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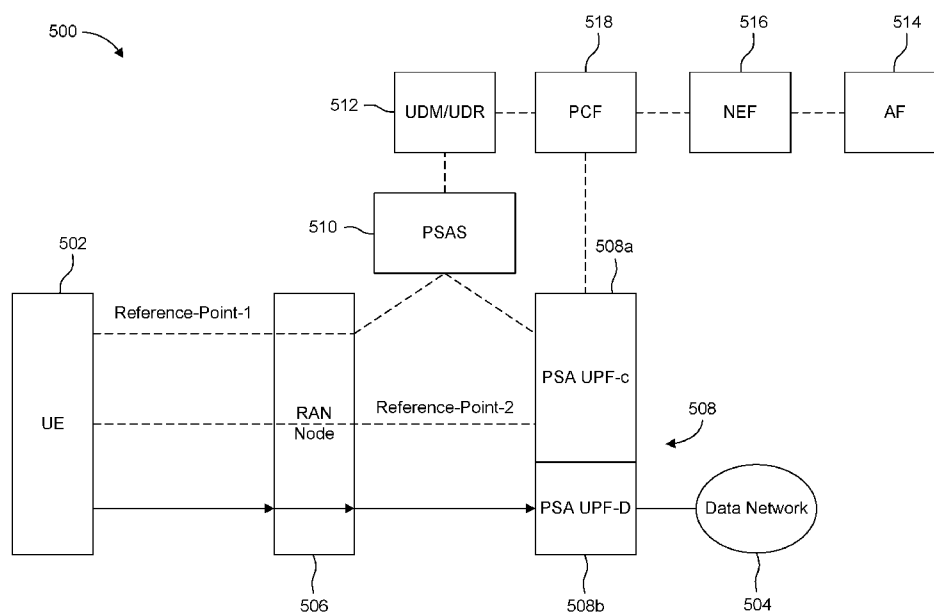


FIG. 5

(57) **Abstract:** Procedures, methods, architectures, apparatuses, systems, devices, and computer program products for connection establishment between a user device, WTRU, and an anchor user plane function. A node in a radio access network receives, from the WTRU, first information indicative of a type of service to invoke for the WTRU; transmits, to a user plane function selection node, a request indicative of a service of the type of service to invoke for the WTRU and of an identifier of the WTRU; receives, from the anchor selection node, a first response indicative of a selected user plane node; establishes a connection with the selected user plane node; and transmits, to the WTRU, a second response indicative of an identifier of the connection.

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METHODS, ARCHITECTURES, APPARATUSES AND SYSTEMS FOR CONNECTION ESTABLISHMENT BETWEEN A USER DEVICE AND AN ANCHOR USER PLANE FUNCTION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 63/596,638, filed 7 November 2023, which is incorporated herein by reference in their entirety.

BACKGROUND

[0002] The present disclosure is generally directed to the fields of communications, software and encoding, including, for example, to methods, architectures, apparatuses, systems directed to establishing a user plane connection between a device and an anchor user plane function (UPF), e.g., a UPF node, device, etc.

SUMMARY

[0003] In a first aspect, the present principles are directed to a method at a wireless transfer/receive unit, WTRU, the method including transmitting, to a node in a radio access network, first information indicative of a type of service to invoke for the WTRU, receiving, from the node in the radio access network, second information indicative of an identifier of a connection established between the node in the radio access network and a user plane node, and of control function contact information, transmitting, to the node in the radio access network, a connection request intended for the user plane node, receiving, from the node in the radio access network, third information indicative of rules related to the connection, and transmitting, using resources determined using the rules, uplink data to the radio access network.

[0004] In a second aspect, the present principles are directed to a wireless transfer/receive unit, WTRU, including at least one hardware processor configured to transmit, to a node in a radio access network, first information indicative of a type of service to invoke for the WTRU, receive, from the node in the radio access network, second information indicative of an identifier of a connection established between the node in the radio access network and a user plane node, transmit, to the node in the radio access network, a connection request intended for the user plane node, receive, from the node in the radio access network, third information indicative of rules related to the connection, and transmit, using resources determined using the rules, uplink data to the radio access network.

[0005] In a third aspect, the present principles are directed to a method at a node in a radio access network, the method including receiving, from a wireless transfer/receive unit, WTRU, first information indicative of a type of service to invoke for the WTRU, transmitting, to a user plane function selection node, a request indicative of a service of the type of service to invoke for the

WTRU and of an identifier of the WTRU, receiving, from the user plane function selection node, a first response indicative of a selected user plane node, establishing with the selected user plane node a connection for sending and receiving control plane information and data related to the connection, and transmitting, to the WTRU, a second response indicative of an identifier of the connection.

[0006] In a fourth aspect, the present principles are directed to a node in a radio access network, including at least one hardware processor configured to receive, from a wireless transfer/receive unit, WTRU, first information indicative of a type of service to invoke for the WTRU, transmit, to a user plane function selection node, a request indicative of a service of the type of service to invoke for the WTRU and of an identifier of the WTRU, receive, from the user plane function selection node, a first response indicative of a selected user plane node, establish with the selected user plane node a connection for sending and receiving control plane information and data related to the connection, and transmit, to the WTRU, a second response indicative of an identifier of the connection.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] A more detailed understanding may be had from the detailed description below, given by way of example in conjunction with drawings appended hereto. Figures in such drawings, like the detailed description, are examples. As such, the Figures (FIGs.) and the detailed description are not to be considered limiting, and other equally effective examples are possible and likely. Furthermore, like reference numerals ("ref.") in the FIGs. indicate like elements, and wherein:

[0008] FIG. 1A is a system diagram illustrating an example communications system;

[0009] FIG. 1B is a system diagram illustrating an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A;

[0010] FIG. 1C is a system diagram illustrating an example radio access network (RAN) and an example core network (CN) that may be used within the communications system illustrated in FIG. 1A;

[0011] FIG. 1D is a system diagram illustrating a further example RAN and a further example CN that may be used within the communications system illustrated in FIG. 1A;

[0012] FIG. 2 illustrates a protocol stack for a protocol data unit (PDU) session;

[0013] FIG. 3 illustrates an example of a performance measurement function (PMF) protocol stack;

[0014] FIG. 4 illustrates an example of a non-access stratum (NAS) protocol stack;

[0015] FIG. 5 illustrates an example system architecture for routing PDUs between a user equipment (UE) and a user plane function (UPF) according to an embodiment of the present principles; and

[0016] FIG. 6, made up of FIGS. 6A-6C, illustrates an example method for creating and using a data plane path according to an embodiment of the present principles.

DETAILED DESCRIPTION

[0017] In the following detailed description, numerous specific details are set forth to provide a thorough understanding of embodiments and/or examples disclosed herein. However, it will be understood that such embodiments and examples may be practiced without some or all of the specific details set forth herein. In other instances, well-known methods, procedures, components and circuits have not been described in detail, so as not to obscure the following description. Further, embodiments and examples not specifically described herein may be practiced in lieu of, or in combination with, the embodiments and other examples described, disclosed or otherwise provided explicitly, implicitly and/or inherently (collectively "provided") herein. Although various embodiments are described and/or claimed herein in which an apparatus, system, device, etc. and/or any element thereof carries out an operation, process, algorithm, function, etc. and/or any portion thereof, it is to be understood that any embodiments described and/or claimed herein assume that any apparatus, system, device, etc. and/or any element thereof is configured to carry out any operation, process, algorithm, function, etc. and/or any portion thereof.

[0018] Example Communications System

[0019] The methods, apparatuses and systems provided herein are well-suited for communications involving both wired and wireless networks. An overview of various types of wireless devices and infrastructure is provided with respect to FIGs. 1A-1D, where various elements of the network may utilize, perform, be arranged in accordance with and/or be adapted and/or configured for the methods, apparatuses and systems provided herein.

[0020] FIG. 1A is a system diagram illustrating an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), zero-tail (ZT) unique-word (UW) discrete Fourier transform (DFT)

spread OFDM (ZT UW DTS-s OFDM), unique word OFDM (UW-OFDM), resource block-filtered OFDM, filter bank multicarrier (FBMC), and the like.

[0021] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a radio access network (RAN) 104/113, a core network (CN) 106/115, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d, any of which may be referred to as a "station" and/or a "STA", may be configured to transmit and/or receive wireless signals and may include (or be) a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a subscription-based unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, a hotspot or Mi-Fi device, an Internet of Things (IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device and applications (e.g., remote surgery), an industrial device and applications (e.g., a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. Any of the WTRUs 102a, 102b, 102c and 102d may be interchangeably referred to as a UE.

