the subject disclosure.

[0024] Throughout the drawings, the same or similar reference numerals may represent the same or similar element.

DETAILED DESCRIPTION

[0025] Various example example embodiments of the subject disclosure are further described. It is to be understood that these example embodiments are described only for the purpose of illustration and to aid those skilled in the art to understand and implement the subject disclosure, without suggesting any specific limitation as to the scope of the subject disclosure. Example embodiments described herein may be implemented in various manners other than the ones described below.

[0026] The terminology used herein is generally provided for the purpose of describing certain example embodiments only and is not intended to be limiting. In the following description and claims, all technical and scientific terms used herein may have the same meaning as commonly understood by one of ordinary skill in the art to which this subject disclosure pertains, unless otherwise defined.

[0027] References in the subject disclosure to "one embodiment," "an embodiment," "an example embodiment," "some example embodiments," "certain example embodiments," "various example embodiments," and the like indicate that the referenced embodiment(s)

described may include particular feature(s), structure(s), or characteristic(s), but it is not necessary that every embodiment or example embodiment described herein includes the particular feature(s), structure(s), or characteristic(s). Moreover, such phrases are not necessarily referring to the same embodiment or same example embodiment. Further, when particular feature(s), structure(s), or characteristic(s) are described in connection with an embodiment or example embodiment, it is submitted that it is within the knowledge of one skilled in the art to combine such feature(s), structure(s), or characteristic(s) in connection with any other embodiments or example embodiments described herein, whether or not such combination is explicitly described.

[0028] It shall be understood that although the terms "first," "second," and the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and similarly, a second element could be termed a first element without departing from the scope of example embodiments.

[0029] As used herein, "at least one of the following: <a list of two or more elements>" and "at least one of <a list of two or more elements>" and similar wording, where the list of two or more elements are joined by "and" or "or", mean at least any one of the elements, or at least any two or more of the elements, or at least all the elements. As used herein, the term "and/or" includes any and all combinations of one or more of the listed terms.

[0030] As used herein, unless stated explicitly, performing a step "in response to A" does not indicate that the step is performed immediately after "A" occurs, and one or more intervening steps may be included between "A" and the step.

[0031] As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "has", "having", "includes" and/or "including", when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof.

[0032] As used herein, the term "circuitry" may refer to one or more or all of the following example embodiments:

(a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and

(b) combinations of hardware circuits and software, such as (as applicable):

(i) a combination of analog and/or digital hardware circuit(s) with software/firmware and

(ii) any portions of hardware processor(s) with software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and

(c) hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor(s), that requires software (e.g., firmware) for operation, but the software may not be present when it is not needed for operation.

[0033] This definition of circuitry applies to all uses of this term herein, including in any claims. As a further example, as used herein, the term circuitry also covers an implementation of merely a hardware circuit or processor (or multiple processors) or portion of a hardware circuit or processor and its (or their) accompanying software and/or firmware. The term circuitry also covers, for example and if applicable to the particular claim element, a baseband integrated circuit or processor integrated circuit for a mobile device or a similar integrated circuit in server, a cellular network node, or other computing or network node.

[0034] As used herein, the term "communication network" refers to a network following any suitable communication standards, such as New Radio (NR), Long Term Evolution (LTE), LTE-Advanced (LTE-A), Wideband Code Division Multiple Access (WCDMA), High-Speed Packet Access (HSPA), Narrow Band Internet of Things (NB-IoT), an Enhanced Machine type communication (eMTC) and so on. Furthermore, the communications between a terminal device and a network node in the communication network may be performed according to any suitable generation communication protocols, including, but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the fifth generation (5G), the sixth generation (6G) communication protocols, and/or any other protocols either currently known or to be developed in the future. Exampel embodiments of the subject disclosure may be applied in various communication systems. Given the rapid development in communications, there will also be future type communication technologies and systems with which the subject disclosure may be embodied. It should not be seen as limiting the scope of the subject disclosure to only the aforementioned communication technologies and systems.

[0035] As used herein, the terms "network node", "radio network node" and/or "radio

access network node" refers to a node in a communication network via which a terminal device accesses the network and receives services therefrom. The network node may refer to a base station (BS/BTS) or an access point (AP), for example, a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), an NR NB (also referred to as a gNB), a Remote Radio Unit (RRU), a remote radio head (RRH), a relay, an Integrated Access and Backhaul (IAB) node, a low power node such as a femto, a pico, a non-terrestrial network (NTN) or non-ground network node such as a satellite network node, a low earth orbit (LEO) satellite and a geosynchronous earth orbit (GEO) satellite, an aircraft network node, and so forth, depending on the applied terminology and technology. In some example embodiments, low earth orbit (RAN) split architecture includes a Centralized Unit (CU) and a Distributed Unit (DU). In some other example embodiments, part of the radio access network node or full of the radio access network node may embark on an airborne or space-borne NTN vehicle.

[0036] The term "terminal device" refers to any end device that may be capable of wireless communication. By way of example rather than limitation, a terminal device may also be referred to as a communication device, user equipment (UE), an IP host connected to UE acting as a router, a Subscriber Station (SS), a Portable Subscriber Station, a Mobile Station (MS), or an Access Terminal (AT). The terminal device may include, but is not limited to, a mobile phone, a cellular phone, a smart phone, voice over IP (VoIP) phones, wireless local loop phones, a tablet, a wearable terminal device, a personal digital assistant (PDA), portable computers, desktop computer, image capture terminal devices such as digital cameras, gaming terminal devices, music storage and playback appliances, vehicle-mounted wireless terminal devices, wireless endpoints, mobile stations, laptop-embedded equipment (LEE), laptop-mounted equipment (LME), USB dongles, smart devices, wireless customer-premises equipment (CPE), an Internet of Things (loT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device and applications (e.g., remote surgery), an industrial device and applications (e.g., a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. The terminal device may also correspond to a Mobile Termination (MT) part of an IAB node (e.g., a relay node). As used herein, the terms "terminal device", "communication device", "terminal", "user equipment" and "UE" may be used interchangeably.

[0037] As used herein, the term "resource," "transmission resource," "resource block,"

"physical resource block" (PRB), "uplink resource," or "downlink resource" may refer to any resource for performing communication, for example, a communication between a terminal device and a network node, such as a resource in the time domain, a resource in the frequency domain, a resource in the space domain, a resource in the code domain, or any other resource enabling communication, and the like. A resource in both the frequency domain and time domain will be used as an example of a transmission resource for describing some example embodiments of the present disclosure. It is noted that example embodiments of the subject disclosure are equally applicable to other resources in other domains.

[0038] In industrial applications, there can be devices which lack capability to access the 5G network. Such device(s) may be configured to use a 5G UE as an access router to access 5G services and applications.

[0039] Certain industrial applications can be time-sensitive. Relying on one UE acting as the router has a certain degree of risk associated therewith, which may lead to single point of failure. Failure at a UE-router could be due to various reasons, such as UE power failure(s), connectivity failure(s) from the UE to the radio access network (RAN), line of sight (LOS) problem(s), overload condition(s), etc.In the following, various example embodiments of the subject disclosure are further explained with reference to mobile communication devices capable of communication via a wireless cellular system and mobile communication systems serving such mobile communication devices. Before further detailing the various example embodiments, certain general aspects of a wireless communication system, access systems thereof, and mobile communication devices are briefly explained with reference to FIG. 1 to assist in understanding the technology underlying the described examples.

[0040] FIG. 1 shows an example communication network 100 in which example embodiments of the subject disclosure may be implemented. As shown in FIG. 1, communication network 100 may comprise terminal devices 130-1 and 130-2. Terminal devices 130-1 and 130-2 may connect with one or more devices 140-1, 140-2, 140-3 and 140-4. Devices 140-1, 140-2, 140-3 and 140-4 may be configured without the capability to access the 5G System (5GS). For example, as shown, devices 140-1, 140-2, 140-3 and 140-4 may connect to terminal device 130-1 and/or 130-2 via a network, such as an IP network, a subnetwork, etc., to access the 5GS. That is, terminal device 130-1 and/or 130-2 may act as a router for devices 140-1, 140-2, 140-3 and 140-4.

[0041] Hereinafter devices 140-1, 140-2, 140-3 and/or 140-4 may also be referred to as

device 140 (more generally) without the capability to access the 5G collectively, whereas terminal devices 130-1 and 130-2 may also be referred to as terminal device routers 130-1 and 130-2, respectively, or a terminal device router 130 (more generally).

[0042] Communication network 100 may comprise a core network (CN) 103, which may, for example, comprise one or more network functions (NF) to support a user plane (UP) function, such as User Plane Function (UPF) 120. UPF 120 may be configured to forward traffic communicated between RAN 102 and one or more devices 140 behind the terminal device router 130. The forwarding path between UPF 120 and RAN 102 may be referred to as an N3 path.

[0043] CN 103 may also include a Session Management Element (SMF) 110 configured to implement a session management function in CN 103. SMF 110 is further configured to interact with the decoupled data plane, create, update, and remove Protocol Data Unit (PDU) sessions, and manage session context with UPF 120. Each of SMF 110 and UPF 120 can be implemented by one or more physical devices, apparatus or servers.

[0044] Furthermore, CN 103 may also include other NFs, such as an Access and Mobility Management function (AMF) 150 AMF 150 may be configured to provide various functions relating to security and access management and authorization. For example, AMF 150 may be configured to receive a new session management request from terminal device router 130 and/or RAN 102 and forward the session management request to SMF 110. CN 103 may further comprise a data network (DN) 160. The forwarding path between UPF 120 and DN 160 may be referred to as an N6 path.

[0045] It is to be understood that the number of network nodes and terminal devices depicted in FIG. 1 is provided for the purpose of illustration without suggesting any limitations. Communication network 100 may include any suitable number of network nodes and terminal devices.

