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(54) **Title:** METHOD AND APPARATUS FOR USER EQUIPMENT DOMAIN INFORMATION EXPOSURE TO APPLICATION FUNCTION

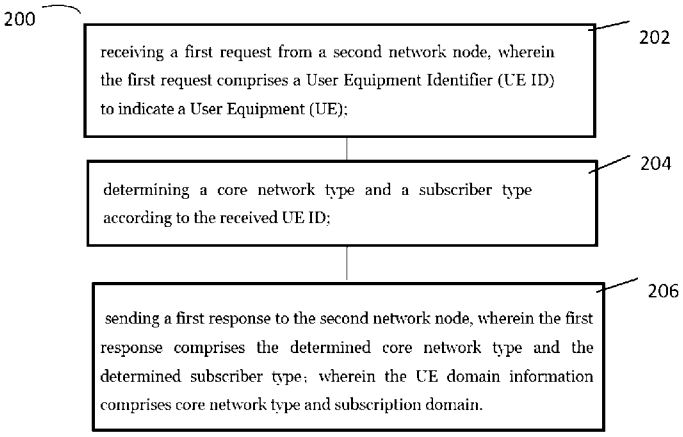

Fig.2

(57) **Abstract:** Embodiments of the present disclosure provide method and apparatus for UE domain information exposure to application function. A method performed by a first network node in Communication Network comprises receiving a first request from a second network node, wherein the first request comprises a User Equipment Identifier (UE ID) to indicate a User Equipment (UE), determining a UE domain information according to the received UE ID, and sending a first response to the second network node. The first response comprises the determined UE domain information. The UE domain information comprises core network type and subscription domain.

WO 2025/002402 A1

METHOD AND APPARATUS FOR USER EQUIPMENT DOMAIN INFORMATION EXPOSURE TO APPLICATION FUNCTION

TECHNICAL FIELD

[0001] The non-limiting and exemplary embodiments of the present disclosure generally relate to the technical field of communications, and specifically to methods and apparatuses for User Equipment (UE) domain information exposure to application function.

BACKGROUND

[0002] This section introduces aspects that may facilitate a better understanding of the disclosure. Accordingly, the statements of this section are to be read in this light and are not to be understood as admissions about what is in the prior art or what is not in the prior art.

[0003] 3rd Generation Partnership Project (3GPP) Technical Specification (TS) 23.501 V17.7.0 specifies system architecture for the 5th Generation Mobile Communication Technology (5G) System (5GS). Figure 1 shows the non-roaming architecture for Service Exposure for Evolved Packet Core (EPC) - 5th Generation Core (5GC) Interworking.

[0004] 3GPP TS29.503 V17.9.0 specifies Unified Data Management Services. In the specification, Network Exposure Function (NEF) can subscribe Core Network (CN) Type Change from Unified Data Management (UDM).

SUMMARY

[0005] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

[0006] More and more operators deploy 5GC and enable 5GC interworking with EPC. A 5th Generation Mobile Communication Technology (5G) subscriber has 5G/4th Generation Mobile Communication Technology (4G) switching capability when UE moves between 5GC and EPC. This improves the UE-Side user experience.

[0007] Meanwhile, operators deploys Service Capability Exposure Function/Network Exposure Function (SCEF/NEF). Through SCEF/NEF, network capabilities are exposed to Application Function (AF) via programmable Application Programming Interfaces (APIs).

[0008] Currently, 3GPP TS29.503 V17.9.0 specifies Unified Data Management Services. In the specification, NEF can subscribe Core Network (CN) Type Change from Unified Data

Management (UDM). However, AF doesn't know the Core Network Type for a UE. There is no mechanism and data model between NEF and AF to let AF get the Core Network Type for a UE.

[0009] Meanwhile, 3GPP does not define a solution for NEF/SCEF/ SCEF+NEF to distinguish subscription domain to know if the UE is 4G subscription or 5G subscription, the consequent is that SCEF+NEF cannot return valid subscription domain information to AF. For a combined SCEF+NEF, it doesn't know if it need to interact with 4GC or 5GC.

[0010] The core network type is a kind of network domain information. The core network type and subscription domain mentioned above belong to UE domain information.

[0011] To overcome or mitigate at least one of above mentioned problems or other problems, the embodiments of the present disclosure propose an solution for exposing UE domain information to an application function.

[0012] In a first aspect of the disclosure, there is provided a method performed by a first network node in Communication Network. The method may comprise receiving a first request from a second network node. In the first request, it may comprise a User Equipment Identifier (UE ID) to indicate a User Equipment (UE). The method may further comprise determining a UE domain information according to the received UE ID. The method may further comprise sending a first response to the second network node. The first response may comprise the determined UE domain information.

[0013] In an embodiment, the UE domain information may comprise core network type and subscription domain.

[0014] In an embodiment, the core network type may comprise at least one of Evolved Packet Core (EPC), Fifth Generation Core network (5GC), Dual EPC and 5GC.

[0015] In an embodiment, the subscription domain may comprise at least one of 4th Generation Mobile Communication Technology subscription (4G subscription), and 5th Generation Mobile Communication Technology subscription (5G subscription).

[0016] In an embodiment, the first network node may comprise a Network Exposure Function (NEF), or a Service Capability Exposure Function (SCEF), or a combination of NEF and SCEF.

[0017] In an embodiment, the second network node may comprise an Application Function (AF).

[0018] In an embodiment, the third network node may comprise a Network Repository Function (NRF).

[0019] In an embodiment, the fourth network node may comprise a Unified Data Management (UDM), or a combination of UDM and Home Subscriber Server (HSS).

[0020] In a second aspect of the disclosure, there is provided a method performed by a second network node in Communication Network. The method may comprise sending a first request to a first network node. The first request may comprise a User Equipment Identifier (UE ID) to indicate

a User Equipment (UE). The method may further comprise receiving a first response, from the first network node. The first response may comprise a UE domain information according to the UE ID.

[0021] In an embodiment, the UE domain information may comprise core network type and subscription domain.

[0022] In an embodiment, the core network type may comprise at least one of Evolved Packet Core (EPC), Fifth Generation Core network (5GC), Dual EPC and 5GC.

[0023] In an embodiment, the subscription domain may comprise at least one of 4th Generation Mobile Communication Technology subscription (4G subscription), and 5th Generation Mobile Communication Technology subscription (5G subscription).

[0024] In an embodiment, the first network node may comprise a Network Exposure Function (NEF), or a Service Capability Exposure Function (SCEF), or a combination of NEF and SCEF.

[0025] In an embodiment, the second network node may comprise an Application Function (AF).

[0026] In a third aspect of the disclosure, there is provided an apparatus which may be implemented as a network entity. The apparatus may comprise one or more processors and one or more memories storing computer program codes. The one or more memories and the computer program codes may be configured to, with the one or more processors, cause the apparatus at least to perform any step of the method according to the first aspect of the present disclosure.

[0027] In a fourth aspect of the disclosure, there is provided an apparatus which may be implemented as a network entity. The apparatus may comprise one or more processors and one or more memories storing computer program codes. The one or more memories and the computer program codes may be configured to, with the one or more processors, cause the apparatus at least to perform any step of the method according to the second aspect of the present disclosure.

[0028] In a fifth aspect of the present disclosure, there is provided a computer-readable medium having computer program codes embodied thereon which, when executed on a computer, cause the computer to perform any step of the method according to the first aspect or the second aspect of the present disclosure.

[0029] Embodiments herein may provide many advantages, of which a non-exhaustive list of examples follows. It proposes a solution for exposing UE domain information to an application function. Through the proposed method, AF can provide the fine-grained granularity service, based on the exposure of the UE domain information. The embodiments herein are not limited to the features and advantages mentioned above. A person skilled in the art will recognize additional features and advantages upon reading the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The above and other aspects, features, and benefits of various embodiments of the present disclosure will become more fully apparent, by way of example, from the following detailed description with reference to the accompanying drawings, in which like reference numerals or letters are used to designate like or equivalent elements. The drawings are illustrated for facilitating better understanding of the embodiments of the disclosure and not necessarily drawn to scale, in which:

[0031] FIG.1 shows a Service Exposure Architecture for EPC-5GC Interworking;

[0032] FIG.2 shows a flowchart of a method according to an embodiment of the present disclosure;

[0033] FIG.3 shows a flowchart of a method according to an embodiment of the present disclosure;

[0034] FIG.4 shows a flowchart of a method according to an embodiment of the present disclosure;

[0035] FIG.5 shows a flowchart of a method according to an embodiment of the present disclosure;

[0036] FIG.6 shows an example of a communication system according to an embodiment of the disclosure;

[0037] FIG.7 is a block diagram showing an apparatus suitable for practicing some embodiments of the disclosure;

[0038] FIG.8 is a block diagram showing a network function according to an embodiment of the disclosure;

[0039] FIG.9 is a block diagram showing a network function according to an embodiment of the disclosure;

[0040] FIG.10 is a block diagram of a host according to an embodiment of the disclosure; and

[0041] FIG.11 shows a communication diagram of a host communicating via a network node with a UE over a partially wireless connection according to an embodiment of the disclosure.

DETAILED DESCRIPTION

[0042] The embodiments of the present disclosure are described in detail with reference to the accompanying drawings. It should be understood that these embodiments are discussed only for the purpose of enabling those skilled persons in the art to better understand and thus implement the present disclosure, rather than suggesting any limitations on the scope of the present disclosure. Reference throughout this specification to features, advantages, or similar language does not imply that all of the features and advantages that may be realized with the present disclosure should be

or are in any single embodiment of the disclosure. Rather, language referring to the features and advantages is understood to mean that a specific feature, advantage, or characteristic described in connection with an embodiment is included in at least one embodiment of the present disclosure. Furthermore, the described features, advantages, and characteristics of the disclosure may be combined in any suitable manner in one or more embodiments. One skilled in the relevant art will recognize that the disclosure may be practiced without one or more of the specific features or advantages of a particular embodiment. In other instances, additional features and advantages may be recognized in certain embodiments that may not be present in all embodiments of the disclosure.

[0043] As used herein, the term "network" refers to a network following any suitable communication standards such as new radio (NR), long term evolution (LTE), LTE-Advanced, wideband code division multiple access (WCDMA), high-speed packet access (HSPA), Code Division Multiple Access (CDMA), Time Division Multiple Address (TDMA), Frequency Division Multiple Access (FDMA), Orthogonal Frequency-Division Multiple Access (OFDMA), Single carrier frequency division multiple access (SC-FDMA) and other wireless networks. A CDMA network may implement a radio technology such as Universal Terrestrial Radio Access (UTRA), etc. UTRA includes WCDMA and other variants of CDMA. A TDMA network may implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA network may implement a radio technology such as Evolved UTRA (E-UTRA), Ultra Mobile Broadband (UMB), IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDMA, Ad-hoc network, wireless sensor network, etc. In the following description, the terms "network" and "system" can be used interchangeably. Furthermore, the communications between two devices in the network may be performed according to any suitable communication protocols, including, but not limited to, the communication protocols as defined by a standard organization such as 3GPP. For example, the communication protocols may comprise the first generation (1G), 2G, 3G, 4G, 4.5G, 5G communication protocols, and/or any other protocols either currently known or to be developed in the future.

[0044] The term "network device" or "network node" refers to any suitable network function (NF) which can be implemented in a network function (physical or virtual) of a communication network. For example, the network function can be implemented either as a network element on a dedicated hardware, as a software instance running on a dedicated hardware, or as a virtualized function instantiated on an appropriate platform, e.g. on a cloud infrastructure. For example, the 5G system (5GS) may comprise a plurality of NFs such as AMF (Access and mobility Function), SMF (Session Management Function), AUSF (Authentication Service Function), UDM (Unified Data Management), PCF (Policy Control Function), AF (Application Function), NEF (Network Exposure Function), UPF (User plane Function) and NRF (Network Repository Function), RAN

(radio access network), SCP (service communication proxy), NWDAF (network data analytics function), NSSF (Network Slice Selection Function), NSSAAF (Network Slice-Specific Authentication and Authorization Function), etc. For example, the 4G system (such as LTE) may include MME (Mobile Management Entity), HSS (home subscriber server), Policy and Charging Rules Function (PCRF), Packet Data Network Gateway (PGW), PGW control plane (PGW-C), Serving gateway (SGW), SGW control plane (SGW-C), E-UTRAN Node B (eNB), etc. In other embodiments, the network node may comprise different types of NFs for example depending on a specific network.