[0022] The communications systems 100 may also include a base station 114a and/or a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d, e.g., to facilitate access to one or more communication networks, such as the CN 106/115, the Internet 110, and/or the networks 112. By way of example, the base stations 114a, 114b may be any of a base transceiver station (BTS), a Node-B (NB), an eNode-B (eNB), a Home Node-B (HNB), a Home eNode-B (HeNB), a gNode-B (gNB), a NR Node-B (NR NB), a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0023] The base station 114a may be part of the RAN 104/113, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals on one or more carrier frequencies, which may be referred to as a cell (not shown). These frequencies may be in licensed spectrum,

unlicensed spectrum, or a combination of licensed and unlicensed spectrum. A cell may provide coverage for a wireless service to a specific geographical area that may be relatively fixed or that may change over time. The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in an embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In an embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and may utilize multiple transceivers for each or any sector of the cell. For example, beamforming may be used to transmit and/or receive signals in desired spatial directions.

[0024] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 116, which may be any suitable wireless communication link (e.g., radio frequency (RF), microwave, centimeter wave, micrometer wave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 116 may be established using any suitable radio access technology (RAT).

[0025] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104/113 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 116 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink Packet Access (HSDPA) and/or High-Speed Uplink Packet Access (HSUPA).

[0026] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 116 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A) and/or LTE-Advanced Pro (LTE-A Pro).

[0027] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as NR Radio Access, which may establish the air interface 116 using New Radio (NR).

[0028] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement multiple radio access technologies. For example, the base station 114a and the WTRUs 102a, 102b, 102c may implement LTE radio access and NR radio access together, for instance using dual connectivity (DC) principles. Thus, the air interface utilized by WTRUs 102a, 102b,

102c may be characterized by multiple types of radio access technologies and/or transmissions sent to/from multiple types of base stations (e.g., an eNB and a gNB).

[0029] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.11 (i.e., Wireless Fidelity (Wi-Fi)), IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000), Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0030] The base station 114b in FIG. 1A may be a wireless router, Home Node-B, Home eNode-B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, an industrial facility, an air corridor (e.g., for use by drones), a roadway, and the like. In an embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In an embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In an embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g., WCDMA, CDMA2000, GSM, LTE, LTE-A, LTE-A Pro, NR, etc.) to establish any of a small cell, picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the CN 106/115.

[0031] The RAN 104/113 may be in communication with the CN 106/115, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. The data may have varying quality of service (QoS) requirements, such as differing throughput requirements, latency requirements, error tolerance requirements, reliability requirements, data throughput requirements, mobility requirements, and the like. The CN 106/115 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 104/113 and/or the CN 106/115 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104/113 or a different RAT. For example, in addition to being connected to the RAN 104/113, which may be utilizing an NR radio technology, the CN 106/115 may also be in communication with another RAN (not shown) employing any of a GSM, UMTS, CDMA 2000, WiMAX, E-UTRA, or Wi-Fi radio technology.

[0032] The CN 106/115 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and/or the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired and/or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another CN connected to one or more RANs, which may employ the same RAT as the RAN 104/114 or a different RAT.

[0033] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities (e.g., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links). For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0034] FIG. 1B is a system diagram illustrating an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and/or other elements/peripherals 138, among others. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0035] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together, e.g., in an electronic package or chip.

[0036] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g., the base station 114a) over the air interface 116. For example, in an embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In an embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In an embodiment, the transmit/receive element 122 may be configured to transmit and/or receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0037] Although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. For example, the WTRU 102 may employ MIMO technology. Thus, in an embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g., multiple antennas) for transmitting and receiving wireless signals over the air interface 116.

[0038] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as NR and IEEE 802.11, for example.

[0039] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128 (e.g., a liquid crystal display (LCD) display unit or organic light-emitting diode (OLED) display unit). The processor 118 may also output user data to the speaker/microphone 124, the keypad 126, and/or the display/touchpad 128. In addition, the processor 118 may access information from, and store data in, any type of suitable memory, such as the non-removable memory 130 and/or the removable memory 132. The non-removable memory 130 may include random-access memory (RAM), read-only memory (ROM), a hard disk, or any other type of memory storage device. The removable memory 132 may include a subscriber identity module (SIM) card, a memory stick, a secure digital (SD) memory card, and the like. In other embodiments, the processor 118 may access information from, and store data in, memory that is not physically located on the WTRU 102, such as on a server or a home computer (not shown).

[0040] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134

may include one or more dry cell batteries (e.g., nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0041] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g., longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 116 from a base station (e.g., base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

[0042] The processor 118 may further be coupled to other elements/peripherals 138, which may include one or more software and/or hardware modules/units that provide additional features, functionality and/or wired or wireless connectivity. For example, the elements/peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (e.g., for photographs and/or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, a virtual reality and/or augmented reality (VR/AR) device, an activity tracker, and the like. The elements/peripherals 138 may include one or more sensors, the sensors may be one or more of a gyroscope, an accelerometer, a hall effect sensor, a magnetometer, an orientation sensor, a proximity sensor, a temperature sensor, a time sensor, a geolocation sensor, an altimeter, a light sensor, a touch sensor, a magnetometer, a barometer, a gesture sensor, a biometric sensor, and/or a humidity sensor.

[0043] The WTRU 102 may include a full duplex radio for which transmission and reception of some or all of the signals (e.g., associated with particular subframes for both the uplink (e.g., for transmission) and downlink (e.g., for reception) may be concurrent and/or simultaneous. The full duplex radio may include an interference management unit to reduce and or substantially eliminate self-interference via either hardware (e.g., a choke) or signal processing via a processor (e.g., a separate processor (not shown) or via processor 118). In an embodiment, the WTRU 102 may include a half-duplex radio for which transmission and reception of some or all of the signals (e.g., associated with particular subframes for either the uplink (e.g., for transmission) or the downlink (e.g., for reception)).

[0044] FIG. 1C is a system diagram illustrating the RAN 104 and the CN 106 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to

communicate with the WTRUs 102a, 102b, and 102c over the air interface 116. The RAN 104 may also be in communication with the CN 106.

[0045] The RAN 104 may include eNode-Bs 160a, 160b, 160c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 160a, 160b, 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In an embodiment, the eNode-Bs 160a, 160b, 160c may implement MIMO technology. Thus, the eNode-B 160a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a.

[0046] Each of the eNode-Bs 160a, 160b, and 160c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the uplink (UL) and/or downlink (DL), and the like. As shown in FIG. 1C, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0047] The CN 106 shown in FIG. 1C may include a mobility management entity (MME) 162, a serving gateway (SGW) 164, and a packet data network (PDN) gateway (PGW) 166. While each of the foregoing elements are depicted as part of the CN 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the CN operator.

[0048] The MME 162 may be connected to each of the eNode-Bs 160a, 160b, and 160c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 162 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 162 may provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM and/or WCDMA.

[0049] The SGW 164 may be connected to each of the eNode-Bs 160a, 160b, 160c in the RAN 104 via the S1 interface. The SGW 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The SGW 164 may perform other functions, such as anchoring user planes during inter-eNode-B handovers, triggering paging when DL data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0050] The SGW 164 may be connected to the PGW 166, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0051] The CN 106 may facilitate communications with other networks. For example, the CN 106 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the CN 106 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the CN 106 and the PSTN 108. In addition, the CN 106 may provide the WTRUs 102a, 102b, 102c with access to the other networks 112, which may include other wired and/or wireless networks that are owned and/or operated by other service providers.

[0052] Although the WTRU is described in FIGs. 1A-1D as a wireless terminal, it is contemplated that in certain representative embodiments that such a terminal may use (e.g., temporarily or permanently) wired communication interfaces with the communication network.

[0053] In representative embodiments, the other network 112 may be a WLAN.

[0054] A WLAN in infrastructure basic service set (BSS) mode may have an access point (AP) for the BSS and one or more stations (STAs) associated with the AP. The AP may have an access or an interface to a distribution system (DS) or another type of wired/wireless network that carries traffic into and/or out of the BSS. Traffic to STAs that originates from outside the BSS may arrive through the AP and may be delivered to the STAs. Traffic originating from STAs to destinations outside the BSS may be sent to the AP to be delivered to respective destinations. Traffic between STAs within the BSS may be sent through the AP, for example, where the source STA may send traffic to the AP and the AP may deliver the traffic to the destination STA. The traffic between STAs within a BSS may be considered and/or referred to as peer-to-peer traffic. The peer-to-peer traffic may be sent between (e.g., directly between) the source and destination STAs with a direct link setup (DLS). In certain representative embodiments, the DLS may use an 802.11e DLS or an 802.11z tunneled DLS (TDLS). A WLAN using an Independent BSS (IBSS) mode may not have an AP, and the STAs (e.g., all of the STAs) within or using the IBSS may communicate directly with each other. The IBSS mode of communication may sometimes be referred to herein as an "ad-hoc" mode of communication.