[0046] Communications in communication network 100 may be implemented according to any proper communication protocol(s), including, but not limited to, cellular communication protocols of the first generation (1G), the second generation (2G), the third generation (3G), the fourth generation (4G), 5G, the sixth generation (6G), and the like, wireless local network communication protocols such as Institute for Electrical and Electronics Engineers (IEEE) 802.11 and the like, and/or any other protocols currently known or to be developed in the future. Moreover, the communication may utilize any proper wireless communication

technology, includes but not limited to: Code Division Multiple Access (CDMA), Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), FDD, TDD, Multiple-Input Multiple-Output (MIMO), Orthogonal Frequency Division Multiple (OFDM), Discrete Fourier Transform spread OFDM (DFT-s-OFDM) and/or any other technologies currently known or to be developed in the future.

[0047] As described above, a UE may be used as a router for devices, which do not have 5GS access capability. In such case, data transmission requirements for an industrial application may not be satisfied if it relies on only one UE due to the possibility of failure, such as UE power failure(s), UE-RAN connectivity failure(s), line of sight problem(s), overload condition(s), and so on.

[0048] The network behind the UE can only be manually configured via framed routes or prefixes delegated to the UE by the Internet Protocol Version 6 (IPv6) prefix delegation. The framed route feature allows the 5G Core (5GC) to identify the host device subnet present behind UE. Similarly, the IPv6 prefix represents the IPv6 prefix of the device(s) present behind UE.

[0049] A controller may be implemented as a software defined networking (SDN) controller. The controller may be configured to collect route or path information to understand network topology and manage flow control. The controller may, for example, consider various downlink (DL) routes present in the 5GC (e.g., CN 130 of FIG. 1) to reach device(s) behind UE that is/are acting as a router. In the case of multiple UE-routers, the controller should collect all the available routing information and then select a route from the collected information based on various network and device conditions.

[0050] For example, the 5GC can determine UEs to be used to forward packets to these devices, based on above-stated support of SMF and UPF. For reliability reasons, the same device(s) behind the UEs can be in the same sub-network, which is reachable via multiple UEs.

[0051] In CN 130 of FIG. 1, the SMF 110 may, for example, be configured to control user plane packet forwarding for uplink (UL) and DL traffic detected by a Packet Detection Rule (PDR) by providing a Forwarding Action Rule (FAR) with instructions to UPF 120. UPF 120 can forward the received DL/UL IP packets to/from Protocol Data Unit (PDU) session(s) based on the IP address/prefix provided to UE 130 or an IPv6 Prefix delegated to UE 130 or framed routes associated with UE 130. SMF 110 may be configured to establishe and update

the packet processing rules (PDR, FAR, etc.) applied at UPF 120 via N4 session signalling.

[0052] Packet forwarding in the 5GC is governed by the Packet Forwarding Control Protocol (PFCP). SMF 110 may be configured to control packet processing in UPF 120 by establishing, modifying, or deleting PFCP session contexts via the N4 interface between SMF 110 and UPF 120. A PFCP session context corresponds to an individual PDU session and includes PDRs. A PDR shall contain packet detection information (e.g., one or more match fields against which incoming packets are matched), in addition to one or more FARs, etc.

[0053] Currently, different PDRs of different PFCP sessions may not overlap. For example, any incoming user plane packet may only match PDRs of a single PFCP session and be forwarded via a single PDU session. An exception is considered for multicast/broadcast traffic, in which UPF 120 continues to look-up other PDRs of the other PFCP sessions matching the packet. The current packet processing flow of the 5GC limits the use of multiple PDU sessions associated with the same set of UEs serving IP hosts behind the UE subnetwork, when forwarding packets to a subnetwork behind UEs.

[0054] When two or more UEs act as a router for the same set of device(s), they will be mapped to the same framed route or IPv6 prefix in the UPF. By way of example, terminal device routers 130-1 and 130-2 of FIG. 1 may be configured to act as a router for a set of devices 140-1, 140-2, 140-3 and 140-4. If they are connected to the same UPF, it will create an overlapping packet detection rule with the same subnet(s) (e.g., framed-route(s) or IPv6 prefix(es) entry). The UPF may not know which DL tunnel to use these subnet filters for reaching the device(s) behind the UE.

[0055] In this case, to address the above issue(s), one group of terminal device routers (e.g., terminal device routers 130-1 and 130-2 of FIG. 1) is providing IP path management and IP packet forwarding support to IP hosts behind these terminal device routers. Similarly, another set of terminal device routers (not shown in FIG. 1) may also be configured to provide IP path management and IP packet forwarding support to IP hosts behind these terminal device routers. It means that logically a group of terminal device routers is providing traffic steering support for the same set of IP hosts. In various example embodiments of the subject disclosure, each group of terminal device routers providing traffic steering support for the same set of IP hosts may grouped to form one UE Virtual Network (UVN).

[0056] In such situation, a study of how the 5GS creates and maintains one or more UVNs based on local configurations, session management subscriptions, or service requirements

and how to facilitate data forwarding within maintained UVNs is the subject of further discussion.

[0057] Various example emobidments of the subject disclosure propose example solutions for UE virtual network group management. By way of non-limiting and illustrative example, the SMF may, during establishment or modification of session management for a terminal device router, be configured to determine that there is a request, associated with session management, that indicates a shared router group identity, where the terminal device router belongs to a UVN and one or more terminal device routers belonging to the UVN share a same shared router group identity.

[0058] Based thereon, a UVN internal interface may be created dynamically within a UPF, based on subscription or local configuration. A UVN internal interface may be implemented as a virtual interface in the UPF and used to collect incoming packets from the N6. The UVN internal interface may used to avoid PDR overlapping at the N6 interface. Various FAR rules with their weightage, replication, and active/standby status can be associated with the UVN internal interface when packet(s) are received. Multiple UVN internal interfaces can be created within a UPF by adding a unique UVN group suffix to the UVN internal interface name to support multiple subnets or even apply different routing rules for different prefixes/subnet behind the UE.

[0059] Furthermore, the SMF may provide instruction to the UPF on path selection based on path delay, packet duplication, or load balancing requirements, dynamically. The decision process for path selection based on path availability, packet duplication requirement, and load balancing between multiple N3 paths is performed by a policy control function (PCF)/SMF and UPF. This may be based on various information, e.g., application policy requirement for packet duplication for critical service, load balancing between paths based on load and capacity of the path and/or path selection based on priority value based on configured/defined policy.

[0060] Example embodiments of the subject disclosure will be described in detail below with reference to the accompanying drawings.

[0061] Reference is now made to FIG. 2, which shows signaling chart 200 for communication according to some example embodiments of the subject disclosure. As shown in FIG. 2, signaling chart 200 involves SMF 110 and UPF 120. For the purpose of discussion, reference is made to FIG. 1 to describe signaling chart 200.

[0062] As shown in FIG. 2, SMF 110 may prepare (202) a PFCP session request. Before that, SMF 110 may, for example, receive a session management subscription request from a terminal device router (e.g., terminal device router 130-1) via an AMF. The session management subscription request may comprise a request for a subscription of a shared router group identity (e.g., *sharedRouterGroupDataID*), which may, for example, be indicated in session management subscription data (e.g., *SM_Subs_Data*). The shared router group identity may indicate that the terminal device router 130-1 belongs to a virtual network of terminal device routers (e.g., a UVN). As described above, each group of terminal device routers providing traffic steering support for the same set of IP hosts may be grouped to form one UVN. One or more terminal device routers belonging to the UVN may share the same share router group identity. For example, if terminal device router 130-2 also belongs to this UVN, then terminal device router 130-2 may share a share router group identity (e.g., same as that of terminal device router 130-1).

[0063] In various example embodiments of the subject disclosure, if a terminal device is going to act as a router for an end-user device or set of devices that lack capability to access the 5GS, it is to have subscription information in 5GS, which can be controlled by a network operator to add this terminal device as a router device in the network. If the network operator wishes to add more terminal device routers serving the same device set then the terminal device routers must share the common identifier to identify them as a grouped router, which may be referred to as the share router group identity (e.g., *sharedRouterGroupDataID* as described above). The shared router group identity may be considered part of the session management subscription data.

[0064] FIG. 3 shows an example of UE's session management subscription model according to some example embodiments of the subject disclosure. As shown in FIG. 3, when SMF 110 receives session management subscription data 310 (e.g., *SM_subs_Data*) from terminal device router 130-1, SMF 110 may be configured to recognize if the terminal device router 130-1 is acting a router and also recognize which terminal device router group it belongs to (e.g., based on the field of the shared router group ID 301 indicated in session management subscription data 310).

[0065] This may help SMF 130 to select UPF 120, based on the identity of the router group (e.g., the UVN). For example, if SMF 110 receives session management subscription data 311 for terminal device router 130-2 indicating the same shared router group ID as device router 130-1 (indicated by the field of shared router group ID 312 indicated in the session

management subscription data 311), then SMF 110 may recognize that terminal device routers 130-1 and 130-2 belong to a same UVN.

[0066] A group of terminal devices belonging to the same group identity can be served by UPF 120 (e.g., the same UPF). Then, UPF selection during one PDU session management procedure may be based on the shared router group identity.

[0067] As shown in FIG. 3, shared router group ID 301 may be mapped to shared data 320 comprising a field called "*SharedRouterGroupDatas*" 303. "*SharedRouterGroupDatas*" 303 may indicate that shared data 320 may be associated with the data of the shared router group. Shared data 320 may be mapped to router group data 330 comprising a field called "*FramedRoute*" 304, which may be configured to point to a "*FrameRouteInfo*" 340.

[0068] Referring back to FIG. 2, SMF 110 may, after determining and preparing the PFCP session request, transmit (204) a request associated with a PFCP session to UPF 120. The request for the associated PFCP session may indicate the shared router group identity, which was obtained from session management subscription data from a terminal device router. If the shared router group identity is new, the request for the associated with PFCP session may indicate UPF 120 is to create a virtual interface for a UVN associated with the shared router group identity at UPF 120 (which may also be called a UVN internal virtual interface or a UVN virtual interface).