[0045] The term "terminal device" or " user equipment (UE)" refers to any end device that can access a communication network and receive services therefrom. By way of example and not limitation, the terminal device refers to a mobile terminal or other suitable devices. The UE may be, for example, a Subscriber Station (SS), a Portable Subscriber Station, a Mobile Station (MS), or an Access Terminal (AT). The terminal device may include, but not limited to, a portable computer, an image capture terminal device such as a digital camera, a gaming terminal device, a music storage and a playback appliance, a mobile phone, a cellular phone, a smart phone, a voice over IP (VoIP) phone, a wireless local loop phone, a tablet, a wearable device, a personal digital assistant (PDA), a portable computer, a desktop computer, a wearable terminal device, a vehicle-mounted wireless terminal device, a wireless endpoint, a mobile station, a Laptop-Embedded Equipment (LEE), a Laptop-Mounted Equipment (LME), a Universal Serial Bus (USB) dongle, a smart device, a wireless Customer-Premises Equipment (CPE) and the like. In the following description, the terms "terminal device", "terminal", "user equipment" and "UE" may be used interchangeably. As one example, a terminal device may represent a UE configured for communication in accordance with one or more communication standards promulgated by the 3GPP (3rd Generation Partnership Project), such as 3GPP' LTE standard or NR standard. As used herein, a "user equipment" or "UE" may not necessarily have a "user" in the sense of a human user who owns and/or operates the relevant device. In some embodiments, a terminal device may be configured to transmit and/or receive information without direct human interaction. For instance, a terminal device may be designed to transmit information to a network on a predetermined schedule, when triggered by an internal or external event, or in response to requests from the communication network. Instead, a UE may represent a device that is intended for sale to, or operation by, a human user but that may not initially be associated with a specific human user.

[0046] As yet another example, in an Internet of Things (IoT) scenario, a terminal device may represent a machine or other device that performs monitoring and/or measurements, and transmits the results of such monitoring and/or measurements to another terminal device and/or network

equipment. The terminal device may in this case be a machine-to-machine (M2M) device, which may in a 3GPP context be referred to as a machine-type communication (MTC) device. As one particular example, the terminal device may be a UE implementing the 3GPP narrow band internet of things (NB-IoT) standard. Particular examples of such machines or devices are sensors, metering devices such as power meters, industrial machinery, or home or personal appliances, for example refrigerators, televisions, personal wearables such as watches etc. In other scenarios, a terminal device may represent a vehicle or other equipment that is capable of monitoring and/or reporting on its operational status or other functions associated with its operation.

[0047] References in the specification to "one embodiment," "an embodiment," "an example embodiment," and the like indicate that the embodiment described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0048] It shall be understood that although the terms "first" and "second" etc. 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. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed terms.

[0049] As used herein, the phrase "at least one of A and B" or "at least one of A or B" should be understood to mean "only A, only B, or both A and B." The phrase "A and/or B" should be understood to mean "only A, only B, or both A and B".

[0050] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. 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.

[0051] The terminologies core network type, Core Network Type (CN Type), core network Type (cnType), Core network Type (CnType), etc., are all used to describe the registration type to the core network.

[0052] It is noted that these terms as used in this document are used only for ease of description and differentiation among nodes, devices or networks etc. With the development of the technology, other terms with the similar/same meanings may also be used.

[0053] In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0054] More and more operators deploy 5GC and enable 5GC interworking with EPC. A 5G subscriber has 5G/4G switching capability when UE moves between 5GC and EPC. This improves the UE-Side user experience.

[0055] Meanwhile, operators deploys SCEF/NEF (Service Capability Exposure Function, Network Exposure Function). Through NEF/SCEF, network capabilities are exposed to Application Function (AF) via programmable Application Programming Interfaces (APIs). This improves the AF-Side user experience, e.g. as defined in 3GPP TS 23.502 v17.7.0 section 4.15.3 "Event Exposure using NEF", AF can monitor the status/event of UE reachability, roaming, PDU session establishment/release, location-change, etc.

[0056] For example, the information exposed to AF currently defined from 3GPP 29.122 Section 5.3.2.4.3 Enumeration: MonitoringType is given in below table 1.

[0057] Table 1. Enumeration: MonitoringType

Enumeration value	Description	Applicability (NOTE 1)
LOSS_OF_CONNECTIVITY	The SCS/AS requests to be notified when the 3GPP network detects that the UE is no longer reachable for signalling or user plane communication	Loss_of_connectivity_notification
UE_REACHABILITY	The SCS/AS requests to be notified when the UE becomes reachable for sending either SMS or downlink data to the UE	Ue-reachability_notification
LOCATION_REPORTING	The SCS/AS requests to be notified of the current location or the last known location of the UE	Location_notification, eLCS
CHANGE_OF_IMSI_IMEI_ASSOCIATION	The SCS/AS requests to be notified when the association of an ME (IMEI(SV)) that uses a specific subscription (IMSI) is changed	Change_of_IMSI_IMEI_association_notification
ROAMING_STATUS	The SCS/AS queries the UE's current roaming status and requests to get notified when the status changes	Roaming_status_notification
COMMUNICATION_FAILURE	The SCS/AS requests to be notified of communication failure events	Communication_failure_notification
AVAILABILITY_AFTER_DDN_FAILURE	The SCS/AS requests to be notified when the UE has become available after a DDN failure	Availability_after_DDN_failure_notification, Availability_after_DDN_failure_notification_enhancement
NUMBER_OF_UES_IN_AN_AREA	The SCS/AS requests to be notified the number of UEs in a given geographic area	Number_of_UEs_in_an_area_notification, Number_of_UEs_in_an_area_notification_5G
PDN_CONNECTIVITY_STATUS	The SCS/AS requests to be notified when the 3GPP network detects that the UE's PDN connection is set up or torn down.	Pdn_connectivity_status
DOWNLINK_DATA_DELIVERY_STATUS	The AF requests to be notified when the 3GPP network detects that the downlink data delivery status is changed.	Downlink_data_delivery_status_5G
API_SUPPORT_CAPABILITY	The SCS/AS requests to be notified of the availability of support of service APIs.	API_support_capability_notification
NUM_OF_REGD_UES	The AF requests to be notified of the current number of registered UEs for a network slice.	NSAC
NUM_OF_ESTD_PDU_SESSIONS	The AF requests to be notified of the current number of established PDU Sessions for a network slice.	NSAC
AREA_OF_INTEREST	The SCS/AS requests to be notified when the UAV moves in or out of the geographic area.	UAV
NOTE 1: Properties marked with a feature as defined in clause 5.3.4 are applicable as described in clause 5.2.7. If no features are indicated, the related property applies for all the features. NOTE 2: More monitoring types can be added in the future based on stage 2.		

[0058] Currently, 3GPP TS29.503 V17.9.0 specifies Unified Data Management Services. In the specification, NEF can subscribe Core Network (CN) Type Change from Unified Data Management (UDM).

[0059] However, AF doesn't know the Core Network Type for a UE. There is no mechanism and data model between NEF and AF to let AF get the Core Network Type for a UE.

[0060] Meanwhile, 3GPP does not define a solution for SCEF+NEF/NEF/SCEF to distinguish subscription domain to know if the UE is 4G subscription or 5G subscription, the consequent is that SCEF+NEF/NEF/SCEF cannot return valid subscription domain information to AF. For a combined SCEF+NEF, it doesn't know if it need to interact with 4GC or 5GC.

[0061] The core network type and subscription domain mentioned above belong to UE domain information. The core network type is a kind of network domain information.

[0062] The UE domain information may comprise at least one of subscription domain, and network domain information (core network type).

[0063] In this disclosure, the UE domain information may comprise at least one of subscription domain, and core network type.

[0064] To overcome or mitigate at least one of above mentioned problems or other problems, the embodiments of the present disclosure propose an solution for exposing UE domain information to an application function according to a UE ID.

[0065] Fig. 1 shows an architecture for Service Exposure for EPC-5GC Interworking, which is defined in 3GPP TS 23.501 v17.7.0. If the UE is capable of mobility between EPS and 5GS, the network is expected to associate the UE with an SCEF+NEF node for Service Capability Exposure.

[0066] In Fig .1, EPC Interface represents southbound interfaces between SCEF and EPC nodes e.g. the S6t interface between SCEF and HSS, the T6a interface between SCEF and MME, etc.

[0067] 5GC Interface represents southbound interfaces between NEF and 5GC Network Functions e.g. N29 interface between NEF and SMF, N30 interface between NEF and PCF, etc.

[0068] Interaction between the SCEF and NEF within the combined SCEF+NEF is required. For example, when the SCEF+NEF supports monitoring APIs, the SCEF and NEF need to share context and state information on a UE's configured monitoring events if the UE moves between from EPC and 5GC.

[0069] The north-bound APIs which can be supported by an EPC or 5GC network are discovered by the SCEF+NEF node.

[0070] FIG.2 shows a flowchart of a method according to an embodiment of the present disclosure, which may be performed by an apparatus implemented in/as or communicatively coupled to a first network node. As such, the apparatus may provide means for accomplishing various parts of the method 200 as well as means for accomplishing other processes in conjunction with other components.

[0071] At block 202, the first network node may receive a first request from a second network node. The first request may comprise a User Equipment Identifier (UE ID) to indicate a User Equipment (UE).

[0072] At block 204, the first network node may determine a UE domain information according to the received UE ID.

[0073] At block 206, the first network node may send a first response to the second network node. The first response may comprise the determined UE domain information.

[0074] The first request may be any suitable message, such as a HTTP Post request, a HTTP Get request, etc.

[0075] The first response may be any suitable message, such as a HTTP post response, a HTTP Get response, etc.

[0076] The UE ID may be any suitable information which can be used to identify the one or more user equipment devices, such as it may comprise at least one of UE address (such as IP address or MAC (Media Access Control) address), Generic Public Subscription Identifier (GPSI), Subscription Permanent Identifier (SUPI), MobileStationIntegratedServicesDigitalNetwork (MSISDN), external identifier (ID).

[0077] The first network node may be a physical entity or a virtualized network function. For example, the first network node may be any suitable network device or node or entity or function (physical or virtual) which can provide a network exposure function or service capability exposure function.

[0078] In an embodiment, the first network node may provide a means to securely expose the services and capabilities provided by the network interfaces. The first network node may provide a means for the discovery of the exposed services and capabilities. The first network node may provide access to network capabilities through homogenous network application programming interfaces (e.g. Network APIs). The first network node may abstract the services from the underlying network interfaces and protocols.

[0079] In an embodiment, the first network node may be NEF as described in 3GPP TS 23.501 V17.7.0. In another embodiment, the first network node may be SCEF. In another embodiment, the first network node may comprise a combination of NEF and SCEF.

[0080] In an embodiment, the second network node may be a physical entity or a virtualized network function. For example, the network node may be any suitable network device or node or entity or function (physical or virtual) which can provide an application function. The second network node may be Application Function (AF) as described in 3GPP TS 23.501 V17.7.0. In another embodiment, the second network node may be service capability server (SCS)/application server (AS) as described in 3GPP TS 23.682 V17.3.0.

[0081] In an embodiment, the UE domain information may comprise at least one of core network type, subscription domain.

[0082] In this disclosure, the terminologies core network type, Core Network Type (CN Type), core network Type (cnType), Core network Type (CnType), etc., are all used to describe the registration type to the core network.

[0083] In an embodiment, the core network type (CnType) may comprise at least one of Evolved Packet Core (EPC), Fifth Generation Core network (5GC), Dual EPC and 5GC.

[0084] For example, table 2.a shows an enumeration of CnType. The CnType may comprise three different kinds of core network types of a UE: EPC, 5GC, Dual EPC and 5GC. The three different types of CnType may take any suitable form, such as an array, an indication, or a bit, or a flag, etc.

[0085] In an embodiment, the core network type (CnType) may comprise at least one of SINGLE_4G, SINGLE_5G, DUAL_4G5G. The enumeration of it is shown in Table 2b.

[0086] The "EPC" corresponds to "SINGLE_4G", "5GC" corresponds to "SINGLE_5G", "Dual EPC and 5GC" corresponds to "DUAL_4G5G".

[0087] The three different types of core network type may take any suitable names to denote the three kinds of registration type in core network.

Table 2a. Enumeration CnType

Enumeration value	Description
"EPC"	Single registration in 4G/EPC
"5GC"	Single registration in 5G/5GC
"DUAL EPC and 5GC"	Dual registration in 4G/EPC and 5G/5GC

Table 2b. Enumeration CnType

Enumeration value	Description
"SINGLE_4G"	Single registration in 4G/EPC
"SINGLE_5G"	Single registration in 5G/5GC
"DUAL_4G5G"	Dual registration in 4G/EPC and 5G/5GC

[0088] The subscription domain for a UE may comprise 4th Generation Mobile Communication Technology subscription (4G subscription), 5th Generation Mobile Communication Technology subscription (5G subscription).

[0089] Table 3 shows an enumeration example of subscription domain. The subscription domain may take any suitable form, such as an array, an indication, or a bit, or a flag, etc.

[0090] Table 3. Enumeration subscription domain

Enumeration value	Description
"5G"	5G Subscription
"4G"	4G Subscription

[0091] In an embodiment, the method may further comprise determining UE domain information (a core network type and/or a subscription domain) according to the received UE ID may comprise sending a second request to a third network node to discover if there exist a fourth network node service instance for the UE ID，receiving a second response from the third network node. The second response indicating whether there exist a fourth network node service instance for the UE ID.

[0092] In an embodiment, when the second response indicates there not exist a fourth network node service instance for the UE ID, the method may further comprise determining the subscription domain as 4G subscription and the first core network type as EPC.

[0093] In an embodiment, when the second response indicates there exist a fourth network node service instance for the UE ID, the method may further comprise sending a third request, to the fourth network node, to subscribe the core network type change according to the UE ID.