[0055] When using the 802.11ac infrastructure mode of operation or a similar mode of operations, the AP may transmit a beacon on a fixed channel, such as a primary channel. The primary channel may be a fixed width (e.g., 20 MHz wide bandwidth) or a dynamically set width via signaling. The primary channel may be the operating channel of the BSS and may be used by the STAs to establish a connection with the AP. In certain representative embodiments, Carrier sense multiple access with collision avoidance (CSMA/CA) may be implemented, for example in 802.11 systems. For CSMA/CA, the STAs (e.g., every STA), including the AP, may sense the

primary channel. If the primary channel is sensed/detected and/or determined to be busy by a particular STA, the particular STA may back off. One STA (e.g., only one station) may transmit at any given time in a given BSS.

[0056] High throughput (HT) STAs may use a 40 MHz wide channel for communication, for example, via a combination of the primary 20 MHz channel with an adjacent or nonadjacent 20 MHz channel to form a 40 MHz wide channel.

[0057] Very high throughput (VHT) STAs may support 20 MHz, 40 MHz, 80 MHz, and/or 160 MHz wide channels. The 40 MHz, and/or 80 MHz, channels may be formed by combining contiguous 20 MHz channels. A 160 MHz channel may be formed by combining 8 contiguous 20 MHz channels, or by combining two non-contiguous 80 MHz channels, which may be referred to as an 80+80 configuration. For the 80+80 configuration, the data, after channel encoding, may be passed through a segment parser that may divide the data into two streams. Inverse fast fourier transform (IFFT) processing, and time domain processing, may be done on each stream separately. The streams may be mapped on to the two 80 MHz channels, and the data may be transmitted by a transmitting STA. At the receiver of the receiving STA, the above-described operation for the 80+80 configuration may be reversed, and the combined data may be sent to a medium access control (MAC) layer, entity, etc.

[0058] Sub 1 GHz modes of operation are supported by 802.11af and 802.11ah. The channel operating bandwidths, and carriers, are reduced in 802.11af and 802.11ah relative to those used in 802.11n, and 802.11ac. 802.11af supports 5 MHz, 10 MHz and 20 MHz bandwidths in the TV white space (TVWS) spectrum, and 802.11ah supports 1 MHz, 2 MHz, 4 MHz, 8 MHz, and 16 MHz bandwidths using non-TVWS spectrum. According to a representative embodiment, 802.11ah may support meter type control/machine-type communications (MTC), such as MTC devices in a macro coverage area. MTC devices may have certain capabilities, for example, limited capabilities including support for (e.g., only support for) certain and/or limited bandwidths. The MTC devices may include a battery with a battery life above a threshold (e.g., to maintain a very long battery life).

[0059] WLAN systems, which may support multiple channels, and channel bandwidths, such as 802.11n, 802.11ac, 802.11af, and 802.11ah, include a channel which may be designated as the primary channel. The primary channel may have a bandwidth equal to the largest common operating bandwidth supported by all STAs in the BSS. The bandwidth of the primary channel may be set and/or limited by a STA, from among all STAs in operating in a BSS, which supports the smallest bandwidth operating mode. In the example of 802.11ah, the primary channel may be 1 MHz wide for STAs (e.g., MTC type devices) that support (e.g., only support) a 1 MHz mode,

even if the AP, and other STAs in the BSS support 2 MHz, 4 MHz, 8 MHz, 16 MHz, and/or other channel bandwidth operating modes. Carrier sensing and/or network allocation vector (NAV) settings may depend on the status of the primary channel. If the primary channel is busy, for example, due to a STA (which supports only a 1 MHz operating mode), transmitting to the AP, the entire available frequency bands may be considered busy even though a majority of the frequency bands remains idle and may be available.

[0060] In the United States, the available frequency bands, which may be used by 802.11ah, are from 902 MHz to 928 MHz. In Korea, the available frequency bands are from 917.5 MHz to 923.5 MHz. In Japan, the available frequency bands are from 916.5 MHz to 927.5 MHz. The total bandwidth available for 802.11ah is 6 MHz to 26 MHz depending on the country code.

[0061] FIG. 1D is a system diagram illustrating the RAN 113 and the CN 115 according to an embodiment. As noted above, the RAN 113 may employ an NR radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 113 may also be in communication with the CN 115.

[0062] The RAN 113 may include gNBs 180a, 180b, 180c, though it will be appreciated that the RAN 113 may include any number of gNBs while remaining consistent with an embodiment. The gNBs 180a, 180b, 180c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In an embodiment, the gNBs 180a, 180b, 180c may implement MIMO technology. For example, gNBs 180a, 180b may utilize beamforming to transmit signals to and/or receive signals from the WTRUs 102a, 102b, 102c. Thus, the gNB 180a, for example, may use multiple antennas to transmit wireless signals to, and/or receive wireless signals from, the WTRU 102a. In an embodiment, the gNBs 180a, 180b, 180c may implement carrier aggregation technology. For example, the gNB 180a may transmit multiple component carriers to the WTRU 102a (not shown). A subset of these component carriers may be on unlicensed spectrum while the remaining component carriers may be on licensed spectrum. In an embodiment, the gNBs 180a, 180b, 180c may implement Coordinated Multi-Point (CoMP) technology. For example, WTRU 102a may receive coordinated transmissions from gNB 180a and gNB 180b (and/or gNB 180c).

[0063] The WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c using transmissions associated with a scalable numerology. For example, OFDM symbol spacing and/or OFDM subcarrier spacing may vary for different transmissions, different cells, and/or different portions of the wireless transmission spectrum. The WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c using subframe or transmission time intervals (TTIs) of various or

scalable lengths (e.g., including a varying number of OFDM symbols and/or lasting varying lengths of absolute time).

[0064] The gNBs 180a, 180b, 180c may be configured to communicate with the WTRUs 102a, 102b, 102c in a standalone configuration and/or a non-standalone configuration. In the standalone configuration, WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c without also accessing other RANs (e.g., such as eNode-Bs 160a, 160b, 160c). In the standalone configuration, WTRUs 102a, 102b, 102c may utilize one or more of gNBs 180a, 180b, 180c as a mobility anchor point. In the standalone configuration, WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c using signals in an unlicensed band. In a non-standalone configuration WTRUs 102a, 102b, 102c may communicate with/connect to gNBs 180a, 180b, 180c while also communicating with/connecting to another RAN such as eNode-Bs 160a, 160b, 160c. For example, WTRUs 102a, 102b, 102c may implement DC principles to communicate with one or more gNBs 180a, 180b, 180c and one or more eNode-Bs 160a, 160b, 160c substantially simultaneously. In the non-standalone configuration, eNode-Bs 160a, 160b, 160c may serve as a mobility anchor for WTRUs 102a, 102b, 102c and gNBs 180a, 180b, 180c may provide additional coverage and/or throughput for servicing WTRUs 102a, 102b, 102c.

[0065] Each of the gNBs 180a, 180b, 180c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the UL and/or DL, support of network slicing, dual connectivity, interworking between NR and E-UTRA, routing of user plane data towards user plane functions (UPFs) 184a, 184b, routing of control plane information towards access and mobility management functions (AMFs) 182a, 182b, and the like. As shown in FIG. 1D, the gNBs 180a, 180b, 180c may communicate with one another over an Xn interface.

[0066] The CN 115 shown in FIG. 1D may include at least one AMF 182a, 182b, at least one UPF 184a, 184b, at least one session management function (SMF) 183a, 183b, and at least one Data Network (DN) 185a, 185b. While each of the foregoing elements are depicted as part of the CN 115, it will be appreciated that any of these elements may be owned and/or operated by an entity other than the CN operator.

[0067] The AMF 182a, 182b may be connected to one or more of the gNBs 180a, 180b, 180c in the RAN 113 via an N2 interface and may serve as a control node. For example, the AMF 182a, 182b may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, support for network slicing (e.g., handling of different protocol data unit (PDU) sessions with different requirements), selecting a particular SMF 183a, 183b, management of the registration area, termination of non-access stratum (NAS) signaling, mobility management, and the like. Network

slicing may be used by the AMF 182a, 182b, e.g., to customize CN support for WTRUs 102a, 102b, 102c based on the types of services being utilized WTRUs 102a, 102b, 102c. For example, different network slices may be established for different use cases such as services relying on ultra-reliable low latency (URLLC) access, services relying on enhanced massive mobile broadband (eMBB) access, services for MTC access, and/or the like. The AMF 162 may provide a control plane function for switching between the RAN 113 and other RANs (not shown) that employ other radio technologies, such as LTE, LTE-A, LTE-A Pro, and/or non-3GPP access technologies such as Wi-Fi.

[0068] The SMF 183a, 183b may be connected to an AMF 182a, 182b in the CN 115 via an N11 interface. The SMF 183a, 183b may also be connected to a UPF 184a, 184b in the CN 115 via an N4 interface. The SMF 183a, 183b may select and control the UPF 184a, 184b and configure the routing of traffic through the UPF 184a, 184b. The SMF 183a, 183b may perform other functions, such as managing and allocating UE IP address, managing PDU sessions, controlling policy enforcement and QoS, providing downlink data notifications, and the like. A PDU session type may be IP-based, non-IP based, Ethernet-based, and the like.