[0069] Furthermore, the request associated with the PFCP session may also indicate UPF 120 is to create PDRs and FARs for both incoming packets at the N6 path (e.g., from the DN) and for packets received at the UVN virtual interface.

[0070] Based on the request associated with the PFCP session, UPF 120 may (206) create a UVN internal virtual interface with an active forwarding path and install UE IP based FAR(s) at the N6 path (e.g., the UE behind routers).

[0071] A further terminal device router (e.g., the terminal device router 130-2) may be configured to create PDU session and the PDU session request that includes a shared router group identity. If the SMF 120 determines that a UVN virtual interface for a UVN associated with this shared router group identity has already been created at the UPF 120 (e.g., this shared router group identity is same as the shared router group identity included in the PDU Session request from the terminal device router 130-1 and a PFCP session for the terminal device router 130-1 has been created before between SMF and UPF), the SMF 110 may transmit (204) a request for an establishment or modification of a PFCP session to the UPF

120 indicating that one more FAR should be added for a new N3 path associated with the same UVN virtual interface (e.g., that has been created at the UPF 120). In this case, the N6 PDR may not be added.

[0072] Then, UPF 120 may add (208) a new FAR for the new N3 path associated with the UVN virtual interface.

[0073] It is to be understood that if SMF 110 receives a session management request including a new shared router group identify, SMF 110 may indicate, for example, via a PFCP session establishment or modification request, UPF 120 is to create a new UVN virtual interface for a UVN associated with this new shared router group identify.

[0074] In some example embodiments, the PFCP sessions between SMF 110 and UPF 120 for multiple PDUs have different PFCP session IDs, but may include the same router group ID to be treated as UVN group creation, modification, or deletion.

[0075] Furthermore, UPF 120 may be configured to perform (210) FAR selection for data packet forwarding.

[0076] For example, UPF 120 may always have at least one FAR present at UVN internal virtual interface to forward packets on an N3 path (e.g., at least one PDU for one of the UE acting as the router is active).

[0077] Each FAR may be associated with a priority. UPF 120 may perform FAR selection based on the respective priorities of the FARs.

[0078] In some example embodiments, IP path selection for data forwarding, among the IP paths (FARs) associated with the same UVN internal virtual interface, may be performed based on the priorities assigned for respective FARs.

[0079] In some example embodiments, priority assignment may be performed depending on various aspects, such as a) shortest path; b) quality of service (QoS) monitoring delay result; c) service awareness; and/or d) current load situation on an IP Path.

[0080] Furthermore, UPF 120 may be configured to store the status of each FAR based on GTP-echo or QoS path monitoring mechanisms. UPF 120 may further be configured to shuffle the priority of FAR based on the above results if allowed by SMF 110.

[0081] For example, UPF 120 may be configured to rearrange priority based on QoS monitoring delay result; for instance, a faster path may be chosen by UPF 120 for the data packet forwarding.

[0082] Moreover, depending on the type of service, multiple IP Paths may also have the same priority level to achieve packet replication(duplication) functionality.

[0083] With reference back to FIG. 2, PDR/FAR installation based on the proposed UVN virtual interface of the subject disclosure may be further described with reference to FIG. 1.

[0084] When a packet matches a packet detection rule on the N6, UPF may forward the packet to the terminal device router group specific to matching packet filters. When a packet reaches a UVN virtual interface specific to this router group, UVN virtual interface may have multiple FARs pointing towards N3 tunnel towards specific terminal device router. For example, if terminal device routers 130-1 and 130-2 share the same terminal device router group identity when a packet reaches this UVN virtual interface specific to this router group, it may have a FAR pointing towards the N3 tunnel towards terminal device router 130-1 and a further FAR pointing towards the N3 tunnel towards terminal device router 130-2.

[0085] When installing multiple FAR rules at a UVN virtual interface, the SMF 110 may instruct UPF 120 to select and use FAR-based on application awareness, load balancing, packet duplication, path priority, path delay, etc. Furthermore, how a PCF/SMF determines path selection can be based on static or dynamic policy, in view of the network operator's environment and application demand.

[0086] In some example embodiments, a forwarded packet of the PDR/FAR rule may carry various instruction parameters, such as packet duplication (where the packet is duplicated and sent over all the FARs associated with the PDR), a FAR priority (where the packet is sent only on the highest priority FAR), a FAR load balancing (where packets are sent based on the weight assigned to each FAR).

[0087] In various examples of the subject disclosure, a mechanism is proposed by which the 5GS creates and maintains a "UE virtual network group" that logically groups a set of UEs acting as routers for the same set of IP hosts behind an IP subnetwork.

[0088] The UVN group may, for example, represent a dedicated internal virtual interface within UPF 120, which is mapped to one certain router group. For example, terminal device routers with the same router group identity serve the same set of device(s) behind it. This interface may be used as a forwarding interface for N6 PDRs/FARs. This interface may also act as receiving interface to bind to multiple FARs with the same subnet/prefix towards different N3 (access) tunnels.

[0089] In this example embodiment, the UVN group can be dynamically created or

maintained upon a new terminal device router joining or a terminal device router leaving the group, which may be triggered by subscription, local configuration, or AF's request. Therefore, the internal virtual interface associated with the UVN is created or maintained dynamically with consideration of public IP traffic utilization.

[0090] In this situation, a 2-step PDR/FAR rule is introduced. As and when a terminal device router joins the UVN, UPF 120 may bind the N3 tunnel (FAR) to the same PDR as an incoming port for UE virtual network group interface.

[0091] FIG. 4 shows an example of an implantation of a 2-step PDR/FAR rule according to some example embodiments of the subject disclosure. When a packet 401 arrives, in N6 processing, PDR 410 installed in UPF (e.g., destination IP address is set to UE IP address or IP address of a host behind the UE) may point to FAR 420 sending packets to a certain UVN internal interface (e.g., by setting destination interface as "UVN group ID#1"). Then, in N3 processing, PDR 430 installed at the UPF UVN internal interface (e.g., source interface is set to "UVN group ID#1") detects the packet, finds FAR 440, and forwards it to the right N3 path. Based on various example embodiments of the subject disclosure, UPF 120 may perform a FAR selection based on the UVN internal interface, which can be based on different criteria, such as packet duplication, priority of N3 path, and/or dynamic delay.

[0092] Moreover, the PFCP N4 session may be created, deleted or modified at UPF 120. For example, if SMF 110 transmits a PFCP session establishment/deletion request to UPF 120, UPF 120 may check if any session is present within a router group identity (e.g., the shared router group identity). If present, UPF 120 may add or delete N3 PDR into existing router interfaces. If not present, UPF 120 may create a unique virtual interface for the UVN for PFCP session requests and create PDR and FAR.

[0093] It is also possible that SMF 110 may transmit to UPF 120 a PFCP session modification request, which may indicate an old router group identity and a new one. UPF 120 may check if any session is present within the old router group identity. If present, UPF 120 may delete the N3 PDR associated with this old router group identity and cause the N6 PDR to be associated with an interface corresponding to the new router group identity.

[0094] If not present, UPF 120 may check if any session is present within the new router group identity. If a session is present within the new router group identity, the UPF 120 may add N3 PDR and N6 PDR to the new router group identity. And if a session is not present within the new router group identity, UPF 120 may create a unique virtual interface for the

UVN for PFCP session modification request and create PDR and FAR.

[0095] Therefore, various example embodiments may allow the UVN internal interface to be created dynamically within a UPF based on subscription or local configuration. Multiple UVN internal interfaces can be created within a UPF by adding a unique UVN group suffix to the UVN internal interface name. Since the UVN group identifier is subscription-driven, multiple SMFs can manage the same UVN group.

[0096] FIG. 5 shows a flowchart of an example method 500 of UE virtual network group management according to some example embodiments of the subject disclosure. Method 500 may be implemented by an apparatus. The apparatus may be configured to operate as SMF 110 of FIG. 1. For example, the apparatus may be configured to perform one or more functions of SMF 110. For the purpose of discussion, method 500 will be described with reference to FIG.1.

[0097] At 510, the apparatus determines that there is a request associated with session management indicating a shared router group identity, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity.

[0098] At 520, the apparatus transmits, to UPF 120, a request associated with a PFCP session, at least indicating the shared router group identity.

[0099] In some example embodiments, the request associated with a PFCP session indicates the UPF is to perform: creating, at the UPF, an interface for the virtual network associated with the shared router group identity, installing a packet detection rule, PDR, and a forwarding action rule, FAR, for packets received at an N6 path; and causing the PDR and FAR to be associated with the virtual network interface.

[00100] In some example embodiments, in accordance with a determination that request associated with further session management for a further terminal device router is triggered and subscription data associated with the further session management indicates the shared router group identity, the apparatus may transmit, to the UPF, a request associated with a further PFCP session that indicates the UPF is to perform: adding a further FAR for packets at a further N3 path associated with the further terminal device router; and causing the further FAR to be associated with the virtual network interface.

[00101] In some example embodiments, the PFCP session, between the terminal device router and the UPF, for packets associated with the terminal device router, and the further

PFCP session, between the apparatus and the UPF, for packets associated with the further terminal device router, have different PFCP session identities.

[00102] In some example embodiments, the request associated with the PFCP session indicates the UPF is to delete the PDR at the N3 path associated with the PFCP session of the terminal device router. The request may be associated with the modification or deletion of a PFCP session.

[00103] In some example embodiments, the request associated with the PFCP session indicates the UPF is to delete the PDR at both the N6 path and at N3 path associated with the PFCP session of the terminal device router; and/or associate the PDR at both the N6 path and N3 path associated with the PFCP session to a further virtual network associated with a further shared router group identity.

[00104] In some example embodiments, the request associated with the PFCP session comprises: a request for establishing the PFCP session, a request for modifying the PFCP session, or a request for deleting the PFCP session.