[0094] In an embodiment, the method may further comprise receiving a third response from the fourth network node, wherein the third response indicating the core network type according to the UE ID, determining the core network type comprised in the UE domain information as the received core network type in the third response according to the UE ID and the subscription domain as 5G subscription.

[0095] In an embodiment, when the UE moves between EPC and 5GC, the method may further comprise receiving a first message from the fourth network node, wherein the first message comprises an updated core network type according to the UE ID, determining the core network type comprised in the UE domain information as the updated core network type received in the first message and the subscription domain as 5G subscription. The method may further comprise sending a second message to the second network node. The second message may comprise an updated UE domain information. The updated UE domain information may comprise the updated core network type and subscription domain.

[0096] In an embodiment, the first request may be a network exposure function event exposure subscribe request. For example: the first request is a Nnef_EventExposure_Subscribe request.

[0097] In an embodiment, the first response may be a network exposure function event exposure subscribe response. For example, the first response is a Nnef_EventExposure_Subscribe response.

[0098] In an embodiment, the first message may be a notification message. For example, the first message is a Nudm_EventExposure_Notify message.

[0099] In an embodiment, the second message may be a notification message. For example, the first message is a Nnef_EventExposure Notification.

[00100] In an embodiment, the third network node may comprise a Network Repository Function (NRF).

[00101] In an embodiment, the fourth network node may comprise a Unified Data Management (UDM), or a combination of UDM and Home Subscriber Server (HSS).

[00102] FIG.3 shows a flowchart of a method according to an embodiment of the present disclosure, which may be performed by an apparatus implemented in/as or communicatively coupled to a first network node. As such, the apparatus may provide means for accomplishing various parts of the method 300 as well as means for accomplishing other processes in conjunction with other components.

[00103] At block 302, the first network node may receive a first request from a second network node. The first request may comprise a User Equipment Identifier (UE ID) to indicate a User Equipment (UE).

[00104] At block 304, the first network node may send a first response to the second network node. The first response may comprise the a core network type and/or a subscription domain for the requested UE ID.

[00105] The first request may be any suitable message, such as a HTTP Post request, a HTTP Get request, etc.

[00106] The first response may be any suitable message, such as a HTTP post response, a HTTP Get response, etc.

[00107] The UE ID may be any suitable information which can be used to identify the one or more user equipment devices, such as it may comprise at least one of UE address (such as IP address or MAC (Media Access Control) address)，Generic Public Subscription Identifier (GPSI), Subscription Permanent Identifier (SUPI), MobileStationIntegratedServicesDigitalNetwork (MSISDN)，external identifier (ID).

[00108] In an embodiment, the first network node may further comprising determining a core network type and/or a subscription domain according to the received UE ID.

[00109] The first network node may be a physical entity or a virtualized network function. For example, the first network node may be any suitable network device or node or entity or function (physical or virtual) which can provide a network exposure function or service capability exposure function.

[00110] In an embodiment, the first network node may provide a means to securely expose the services and capabilities provided by the network interfaces. The first network node may provide a means for the discovery of the exposed services and capabilities. The first network node may provide access to network capabilities through homogenous network application programming interfaces (e.g. Network APIs). The first network node may abstract the services from the underlying network interfaces and protocols.

[00111] In an embodiment, the first network node may be NEF as described in 3GPP TS 23.501 V17.7.0. In another embodiment, the first network node may be SCEF. In another embodiment, the first network node may comprise a combination of NEF and SCEF.

[00112] In an embodiment, the second network node may be a physical entity or a virtualized network function. For example, the network node may be any suitable network device or node or entity or function (physical or virtual) which can provide an application function. The second network node may be Application Function (AF) as described in 3GPP TS 23.501 V17.7.0. In another embodiment, the second network node may be service capability server (SCS)/application server (AS) as described in 3GPP TS 23.682 V17.3.0.

[00113] In an embodiment, the core network type may comprise at least one of Evolved Packet Core (EPC), Fifth Generation Core network (5GC), Dual EPC and 5GC.

[00114] In this disclosure, the terminologies core network type, Core Network Type (CN Type), core network Type (cnType), Core network Type (CnType), etc., are all used to describe the registration type in the core network.

[00115] In an embodiment, the core network type may comprise at least one of Evolved Packet Core (EPC), Fifth Generation Core network (5GC), Dual EPC and 5GC.

[00116] For example, table 2.a shows an enumeration of CnType. The CnType may comprise three different kinds of core network types of a UE: EPC, 5GC, Dual EPC and 5GC. The three different types of CnType may take any suitable form, such as an array, an indication, or a bit, or a flag, etc.

[00117] In another embodiment, the core network type may comprise at least one of SINGLE_4G, SINGLE_5G, DUAL_4G5G. The enumeration of it is shown in Table 2b.

[00118] The "EPC" corresponds to "SINGLE_4G", "5GC" corresponds to "SINGLE_5G", "Dual EPC and 5GC" corresponds to "DUAL_4G5G".

[00119] The three different types of core network type may take any suitable names to denote the three kinds of registration type in core network.

[00120] The subscription domain for a UE may comprise 4th Generation Mobile Communication Technology subscription (4G subscription), 5th Generation Mobile Communication Technology subscription (5G subscription).

[00121] Table 3 shows an enumeration example of subscription domain. The subscription domain may take any suitable form, such as an array, an indication, or a bit, or a flag, etc.

[00122] In an embodiment, the method may further comprise determining a core network type and a subscription domain according to the received UE ID comprises sending a second request to a third network node to discover if there exist a fourth network node service instance for the UE ID, receiving a second response from the third network node. The second response indicating whether there exist a fourth network node service instance for the UE ID.

[00123] In an embodiment, when the second response indicates there not exist a fourth network node service instance for the UE ID, the method may further comprise determining the subscription domain as 4G subscription an d the first core network type as "EPC".

[00124] In an embodiment, when the second response indicates there exist a fourth network node service instance for the UE ID, the method may further comprise sending a third request, to the fourth network node, to subscribe the core network type change according to the UE ID.

[00125] In an embodiment, the method further may further comprise receiving a third response from the fourth network node, wherein the third response indicating the core network type according to the UE ID, determining the core network type as the received core network type in the third response according to the UE ID and the subscription domain as 5G subscription.

[00126] In an embodiment, when the UE moves between EPC and 5GC, the method may further comprise receiving a first message from the fourth network node. The first message may comprise a current core network type according to the UE ID. The method further comprise determining the core network type as the updated core network type received in the first message and the subscription domain as 5G subscription, and sending a second message to the second network node. The second message may comprise the determined core network type and the determined subscriber domain.

[00127] In an embodiment, the first request may be a network exposure function event exposure subscribe request. For example: the first request is a Nnef_EventExposure_Subscribe request.

[00128] In an embodiment, the first response may be a network exposure function event exposure subscribe response. For example, the first response is a Nnef_EventExposure_Subscribe response.

[00129] In an embodiment, the first message may be a notification message. For example, the first message is a Nudm_EventExposure_Notify message.

[00130] In an embodiment, the second message may be a notification message. For example, the first message is a Nnef_EventExposure Notification.

[00131] In an embodiment, the third network node may comprise a Network Repository Function (NRF).

[00132] In an embodiment, the fourth network node may comprise a Unified Data Management (UDM), or a combination of UDM and Home Subscriber Server (HSS).

[00133] FIG.4 shows a flowchart of a method according to an embodiment of the present disclosure, which may be performed by an apparatus implemented in/as or communicatively coupled to a second network node. As such, the apparatus may provide means for accomplishing various parts of the method 400 as well as means for accomplishing other processes in conjunction with other components.

[00134] At block 402, the second network node may send a first request to a first network node. The first request may comprise a User Equipment Identifier (UE ID) to indicate a User Equipment (UE).

[00135] At block 404, the second network node may receive a first response, from the first network node. The first response may comprise a UE domain information according to the UE ID.

[00136] The first request may be any suitable message, such as a HTTP Post request, a HTTP Get request, etc.

[00137] The first response may be any suitable message, such as a HTTP post response, a HTTP Get response, etc.

[00138] The UE ID may be any suitable information which can be used to identify the one or more user equipment devices, such as it may comprise at least one of UE address (such as IP address or MAC (Media Access Control) address), Generic Public Subscription Identifier (GPSI), Subscription Permanent Identifier (SUPI), MobileStationIntegratedServicesDigitalNetwork (MSISDN), external identifier (ID).

[00139] The second network node may be a physical entity or a virtualized network function. For example, the second network node may be any suitable network device or node or entity or function (physical or virtual) which can provide a network exposure function or service capability exposure function.

[00140] In an embodiment, the second network node may be a physical entity or a virtualized network function. For example, the network node may be any suitable network device or node or entity or function (physical or virtual) which can provide an application function. The second network node may be Application Function (AF) as described in 3GPP TS 23.501 V17.7.0. In another embodiment, the second network node may be service capability server (SCS)/application server (AS) as described in 3GPP TS 23.682 V17.3.0.

[00141] In an embodiment, the first network node may comprise a Network Exposure Function (NEF), or a Service Capability Exposure Function (SCEF), or a combination of NEF and SCEF.

[00142] In an embodiment, the UE domain information may comprise at least one of core network type, subscription domain.

[00143] For example, table 2.a shows an enumeration of CnType. The CnType may comprise three different kinds of core network types of a UE: EPC, 5GC, Dual EPC and 5GC. The three different types of CnType may take any suitable form, such as an array, an indication, or a bit, or a flag, etc.

[00144] In another embodiment, the core network type (CnType) may comprise at least one of SINGLE_4G, SINGLE_5G, DUAL_4G5G. The enumeration of it is shown in Table 2b.

[00145] The "EPC" corresponds to "SINGLE_4G", "5GC" corresponds to "SINGLE_5G", "Dual EPC and 5GC" corresponds to "DUAL_4G5G".

[00146] The three different types of core network type may take any suitable names to denote the three kinds of registration type in core network.

[00147] In an embodiment, the subscription domain may comprise at least one of 4th Generation Mobile Communication Technology subscription (4G subscription), 5th Generation Mobile Communication Technology subscription (5G subscription). The enumeration of subscription domain is shown in Table 3.

[00148] In an embodiment, the first request may be a network exposure function event exposure subscribe request. For example: the first request is a Nnef_EventExposure_Subscribe request.

[00149] In an embodiment, the first response may be a network exposure function event exposure subscribe response. For example, the first response is a Nnef_EventExposure_Subscribe message.

[00150] In an embodiment, the second message may be a notification message. For example, the first message is a Nnef_EventExposure Notification.

[00151] In an embodiment, when the UE moves between EPC and 5GC, the method may further comprise receiving a second message from the first network node. The second message may comprise an updated UE domain information core network type and the according to the UE ID. The updated UE domain information may comprise an updated core network type and a subscription domain.

[00152] In an embodiment, the first network node may comprise a Network Exposure Function (NEF), or a Service Capability Exposure Function (SCEF), or a combination of NEF and SCEF.

[00153] In an embodiment, the second network node may comprise an Application Function (AF).

[00154] Fig.5 shows an example of a communication system according to an embodiment of the disclosure. There are four network nodes.

[00155] The first network node may be a NEF, SCEF, or a combination of NEF+SCEF.

[00156] The second network node may be an Application Function (AF).

[00157] The third network node may be an NRF.

[00158] The fourth network node may be a UDM, or a combination of UDM + HSS.

[00159] In 5GC architecture, each NF producer registers its own services to NRF, the other NF consumers discovers the registered services via NRF through input specific parameters. The procedure is described in 3GPP TS23.502 v17.7.0 section 4.17.4.

[00160] UDM is dedicated for 5G subscriptions' management. It registers its services to NRF. Each UDM instance is responsible for a specific UE segmentation. The UE segmentation uses different UE ID range, such as GPSI range.

[00161] At step 1, the second network node (AF) may send a subscribe request to the first network node (NEF/SCEF/NEF+SCEF) to subscribe Nnef_APISupportCapability service for a User Equipment (UE). A UE ID is used to indicate the UE. The request may be a Nnef_EventExposure Subscribe Request, with parameters UE ID, Event Type(API_Support_Capability), callback URI in the request message. The request may be a Nnef_EventExposure Subscribe (UE ID, Event Type(API_Support_Capability), callback URI) message.

[00162] At step2, the first network node may discover EventExposure service of the fourth network node (UDM/HSS) by sending a Nnrf_NFDiscovery_Request to the third network (NRF). The service discovery procedure is detailed described in 3GPP TS23.502 section 4.17.4.

For example, the first network node sends a request to NRF. The request is GET /nnrf-disc/v1/nf-instances?target-nf-type=UDM&requester-nf-type=NEF&service-names=nudm-ee&gpsi=gpsi.

[00163] The first network node may determine a subscription domain for the UE according to UDM discovery response from NRF.

[00164] If there is no UDM EventExposure service instance in the discovery response, the first network node may determine this is a 4G subscription for the UE. It may determine the UE's subscription domain = "4G" subscription. It may determine Core network Type (CType) = "SINGLE_4G"/ "EPC".