[0069] The UPF 184a, 184b may be connected to one or more of the gNBs 180a, 180b, 180c in the RAN 113 via an N3 interface, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, e.g., to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The UPF 184a, 184b may perform other functions, such as routing and forwarding packets, enforcing user plane policies, supporting multi-homed PDU sessions, handling user plane QoS, buffering downlink packets, providing mobility anchoring, and the like.

[0070] The CN 115 may facilitate communications with other networks. For example, the CN 115 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the CN 115 and the PSTN 108. In addition, the CN 115 may provide the WTRUs 102a, 102b, 102c with access to the other networks 112, which may include other wired and/or wireless networks that are owned and/or operated by other service providers. In an embodiment, the WTRUs 102a, 102b, 102c may be connected to a local Data Network (DN) 185a, 185b through the UPF 184a, 184b via the N3 interface to the UPF 184a, 184b and an N6 interface between the UPF 184a, 184b and the DN 185a, 185b.

[0071] In view of FIGs. 1A-1D, and the corresponding description of FIGs. 1A-1D, one or more, or all, of the functions described herein with regard to any of: WTRUs 102a-d, base stations 114a-b, eNode-Bs 160a-c, MME 162, SGW 164, PGW 166, gNBs 180a-c, AMFs 182a-b, UPFs 184a-b, SMFs 183a-b, DNs 185a-b, and/or any other element(s)/device(s) described herein, may be

performed by one or more emulation elements/devices (not shown). The emulation devices may be one or more devices configured to emulate one or more, or all, of the functions described herein. For example, the emulation devices may be used to test other devices and/or to simulate network and/or WTRU functions.

[0072] The emulation devices may be designed to implement one or more tests of other devices in a lab environment and/or in an operator network environment. For example, the one or more emulation devices may perform the one or more, or all, functions while being fully or partially implemented and/or deployed as part of a wired and/or wireless communication network in order to test other devices within the communication network. The one or more emulation devices may perform the one or more, or all, functions while being temporarily implemented/deployed as part of a wired and/or wireless communication network. The emulation device may be directly coupled to another device for purposes of testing and/or may performing testing using over-the-air wireless communications.

[0073] The one or more emulation devices may perform the one or more, including all, functions while not being implemented/deployed as part of a wired and/or wireless communication network. For example, the emulation devices may be utilized in a testing scenario in a testing laboratory and/or a non-deployed (e.g., testing) wired and/or wireless communication network in order to implement testing of one or more components. The one or more emulation devices may be test equipment. Direct RF coupling and/or wireless communications via RF circuitry (e.g., which may include one or more antennas) may be used by the emulation devices to transmit and/or receive data.

[0074] Certain terms used herein will now be introduced.

[0075] The term "traffic flow" is used herein. A traffic flow may be an IP Flow. When a traffic flow is an IP Flow the flow may be described as all the traffic to an IP Address and Port Number combination. When a traffic flow is bi-directional, the traffic flow may be described by a destination IP Address, destination Port Number, source IP Address, and source Port Number. A traffic flow may also be an Application Flow. When a traffic flow is an Application Flow, the flow may be described as all data that is sent to and from the Application. A traffic flow may further be certain traffic within an IP Flow. For example, a traffic flow may be all traffic that is sent a certain IP Address and Port Number combination and has certain information in the packet header (e.g., a QUIC stream).

[0076] The term "RAN Node" is used herein. A cellular base station may be a type of RAN Node. It will be appreciated that the RAN Node may also be applied to a Non-3GPP Interworking Function (N3IWF) or Trusted Non-3GPP Gateway Function (TNGF).

[0077] The term "PDU Session Anchor (PSA)" is used herein. A PDU Session anchor may be a UPF.

[0078] This description describes "services" that may be invoked, may invoke other services, and may provide information. Services may be invoked by a Network Function.

[0079] "Non-Access Stratum Session Management" (NAS-SM) is a type of session management protocol. NAS-SM messaging is a protocol that is used between a UE and an SMF. NAS-SM can be used to establish PDU Sessions, modify PDU Sessions, and release PDU Sessions.

[0080] "Service Data Adaptation Protocol" (SDAP) is a type of protocol stack layer in the UE and RAN Node. The SDAP layer maps PDUs to network resources.

[0081] A "radio bearer" is a type of network resource. A radio bearer may be described by a combination of a frequency range and time period.

[0082] "Computing resources" are a type of network resources. RAN Nodes and Core Network functions consume computing resources. The invocation of services causes the consumption, or utilization, of network resources.

[0083] In a mobile telecommunication system, such as the 5G System that will be used as an example, a "PDU Session" may be described as having at least some of the following characteristics.

[0084] A PDU Session is session between a UE and one or more anchor UPF(s).

[0085] A PDU Session is associated with a Single Network Slice Selection Assistance Information (S-NSSAI) and a DNN.

[0086] A PDU Session may be associated with multiple access network connections. For example, a UE may send PDUs in a PDU Session over both NR and non-3GPP (i.e. Wi-Fi access).

[0087] A PDU Session is made up of one or more QoS Flows and each QoS Flow is associated with only one access.

[0088] For each access network node (e.g. RAN Node or N3IWF) that is associated with a UE's PDU Session, there is a GPRS Tunneling Protocol User Plane (GTP-U) tunnel between the access network node and a UPF of the PDU Session.

[0089] In the 5G System, the UE may be configured with UE Route Selection Policy (URSP) Rules that are used by the UE to associate uplink traffic with a PDU Session. The URSP Rules can be used to configure the UE with information to determine a DNN and S-NSSAI combination that should be associated with the PDU Session that carries uplink traffic associated with an application.

[0090] A "Data Network Name" (DNN) is a human readable string of characters. Some Applications are designed such that they provide a DNN to the Mobile Termination (MT) part of

the UE so that the UE can use the DNN to determine the properties of the PDU Session that should carry the applications uplink traffic.

[0091] A "S-NSSAI" does not identify a slice. Rather, it is a piece of information that is used by the network to select a slice. When a UE registers to a slice that is associated with a S-NSSAI, the identity of the slice that the UE registers is not provided to the UE. There may or may not be a one-to-one mapping between S-NSSAI and Network Slice Instance Identifier (NSI ID).

[0092] When a UE establishes PDU Sessions in multiple network slices, the UE indicates the S-NSSAI that should be associated with each PDU Session. Thus, the UE has some awareness of what network slice is used in a PDU Session. Furthermore, the UE must register to a network slice prior to using the network slice to send and receive PDUs.

[0093] The AMF performs network slice selection in the 5G System. The UE is involved in the network slice selection procedure in the sense that the UE may provide an S-NSSAI to the AMF and the AMF uses the S-NSSAI in the network slice selection procedure.

[0094] FIG. 2 illustrates a protocol stack for a PDU Session, as described in 3GPP TS 23.501, System Architecture for the 5G System, Stage 2, Release 18, v18.3.0. The PDU Layer represents the layer that passes PDUs to and from the UE. Examples of PDUs are IP Packets and Ethernet packets.

[0095] In the protocol stack of FIG. 2, it will be noticed that there is no way for the UE to convey information to the UPF when delivering a PDU.

[0096] When the Access Traffic Steering, Switching and Splitting (ATSSS) feature is deployed, the performance measurement function (PMF) protocol may be used between the UE and PSA UPF to exchange measurement information and traffic steering configuration information. FIG. 3 illustrates an example of a PMF protocol stack, taken from 3GPP TS 23.501. More specifically, FIG. 3 illustrates a UE/UPF measurements related protocol stack for 3GPP access and for an MA PDU Session with type IP.

[0097] In the 5G System, control plane messages are sent from the UE to the 5GC (i.e. NAS Messages) are transparently passed through a RAN Node and to the AMF Serving the UE. When the UE transmits a NAS message, the AMF receives the NAS message and may forward parts of the NAS message to other network functions, such as an SMF. It will be noticed that the AMF must act as a router for various types of control plane messaging from the UE. Thus, the AMF is both the main network function that deals with mobility management processing and a network function that deals with session management signaling between the UE and the network. FIG. 4 illustrates an example of a NAS protocol stack, taken from 3GPP TS 23.501, with NAS transport for SM, SMS, UE Policy and Location Services (LCS).

[0098] There are two types of "radio bearers" in the 5G system. A first type of radio bearer is a Signaling Radio Bearer (SRB). SRBs are used for the transmission of Radio Resource Control (RRC) and NAS messages. A second type of radio bearer is a Data Radio Bearer (DRB), used to transmit user plane data. Since DRBs are used to transmit data from a QoS Flow of a PDU Session, usage of a DRB may be associated with a network slice.

[0099] Existing network architectures such as the Evolved Packet System and 5G System use control plane messaging between the UE and network to initiate configuration of a data plane connection and modify the data plane connection. The control plane messages in these existing systems are not sent using resources specifically associated with the data plane. Rather, the control plane messages are sent using dedicated resources such as SRBs and network nodes that are not specifically associated with the data plane (e.g., an AMF or MME). These shared resources are common to multiple network slices.