[00105] FIG. 6 shows a flowchart of an example method 600 of UE virtual network group management according to some example embodiments of the subject disclosure. Method 600 may be implemented by an apparatus. The apparatus may be configured to operate as UPF 120 of FIG. 1. For example, the apparatus may be configured to perform one or more functions of UPF 120. For the purpose of discussion, method 600 with be described with reference to FIG. 1.

[00106] At 610, the apparatus receives, from SMF 110, a request associated with a PFCP session at least indicating a shared router group identity associated with a terminal device router, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity.

[00107] At 620, the apparatus performs an operation associated with the PFCP session at least based on the shared router group identity.

[00108] In some example embodiments, the apparatus may perform, based on the request associated with the PFCP session: creating an interface for the virtual network associated with the shared router group identity, installing a packet detection rule, PDR, and a forwarding action rule, FAR, for both packets at a N6 path and at a N3 path associated with the terminal device router, and causing the created PDR and FAR to be associated with the

virtual network.

[00109] In some example embodiments, the apparatus may receive a request associated with a further PFCP session associated with a further terminal device router sharing the same shared router group identity; and perform, based on the request associated with a further PFCP session: adding a further FAR for packets at a further N3 path associated the further terminal device router; and causing the further FAR to be associated with the virtual network.

[00110] In some example embodiments, the apparatus may delete, based on the request associated with the PFCP session, the PDR at the N3 path associated with the PFCP session of the terminal device router.

[00111] In some example embodiments, the apparatus may, based on the request associated with the PFCP session, delete the PDR at both the N6 path and at the N3 path associated with the PFCP session of the terminal device router; and/or associate the PDR at both N6 path and at N3 path associated with the PFCP session to a further virtual network associated with a further shared router group identity.

[00112] In some example embodiments, the request associated with the PFCP session comprises: a request for establishing the PFCP session, a request for modifying the PFCP session, or a request for deleting the PFCP session.

[00113] In some example embodiments, in accordance with a determination that a data packet associated with the shared router group identity is incoming, the apparatus may determine a FAR at the N6 path based on a PDR corresponding to the data packet at the N6 path; cause, based on the FAR at N6 path, the data packet to be delivered to the interface for the virtual network associated with the shared router group identity; and route the data packet based on the PDR and FAR at N3 path.

[00114] In some example embodiments, at least one of the FAR for the packets at the N3 path associated with the terminal device router, and the further FAR for the packets at a further N3 path associated with the further terminal device router, is active.

[00115] In some example embodiments, the apparatus may monitor the status of the FAR and the further FAR, based on a General Packet Radio Service Tunnelling Protocol-echo or a Quality-of-Service path monitoring.

[00116] In some example embodiments, the apparatus may perform a FAR selection for data forwarding from the FAR and the further FAR associated with the interface for the virtual

network based on priorities assigned for the FAR and the further FAR.

[00117] In some example embodiments, the priorities are assigned for the FAR and the further FAR based on at least one of the following: the respective distances of paths associated with the FAR or the further FAR or respective QoS monitoring delay results associated with the FAR and the further FAR.

[00118] In some example embodiments, the apparatus may rearrange the assigned priorities of the FAR and the further FAR, at least based on the respective QoS monitoring delay results associated with the FAR and the further FAR; and perform the data forwarding based on the rearranged priorities of the FAR and the further FAR.

[00119] In some example embodiments, the apparatus may perform a FAR selection for data forwarding from the FAR and the further FAR, associated with the interface for the virtual network, based on at least one of the following: the respective capabilities of a service awareness associated with the FAR and the further FAR; or respective load situation associated with the FAR and the further FAR; or a requirement of packet duplication.

[00120] FIG. 7 shows a flowchart of an example method 700 of UE virtual network group management according to some example embodiments of the subject disclosure. The method 700 may be implemented by an apparatus. The apparatus may be configured to operate as terminal device router 130 of FIG. 1. For example, the apparatus may be configured to perform one or more functions of terminal device router 130. For the purpose of discussion, method 700 with be described with reference to FIG. 1.

[00121] At 710, apparatus provides, to SMF 110, a request associated with session management indicating a shared router group identity, wherein the apparatus belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity.

[00122] In some example embodiments, the request associated with the session management comprises: a request for establishing a session, a request for modifying the PFCP session, or a request for deleting the PFCP session.

[00123] In some example embodiments, an apparatus configured to perform method 500 may include means for performing the respective steps of the method 500. The apparatus may be configured to operate as SMF 110 of FIG. 1. For example, the apparatus may be configured to perform one or more functions of SMF 100. The means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software

module.

[00124] In some example embodiments, the apparatus comprises means for, determining that there is a request associated with session management indicating a shared router group identity, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity; and means for transmitting, to a UPF, a request associated with a PFCP session at least indicating the shared router group identity.

[00125] The request associated with the PFCP session indicates the UPF is to perform at least one of the following: creating, at the UPF, an interface for the virtual network associated with the shared router group identity, installing a packet detection rule, PDR and a forwarding action rule, FAR, for DL packets at both N6 path and at N3 path associated with the PFCP session of the terminal device router, or associating the created PDR and FAR to the virtual network.

[00126] In some example embodiments, the apparatus may further comprise means for, in accordance with a determination that the interface for the virtual network associated with the shared router group identity exist, transmit, to the UPF, a request, associated with a further PFCP session, that indicates the UPF is to perform at least one of the following: adding a further FAR for packets at a further N3 path associated with the further terminal device router; or associating the further FAR to the virtual network.

[00127] In some example embodiments, the PFCP session between the apparatus and the UPF for packets associated with the terminal device router and the further PFCP session between the apparatus and the UPF for packets associated with the further terminal device router have different PFCP session identities.

[00128] In some example embodiments, the request associated with the PFCP session indicates the UPF is to delete the PDR at the N3 path associated with the PFCP session of the terminal device router.

[00129] In some example embodiments, the request, associated with the PFCP session, indicates the UPF is to delete the PDR at both the N6 path and at the N3 path associated with the PFCP session of the terminal device router; and/or associate the PDR at both N6 path and at N3 path associated with the PFCP session to a further virtual network associated with a further shared router group identity.

[00130] In some example embodiments, the request associated with the PFCP session

comprises: a request for establishing the PFCP session, a request for modifying the PFCP session, or a request for deleting the PFCP session.

[00131] In some example embodiments, an apparatus configured to perform method 600 may include means for performing the respective steps of the method 600. The apparatus may be configured to operate as UPF 120 of FIG. 1. For example, the apparatus may be configured to perform one or more functions of UPF 120. The means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software module.

[00132] In some example embodiments, the apparatus comprises means for receiving from a SMF, a request associated with a PFCP session at least indicating a shared router group identity associated with a terminal device router, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity; and means for performing an operation associated with the PFCP session at least based on the shared router group identity.

[00133] In some example embodiments, the means for performing the operation associated with the PFCP session may comprise means for performing, based on the request associated with the PFCP session, at least one of the following: creating an interface for the virtual network associated with the shared router group identity, installing a PDR and a FAR for both packets at a N6 path and at a N3 path associated with the PFCP session of the terminal device router, or associating the created PDR and FAR to the virtual network.

[00134] In some example embodiments, the apparatus may further comprise means for receiving, a request associated with a further PFCP session of a further terminal device router sharing the shared router group identity; and means for performing, based on the request associated with the further PFCP session, at least one of the following: adding a further FAR for packets at a further N3 path associated the further PFCP session of the further terminal device router; or associating the further FAR to the created PDR of the virtual network.

[00135] In some example embodiments, at least one of the FAR for the packets at the N3 path associated with the terminal device router and the further FAR for the packets at a further N3 path associated with the further terminal device router is active.

[00136] In some example embodiments, the apparatus may further comprise means for, based on the request associated with the PFCP session, deleting the PDR at both N6 path and at N3 path associated with the PFCP session of the terminal device router; and/or means for

associating the PDR at both N6 path and at N3 path associated with the PFCP session to a further virtual network associated with a further shared router group identity.

[00137] In some example embodiments, the request associated with the PFCP session comprises: a request for establishing the PFCP session, a request for modifying the PFCP session, or a request for deleting the PFCP session.

[00138] In some example embodiments, the apparatus may further comprise means for, in accordance with a determination that a data packet associated with the shared router group identity is incoming, determining a FAR at N6 path based on a PDR corresponding to the data packet at N6 path; means for causing, based on the FAR at N6 path, the data packet to be delivered to the interface for the virtual network associated with the shared router group identity; and means for routing the data packet based on the PDR and FAR at N3 path.

[00139] In some example embodiments, the apparatus may further comprise means for monitoring the status of the FAR and the further FAR based on a Quality-of-Service path monitoring.

[00140] In some example embodiments, the apparatus may further comprise means for performing a FAR selection for data forwarding from the FAR and the further FAR, associated with the interface for the virtual network, based on priorities assigned for the FAR and the further FAR.

[00141] In some example embodiments, the priorities are assigned for the FAR and the further FAR based on at least one of the following: the respective distances of paths associated with the FAR and the further FAR; or respective QoS monitoring delay results associated with the FAR and the further FAR.

[00142] In some example embodiments, the apparatus may further comprise means for performing a FAR selection for data forwarding from the FAR and the further FAR, associated with the interface for the virtual network, based on at least one of the following: the respective capabilities of a service awareness associated with the FAR and the further FAR; or respective load situation associated with the FAR and the further FAR; or a requirement of packet duplication.

[00143] In some example embodiments, the apparatus may further comprise means for rearranging the assigned priorities of the FAR and the further FAR at least based on the respective QoS monitoring delay results associated with the FAR and the further FAR; and means for performing the data forwarding based on the rearranged priorities of the FAR and

the further FAR.