[00165] In an embodiment, the core network type may comprise at least one of Evolved Packet Core (EPC), Fifth Generation Core network (5GC), Dual EPC and 5GC.

[00166] For example, table 2.a shows an enumeration of CnType. The CnType may comprise three different kinds of registration type in core network for a UE: EPC, 5GC, Dual EPC and 5GC. The three different types of CnType may take any suitable form, such as an array, an indication, or a bit, or a flag, etc. The three different types of CnType may take any suitable name, such as SINGLE_4G, SINGLE_5G, DUAL_4G5G can also be used to denote the three kinds of CnType, which is shown in Table 2b.

Table 2a. Enumeration CnType

Enumeration value	Description
"EPC"	Single registration in 4G/EPC
"5GC"	Single registration in 5G/5GC
"DUAL EPC and 5GC"	Dual registration in 4G/EPC and 5G/5GC

Table 2b. Enumeration CnType

Enumeration value	Description
"SINGLE_4G"	Single registration in 4G/EPC
"SINGLE_5G"	Single registration in 5G/5GC
"DUAL_4G5G"	Dual registration in 4G/EPC and 5G/5GC

[00167] The subscription domain for a UE may comprise 4th Generation Mobile Communication Technology subscription (4G subscription), 5th Generation Mobile Communication Technology subscription (5G subscription).

[00168] Table 3 shows an Enumeration example of subscription domain. The subscription domain may take any suitable form, such as an array, an indication, or a bit, or a flag, etc.

[00169] Table 3. Enumeration subscription domain

Enumeration value	Description
"5G"	5G Subscription
"4G"	4G Subscription

[00170] Otherwise, if there exist an UDM EventExposure service instance in the discovery response, the first network node may determine this is a 5G subscription. Then it may execute steps from 3b to 5b for subscribing core network type change event to UDM, and may execute steps from 6b to 7b for getting a core network type change event notification from UDM.

[00171] Step 3a. (This is a 4G subscription) According to the CN type ("SINGLE_4G") and Subscription domain ("4G"), the first network node may determine the availability or expected level of support of common APIs for the received UE ID.

[00172] The first network node may determine the UE domain information. In the UE domain information, the CnType = "SIGNLE_4G" or "EPC", the subscription domain ="4G".

[00173] The first network node may immediately send a MonitoringEventReport with parameters CnType, subscription domain in a Nnef_EventExposure_Subscribe Response message. Meanwhile, the availability or expected level of support of common APIs are also comprised in the Nnef_EventExposure_Subscribe Response. Then the first network node may send the response to the AF.

[00174] Step 3b. (This is a 5G subscription) The first network node may subscribe the core network type change event to UDM by sending Nudm_EventExposure_Subscribe Request (CN Type Change, Report Type, UE ID, Duration of Reporting) message.

[00175] Step 4b. (This is a 5G subscription) According to the received UE ID, the UDM may determine the CnType for the indicated UE based on the registered MME or AMF. The UDM may send a Nudm_EventExposure_Subscribe Response to the first network node to inform the new CnType for the UE.

[00176] The new CnType may be comprised in a CnTypeChangeReport.

[00177] Table 4 shows a definition of the Report, which is described in 3GPP TS29.503 v17.9.0.

Table 4 Report

Data type	Cardinality	Description
ChangeOfSupiPeiAssociationReport	1	Report Change of SUPI-PEI Association
RoamingStatusReport	1	Report Roaming Status
CnTypeChangeReport	1	Report new CN type after switching
CmInfoReport	1	Report the UE's CM state
LossConnectivityReport	1	Report of "LOSS_OF_CONNECTIVITY" event
LocationReport	1	"LOCATION_REPORTING"
PdnConnectivityStatReport	1	"PDN_CONNECTIVITY_STATUS"

[00178] For the CnTypeChangeReport, the detailed description of it is described in 3GPP TS29.503 v17.9.0. Table 5 shows a definition of the CnTypeChangeReport.

Table 5 Definition of type CnTypeChangeReport

Attribute name	Data type	P	Cardinality	Description
oldCnType	CnType	O	0..1	the old CN type
newCnType	CnType	M	1	the new CN type

[00179] Step 5b. (This is a 5G subscription) According to the received CnType from UDM/HSS and the determined subscription domain. The subscription domain = "5G" subscription. The first network node may determine the availability of support of APIs for the indicated UE.

[00180] The first network node may send a Nnef_EventExposure Subscribe Response to the second network node. In the response, a MonitoringEventReport, API support capabilities are included in it. The MonitoringEventReport may comprise the CnType and the subscription domain in the report.

[00181] Step 6b. When the fourth network node (UDM or HSS) detects that the indicated UE is switching between EPC and 5GC, the UDM may determine the CnType for the indicated UE. The fourth network node (UDM/HSS) may inform the first network node of the CnType by sending Nudm_EventExposure_Notify (CN type).

[00182] Step 7b. According to the received CnType ("SINGLE_4G", "SINGLE_5G" or "DUAL_4G5G") and Subscription domain (Subscription domain = 5G), the first network node may determine the availability of support of APIs for the requested UE ID.

[00183] The first network node may send a Nnef_EventExposure Notification to the second network node. In the notification, a MonitoringEventReport, API support capabilities are included in it. The MonitoringEventReport may comprise the updated CnType and subscription domain in it. The CnType is updated as the received newCnType, CnType = newCnType. The subscription domain = "5G". Further, MonitoringEventReport may comprise API support capabilities in it. The first network node may send a Nnef_EventExposure Notif to the second network node.

[00184] In order to support above solutions, a cnType and a subscriptionDomain Information Elements are added to the MonitoringEventReport.

Table 6: Definition of type MonitoringEventReport

Attribute name	Data type	Cardinality	Description	Applicability (NOTE 1)
imeiChange	AssociationType	0..1	If "monitoringType" is "CHANGE_OF_IMSI_IMEI_ASSOCIATION", this parameter shall be included to identify the event of change of IMSI-IMEI or IMSI-IMEISV association is detected. Refer to 3GPP TS 29.336 [11] Clause 8.4.22.	Change_of_IMSI_IMEI_association_notification
externalId	ExternalId	0..1	External identifier. This attribute may also be present in the monitoring event subscription one-time response message, if the "UEId_retrieval" feature is supported and the corresponding request message includes the "ueIpAddr" attribute or the "ueMacAddr" attribute. (NOTE 2)	
...	....	...	.....	...
uavPresInd	boolean	0..1	If "monitoringType" is "AREA_OF_INTEREST", this parameter shall be set to true if the specified UAV is in the monitoring area. Set to false or omitted otherwise.	UAV
cnType	CnType	0..1	If "monitoringType" is "API_SUPPORT_CAPABILITY", this parameter could be included to indicate the core network type with which UE registers	API_support_capability_notification
subscriptionDomain	SubscriptionDomain	0..1	If "monitoringType" is "API_SUPPORT_CAPABILITY", this parameter could be included to indicate the subscriber type	API_support_capability_notification

[00185] The subscription domain could be included in the MonitoringEventReport to indicate the subscriber type, such as 4G subscription or 5G subscription.

[00186] If AF requests One-time report to NEF in step1 (e.g. maxNumberReport=1), then steps 6b – 7b are omitted.

[00187] Embodiments herein may provide many advantages, of which a non-exhaustive list of examples follows. It proposes a solution for exposing UE domain information to an application function. Through the proposed method, AF can provide the fine-grained granularity service, based on the exposure of the UE domain information. E.g. AF gives the higher video quality if UE registered with 5GS. The embodiments herein are not limited to the features and advantages mentioned above. A person skilled in the art will recognize additional features and advantages upon reading the following detailed description.

[00188] FIG.6 is a block diagram showing an apparatus suitable for practicing some embodiments of the disclosure. For example, the first network node described above may be implemented as or through the apparatus 600.

[00189] The apparatus 600 comprises at least one processor 601, such as a digital processor (DP), and at least one memory (MEM) 602 coupled to the processor 601. The apparatus 600 may further comprise a transmitter TX and receiver RX 603 coupled to the processor 601. The MEM 602 stores a program (PROG) 604. The PROG 604 may include instructions that, when executed on the associated processor 601, enable the apparatus 600 to operate in accordance with the embodiments of the present disclosure. A combination of the at least one processor 601 and the at least one MEM 602 may form processing means 605 adapted to implement various embodiments of the present disclosure.

[00190] Various embodiments of the present disclosure may be implemented by computer program executable by one or more of the processor 601, software, firmware, hardware or in a combination thereof.

[00191] The MEM 602 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memories and removable memories, as non-limiting examples.

[00192] The processor 601 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multicore processor architecture, as non-limiting examples.

[00193] In an embodiment where the apparatus is implemented as or at the network node, the memory 602 contains instructions executable by the processor 601, whereby the network node operates according to any of the methods related to the network node as described above.

[00194] In an embodiment where the apparatus is implemented as or at the application node, the memory 602 contains instructions executable by the processor 601, whereby the application node operates according to any of the methods related to the application node as described above.

[00195] FIG.7 is a block diagram showing an apparatus suitable for practicing some embodiments of the disclosure. For example, the second network node described above may be implemented as or through the apparatus 700.

[00196] The apparatus 700 comprises at least one processor 701, such as a digital processor (DP), and at least one memory (MEM) 702 coupled to the processor 701. The apparatus 700 may further comprise a transmitter TX and receiver RX 703 coupled to the processor 701. The MEM 702 stores a program (PROG) 704. The PROG 704 may include instructions that, when executed on the associated processor 701, enable the apparatus 700 to operate in accordance with the embodiments of the present disclosure. A combination of the at least one processor 801 and the at least one

MEM 702 may form processing means 705 adapted to implement various embodiments of the present disclosure.

[00197] Various embodiments of the present disclosure may be implemented by computer program executable by one or more of the processor 701, software, firmware, hardware or in a combination thereof.

[00198] The MEM 702 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memories and removable memories, as non-limiting examples.

[00199] The processor 701 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multicore processor architecture, as non-limiting examples.

[00200] In an embodiment where the apparatus is implemented as or at the network node, the memory 702 contains instructions executable by the processor 701, whereby the network node operates according to any of the methods related to the network node as described above.

[00201] In an embodiment where the apparatus is implemented as or at the application node, the memory 702 contains instructions executable by the processor 701, whereby the application node operates according to any of the methods related to the application node as described above.

[00202] FIG.8 is a block diagram showing a network node according to an embodiment of the disclosure.

[00203] As shown, the first network node 800 may comprise a first receiving module 801 configured to receive a first request from a second network node, wherein the first request comprises a User Equipment Identifier (UE ID) to indicate a User Equipment (UE).

[00204] In an embodiment, the first network node 800 further comprises a first determining module 807 configured to determine a UE domain information according to the received UE ID.

[00205] In an embodiment, the first network node 800 may further comprise a first sending module 802 configured to send a first response to the second network node. The first response may comprise the determined UE domain information.

[00206] In an embodiment, the first network node 800 may further comprise a second sending module 804 configured to send a second request to a third network node to discover if there exist a fourth network node service instance for the UE ID.

[00207] In an embodiment, the first network node 800 may further comprise a second receiving module 803 configured to receive a second response from the third network node, wherein the

second response indicating whether there exist a fourth network node service instance for the UE ID.

[00208] In an embodiment, the first network node 800 may further comprise a third sending module 806 configured to send a third request, to the fourth network node, to subscribe the core network type change according to the UE ID, when the second response indicates there exist a fourth network node service instance for the UE ID.

[00209] In an embodiment, the first network node 800 may further comprise a third receiving module 805 configured to receive response or message from the fourth network node.

[00210] FIG.9 is a block diagram showing a network node according to an embodiment of the disclosure.

[00211] As shown, the second network node 900 may comprise a sending module 901 configured to send a first request to a first network node. The first request may comprise a User Equipment Identifier (UE ID) to indicate a User Equipment (UE).

[00212] In an embodiment, the second network node 900 may further comprise a first receiving module 902 configured to receive a first response, from the first network node. The first response may comprise a UE domain information according to the UE ID.

[00213] In an embodiment, the second network node 900 may further comprise a second receiving module 903 configured to receive a second message from the first network node. The second message may comprise an updated UE domain information according to the UE ID.

[00214] FIG.10 shows an example of a communication system QQ1000 in accordance with some embodiments.

[00215] In the example, the communication system QQ1000 includes a telecommunication network QQ1002 that includes an access network QQ1004, such as a radio access network (RAN), a core network QQ1006, which includes one or more core network nodes QQ1008. The access network QQ1004 includes one or more access network nodes, such as network nodes QQ1010a and QQ1010b (one or more of which may be generally referred to as network nodes QQ1010), or any other similar 3rd Generation Partnership Project (3GPP) access node or non-3GPP access point. The network nodes QQ1010 facilitate direct or indirect connection of user equipment (UE), such as by connecting UEs QQ1012a, QQ1012b, QQ1012c, and QQ1012d (one or more of which may be generally referred to as UEs QQ1012) to the core network QQ1006 over one or more wireless connections.