[0100] For example, NAS signaling from a UE in the EPS and 5G System is routed via the MME or AMF that is serving the UE. The serving MME or AMF is thus associated with the UE's data plane activity as well as handling mobility management signaling.

[0101] For example, NAS-SM signaling in the 5G System is sent between a UE and SMF. However, NAS-SM messages are sent via SRBs between the UE and RAN Node and routed through the AMF. The SRBs are resources, and the AMF is a network node. Both the SRBs and AMFs thus shared by multiple network slices.

[0102] It is desirable to enhance the 5G System or design a new system that does not require a single network node, such as the AMF, to route the control plane session management signaling. Furthermore, it is desired that any network function that is associated with multiple network slices does not also need to perform other general network functionality such as mobility management. The present principles provide a solution.

[0103] FIG. 5 illustrates an example system architecture for routing PDUs between a UE and a UPF according to an embodiment of the present principles.

[0104] In this example architecture 500, when the UE 502 wants to establish a connection, or session, with a Data Network 504, the UE 502 uses control plane signaling to communicate with a PDU Session Anchor Selection Service (PSAS) 510 in the core network. The result of the interaction with the PSAS is that a UPF 508 will be selected to serve the UE's connection to the Data Network 504. The UPF 508 can include a UPF-C 508a and a UPF-D 508b.

[0105] Communication between the UE 502 and PSAS takes place over a reference point that is labeled Reference-Point-1 in FIG. 5. The UE 502 may use this interface to trigger a procedure where a UPF 508 for a new PDU Session is selected or a procedure where a new UPF 508 for an

existing PDU Session is selected. Selecting a UPF for an existing PDU Session is called UPF re-selection.

[0106] Once a UPF is selected, the UE 502 may then communicate directly with the UPF for session management signaling. An advantage of this architecture is that session management signaling between the UE and UPF may be sent via the same network resources (e.g., radio bearers and network functions).

[0107] The communication between the UE 502 and UPF for session management signaling takes place over the reference point labeled Reference-Point-2 in FIG. 5.

[0108] PDUs are sent from the UE 502 to the RAN Node 506 and forwarded by the RAN Node 506 to the UPF 508.

[0109] The UPF 508 may have a control plane part, UPF-C, 508a. The UPF-C 508a may be the termination point and source of session management signaling between the UPF 508 and UE 502.

[0110] The UPF may have a data plane part, UPF-D, 508b. The UPF-D 508b may be the termination point and source of data plane traffic between the UPF 508 and UE 502.

[0111] The UPF-C 508a and UPF-D 508b may have an interface. The interface may be used by the UPF-C to configure the UPF-D 508b. The UPF-C 508a and UPF-D 508b may be distinct network functions.

[0112] An Application Function (AF) 514 may invoke an API of a Network Exposure Function (NEF) 516 to provide information about a traffic flow of the UE 502. For example, the AF 514 may provide information about the QoS requirements of the UE's traffic flows. The traffic flows may be described in the API invocation by a combination of source IP Address, destination IP Address, DNN, and S-NSSAI. The NEF 516 may determine what Policy Control Function (PCF) 518 serves the traffic flow and provide the QoS Requirements to the PCF 518. The QoS Requirements may be stored in the PCF 518 or in the subscription information of the UE in the UDM/UDR 512. When a UPF is selected for the UE, the PSAS 510 may obtain the QoS Requirements from the PCF 518 or UDM/UDR 512 and use the QoS Requirements to determine a QoS configuration for the UPF, UE 502, and RAN Node 506.

[0113] It is proposed that the system architecture include a network function that handles mobility management signaling for the UE. However, the network function that handles mobility management signaling does not need to be involved in session management signaling. Specifically, the network function that handles mobility management signaling does not need to route session management signaling. Note that the mobility management function is not shown in FIG. 5.

[0114] The UE may be configured with policies that are used to determine a DNN identifier that should be associated with application traffic. The UE may use a determined DNN identifier to

establish a connection to the data network. A DNN Identifier, which may be a number, may be associated with Application Layer traffic.

[0115] A DNN Identifier Determination policy may have an Application Detection Part. The Application Detection Part is used by the UE to detect that the policy applies to an application data flow. For example, the Application Detection Part may include a Traffic Descriptor and the UE may determine that the policy applies to an application data flow if the Traffic Descriptor is associated with the application data flow.

[0116] The Traffic Descriptor may include information that can be found in the application data flow. Examples of information that can be found in the application data flow include a Destination IP Address. The Traffic Descriptor may include information that is provided to the MT part of the UE by the application. For example, a DNN is string of text that can be provided by the application.

[0117] A DNN Identifier Determination policy may have a DNN ID Mapping Part. The DNN ID Mapping Part may be a prioritized list of DNN Identifiers. The list may represent the preferred DNN IDs that are used to route the application data flow that was determined to be associated with the Traffic Descriptor.

[0118] In a first example, the Traffic Descriptor of a DNN Identifier Determination policy may include a destination IP Address. The UE may detect that an application data flow is directed to the destination IP Address in the Traffic Descriptor and therefore determine that the policy applies to the application data flow. The UE may then use the DNN ID Mapping Part of the DNN Identifier Determination policy to determine a DNN ID that should be associated with the application data flow.

[0119] In a second example, the Traffic Descriptor of a DNN Identifier Determination policy may include a DNN. The format of the DNN may be a character string. The MT part of the UE may receive the DNN from an application that is generating an application data flow and therefore determine that the policy applies to the application data flow. The UE may then use the DNN ID Mapping Part of the DNN Identifier Determination policy to determine a DNN ID that should be associated with the application data flow. In this second example, a DNN in the format of a character string is mapped to a DNN ID whose format is a number (e.g., an integer). Additionally, the identity of the PLMN that the UE is registered to may be used to determine the DNN ID. For example, the PLMN ID of the network that the UE is registered to may be used to determine which DNN Identifier Determination Policy to apply.

[0120] The DNN Identifier Determination Policy may also be used to derive selection assistance information that may be sent to the network to select a PSAS.

[0121] It should be noticed that UEs may receive different DNN Identifier Determination Policies. For example, a first UE may receive a first DNN Identifier Determination Policy and a second UE may receive a second DNN Identifier Determination Policy. The first DNN Identifier Determination Policy may indicate that a first DNN Identifier maps to a first DNN ID. The second DNN Identifier Determination Policy may indicate that the first DNN Identifier maps to a second DNN ID. Each DNN Identifier may be mapped by the network to different network resources (e.g., different network slices). In this way, the policies can be configured to provide different levels of service to different users, even if the users are accessing the same data network.

[0122] FIG. 6, made up of FIGS. 6A-6C, illustrates an example method for creating and using a data plane path according to an embodiment of the present principles. In this example method, the proposed system architecture allows the UE to be unaware of network slicing. In the example method of FIG. 6, the UE 502 can request a data plane connection to a Data Network 504. The network can select what resources (i.e., Network Slice) serves the UE 502 and the UE 502 does not need to be involved in selecting a network slice type (e.g., S-NSSAI) or a specific network slice (e.g., NSI-ID).

[0123] The example method of FIG. 6 shows how the UE can establish a path between the UE and a PDU Session Anchor of a Data Network. The establishment procedure will be triggered when a UE detects that an application needs to send user plane data. In this method, session management messages for the UE are routed by the RAN Node towards core network services.

[0124] In the example method, it is assumed that the UE 502 is registered to the network and has established a secure connection with the RAN Node 506.

[0125] Starting with FIG. 6A, in step S602, the UE 502 is configured one or more DNN Identifier Determination Policies. The DNN Identifier Determination Policies may be received from a Policy Management Function in the core network, for example in a NAS message.

[0126] In step S604, a UE Application in the UE 502 may begin to generate user plane data to be transmitted in the uplink.

[0127] In step S606, the MT part of the UE 502 detects that there is uplink data from the application to be transmitted. As already described, the MT part of the UE 502 may use DNN Identifier Determination Policies to determine a DNN Identifier that is associated with the traffic.

[0128] In step S608, the MT part of the UE 502 initiates a procedure to establish a session with a PDU Session Anchor. The MT part of the UE transmits a RRC Message to the RAN Node 506.

[0129] The RRC Message may include one or more of: an information element indicating that the RRC Message carries a NAS Message, an information element indicating that the NAS Message is a request that the RAN Node 506 invoke a service on behalf of the UE 502, an

information element indicating the type of service that the UE 502 requests to be invoked (in this example, the type of service is to establish a session with a PDU Session Anchor), an information element providing service selection assistance information that can be used by the RAN Node 506 to determine which instance of a service should be contacted by the RAN Node 506, an information element that carries a service invocation request payload that may be encrypted and opaque to the RAN Node 506.

[0130] Payload information elements can include the DNN Identifier, a Subscription Permanent Identifier (SUPI) of the UE 502, and a User Identifier identifying an application that will use the session to send and receive data, a device that will use the session to send and receive data, or a human that will use the applications that will use the session to send and receive data.