[00144] In some example embodiments, an apparatus configured to perform method 700 may include means for performing the respective steps of method 700. The apparatus may be configured to operate as terminal device router 130. For example, the apparatus may be configured to perform one or more functions of terminal device router 130. The means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software module.

[00145] In some example embodiments, the apparatus comprises means for transmitting, to a SMF, a request associated with session management indicating a shared router group identity, wherein the apparatus belongs to a virtual network and one or more apparatuses belonging to the virtual network share a same shared router group identity.

[00146] In some example embodiments, the request associated with the session management comprises: a request for establishing a session, a request for modifying the PFCP session, or a request for deleting the PFCP session.

[00147] FIG. 8 is a simplified block diagram of device 800 that may implement one or more example embodiments of the subject disclosure. Device 800 may be configured to operate as a communication device (e.g., SMF 110, UPF 120 or terminal device router 130, as shown in FIG. 1). As shown in FIG. 8, device 800 includes one or more processors 810, one or more memories 820 coupled to processor 810, and one or more communication modules 840 coupled to processor 810.

[00148] Communication module 840 is for bidirectional communications. Communication module 840 has one or more communication interfaces to facilitate communication with one or more other modules or devices. The communication interfaces may represent any interface that is utilized for communication with other network elements. In some example embodiments, communication module 840 may include at least one antenna.

[00149] Processor 810 may be of any type suitable to the local technical network and may include one or more of the following: general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multicore processor architecture, as non-limiting and illustrative examples. Device 800 may have multiple processors, such as an application specific integrated circuit chip that is slaved in time to a clock which synchronizes the main processor.

[00150] Memory 820 may include one or more non-volatile memories and one or more

volatile memories. Examples of the non-volatile memories include, but are not limited to, Read Only Memory (ROM) 824, an electrically programmable read only memory (EPROM), a flash memory, a hard disk, a compact disc (CD), a digital video disk (DVD), an optical disk, a laser disk, and other magnetic storage and/or optical storage. Examples of the volatile memories include, but are not limited to, random access memory (RAM) 822 and other volatile memories that will not last in the power-down duration.

[00151] Computer program 830 includes computer executable instructions that are executed by processor 810. The instructions of program 830 may include instructions for performing operations/acts of some example embodiments of the subject disclosure. Program 830 may be stored in the memory, e.g., ROM 824. Processor 810 may perform any suitable actions and processing by loading program 830 into RAM 822.

[00152] The example embodiments of the subject disclosure may be implemented by means of program 830 so that device 800 may be configured to perform any process of the disclosure as discussed with reference to FIG. 2 to FIG. 7. The various example embodiments of the subject disclosure may also be implemented by hardware or by a combination of software and hardware.

[00153] In some example embodiments, program 830 may be tangibly contained in a computer readable medium which may be included in device 800 (such as, in the memory 820) or other storage devices that are accessible by device 800. Device 800 may load program 830 from the computer readable medium to RAM 822 for execution. In some example embodiments, the computer readable medium may include any types of non-transitory storage medium, such as ROM, EPROM, a flash memory, a hard disk, CD, DVD, and the like. The term "non-transitory," as used herein, is a limitation of the medium itself (e.g., tangible, not a signal) as opposed to a limitation on data storage persistency (e.g., RAM vs. ROM).

[00154] FIG. 9 shows an example of computer readable medium 900 which may be in form of CD, DVD or other optical storage disk. The computer readable medium 900 has the program 830 stored thereon.

[00155] Various example embodiments of the subject disclosure may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other

computing device. While various aspects of embodiments of the subject disclosure are illustrated and described as block diagrams, flowcharts, or using some other pictorial representations, it is to be understood that the block, apparatus, system, technique or method described herein may be implemented in, as non-limiting and illustrative examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[00156] Some example embodiments of the subject disclosure also provide at least one computer program product tangibly stored on a computer readable medium, such as a non-transitory computer readable medium. The computer program product includes computer-executable instructions, such as those included in program modules, being executed in a device on a target physical or virtual processor, to carry out any of the methods as described above. Program modules may include routines, programs, libraries, objects, classes, components, data structures, or the like that perform particular tasks or implement particular data types. The functionality of the program modules may be combined or split between program modules as desired in various embodiments. Machine-executable instructions for program modules may be executed within a local or distributed device. In a distributed device, program modules may be located in both local and remote storage media.

[00157] Program code for carrying out methods of the subject disclosure may be written in any combination of one or more programming languages. The program code may be provided to a processor or controller of a general purpose computer, special purpose computer, or other programmable data processing apparatus, such that the program code, when executed by the processor or controller, cause the functions/operations specified in the flowcharts and/or block diagrams to be implemented. The program code may execute entirely on a machine, partly on the machine, as a stand-alone software package, partly on the machine and partly on a remote machine or entirely on the remote machine or server.

[00158] In the context of the subject disclosure, the computer program code or related data may be carried by any suitable carrier to enable the device, apparatus or processor to perform various processes and operations as described above. Examples of the carrier include a signal, computer readable medium, and the like.

[00159] The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable medium may include but not limited to an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor

system, apparatus, or device, or any suitable combination of the foregoing. More specific examples of the computer readable storage medium would include an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing.

[00160] Further, while operations are depicted in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific implementation details are contained in the above discussions, these should not be construed as limitations on the scope of the subject disclosure, but rather as descriptions of features that may be specific to particular example embodiments. Unless explicitly stated, certain features that are described in the context of separate example embodiments may also be implemented in combination in a single example embodiment. Conversely, unless explicitly stated, various features that are described in the context of a single example embodiment may also be implemented in a plurality of example embodiments separately or in any suitable sub-combination.

[00161] Although various example embodiments of the subject disclosure have been described in language specific to structural features and/or methodological acts, it is to be understood that the the various example emboidments of the subject disclosure are not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described herein are disclosed as example forms of implementing the various example embodiments of the subject disclosure.

WHAT IS CLAIMED IS:

1. An apparatus comprising:

at least one processor; and

at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to:

determine that there is a request associated with session management indicating a shared router group identity, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share the same shared router group identity; and

transmit, to a user plane function, UPF, a request associated with a packet forwarding control protocol, PFCP, session at least indicating the shared router group identity.

2. The apparatus of claim 1, wherein the request associated with the PFCP session indicates the UPF is to perform at least one of the following:

creating, at the UPF, an interface for the virtual network associated with the shared router group identity,

installing a packet detection rule, PDR, and a forwarding action rule, FAR, for DL packets at both an N6 path and at an N3 path associated with the PFCP session of the terminal device router, or

associating the created PDR and FAR to the virtual network.

3. The apparatus of claim 2, wherein the apparatus is caused to:

in accordance with a determination that the interface for the virtual network associated with the shared router group identity exists, transmit to the UPF a request associated with a further PFCP session that indicates the UPF is to perform at least one of the following:

adding a further FAR for packets at a further N3 path associated with the further terminal device router to the virtual network.

4. The apparatus of claim 3, wherein the PFCP session between the apparatus and the UPF for packets associated with the terminal device router and the further PFCP session between the apparatus and the UPF for packets associated with the further terminal device router have different PFCP session identities.

5. The apparatus of claim 2, wherein the request associated with the PFCP session indicates the UPF is to delete the PDR at the N3 path associated with the PFCP session of the terminal device router.

6. The apparatus of claim 2, wherein the request associated with the PFCP session indicates the UPF is to at least one of the following:

delete the PDR at both the N6 path and at the N3 path associated with the PFCP session of the terminal device router; or

associate the PDR at both the N6 path and the N3 path associated with the PFCP session to a further virtual network associated with a further shared router group identity.

7. The apparatus of any of claims 1-6, wherein the request associated with the PFCP session comprises:

a request for establishing the PFCP session,

a request for modifying the PFCP session, or

a request for deleting the PFCP session.

8. An apparatus comprising:

at least one processor; and

at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to:

receive, from a session management function, SMF, a request associated with a packet forwarding control protocol, PFCP, session at least indicating a shared router group identity associated with a terminal device router, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity; and

perform an operation associated with the PFCP session based on the shared router group identity.

9. The apparatus of claim 8, wherein the apparatus is caused to:

perform, based on the request associated with the PFCP session, at least one of the following:

creating an interface for the virtual network associated with the shared router

group identity,

installing a packet detection rule, PDR, and a forwarding action rule, FAR, for both packets at an N6 path and an N3 path associated with the PFCP session of the terminal device router, or

associating the created PDR and FAR to the virtual network.

10. The apparatus of claim 9, wherein the apparatus is caused to:

receive, a request associated with a further PFCP session of a further terminal device router sharing the shared router group identity; and

perform, based on the request associated with the further PFCP session, at least one of the following:

adding a further FAR for packets at a further N3 path associated with the further PFCP session of the further terminal device router; or

associating the further FAR to the created PDR of the virtual network.

11. The apparatus of claim 10, wherein at least one of the FARs for the packets at the N3 path associated with the terminal device router and the further FARs for the packets at a further N3 path associated with the further terminal device router is active.

12. The apparatus of claim 9, wherein the apparatus is caused to:

delete, based on the request associated with the PFCP session, the PDR at the N3 path associated with the PFCP session of the terminal device router.

13. The apparatus of claim 9, wherein the apparatus is caused to:

based on the request associated with the PFCP session, delete the PDR at both the N6 path and the N3 path associated with the PFCP session of the terminal device router; and/or

associate the PDR at both the N6 path and at the N3 path associated with the PFCP session to a further virtual network associated with a further shared router group identity.

14. The apparatus of any of claims 8-13, wherein the request associated with the PFCP session comprises:

a request for establishing the PFCP session,

a request for modifying the PFCP session, or

a request for deleting the PFCP session.

15. The apparatus of claim 8, wherein the apparatus is caused to:

in accordance with a determination that a data packet associated with the shared router group identity is incoming, determine a FAR at the N6 path based on a PDR corresponding to the data packet at the N6 path;

cause, based on the FAR at N6 path, the data packet to be delivered to the interface for the virtual network associated with the shared router group identity; and

route the data packet based on the PDR and FAR at the N3 path.