[00216] Example wireless communications over a wireless connection include transmitting and/or receiving wireless signals using electromagnetic waves, radio waves, infrared waves, and/or other types of signals suitable for conveying information without the use of wires, cables, or other material conductors. Moreover, in different embodiments, the communication system QQ1000

may include any number of wired or wireless networks, network nodes, UEs, and/or any other components or systems that may facilitate or participate in the communication of data and/or signals whether via wired or wireless connections. The communication system QQ1000 may include and/or interface with any type of communication, telecommunication, data, cellular, radio network, and/or other similar type of system.

[00217] The UEs QQ1012 may be any of a wide variety of communication devices, including wireless devices arranged, configured, and/or operable to communicate wirelessly with the network nodes QQ1010 and other communication devices. Similarly, the network nodes QQ1010 are arranged, capable, configured, and/or operable to communicate directly or indirectly with the UEs QQ1012 and/or with other network nodes or equipment in the telecommunication network QQ1002 to enable and/or provide network access, such as wireless network access, and/or to perform other functions, such as administration in the telecommunication network QQ1002.

[00218] In the depicted example, the core network QQ1006 connects the network nodes QQ1010 to one or more hosts, such as host QQ1016. These connections may be direct or indirect via one or more intermediary networks or devices. In other examples, network nodes may be directly coupled to hosts. The core network QQ1006 includes one more core network nodes (e.g., core network node QQ1008) that are structured with hardware and software components. Features of these components may be substantially similar to those described with respect to the UEs, network nodes, and/or hosts, such that the descriptions thereof are generally applicable to the corresponding components of the core network node QQ1008. Example core network nodes include functions of one or more of a Mobile Switching Center (MSC), Mobility Management Entity (MME), Home Subscriber Server (HSS), Access and Mobility Management Function (AMF), Session Management Function (SMF), Authentication Server Function (AUSF), Subscription Identifier De-concealing function (SIDF), Unified Data Management (UDM), Security Edge Protection Proxy (SEPP), Network Exposure Function (NEF), and/or a User Plane Function (UPF), Control Function (PCF), Unified Data Management (UDM), etc.

[00219] The host QQ1016 may be under the ownership or control of a service provider other than an operator or provider of the access network QQ1004 and/or the telecommunication network QQ1002, and may be operated by the service provider or on behalf of the service provider. The host QQ1016 may host a variety of applications or application functions (AFs) to provide one or more service. Examples of such applications include live and pre-recorded audio/video content, data collection services such as retrieving and compiling data on various ambient conditions detected by a plurality of UEs, analytics functionality, social media, functions for controlling or otherwise interacting with remote devices, functions for an alarm and surveillance center, or any other such function performed by a server.

[00220] As a whole, the communication system QQ1000 of FIG.10 enables connectivity between the UEs, network nodes, and hosts. In that sense, the communication system may be configured to operate according to predefined rules or procedures, such as specific standards that include, but are not limited to: Global System for Mobile Communications (GSM); Universal Mobile Telecommunications System (UMTS); Long Term Evolution (LTE), and/or other suitable 2G, 3G, 4G, 5G standards, or any applicable future generation standard (e.g., 6G); wireless local area network (WLAN) standards, such as the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards (WiFi); and/or any other appropriate wireless communication standard, such as the Worldwide Interoperability for Microwave Access (WiMax), Bluetooth, Z-Wave, Near Field Communication (NFC) ZigBee, LiFi, and/or any low-power wide-area network (LPWAN) standards such as LoRa and Sigfox.

[00221] In some examples, the telecommunication network QQ1002 is a cellular network that implements 3GPP standardized features. Accordingly, the telecommunications network QQ1002 may support network slicing to provide different logical networks to different devices that are connected to the telecommunication network QQ102. For example, the telecommunications network QQ1002 may provide Ultra Reliable Low Latency Communication (URLLC) services to some UEs, while providing Enhanced Mobile Broadband (eMBB) services to other UEs, and/or Massive Machine Type Communication (mMTC)/Massive IoT services to yet further UEs.

[00222] In some examples, the UEs QQ1012 are configured to transmit and/or receive information without direct human interaction. For instance, a UE may be designed to transmit information to the access network QQ1004 on a predetermined schedule, when triggered by an internal or external event, or in response to requests from the access network QQ1004. Additionally, a UE may be configured for operating in single- or multi-RAT or multi-standard mode. For example, a UE may operate with any one or combination of Wi-Fi, NR (New Radio) and LTE, i.e. being configured for multi-radio dual connectivity (MR-DC), such as E-UTRAN (Evolved-UMTS Terrestrial Radio Access Network) New Radio – Dual Connectivity (EN-DC).

[00223] In the example, the hub QQ1014 communicates with the access network QQ1004 to facilitate indirect communication between one or more UEs (e.g., UE QQ1012c and/or QQ1012d) and network nodes (e.g., network node QQ1010b). In some examples, the hub QQ1014 may be a controller, router, content source and analytics, or any of the other communication devices described herein regarding UEs. For example, the hub QQ1014 may be a broadband router enabling access to the core network QQ1006 for the UEs. As another example, the hub QQ1014 may be a controller that sends commands or instructions to one or more actuators in the UEs. Commands or instructions may be received from the UEs, network nodes QQ1010, or by executable code, script, process, or other instructions in the hub QQ1014. As another example, the

hub QQ1014 may be a data collector that acts as temporary storage for UE data and, in some embodiments, may perform analysis or other processing of the data. As another example, the hub QQ1014 may be a content source. For example, for a UE that is a VR headset, display, loudspeaker or other media delivery device, the hub QQ1014 may retrieve VR assets, video, audio, or other media or data related to sensory information via a network node, which the hub QQ1014 then provides to the UE either directly, after performing local processing, and/or after adding additional local content. In still another example, the hub QQ1014 acts as a proxy server or orchestrator for the UEs, in particular in if one or more of the UEs are low energy IoT devices.

[00224] The hub QQ1014 may have a constant/persistent or intermittent connection to the network node QQ1010b. The hub QQ1014 may also allow for a different communication scheme and/or schedule between the hub QQ1014 and UEs (e.g., UE QQ1012c and/or QQ1012d), and between the hub QQ1014 and the core network QQ1006. In other examples, the hub QQ1014 is connected to the core network QQ1006 and/or one or more UEs via a wired connection. Moreover, the hub QQ1014 may be configured to connect to an M2M service provider over the access network QQ1004 and/or to another UE over a direct connection. In some scenarios, UEs may establish a wireless connection with the network nodes QQ1010 while still connected via the hub QQ1014 via a wired or wireless connection. In some embodiments, the hub QQ1014 may be a dedicated hub – that is, a hub whose primary function is to route communications to/from the UEs from/to the network node QQ1010b. In other embodiments, the hub QQ1014 may be a non-dedicated hub – that is, a device which is capable of operating to route communications between the UEs and network node QQ1010b, but which is additionally capable of operating as a communication start and/or end point for certain data channels.

[00225] FIG.11 is a block diagram of a host QQ100, which may be an embodiment of the host QQ1016 of FIG.10, in accordance with various aspects described herein. As used herein, the host QQ1100 may be or comprise various combinations hardware and/or software, including a standalone server, a blade server, a cloud-implemented server, a distributed server, a virtual machine, container, or processing resources in a server farm. The host QQ1100 may provide one or more services to one or more UEs.

[00226] The host QQ1100 includes processing circuitry QQ1102 that is operatively coupled via a bus QQ1104 to an input/output interface QQ1106, a network interface QQ1108, a power source QQ1110, and a memory QQ1112.

[00227] The memory QQ1112 may include one or more computer programs including one or more host application programs QQ1114 and data QQ1116, which may include user data, e.g., data generated by a UE for the host QQ1100 or data generated by the host QQ1100 for a UE. Embodiments of the host QQ1100 may utilize only a subset or all of the components shown. The

host application programs QQ1114 may be implemented in a container-based architecture and may provide support for edge applications, video codecs (e.g., Versatile Video Coding (VVC), High Efficiency Video Coding (HEVC), Advanced Video Coding (AVC), MPEG, VP9) and audio codecs (e.g., FLAC, Advanced Audio Coding (AAC), MPEG, G.711), including transcoding for multiple different classes, types, or implementations of UEs (e.g., handsets, desktop computers, wearable display systems, heads-up display systems). The host application programs QQ1114 may also provide for user authentication and licensing checks and may periodically report health, routes, and content availability to a central node, such as a device in or on the edge of a core network. Accordingly, the host QQ1100 may select and/or indicate a different host for over-the-top services for a UE. The host application programs QQ1114 may support various protocols, such as the HTTP Live Streaming (HLS) protocol, Real-Time Messaging Protocol (RTMP), Real-Time Streaming Protocol (RTSP), Dynamic Adaptive Streaming over HTTP (MPEG-DASH), etc.

[00228] FIG.12 shows a communication diagram of a host QQ1202 communicating via a network node QQ1204 with a UE QQ1206 over a partially wireless connection in accordance with some embodiments. Example implementations, in accordance with various embodiments, of the UE (such as a UE QQ1012a of FIG.10), network node (such as network node QQ1010a of FIG.10), and host (such as host QQ1016 of FIG.10 and/or host QQ1100 of FIG.11) discussed in the preceding paragraphs will now be described with reference to FIG.12.

[00229] Like host QQ1100, embodiments of host QQ1202 include hardware, such as a communication interface, processing circuitry, and memory. The host QQ1202 also includes software, which is stored in or accessible by the host QQ1202 and executable by the processing circuitry. The software includes a host application that may be operable to provide a service to a remote user, such as the UE QQ1206 connecting via an over-the-top (OTT) connection QQ1250 extending between the UE QQ1206 and host QQ1202. In providing the service to the remote user, a host application may provide user data which is transmitted using the OTT connection QQ1250.

[00230] The network node QQ1204 includes hardware enabling it to communicate with the host QQ1202 and UE QQ1206. The connection QQ1260 may be direct or pass through a core network (like core network QQ1006 of FIG.10) and/or one or more other intermediate networks, such as one or more public, private, or hosted networks. For example, an intermediate network may be a backbone network or the Internet.

[00231] The UE QQ1206 includes hardware and software, which is stored in or accessible by UE QQ1206 and executable by the UE's processing circuitry. The software includes a client application, such as a web browser or operator-specific "app" that may be operable to provide a service to a human or non-human user via UE QQ1206 with the support of the host QQ1202. In the host QQ1202, an executing host application may communicate with the executing client

application via the OTT connection QQ1250 terminating at the UE QQ1206 and host QQ1202. In providing the service to the user, the UE's client application may receive request data from the host's host application and provide user data in response to the request data. The OTT connection QQ1250 may transfer both the request data and the user data. The UE's client application may interact with the user to generate the user data that it provides to the host application through the OTT connection QQ1250.

[00232] The OTT connection QQ1250 may extend via a connection QQ1260 between the host QQ1202 and the network node QQ1204 and via a wireless connection QQ1270 between the network node QQ1204 and the UE QQ1206 to provide the connection between the host QQ1202 and the UE QQ1206. The connection QQ1260 and wireless connection QQ1270, over which the OTT connection QQ1250 may be provided, have been drawn abstractly to illustrate the communication between the host QQ1202 and the UE QQ1206 via the network node QQ1204, without explicit reference to any intermediary devices and the precise routing of messages via these devices.

[00233] As an example of transmitting data via the OTT connection QQ1250, in step QQ1208, the host QQ1202 provides user data, which may be performed by executing a host application. In some embodiments, the user data is associated with a particular human user interacting with the UE QQ1206. In other embodiments, the user data is associated with a UE QQ1206 that shares data with the host QQ1202 without explicit human interaction. In step QQ1210, the host QQ1202 initiates a transmission carrying the user data towards the UE QQ1206. The host QQ1202 may initiate the transmission responsive to a request transmitted by the UE QQ1206. The request may be caused by human interaction with the UE QQ1206 or by operation of the client application executing on the UE QQ1206. The transmission may pass via the network node QQ1204, in accordance with the teachings of the embodiments described throughout this disclosure. Accordingly, in step QQ1212, the network node QQ1204 transmits to the UE QQ1206 the user data that was carried in the transmission that the host QQ1202 initiated, in accordance with the teachings of the embodiments described throughout this disclosure. In step QQ1214, the UE QQ1206 receives the user data carried in the transmission, which may be performed by a client application executed on the UE QQ1206 associated with the host application executed by the host QQ1202.

[00234] In some examples, the UE QQ1206 executes a client application which provides user data to the host QQ1202. The user data may be provided in reaction or response to the data received from the host QQ1202. Accordingly, in step QQ1216, the UE QQ1206 may provide user data, which may be performed by executing the client application. In providing the user data, the client application may further consider user input received from the user via an input/output interface of

the UE QQ1206. Regardless of the specific manner in which the user data was provided, the UE QQ1206 initiates, in step QQ1218, transmission of the user data towards the host QQ1202 via the network node QQ1204. In step QQ1220, in accordance with the teachings of the embodiments described throughout this disclosure, the network node QQ1204 receives user data from the UE QQ1206 and initiates transmission of the received user data towards the host QQ1202. In step QQ1222, the host QQ1202 receives the user data carried in the transmission initiated by the UE QQ1206.