[0131] The presence of the information element indicating that the RRC Message carries a NAS Message may be the indication that the NAS Message is a request that the RAN Node invoke a service on behalf of the UE.

[0132] In step S610, the RAN Node 506 sends a service invocation to the PSAS 510 to invoke a service. The service is to establish a session between the UE 502 and a PDU Session Anchor. The RAN Node 506 is triggered to invoke this service based, in part, on receiving the information element that indicates that the NAS Message is a request that the RAN Node 506 invoke a service on behalf of the UE 502.

[0133] The name of the service that is invoked by the RAN Node may be a PDU Session Anchor Selection Service (PSAS) 510. When the service is invoked, the RAN Node 506 may provide attributes to the PSAS 510. A first attribute may carry the service invocation request payload which includes the DNN ID, SUPI, and User Identifier. A second attribute may be an identifier of the UE (e.g., SUPI or a GUTI).

[0134] It is noted that two UE identifier information elements may be provided to the PSAS 510 by the RAN Node 506. The UE identifier in the service invocation request payload may be used by the PSAS 510 to identify the UE's subscription and may be transparent to the RAN Node 506. The second attribute may be the identifier that is used by the RAN Node to identify the UE.

[0135] If the UE 502 provided service selection assistance information to the RAN Node 506 and there are multiple instances of the PSAS 510 that can be contacted by the RAN Node 506, the RAN Node 506 may use the service selection assistance information to select which PSAS 510 to contact, or invoke, by the RAN Node 506. Examples of service selection assistance information may be the DNN ID or a slice type indication (i.e., S-NSSAI). For example, a PSAS instance may be associated with specific DNNs.

[0136] The PSAS begins to execute and retrieves subscription information for the UE related to the UE's access to the DNN. In step S612, PSAS 510 invokes a service of the UDM/UDR 512. In the service invocation, the SUPI, User Identifier, and DNN ID are provided to the UDM/UDR 512.

[0137] In step S614, the UDM/UDR 512 provides UE subscription information to the PSAS. The UE Subscription Information indicates if the SUPI and User Identifier combination is allowed to access the DNN ID. If the SUPI and User Identifier combination is allowed to access the DNN ID, the UDM/UDR 512 may provide an DNN Connection Configuration Information.

[0138] The DNN Connection Configuration Information may include one or more of a slice identifier to be used to provide the connection between the UE and DNN or a slice type identifier (e.g., S-NSSAI) to be used to provide the connection between the UE and DNN, an indication of whether the UE's connection to the DNN must be home routed, an indication of whether the UE's connection to the DNN must be routed via the network that the UE is registered to (i.e., local routing), an indication that the UE's connection to the DNN may be home routed or routed locally, user plane anchor selection criteria, and a subscribed QoS Profile for the DNN.

[0139] User plane anchor selection criteria is information that should be considered when a user plane anchor is selected for the UE's data plane connection.

[0140] One example of user plane anchor selection criteria is an indication that the selection procedure should consider that the connection the DNN may be used to send data that requires a relatively low latency. An indication that low latency is required may indicate that a user plane anchor that is geographically close to the UE should be selected.

[0141] Another example of user plane anchor selection criteria is an indication that the selection procedure should consider that the connection the DNN may be used to send data that requires a relatively high reliability. An indication that high reliability is required may be indicative that a user plane anchor that is less likely to experience congestion should be selected.

[0142] Another example of user plane anchor selection criteria may be an identity of a user plane anchor, or the identity of a pool of user plane anchors. A user plane anchor identifier, or pool of user plane anchors, may be provided in scenarios where the DNN has network resources that dedicated to serving the DNN.

[0143] Upon reception of the service response, execution of the PSAS continues.

[0144] Moving on to FIG. 6B, in step S616, the PSAS 510 selects a user plane anchor for the UE's connection. The user plane anchor may (as in the example) be a UPF and the UPF may be identified by a UPF ID. The PSAS 510 uses the DNN Connection Configuration Information to select the UPF 508.

[0145] One example of how the PSAS 510 uses the DNN Connection Configuration Information to select the UPF is, if the DNN Connection Configuration Information indicates that the connection should be home routed and the PSAS 510 is not part of the UE's home network, the PSAS 510 may invoke a PSAS that is in the UE's home network and obtain a PSA ID from the PSAS of the home network. The PSAS will provide the DNN Connection Configuration Information to the PSAS in the home network.

[0146] Another example of how the PSAS 510 uses the DNN Connection Configuration Information to select the UPF is that the PSAS considers the information in the DNN Connection Configuration Information (e.g., whether the data requires low latency or high reliability) and the UE's location to determine a UPF ID. The PSAS 510 may determine the UE's location based on the RAN Node 506 that invoked the PSAS 510. In other words, the UE's location may be the RAN Node 506 or a Cell ID that is associated with the RAN Node 506.

[0147] The PSAS 510 may also invoke other services to obtain information that can be considered when selecting a UPF. For example, the PSAS 510 may query an analytic function (e.g., an NWDAF) and obtain predictions of the UE's future mobility patterns and consider this information when selecting a UPF.

[0148] The UPF that is selected in this step may be a part of a network slice. Thus, execution of this service includes slice selection. The PSAS may first use DNN Connection Configuration Information to select a network slice to serve the UE's connection and then use the DNN Connection Configuration Information to select the UPF.

[0149] Alternatively, the PSAS may first use DNN Connection Configuration Information to select the UPF and then select the slice that is associated with the connection based on the UPF ID. For example, the connection may be considered associated with a network slice that the UPF is a part of.

[0150] In step S618, the PSAS sends a notification to the selected UPF 508. The notification informs the UPF 508 that it has been selected to serve the UE's connection to the DNN and that the UE 502 will contact the UPF 508 to establish a connection.

[0151] The notification can include one or more of the UE identifier (i.e., SUPI), the RAN Node identifier, the identity of the DNN that the UE needs to connect to, a network slice identifier, a UE session key, a RAN Node session key, and the subscribed QoS Profile that was received from the UDM/UDR.

[0152] The UE Identifier and network slice identifier may be included in charging reports generated by the UPF for the UE's connection.

[0153] The UE session key may be used to establish a secure connection with the UE.

[0154] The RAN Node session key may be used to establish a secure connection with the RAN Node 506.

[0155] The subscribed QoS Profile may be used to determine what QoS treatment to apply to the UE's connection.

[0156] In step S620, the PSAS sends a service response to the RAN Node 506. The service response can include the identity of the selected UPF and tunnel contact information for the selected UPF (e.g., IP Address of the UPF), a RAN Node session key, the network slice identifier, and a payload response for the UE.

[0157] The network slice identifier may be used by the RAN Node to determine which network resources should be used to provide the connection to the UE. Examples of network resources and radio resources (i.e., identified by time and frequency range), computation resources in the RAN, paging occasions, and random-access opportunities. For example, the RAN Node can configure the UE to use certain Radio Access Channel (RACH) resources when establish a user plane connection to the UPF and the RAN Node may use the network slice identifier to determine which RACH resource to configure the UE to use. For example, the RAN Node can configure the UE with a paging occasion that is specific to this data plane connection and the selected occasion can be based on the network slice identifier.

[0158] The payload response for the UE may include the UE session key, and the identity and control function contact information for the selected UPF 508 (e.g., IP Address and port number of the UPF).

[0159] In step S622, the RAN node 506 uses the tunnel contact information for the selected UPF (e.g., IP Address of the UPF) to establish a tunnel between the RAN Node 506 and the selected UPF 508 for sending and receiving control plane information and data related to the user plane connection. The RAN Node session key may be used by the RAN Node 506 and UPF 508 to perform mutual authentication and establish a secure connection.

[0160] In step S624, the RAN Node sends a RRC response to the MT part of the UE 502. The RRC Response Message can include an indication that a new user plane connection may been established, an identity of the new user plane connection, information that indicates which RACH resources may be used when establishing an RRC Connection to send to receive data for the user plane connection, information that indicates which cells can be used to send to receive data for the user plane connection, an information element that indicates that the RRC Message carries a NAS Message, and a NAS payload that is equal to the payload response for the UE that was received from the PSAS.

[0161] When an application initiates uplink traffic and the UE 502 determines that the traffic is to be sent to the UPF 508 and that the UE 502 needs to transition to the RRC Active state, the UE 502 may use the information about RACH resources to determine which RACH resources to use to establish the RRC connection.

[0162] When an application initiates uplink traffic and the UE 502 determines that the traffic is to be sent to the UPF 508 and the UE 502 may determine to only allow the traffic if the UE 502 is connected to a cell that the network indicated can use to send to receive data for the user plane connection.