16. The apparatus of claim 10, wherein the apparatus is caused to:

monitor status of the FAR and the further FAR based on Quality-of-Service path monitoring.

17. The apparatus of claim 10, wherein the apparatus is caused to:

perform a FAR selection for data forwarding from the FAR and the further FAR associated with the interface for the virtual network based on priorities assigned for the FAR and the further FAR.

18. The apparatus of claim 17, wherein the priorities are assigned for the FAR and the further FAR based on at least one of:

respective distances of paths associated with the FAR and the further FAR;

respective QoS monitoring delay results associated with the FAR and the further FAR.

19. The apparatus of claim 10, wherein the apparatus is caused to:

perform a FAR selection for data forwarding from the FAR and the further FAR associated with the interface for the virtual network, based on at least one of:|

respective capabilities of a service awareness associated with the FAR and the further FAR; or

respective load situation associated with the FAR and the further FAR; or

a requirement of packet duplication.

20. The apparatus of claim 17, wherein the apparatus is caused to:

rearrange the assigned priorities of the FAR and the further FAR, at least based on the respective QoS monitoring delay results associated with the FAR and the further FAR; and

perform the data forwarding based on the rearranged priorities of the FAR and the further FAR.

21. An apparatus comprising:

at least one processor; and

at least one memory storing instruction that, when executed by at least one processor, cause the apparatus at least to:

transmit, to a session management function, SMF, a request associated with session management indicating a shared router group identity, wherein the apparatus belongs to a virtual network and one or more apparatuses belonging to the virtual network share the same shared router group identity.

22. The apparatus of claim 21, wherein the request associated with the session management comprises:

a request for establishing a packet forwarding control protocol, PFCP, session,

a request for modifying the PFCP session, or

a request for deleting the PFCP session.

23. A method comprising:

determining, at a session management function, SMF, that there is a request associated with session management indicating a shared router group identity, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity; and

transmitting, to a user plane function, UPF, a request associated with a packet forwarding control protocol, PFCP, session at least indicating the shared router group identity.

24. A method comprising:

receiving, at a user plane function, UPF, and from a session management function, SMF, a request associated with a packet forwarding control protocol, PFCP, session at least indicating a shared router group identity associated with a terminal device router, wherein the terminal device router belongs to a virtual network and one or more terminal device

routers belonging to the virtual network share a same shared router group identity; and

performing an operation associated with the PFCP session, at least based on the shared router group identity.

25. A method comprising:

transmitting, from a terminal device router and to a session management function, SMF, a request associated with session management indicating a shared router group identity, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity.

26. An apparatus comprising:

means for determining that there is a request associated with session management indicating a shared router group identity, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share the same shared router group identity; and

means for transmitting, to a user plane function, UPF, a request associated with a packet forwarding control protocol, PFCP, session at least indicating the shared router group identity.

27. An apparatus comprising:

means for receiving from a session management function, SMF, a request associated with a packet forwarding control protocol, PFCP, session at least indicating a shared router group identity associated with a terminal device router, wherein the terminal device router belongs to a virtual network and one or more terminal device routers belonging to the virtual network share a same shared router group identity; and

means for performing an operation associated with the PFCP session, at least based on the shared router group identity.

28. An apparatus comprising:

means for transmitting, to a session management function, SMF, a request associated with session management indicating a shared router group identity, wherein the apparatus belongs to a virtual network and one or more apparatuses belonging to the virtual network share the same shared router group identity.

29. A computer readable medium comprising instructions which, when executed by an apparatus, cause the apparatus to perform at least the method of claim 23, the method of claim 24, or the method of claim 25.

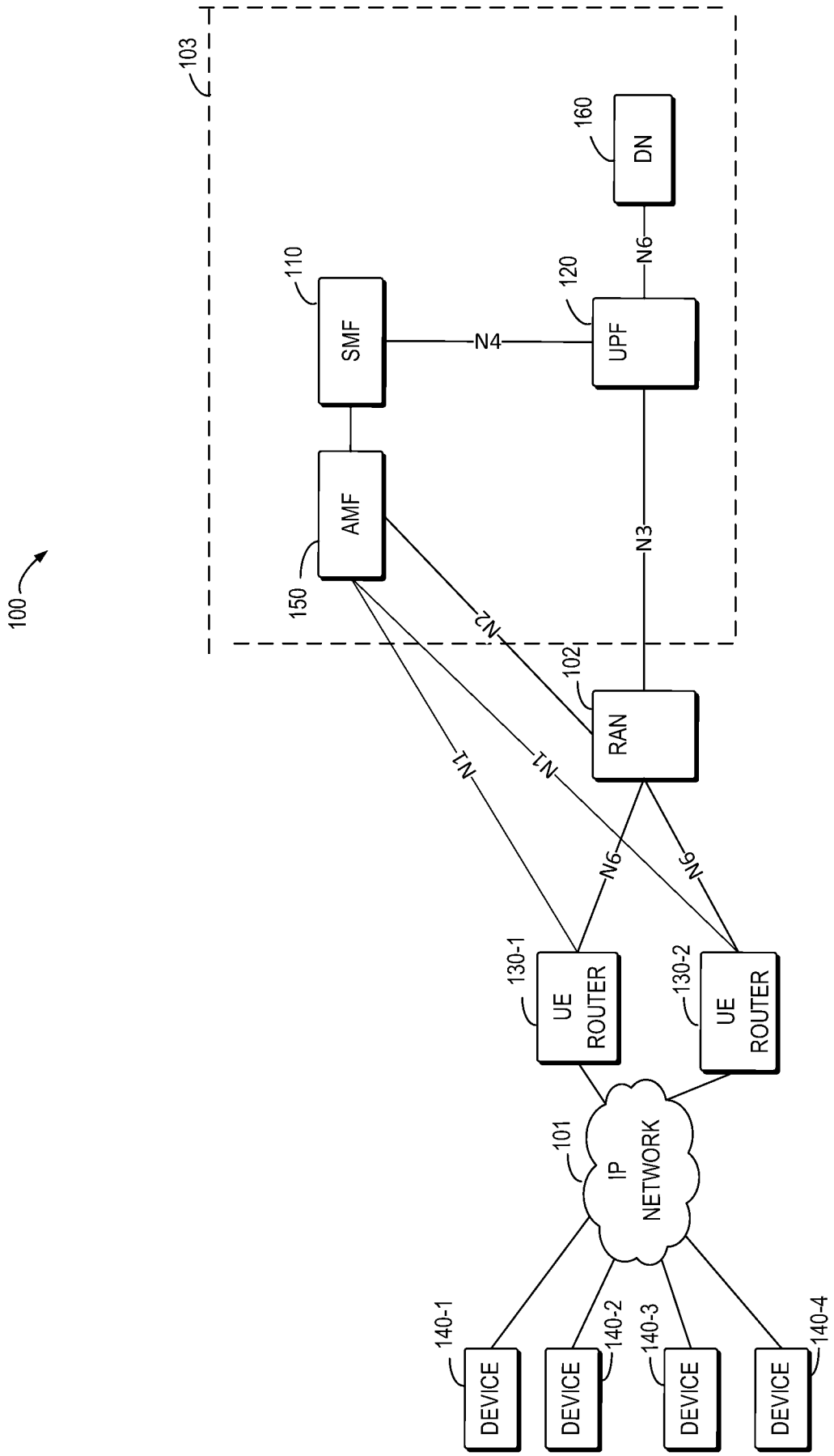

100
103
160
DN
110
SMF
120
UPF
N6
N4
AMF
150
N3
N2
102
RAN
N1
N1
N6
N6
130-1
UE ROUTER
130-2
UE ROUTER
101
IP NETWORK
140-1
DEVICE
140-2
DEVICE
140-3
DEVICE
140-4
DEVICE