[00235] One or more of the various embodiments improve the performance of OTT services provided to the UE QQ1206 using the OTT connection QQ1250, in which the wireless connection QQ1270 forms the last segment. More precisely, the teachings of these embodiments some embodiments herein can optimize the current solution. Some embodiments herein can consider two development cases. In some embodiments herein, it proposed a method to distribute the key of application function in case the VPLMN support or not support AKMA service in AKMA roaming scenario. In some embodiments herein, the key of application function is bound with SN ID, which can resist key leakage attack. In some embodiments herein, when the UE moves to another network, the key KAF used in VPLMN can be deleted both in the UE and VPLMN and cannot be used in HPLMN again, which can resist key leakage attack.

[00236] In an example scenario, factory status information may be collected and analyzed by the host QQ1202. As another example, the host QQ1202 may process audio and video data which may have been retrieved from a UE for use in creating maps. As another example, the host QQ1202 may collect and analyze real-time data to assist in controlling vehicle congestion (e.g., controlling traffic lights). As another example, the host QQ1202 may store surveillance video uploaded by a UE. As another example, the host QQ1202 may store or control access to media content such as video, audio, VR or AR which it can broadcast, multicast or unicast to UEs. As other examples, the host QQ1202 may be used for energy pricing, remote control of non-time critical electrical load to balance power generation needs, location services, presentation services (such as compiling diagrams etc. from data collected from remote devices), or any other function of collecting, retrieving, storing, analyzing and/or transmitting data.

[00237] In some examples, a measurement procedure may be provided for the purpose of monitoring data rate, latency and other factors on which the one or more embodiments improve. There may further be an optional network functionality for reconfiguring the OTT connection QQ1250 between the host QQ1202 and UE QQ1206, in response to variations in the measurement results. The measurement procedure and/or the network functionality for reconfiguring the OTT connection may be implemented in software and hardware of the host QQ1202 and/or UE QQ1206. In some embodiments, sensors (not shown) may be deployed in or in association with other devices

through which the OTT connection QQ1250 passes; the sensors may participate in the measurement procedure by supplying values of the monitored quantities exemplified above, or supplying values of other physical quantities from which software may compute or estimate the monitored quantities. The reconfiguring of the OTT connection QQ1250 may include message format, retransmission settings, preferred routing etc.; the reconfiguring need not directly alter the operation of the network node QQ1204. Such procedures and functionalities may be known and practiced in the art. In certain embodiments, measurements may involve proprietary UE signaling that facilitates measurements of throughput, propagation times, latency and the like, by the host QQ1202. The measurements may be implemented in that software causes messages to be transmitted, in particular empty or 'dummy' messages, using the OTT connection QQ1250 while monitoring propagation times, errors, etc.

[00238] Embodiment 1. A host configured to operate in a communication system to provide an over-the-top (OTT) service, the host comprising: processing circuitry configured to provide user data; and a network interface configured to initiate transmission of the user data to a network node in a cellular network for transmission to a user equipment (UE), the network node having a communication interface and processing circuitry, the processing circuitry of the network node configured to perform the operations related to the wireless device as described above to transmit the user data from the host to the UE.

[00239] Embodiment 2. The host of the previous embodiment, wherein: the processing circuitry of the host is configured to execute a host application that provides the user data; and the UE comprises processing circuitry configured to execute a client application associated with the host application to receive the transmission of user data from the host.

[00240] Embodiment 3. A method implemented in a host configured to operate in a communication system that further includes a network node and a user equipment (UE), the method comprising: providing user data for the UE; and initiating a transmission carrying the user data to the UE via a cellular network comprising the network node, wherein the network node performs the operations related to the wireless device as described above to transmit the user data from the host to the UE.

[00241] Embodiment 4. The method of the previous embodiment, further comprising, at the network node, transmitting the user data provided by the host for the UE.

[00242] Embodiment 5. The method of any of the previous 2 embodiments, wherein the user data is provided at the host by executing a host application that interacts with a client application executing on the UE, the client application being associated with the host application.

[00243] Embodiment 6. A communication system configured to provide an over-the-top service, the communication system comprising: a host comprising: processing circuitry configured to

provide user data for a user equipment (UE), the user data being associated with the over-the-top service; and a network interface configured to initiate transmission of the user data toward a cellular network node for transmission to the UE, the network node having a communication interface and processing circuitry, the processing circuitry of the network node configured to perform the operations related to the wireless device as described above to transmit the user data from the host to the UE.

[00244] Embodiment 7. The communication system of the previous embodiment, further comprising: the network node; and/or the user equipment.

[00245] Embodiment 8. The communication system of the previous 2 embodiments, wherein: the processing circuitry of the host is configured to execute a host application, thereby providing the user data; and the host application is configured to interact with a client application executing on the UE, the client application being associated with the host application.

[00246] Embodiment 9. A host configured to operate in a communication system to provide an over-the-top (OTT) service, the host comprising: processing circuitry configured to initiate receipt of user data; and a network interface configured to receive the user data from a network node in a cellular network, the network node having a communication interface and processing circuitry, the processing circuitry of the network node configured to perform the operations related to the wireless device as described above to receive the user data from the UE for the host.

[00247] Embodiment 10. The host of the previous 2 embodiments, wherein: the processing circuitry of the host is configured to execute a host application, thereby providing the user data; and the host application is configured to interact with a client application executing on the UE, the client application being associated with the host application.

[00248] Embodiment 11. The host of the any of the previous 2 embodiments, wherein the initiating receipt of the user data comprises requesting the user data.

[00249] Embodiment 12. A method implemented by a host configured to operate in a communication system that further includes a network node and a user equipment (UE), the method comprising: at the host, initiating receipt of user data from the UE, the user data originating from a transmission which the network node has received from the UE, wherein the network node performs the operations related to the wireless device as described above to receive the user data from the UE for the host.

[00250] Embodiment 13. The method of the previous embodiment, further comprising at the network node, transmitting the received user data to the host.

[00251] Embodiment 14. A host configured to operate in a communication system to provide an over-the-top (OTT) service, the host comprising: processing circuitry configured to provide user data; and a network interface configured to initiate transmission of the user data to a cellular

network for transmission to a user equipment (UE), wherein the UE comprises a communication interface and processing circuitry, the communication interface and processing circuitry of the UE being configured to perform the operations related to the wireless device as described above to receive the user data from the host.

[00252] Embodiment 15. The host of the previous embodiment, wherein the cellular network further includes a network node configured to communicate with the UE to transmit the user data to the UE from the host.

[00253] Embodiment 16. The host of the previous 2 embodiments, wherein: the processing circuitry of the host is configured to execute a host application, thereby providing the user data; and the host application is configured to interact with a client application executing on the UE, the client application being associated with the host application.

[00254] Embodiment 17. A method implemented by a host operating in a communication system that further includes a network node and a user equipment (UE), the method comprising: providing user data for the UE; and initiating a transmission carrying the user data to the UE via a cellular network comprising the network node, wherein the UE performs the operations related to the wireless device as described above to receive the user data from the host.

[00255] Embodiment 18. The method of the previous embodiment, further comprising: at the host, executing a host application associated with a client application executing on the UE to receive the user data from the UE.

[00256] Embodiment 19. The method of the previous embodiment, further comprising: at the host, transmitting input data to the client application executing on the UE, the input data being provided by executing the host application, wherein the user data is provided by the client application in response to the input data from the host application.

[00257] Embodiment 20. A host configured to operate in a communication system to provide an over-the-top (OTT) service, the host comprising: processing circuitry configured to utilize user data; and a network interface configured to receipt of transmission of the user data to a cellular network for transmission to a user equipment (UE), wherein the UE comprises a communication interface and processing circuitry, the communication interface and processing circuitry of the UE being configured to perform the operations related to the wireless device as described above to transmit the user data to the host.

[00258] Embodiment 21. The host of the previous embodiment, wherein the cellular network further includes a network node configured to communicate with the UE to transmit the user data from the UE to the host.

[00259] Embodiment 22. The host of the previous 2 embodiments, wherein: the processing circuitry of the host is configured to execute a host application, thereby providing the user data;

and the host application is configured to interact with a client application executing on the UE, the client application being associated with the host application.

[00260] Embodiment 23. A method implemented by a host configured to operate in a communication system that further includes a network node and a user equipment (UE), the method comprising: at the host, receiving user data transmitted to the host via the network node by the UE, wherein the UE performs the operations related to the wireless device as described above to transmit the user data to the host.

[00261] Embodiment 24. The method of the previous embodiment, further comprising: at the host, executing a host application associated with a client application executing on the UE to receive the user data from the UE.

[00262] Embodiment 25. The method of the previous embodiments, further comprising: at the host, transmitting input data to the client application executing on the UE, the input data being provided by executing the host application, wherein the user data is provided by the client application in response to the input data from the host application.

[00263] In addition, the present disclosure may also provide a carrier containing the computer program as mentioned above, wherein the carrier is one of an electronic signal, optical signal, radio signal, or computer readable storage medium. The computer readable storage medium can be, for example, an optical compact disk or an electronic memory device like a RAM (random access memory), a ROM (read only memory), Flash memory, magnetic tape, CD-ROM, DVD, Blue-ray disc and the like.

[00264] The techniques described herein may be implemented by various means so that an apparatus implementing one or more functions of a corresponding apparatus described with an embodiment comprises not only prior art means, but also means for implementing the one or more functions of the corresponding apparatus described with the embodiment and it may comprise separate means for each separate function, or means that may be configured to perform two or more functions. For example, these techniques may be implemented in hardware (one or more apparatuses), firmware (one or more apparatuses), software (one or more modules), or combinations thereof. For a firmware or software, implementation may be made through modules (e.g., procedures, functions, and so on) that perform the functions described herein.

[00265] Exemplary embodiments herein have been described above with reference to block diagrams and flowchart illustrations of methods and apparatuses. It will be understood that each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations, respectively, can be implemented by various means including computer program instructions. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing

apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus create means for implementing the functions specified in the flowchart block or blocks.

[00266] 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 matter described herein, but rather as descriptions of features that may be specific to particular embodiments. Certain features that are described in the context of separate embodiments may also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment may also be implemented in multiple embodiments separately or in any suitable sub-combination.

[00267] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any implementation or of what may be claimed, but rather as descriptions of features that may be specific to particular embodiments of particular implementations. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[00268] It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The above described embodiments are given for describing rather than limiting the disclosure, and it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the disclosure as those skilled in the art readily understand. Such modifications and variations are considered to be within the scope of the disclosure and the appended claims. The protection scope of the disclosure is defined by the accompanying claims.

WHAT IS CLAIMED IS:

1. A method (200) performed by a first network node in Communication Network, comprising:

receiving (202) a first request from a second network node, wherein the first request comprises a User Equipment Identifier (UE ID) to indicate a User Equipment (UE);

determining (204) a UE domain information according to the received UE ID; and

sending (206) a first response to the second network node, wherein the first response comprises the determined UE domain information; wherein the UE domain information comprises core network type and subscription domain.

2. The method according to claim 1, wherein the core network type comprises at least one of:

Evolved Packet Core (EPC),

Fifth Generation Core network (5GC), and

Dual EPC and 5GC.

3. The method according to claim 1, wherein the subscription domain comprises at least one of:

4th Generation Mobile Communication Technology subscription (4G subscription), and

5th Generation Mobile Communication Technology subscription (5G subscription).

4. The method according to any of claims 1-3, wherein determining a UE domain information according to the received UE ID comprises:

sending a second request, to a third network node, to discover if there exist a fourth network node service instance for the UE ID; and

receiving a second response from the third network node, wherein the second response indicating whether there exist a fourth network node service instance for the UE ID.

5. The method according to claim 4, when the second response indicates there not exist a fourth network node service instance for the UE ID, further comprises:

determining the subscription domain as 4G subscription and the core network type as EPC.

6. The method according to claim 4, when the second response indicates there exist a fourth network node service instance for the UE ID, the method further comprises:

sending a third request, to the fourth network node, to subscribe the core network type change according to the UE ID.

7. The method according to claim 6, further comprises:

receiving a third response from the fourth network node, wherein the third response indicating the core network type according to the UE ID; and

determining the core network type comprised in the UE domain information as the received core network type in the third response according to the UE ID and the subscription domain as 5G subscription.

8. The method according to claim 7, when the UE moves between EPC and 5GC, further comprises:

receiving a first message from the fourth network node, wherein the first message comprises an updated core network type according to the UE ID;

determining the core network type comprised in the UE domain information as the updated core network type received in the first message and the subscription domain as 5G subscription; and

sending a second message to the second network node, wherein the second message comprises an updated UE domain information, and

wherein the updated UE domain information comprises the updated core network type and a subscription domain.

9. The method according to claim 1, wherein the first request is a network exposure function event exposure subscribe request, and

wherein the first response is a network exposure function event exposure subscribe response.

10. The method according to any of claims 1-9, wherein the first network node comprises a Network Exposure Function (NEF), or a Service Capability Exposure Function (SCEF), or a combination of NEF and SCEF; and/or

wherein the second network node comprises an Application Function (AF); and/or

wherein the third network node comprises a Network Repository Function (NRF); and/or

wherein the fourth network node comprises a Unified Data Management (UDM), or a combination of UDM and Home Subscriber Server (HSS).