[0163] In step S626, the UE 502 sends a (SDAP) payload to the RAN Node 506. The SDAP payload includes the identity of the new user plane connection and a PDU. The PDU can be an IP packet sent to the IP Address and port number of the UPF 508 that was received in the NAS payload response of step S624. The IP packet can carry a PSA Connection Request including an identity of the UE (e.g., SUPI or GUTI), the DNN Identifier, and Identifying information of the Application that needs to use the data plane connection (for example, an Application Identifier, an Application type Identifier, or a Traffic Descriptor).

[0164] It is noted that the message of step S626 may be sent before any QoS Rules for the user plane connection are configured in the UE and before any QoS Profile for the user plane connection is configured in the RAN Node. It will be shown in step S632 that the UE 502 may receive QoS Rules in step S632 and that the RAN Node 506 may receive QoS Profiles in step S634.

[0165] The UE may assume a default QoS Rule to use to transmit the message of step S626. This default QoS Rule may be preconfigured, may be based on the DNN ID, and may be obtained from the DNN ID Determination Policy. For example, the DNN ID Determination Policy may include a default QoS Rule. The UE 502 may assume that the default QoS Rule is active for the connection to the DN until new QoS Rules are received from the UPF 508 (e.g., in step S632).

[0166] The RAN Node 506 may assume a default QoS Profile to use to transmit the message of step 632. This default QoS Profile may be preconfigured, may be based on the DNN ID, and may be obtained from the PSAS 510 in step S620. The UE 502 may assume that the default QoS Profile is active for the connection to the DN until new QoS Profile are received from the UPF 508 (e.g., in step S634).

[0167] In step S628, the RAN Node 506 sends the PDU (i.e. the PSA Connection Request) to the UPF 508. The RAN Node 506 may send the PDU to the UPF 508 through the GTP-U Tunnel.

[0168] In step S630, the UPF sends a PDU (i.e. the PSA Connection Response) to the RAN Node 506. The UPF 508 may send the PDU to the RAN Node 506 through the GTP-U Tunnel.

[0169] The PSA Connection Response in the PDU may include QoS Rules. The UPF 508 may use the Identifying information of the Application to derive the QoS Rules.

[0170] The QoS Rules can include packet filters that describe how to map user plane data to QoS marking. The filters may identify the data that the filter applies to with a 5-tuple (source and destination IP Address, source and destination port number, and protocol type). The packet filters may indicate a marking that should be applies to traffic that matches the packet filter. The packet filter may indicate a Differentiated Services Code Point (DSCP) marking that should be applied to IP packets that match the filter. The packet filter may indicate a QoS Flow Identifier (QFI) that is associated with traffic that matches the flow and may be used to map uplink packets that match the filter to radio resources.

[0171] The UPF 508 may use the Identifying information of the Application that needs to use the data plane connection to determine the QoS Rules.

[0172] Moving on to FIG. 6C, in step S632, the RAN Node 506 sends a (SDAP) payload to the UE 502. The SDAP payload includes the PSA Connection Response.

[0173] Steps S626-S632 illustrate a message exchange between the UE 502 and UPF 508. The UE session key may be used by the UE 502 and UPF 508 to establish a secure connection. Multiple messages exchanges may be needed between the UE 502 and UPF 508 to establish the secure connection. Mutual Authentication may be part of establishing the secure connection.

[0174] In step S634, the UPF 508 sends QoS Profiles to the RAN Node 506 for the user plane connection. The QoS Profile describes the QoS Treatment that should be applied to PDUs of the data plane connection. The QoS Profile may be sent through the GTP-U tunnel between the UPF 508 and RAN Node 506.

[0175] In step S536, the UE 502 sends a PDU to the UPF 508. The PDU may be carried within another protocol such as SDAP or PDCP. An information element of this protocol may be set to the identity of the new user plane connection and a PDU. The RAN Node 506 may receive the PDU from the UE 502 and forward it to the UPF 508. The UE 502 may use the QoS Rules received in step S632 to determine what DRB to use to transmit the PDU.

[0176] A second UE Application may begin to generate traffic and the UE 502 may determine that the traffic from the second UE Application should be routed to the same DNN ID as the DNN ID determined for the first UE Application. In step S638, the UE 502 may then send a payload to the RAN Node 506. The payload may include a PSA Connection Update Request that may include an identity of the UE (e.g., SUPI or GUTI), the DNN Identifier, identifying information of the first Application that needs to use the data plane connection, and identifying information of the second Application that needs to use the data plane connection.

[0177] The UE 502 sends identifying information of both the first and second applications in this message to indicate to the UPF 508 that the first UE application is still using the connection and that the second UE application is now also using the connection. This information may be considered by the UPF 508 when deriving QoS Rules.

[0178] In step S640, similar to step S628, the RAN Node 506 forwards the PSA Connection Update Request to the UPF 508.

[0179] The UPF 508 uses the identifying information of both the first and second applications to derive QoS Rules. In step S642, similar to step S630, the UPF 508 sends a PSA Connection Update Command to the UE. The PSA Connection Update Command is sent to the RAN Node 506 and forwarded to the UE 502 in step S644. Optionally, instead of being triggered by steps S638 and S640, this may be triggered by the UE 502 determining that the congestion level of the network has changed and that QoS Rules therefore need to be changed.

[0180] In step S644, similar to step S632, the RAN Node 506 forwards the PSA Connection Update Command to the UE 502.

[0181] In step S646, similar to step S634, the UPF 508 may send to the RAN Node 506 an updated QoS Profile determined based on both the first and second application identifying information.

[0182] The selection notification in step S618 may trigger the UPF 508 to request policies (e.g., PCC Rules) for the PDU Session from a PCF. The UPF 508 may use the information from the notification to identify the PCF to query. For example, the PCF identifier may be based on the DNN and network slice identifier. The UPF 508 may receive policies from the PCF and use the policies to derive the QoS Rules that are sent to the UE 502 in step S630.

[0183] The PCF may derive the policies based on information that was received from the AF. For example, the AF may request that certain QoS treatment be applied for a UE's connection to a Data Network and network slice combination.

[0184] The UE 502 may use SRBs to transmit the message of step S608 and the RAN Node 506 may use SRBs to transmit the response message of step S624.

[0185] The UE 502 may use DRBs to transmit the message of step S626 and the RAN Node 506 may use SRBs to transmit the response message of step S632.

[0186] The UE 502 may use DRBs to transmit uplink data in step S636.

[0187] The UE 502 may use DRBs to transmit the message of step S638 and the RAN Node 506 may use SRBs to transmit the response message of step S644.

[0188] In the 5G system, when the UE 502 needs to send session management (i.e. NAS) messages to the network, SRBs can be used. Also, in the 5G system, when the UE 502 needs to receive session management (i.e. NAS) messages to the network, SRBs can be used.

[0189] An advantage of the architecture illustrated in FIG. 5 and the example method illustrated in FIG. 6, is that DRBs may be used by the UE 502 to send and receive session management messages. This is advantageous because the messages do not need to use network resources (i.e., SRBs) that are shared across network slices and across network services.

[0190] In the method illustrated in FIG. 6, the UE sends information to a PSAS in step S608 and receives information from the PSAS in step S624. It may be that the identity of the PSAS is determined by the RAN Node in step S610. Therefore, it may be that the UE and PSAS do not have a secure connection when step S608 is initiated.

[0191] The method illustrated in FIG. 6 may be modified so that a security establishment procedure takes place between the UE and PSAS in between steps S608 and S624. In the security establishment procedure, the UE and PSAS may authenticate each other. The PSAS may use UE security credentials from the UDM/UDR to authenticate the UE. The UE may use UE security credentials from a SIM to authenticate the PSAS.

[0192] The method illustrated in FIG. 6 further may be modified so that the messages of steps S608 and step S624 are secured using certificates that are pre-configured in the UE and PSAS.

[0193] From the perspective of the RAN Node 506, the method in FIG. 6 can be described as follows.

[0194] In step S608, it receives an RRC message from a UE 502. The RRC message includes an information element that indicates a type of service that the UE requests to be invoked. The RRC message also includes an invocation request payload. The RRC message may also include service selection assistance information. The RAN Node 506 may use the service selection assistance information to select a service instance to invoke.

[0195] In step S610, it invokes a service of the type that was indicated by the UE. The service is invoked by sending a request message to the service. The request message includes an identifier of the UE (e.g. SUPI) and the invocation request payload. The request message may also include service selection assistance information. The RAN Node may use the service selection assistance information to select a service instance to invoke.

[0196] In step S620, it receives a service response including a payload response for the UE, UPF ID, a UE Session Key, and a Network Slice identifier. The service response may also include a RAN Node Session Key.

[0197] In step S622, it establishes a connection with the UPF 508 that was identified in the service response. The connection may be secured with the RAN Node Session Key.

[0198] In step S624, it sends a RRC response message to the UE. The RRC response message includes an identity of the new user plane connection and the payload response for the UE. The RRC Response message may include information that indicates which RACH resources may be used when establishing an RRC Connection to send to receive data for the user plane connection. The RRC Response message may also include information that indicates which cells can be used to send to receive data for the user plane connection.