FIG. 1

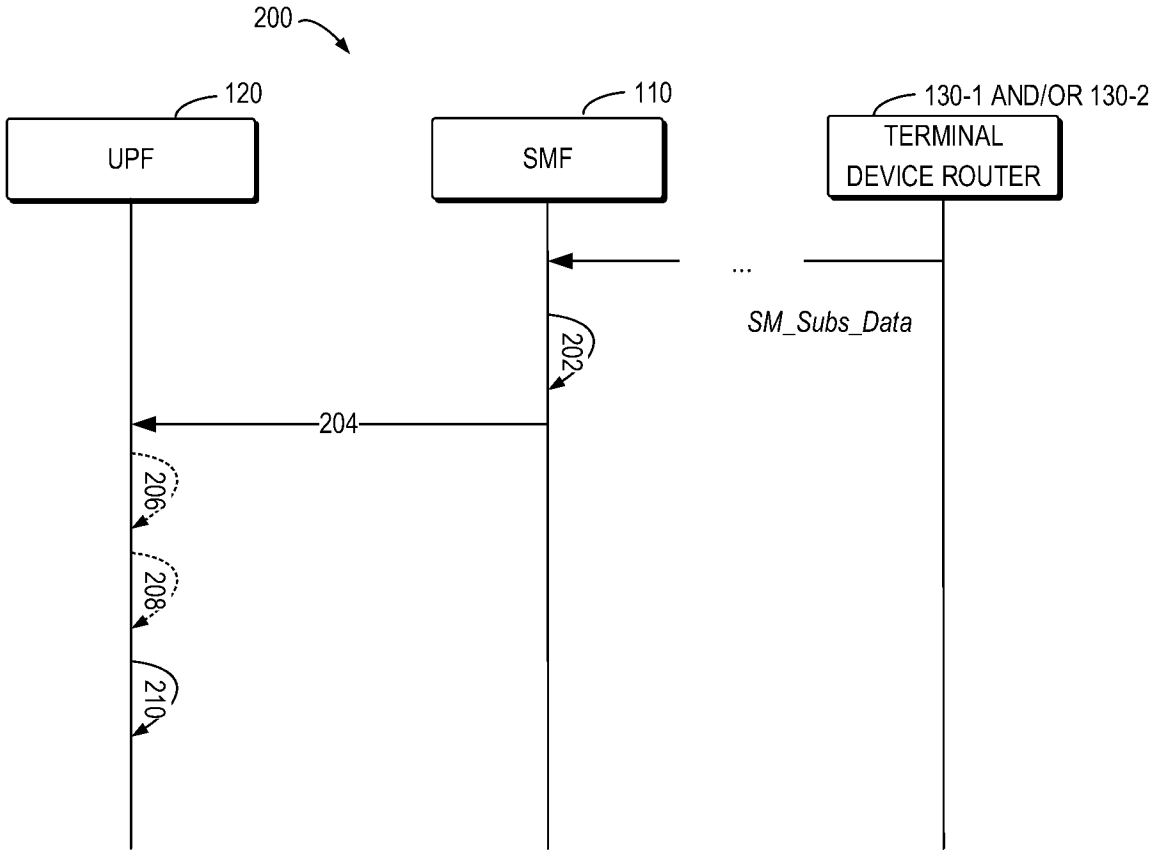
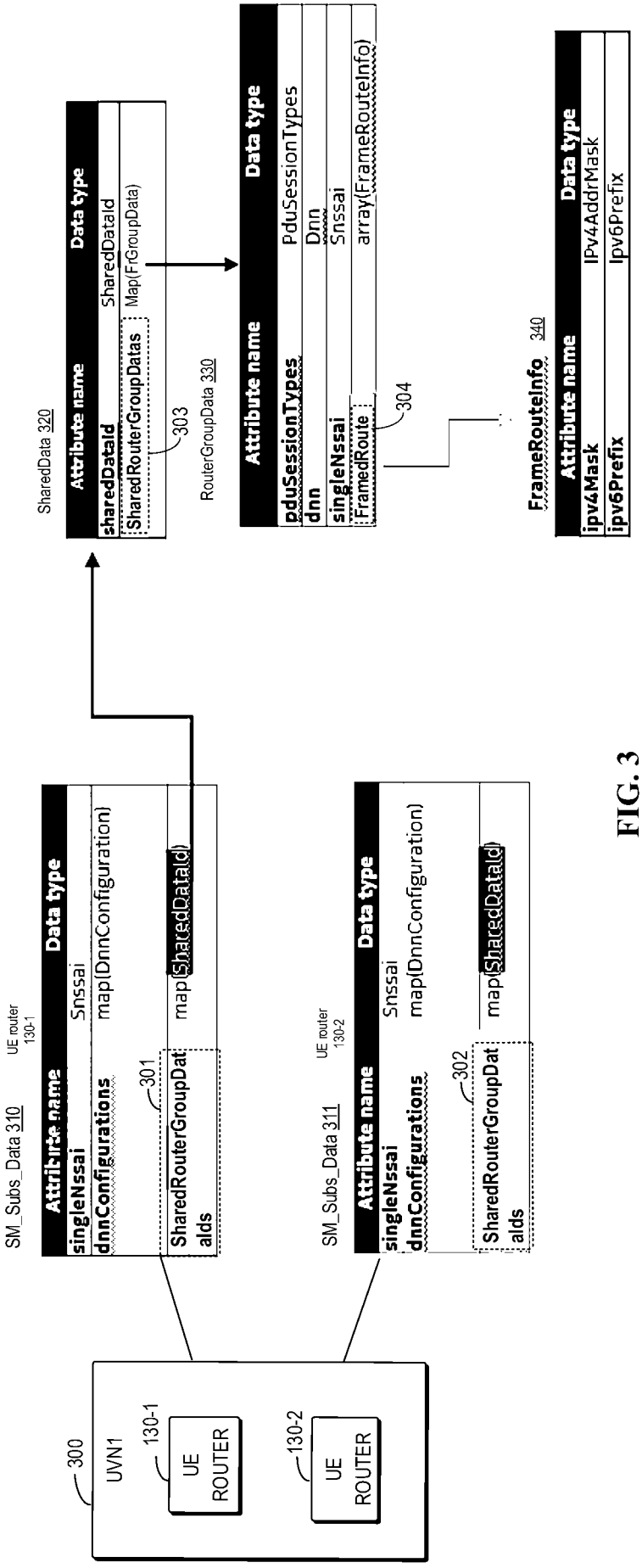

200
120
UPF
110
SMF
130-1 AND/OR 130-2
TERMINAL DEVICE ROUTER
...
SM_Subs_Data
202
204
206
208
210

FIG. 2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Attribute name
Data type
sharedDataId
SharedDataId
SharedRouterGroupDatas
Map(FrGroupData)
303
RouterGroupData 330
Attribute name
Data type
pduSessionTypes
PduSessionTypes
dnn
Dnn
singleNssai
Snssai
FramedRoute
array(FrameRouteInfo)
304
FrameRouteInfo 340
Attribute name
Data type
ipv4Mask
IPv4AddrMask
ipv6Prefix
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SM_Subs_Data 310
UE router 130-1
Attribute name
Data type
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Snssai
dnnConfigurations
map(DnnConfiguration)
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map(SharedDataId)
SM_Subs_Data 311
UE router 130-2
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Data type
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Snssai
dnnConfigurations
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130-1
UE ROUTER
130-2
UE ROUTER

FIG. 3

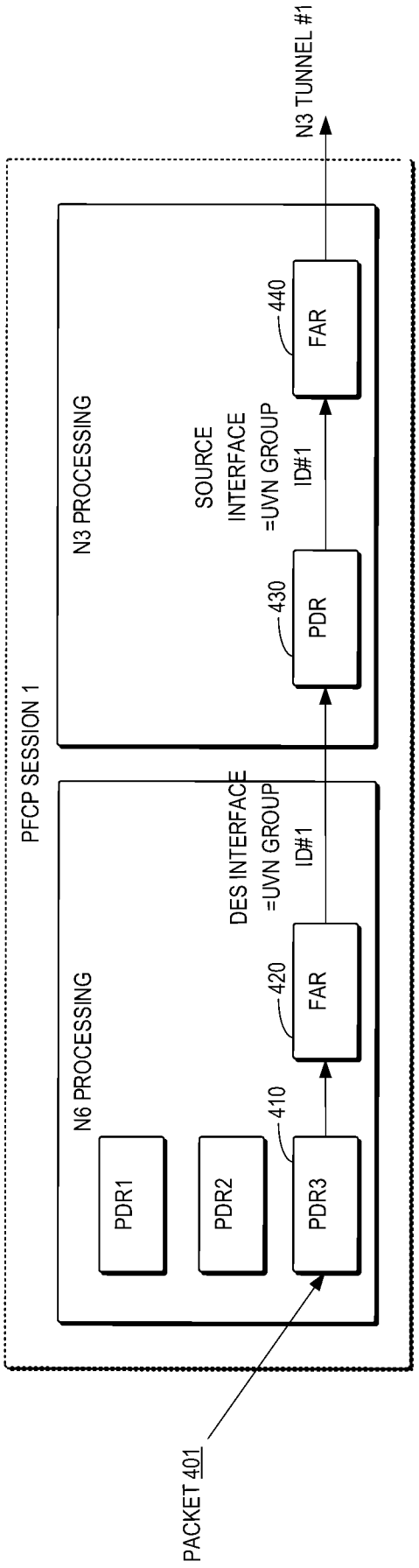
PACKET 401
PFCP SESSION 1
N6 PROCESSING
PDR1
PDR2
PDR3
410
DES INTERFACE
=UVN GROUP
ID#1
FAR
420
N3 PROCESSING
SOURCE
INTERFACE
=UVN GROUP
ID#1
PDR
430
FAR
440
N3 TUNNEL #1

FIG. 4

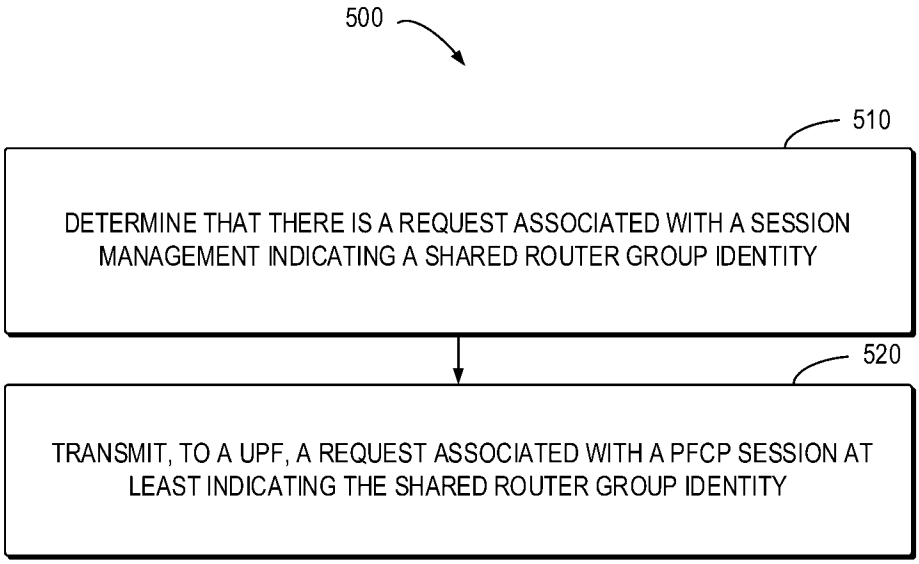
500
510
DETERMINE THAT THERE IS A REQUEST ASSOCIATED WITH A SESSION MANAGEMENT INDICATING A SHARED ROUTER GROUP IDENTITY
520
TRANSMIT, TO A UPF, A REQUEST ASSOCIATED WITH A PFCP SESSION AT LEAST INDICATING THE SHARED ROUTER GROUP IDENTITY