11. A method (400) performed by a second network node in Communication Network, comprising:

sending (402) a first request to a first network node, wherein the first request comprises a User Equipment Identifier (UE ID) to indicate a User Equipment (UE); and

receiving (404) a first response, from the first network node, wherein the first response comprises a UE domain information according to the UE ID; wherein the UE domain information comprises core network type and subscription domain.

12. The method according to claim 11, wherein the core network type comprises at least one of:

Evolved Packet Core (EPC),

Fifth Generation Core network (5GC), and

Dual EPC and 5GC.

13. The method according to claim 12, wherein the subscription domain comprises at least one of:

4th Generation Mobile Communication Technology subscription (4G subscription);

5th Generation Mobile Communication Technology subscription (5G subscription).

14. The method according to claim 11, wherein the first request is a network exposure function event exposure subscribe request, and

wherein the first response is a network exposure function event exposure subscribe response.

15. The method according to any of claims 11-14, when the UE moves between EPC and 5GC, further comprising:

receiving a second message from the first network node, wherein the second message comprises an updated UE domain information according to the UE ID;

wherein the updated UE domain information comprises an updated core network type and a subscription domain.

16. The method according to any of claims 11-14, wherein the first network node comprises a Network Exposure Function (NEF), or a Service Capability Exposure Function (SCEF), or a combination of NEF and SCEF; and/or

wherein the second network node comprises an Application Function (AF).

17. A first network node (600), comprising:

a processor (601); and

a memory (602) coupled to the processor (601), said memory (602) containing instructions executable by said processor (601), whereby the first network node (600) is operative to:

receiving a first request from a second network node, wherein the first request comprises a User Equipment Identifier (UE ID) to indicate a User Equipment (UE);

determining a UE domain information according to the received UE ID; and

sending a first response to the second network node, wherein the first response comprises the determined UE domain information; wherein the UE domain information comprises core network type and subscription domain.

18. The second network node according to claim 17, wherein the first network node is further operative to perform the method of any of claims 2 to 10.

19. A second network node (700), comprising:

a processor (701); and

a memory (702) coupled to the processor (701), said memory (702) containing instructions executable by said processor (701), whereby the second network node (700) is operative to:

sending a first request to a first network node, wherein the first request comprises a User Equipment Identifier (UE ID) to indicate a User Equipment (UE); and

receiving a first response, from the first network node, wherein the first response comprises a UE domain information according to the UE ID; wherein the UE domain information comprises core network type and subscription domain.

20. The second network node according to claim 19, wherein the second network node is further operative to perform the method of any of claims 12 to 16.

21. A computer-readable storage medium storing instructions which when executed by at least one processor, cause the at least one processor to perform the method according to any one of claims 1 to 16.

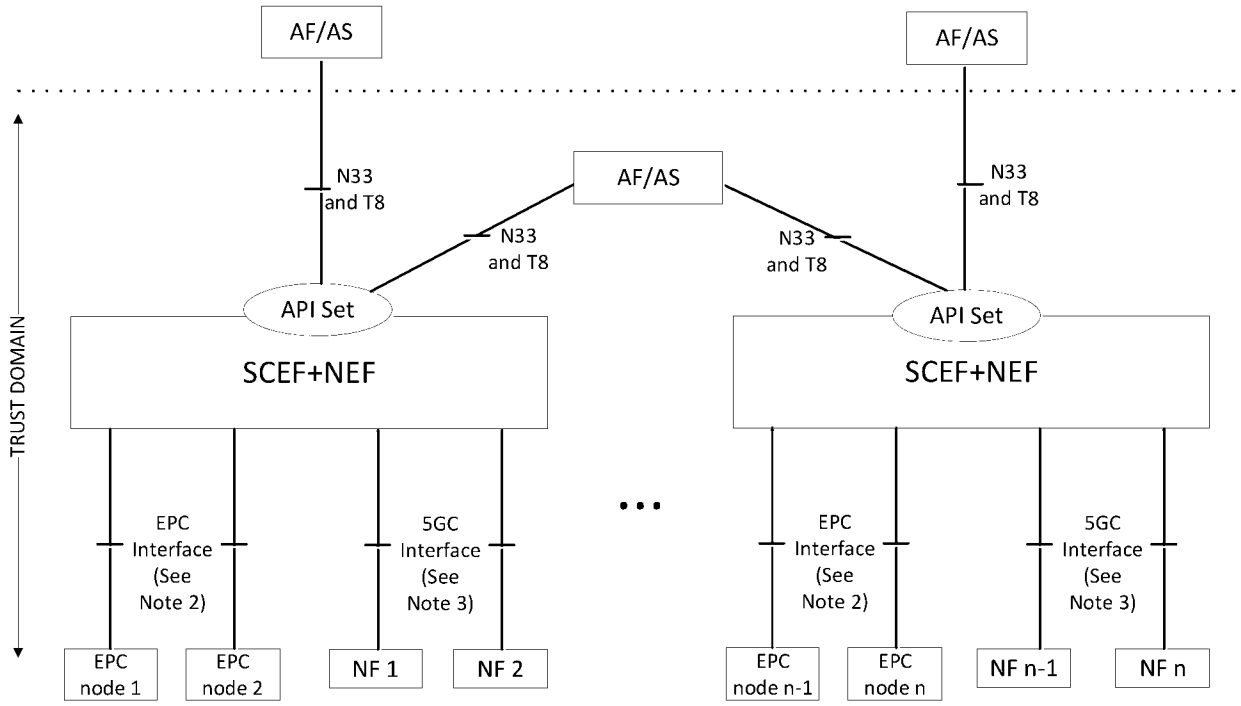
AF/AS
AF/AS
AF/AS
N33
and T8
N33
and T8
N33
and T8
N33
and T8
API Set
API Set
SCEF+NEF
SCEF+NEF
TRUST DOMAIN
EPC
Interface
(See
Note 2)
5GC
Interface
(See
Note 3)
EPC
Interface
(See
Note 2)
5GC
Interface
(See
Note 3)
EPC
node 1
EPC
node 2
NF 1
NF 2
EPC
node n-1
EPC
node n
NF n-1
NF n

Fig.1

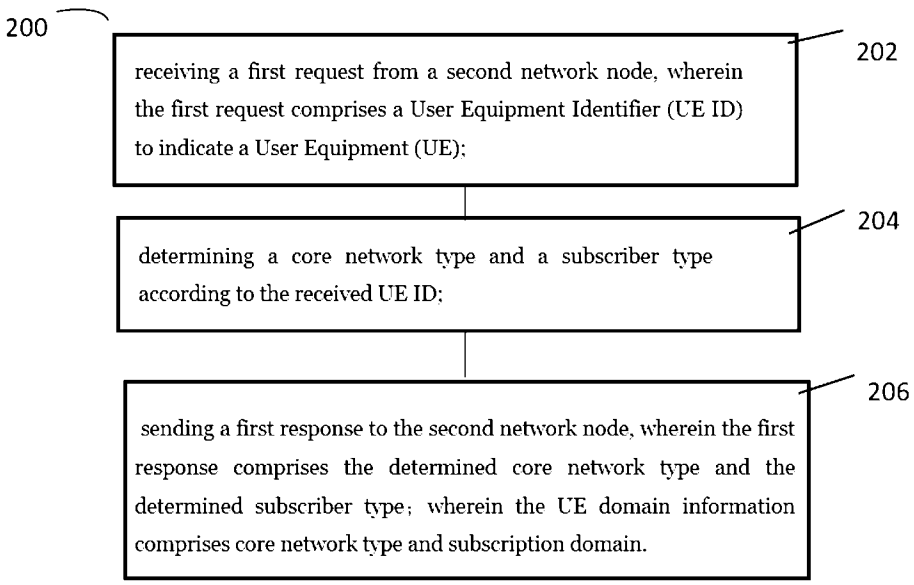
200
receiving a first request from a second network node, wherein the first request comprises a User Equipment Identifier (UE ID) to indicate a User Equipment (UE);
202
determining a core network type and a subscriber type according to the received UE ID;
204
sending a first response to the second network node, wherein the first response comprises the determined core network type and the determined subscriber type; wherein the UE domain information comprises core network type and subscription domain.
206

Fig.2

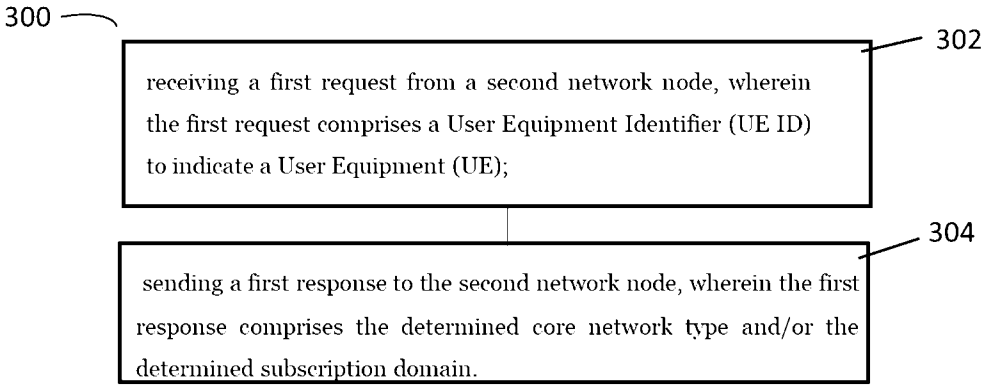
300
302
receiving a first request from a second network node, wherein the first request comprises a User Equipment Identifier (UE ID) to indicate a User Equipment (UE);
304
sending a first response to the second network node, wherein the first response comprises the determined core network type and/or the determined subscription domain.

Fig.3

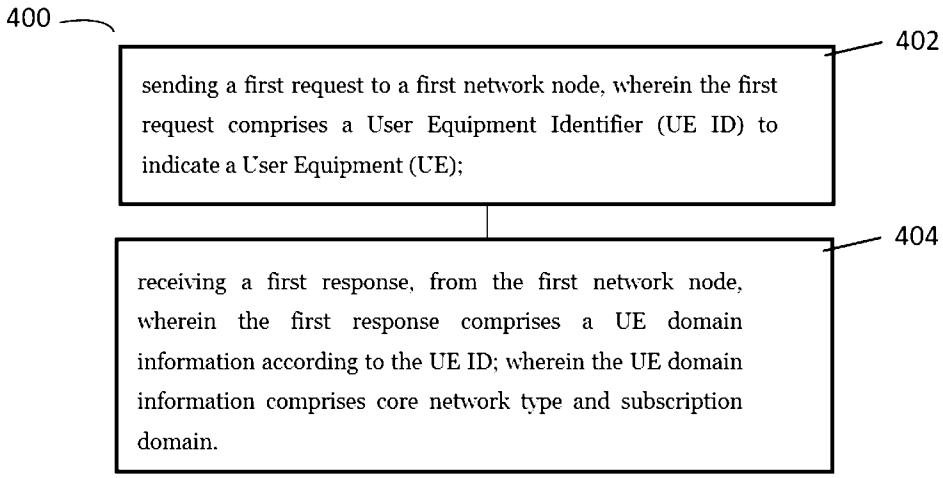
400
402
sending a first request to a first network node, wherein the first request comprises a User Equipment Identifier (UE ID) to indicate a User Equipment (UE);
404
receiving a first response, from the first network node, wherein the first response comprises a UE domain information according to the UE ID; wherein the UE domain information comprises core network type and subscription domain.