FIG. 5

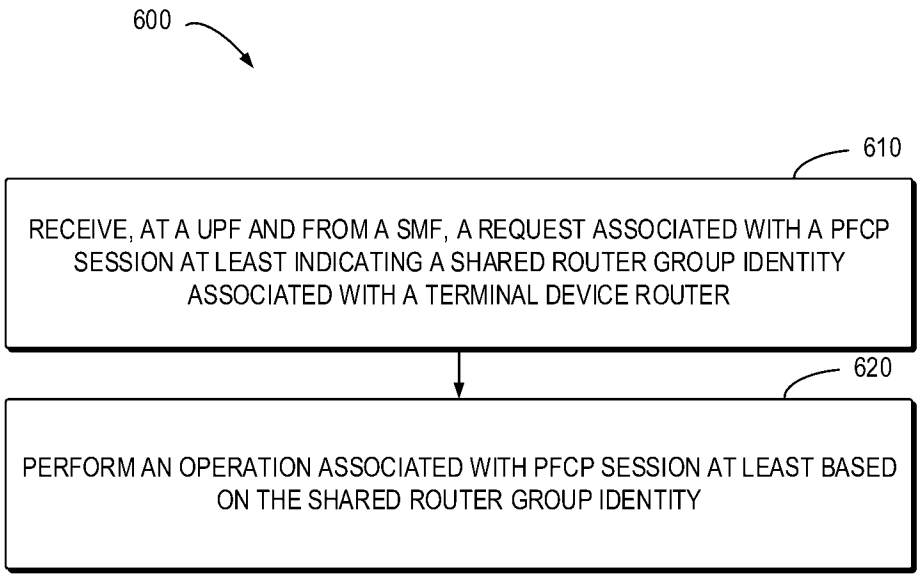
600
610
RECEIVE, AT A UPF AND FROM A SMF, A REQUEST ASSOCIATED WITH A PFCP SESSION AT LEAST INDICATING A SHARED ROUTER GROUP IDENTITY ASSOCIATED WITH A TERMINAL DEVICE ROUTER
620
PERFORM AN OPERATION ASSOCIATED WITH PFCP SESSION AT LEAST BASED ON THE SHARED ROUTER GROUP IDENTITY

FIG. 6

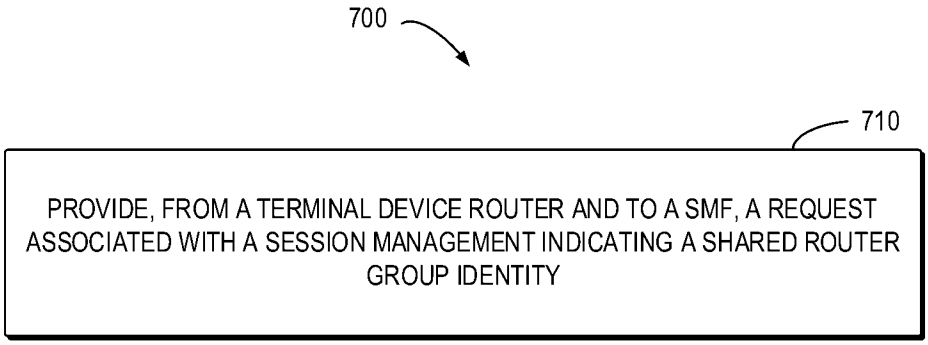
700
710
PROVIDE, FROM A TERMINAL DEVICE ROUTER AND TO A SMF, A REQUEST ASSOCIATED WITH A SESSION MANAGEMENT INDICATING A SHARED ROUTER GROUP IDENTITY

FIG. 7

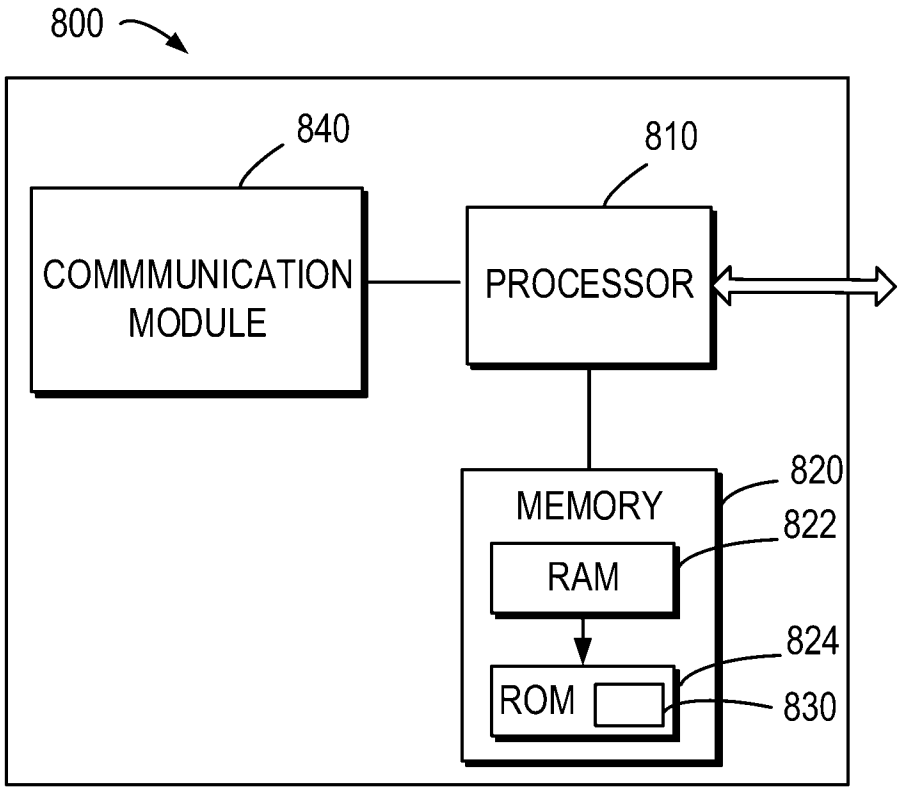
800
840
810
COMMMUNICATION MODULE
PROCESSOR
820
MEMORY
822
RAM
824
ROM
830

FIG. 8

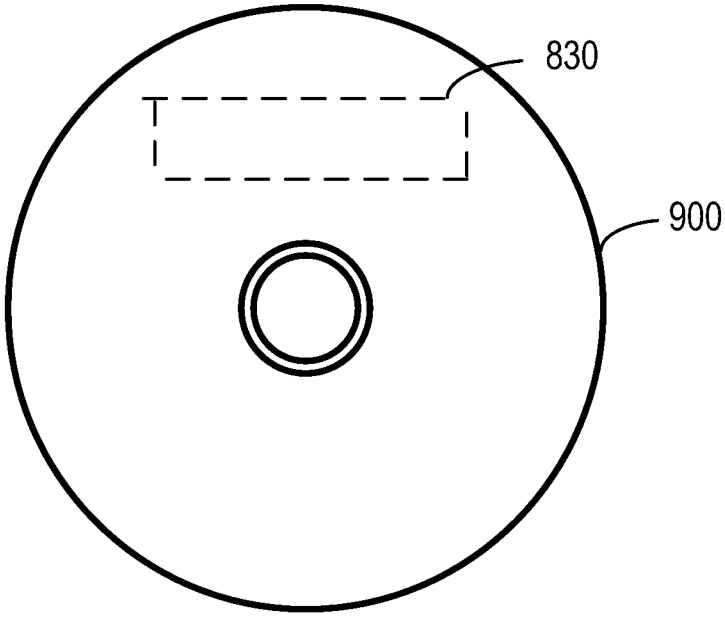

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/112325

A. CLASSIFICATION OF SUBJECT MATTER

H04W 8/02(2009.01)i

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

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

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

CNTXT, WPABS, ENTXTC, DWPI, VEN, 3GPP:router, group, UVN, UPF, SMF, PFCP, identity, ID, PDR, FAR

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2023164641 A1 (INTERDIGITAL PATENT HOLDINGS,INC.) 25 May 2023 (2023-05-25) description, paragraphs [0113]-[0117], [0139], [0200]-[0290], claims 1-40	1-29
A	US 2022022092 A1 (TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)) 20 January 2022 (2022-01-20) the whole document	1-29
A	US 2022132623 A1 (TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)) 28 April 2022 (2022-04-28) the whole document	1-29
A	CN 115835259 A (ALIBABA (CHINA) CO., LTD.) 21 March 2023 (2023-03-21) the whole document	1-29
A	HUAWEI. "Legal Interception support for 5GC SMF/UPF" *3GPP TSG CT WG4 Meeting #89 C4-190024,* No. tsgct4_89_montreal, 01 March 2019 (2019-03-01), the whole document	1-29

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2024	**25 April 2024**

Name and mailing address of the ISA/CN	Authorized officer
CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	**GAO,Yan** Telephone No. **(+86) 010-53961763**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/112325

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 116419423 A (RESEARCH INSTITUTE OF CHINA MOBILE COMMUNICATIONS CORPORATION et al.) 11 July 2023 (2023-07-11) the whole document	1-29

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/112325

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US 2023164641 A1	25 May 2023	WO 2021202891 A1	07 October 2021
		EP 4128879 A1	08 February 2023
		CN 115462123 A	09 December 2022
US 2022022092 A1	20 January 2022	WO 2020119952 A1	18 June 2020
		EP 3895470 A1	20 October 2021
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US 2022132623 A1	28 April 2022	DK 3697171 T3	25 October 2021
		WO 2020164541 A1	20 August 2020
		EP 3697171 A1	19 August 2020
		PL 3955698 T3	05 February 2024
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		KR 20210116555 A	27 September 2021
		ES 2956543 T3	22 December 2023
		JP 2022520040 A	28 March 2022
		EP 3955698 A1	16 February 2022
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CN 116419423 A	11 July 2023	None	