Fig.4

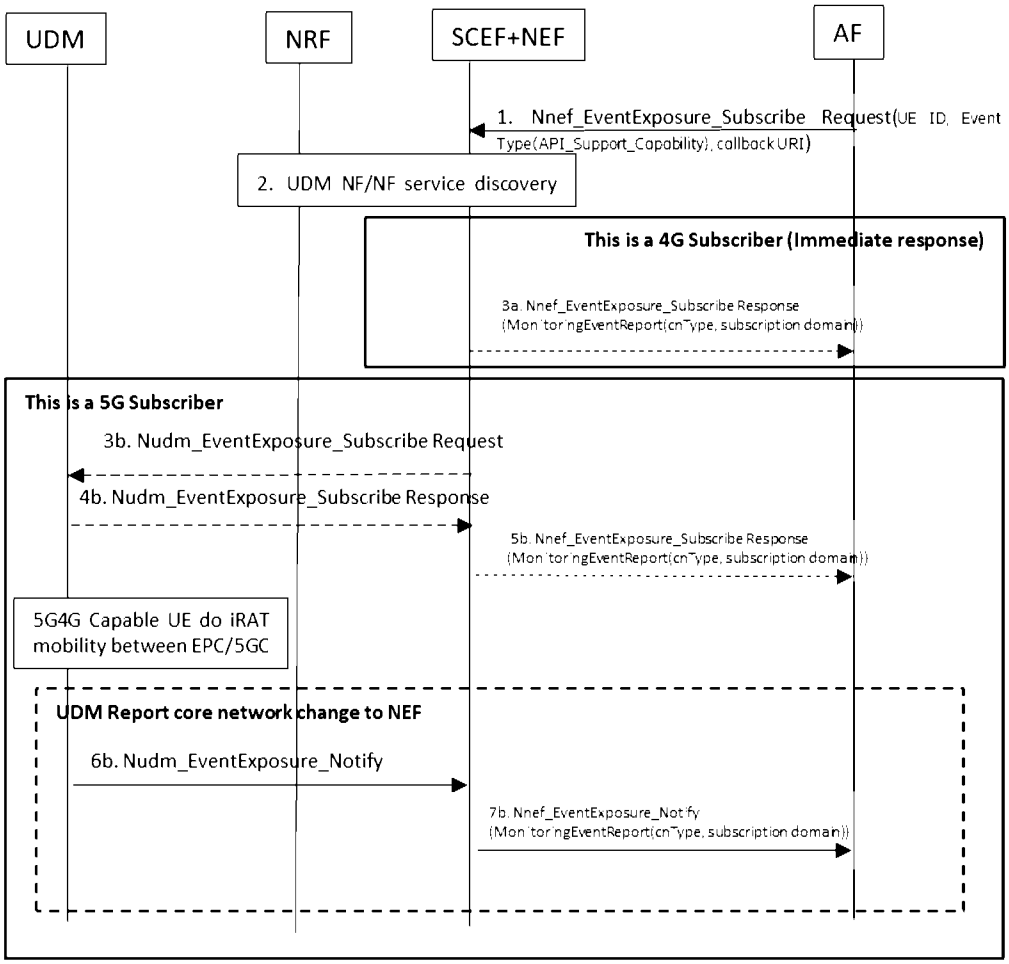
UDM
NRF
SCEF+NEF
AF
1. Nnef_EventExposure_Subscribe Request(UE ID, Event Type(API_Support_Capability), callback URI)
2. UDM NF/NF service discovery
This is a 4G Subscriber (Immediate response)
3a. Nnef_EventExposure_Subscribe Response (MonitoringEventReport(cnType, subscription domain))
This is a 5G Subscriber
3b. Nudm_EventExposure_Subscribe Request
4b. Nudm_EventExposure_Subscribe Response
5b. Nnef_EventExposure_Subscribe Response (MonitoringEventReport(cnType, subscription domain))
5G4G Capable UE do iRAT mobility between EPC/5GC
UDM Report core network change to NEF
6b. Nudm_EventExposure_Notify
7b. Nnef_EventExposure_Notify (MonitoringEventReport(cnType, subscription domain))

Fig.5

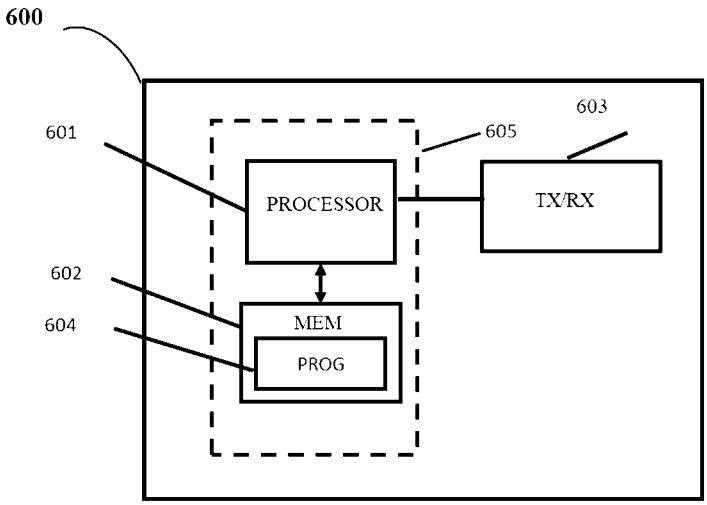
600
601
602
604
603
605
PROCESSOR
TX/RX
MEM
PROG

Fig.6

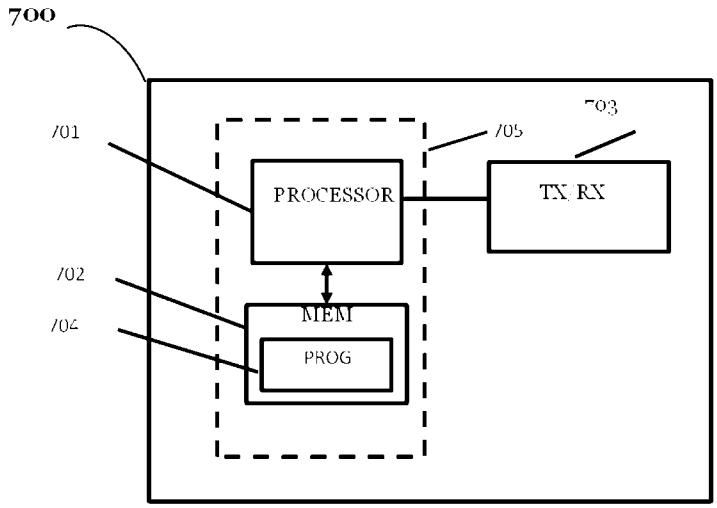

Fig. 7

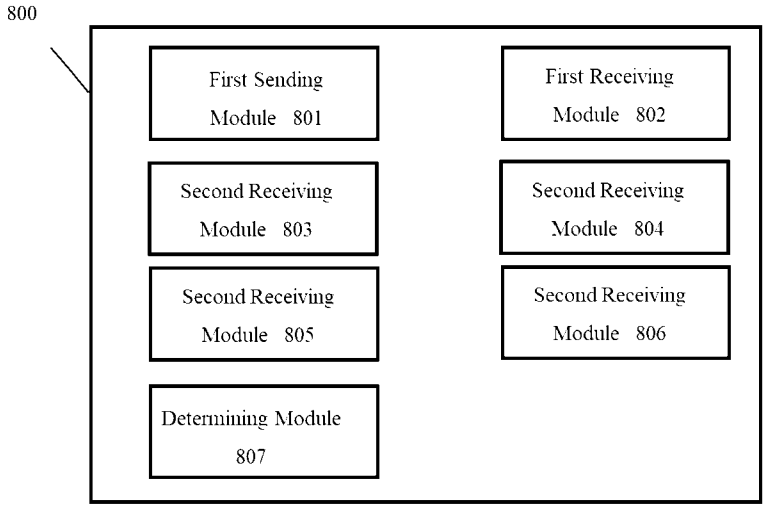

Fig.8

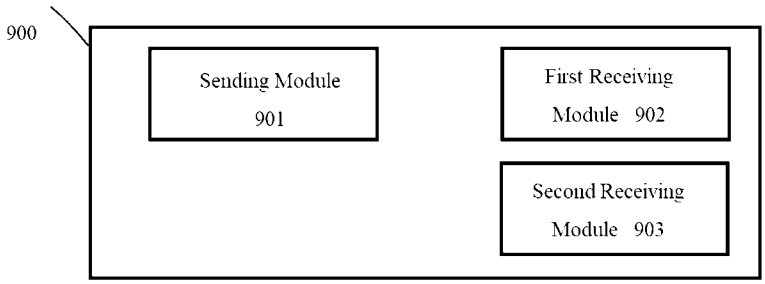

Fig.9

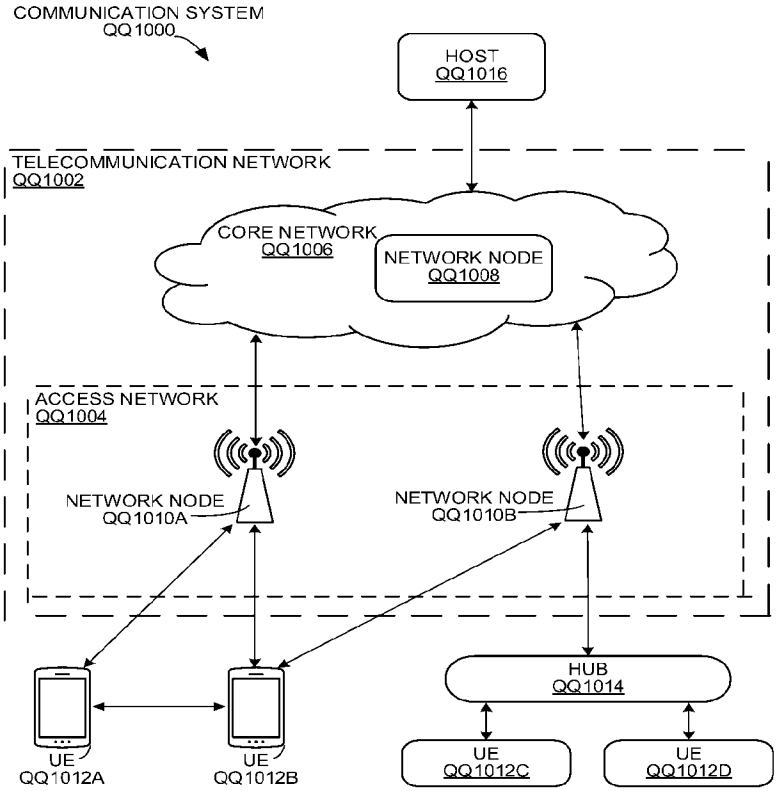
COMMUNICATION SYSTEM
QQ1000
HOST
QQ1016
TELECOMMUNICATION NETWORK
QQ1002
CORE NETWORK
QQ1006
NETWORK NODE
QQ1008
ACCESS NETWORK
QQ1004
NETWORK NODE
QQ1010A
NETWORK NODE
QQ1010B
HUB
QQ1014
UE
QQ1012A
UE
QQ1012B
UE
QQ1012C
UE
QQ1012D

Fig.10

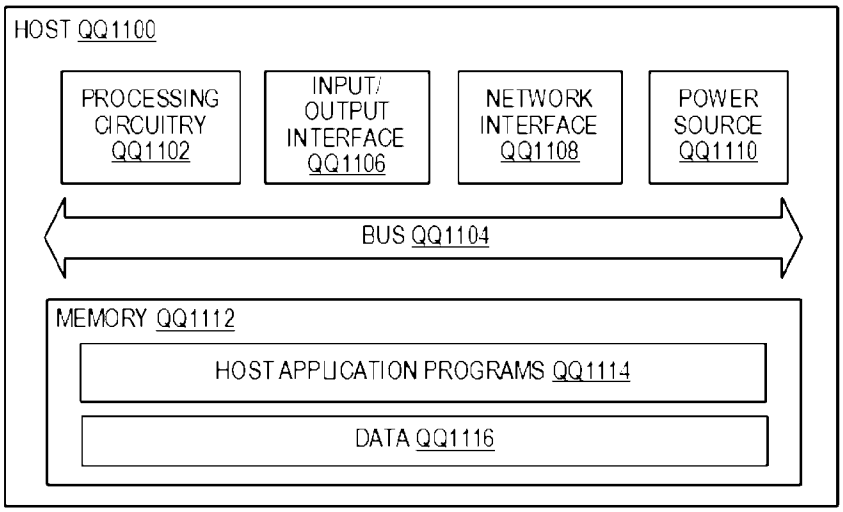
HOST QQ1100
PROCESSING CIRCUITRY QQ1102
INPUT/ OUTPUT INTERFACE QQ1106
NETWORK INTERFACE QQ1108
POWER SOURCE QQ1110
BUS QQ1104
MEMORY QQ1112
HOST APPLICATION PROGRAMS QQ1114
DATA QQ1116

Fig.11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/102554

A. CLASSIFICATION OF SUBJECT MATTER

H04W 12/086(2021.01)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, H04L

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)

3GPP,CNTXT,ENTXTC,WPABSC:5G, 4G, domain, ID, UE, identif+, request, response, core

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2023156453 A1 (TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)) 18 May 2023 (2023-05-18) description, paragraphs 35-88	1-21
A	CN 115989717 A (NOKIA TECHNOLOGIES OY) 18 April 2023 (2023-04-18) the whole document	1-21
A	US 2019141518 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 09 May 2019 (2019-05-09) the whole document	1-21
A	HUAWEI et al. "Slice privacy protection in NSSAA related procedure" *3GPP TSG-SA WG3 Meeting #101e S3-203022,* No. tsgs3_101e, 30 October 2020 (2020-10-30), the whole document	1-21

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

☑ See patent family annex.

* Special categories of cited documents:

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"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
06 August 2024	**12 August 2024**
Name and mailing address of the ISA/CN **CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	Authorized officer **WANG,XinYue** Telephone No. **(+86) 010-53961795**

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2024/102554

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2023156453	A1	18 May 2023	JP	2023521543	A	25 May 2023
				EP	4133760	A1	15 February 2023
				WO	2021204598	A1	14 October 2021
				JP	2024041767	A	27 March 2024
				KR	20220164698	A	13 December 2022
CN	115989717	A	18 April 2023	EP	4154678	A1	29 March 2023
				US	2023232477	A1	20 July 2023
				WO	2021259818	A1	30 December 2021
US	2019141518	A1	09 May 2019	WO	2018006215	A1	11 January 2018
				EP	3468239	A1	10 April 2019
				CN	109314857	A	05 February 2019
				IN	201847049065	A	04 January 2019