[0199] In step S626 (and step S636), it receives user plane data from the UE. The user plane data is carried in a PDU and is received with the identity of the new user plane connection. The RAN Node sends the PDU to the UPF.

[0200] From the perspective of the UE 502, the method in FIG. 6 can be described as follows.

[0201] In steps S604-S606, it detects that an application needs to send uplink traffic and determines a DNN ID that is associated with the uplink traffic. A DNN Identifier Determination Policy may be used by the UE to determine the DNN ID.

[0202] In step S610, it sends an RRC message to a RAN Node. The RRC message includes an information element that indicates an information element that indicates a type of service that the UE requests to be invoked. The RRC message also includes an invocation request payload. The RRC message may also include service selection assistance information. The RAN Node may use the service selection assistance information to select a service instance to invoke.

[0203] In step S624, it receives an RRC response message from the RAN Node. The RRC response message includes an identity of the new user plane connection and the payload response for the UE. The payload response includes the identity and control function contact information for the selected UPF (e.g., IP Address and port number of the UPF). The payload response may include a UE session key. The RRC Response message may include information that indicates which RACH resources may be used when establishing an RRC Connection to send to receive data for the user plane connection. The RRC Response message may include information that indicates which cells can be used to send to receive data for the user plane connection.

[0204] In step S626, it sends a payload to the network. The payload includes a PDU and is sent to the UPF that was identified in the payload response. The content of the PDU may be a message for the UPF. The message may identify a type of application that will use the user plane connection.

[0205] In step S632, it receives a payload from the network. The payload includes a PDU and is sent from the UPF. The content of the PDU may be a message for the UE. The message may provide QoS Rules to the UE. The QoS Rules may be applied to the type of application.

[0206] In step S636, it uses a DRB determined using the QoS Rules to send uplink data to the network.

[0207] Although features and elements are provided above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. The present disclosure is not to be limited in terms of the particular embodiments described in this application, which are intended as illustrations of various aspects. Many modifications and variations may be made without departing from its spirit and scope, as will be apparent to those skilled in the art. No element, act, or instruction used in the description of the present application should be construed as critical or essential to the invention unless explicitly provided as such. Functionally equivalent methods and apparatuses within the scope of the disclosure, in addition to those enumerated herein, will be apparent to those skilled in the art from the foregoing descriptions. Such modifications and variations are intended to fall within the scope of the appended claims. The present disclosure is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. It is to be understood that this disclosure is not limited to particular methods or systems.

[0208] The foregoing embodiments are discussed, for simplicity, with regard to the terminology and structure of infrared capable devices, i.e., infrared emitters and receivers. However, the embodiments discussed are not limited to these systems but may be applied to other systems that use other forms of electromagnetic waves or non-electromagnetic waves such as acoustic waves.

[0209] It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting. As used herein, the term "video" or the term "imagery" may mean any of a snapshot, single image and/or multiple images displayed over a time basis. As another example, when referred to herein, the terms "user equipment" and its abbreviation "UE", the term "remote" and/or the terms "head mounted display" or its abbreviation "HMD" may mean or include (i) a wireless transmit and/or receive unit (WTRU); (ii) any of a number of embodiments of a WTRU; (iii) a wireless-capable and/or wired-capable (e.g., tetherable) device configured with, inter alia, some or all structures and functionality of a WTRU; (iii) a wireless-capable and/or wired-capable device configured with less than all structures and functionality of a WTRU; or (iv) the like. Details of an example WTRU, which may be representative of any WTRU recited herein, are provided herein with respect to FIGs. 1A-1D. As another example, various disclosed embodiments herein *supra* and *infra* are described as utilizing a head mounted display. Those skilled in the art will recognize that a device other than the head mounted display may be utilized and some or all of the disclosure and various disclosed

embodiments can be modified accordingly without undue experimentation. Examples of such other device may include a drone or other device configured to stream information for providing the adapted reality experience.

[0210] In addition, the methods provided herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

[0211] Variations of the method, apparatus and system provided above are possible without departing from the scope of the invention. In view of the wide variety of embodiments that can be applied, it should be understood that the illustrated embodiments are examples only, and should not be taken as limiting the scope of the following claims. For instance, the embodiments provided herein include handheld devices, which may include or be utilized with any appropriate voltage source, such as a battery and the like, providing any appropriate voltage.

[0212] Moreover, in the embodiments provided above, processing platforms, computing systems, controllers, and other devices that include processors are noted. These devices may include at least one Central Processing Unit ("CPU") and memory. In accordance with the practices of persons skilled in the art of computer programming, reference to acts and symbolic representations of operations or instructions may be performed by the various CPUs and memories. Such acts and operations or instructions may be referred to as being "executed," "computer executed" or "CPU executed."

[0213] One of ordinary skill in the art will appreciate that the acts and symbolically represented operations or instructions include the manipulation of electrical signals by the CPU. An electrical system represents data bits that can cause a resulting transformation or reduction of the electrical signals and the maintenance of data bits at memory locations in a memory system to thereby reconfigure or otherwise alter the CPU's operation, as well as other processing of signals. The memory locations where data bits are maintained are physical locations that have particular electrical, magnetic, optical, or organic properties corresponding to or representative of the data

bits. It should be understood that the embodiments are not limited to the above-mentioned platforms or CPUs and that other platforms and CPUs may support the provided methods.

[0214] The data bits may also be maintained on a computer readable medium including magnetic disks, optical disks, and any other volatile (e.g., Random Access Memory (RAM)) or non-volatile (e.g., Read-Only Memory (ROM)) mass storage system readable by the CPU. The computer readable medium may include cooperating or interconnected computer readable medium, which exist exclusively on the processing system or are distributed among multiple interconnected processing systems that may be local or remote to the processing system. It should be understood that the embodiments are not limited to the above-mentioned memories and that other platforms and memories may support the provided methods.

[0215] In an illustrative embodiment, any of the operations, processes, etc. described herein may be implemented as computer-readable instructions stored on a computer-readable medium. The computer-readable instructions may be executed by a processor of a mobile unit, a network element, and/or any other computing device.

[0216] There is little distinction left between hardware and software implementations of aspects of systems. The use of hardware or software is generally (but not always, in that in certain contexts the choice between hardware and software may become significant) a design choice representing cost versus efficiency tradeoffs. There may be various vehicles by which processes and/or systems and/or other technologies described herein may be effected (e.g., hardware, software, and/or firmware), and the preferred vehicle may vary with the context in which the processes and/or systems and/or other technologies are deployed. For example, if an implementer determines that speed and accuracy are paramount, the implementer may opt for a mainly hardware and/or firmware vehicle. If flexibility is paramount, the implementer may opt for a mainly software implementation. Alternatively, the implementer may opt for some combination of hardware, software, and/or firmware.

[0217] The foregoing detailed description has set forth various embodiments of the devices and/or processes via the use of block diagrams, flowcharts, and/or examples. Insofar as such block diagrams, flowcharts, and/or examples include one or more functions and/or operations, it will be understood by those within the art that each function and/or operation within such block diagrams, flowcharts, or examples may be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or virtually any combination thereof. In an embodiment, several portions of the subject matter described herein may be implemented via Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), digital signal processors (DSPs), and/or other integrated formats. However, those skilled in the art will recognize that some

aspects of the embodiments disclosed herein, in whole or in part, may be equivalently implemented in integrated circuits, as one or more computer programs running on one or more computers (e.g., as one or more programs running on one or more computer systems), as one or more programs running on one or more processors (e.g., as one or more programs running on one or more microprocessors), as firmware, or as virtually any combination thereof, and that designing the circuitry and/or writing the code for the software and or firmware would be well within the skill of one of skill in the art in light of this disclosure. In addition, those skilled in the art will appreciate that the mechanisms of the subject matter described herein may be distributed as a program product in a variety of forms, and that an illustrative embodiment of the subject matter described herein applies regardless of the particular type of signal bearing medium used to actually carry out the distribution. Examples of a signal bearing medium include, but are not limited to, the following: a recordable type medium such as a floppy disk, a hard disk drive, a CD, a DVD, a digital tape, a computer memory, etc., and a transmission type medium such as a digital and/or an analog communication medium (e.g., a fiber optic cable, a waveguide, a wired communications link, a wireless communication link, etc.).

[0218] Those skilled in the art will recognize that it is common within the art to describe devices and/or processes in the fashion set forth herein, and thereafter use engineering practices to integrate such described devices and/or processes into data processing systems. That is, at least a portion of the devices and/or processes described herein may be integrated into a data processing system via a reasonable amount of experimentation. Those having skill in the art will recognize that a typical data processing system may generally include one or more of a system unit housing, a video display device, a memory such as volatile and non-volatile memory, processors such as microprocessors and digital signal processors, computational entities such as operating systems, drivers, graphical user interfaces, and applications programs, one or more interaction devices, such as a touch pad or screen, and/or control systems including feedback loops and control motors (e.g., feedback for sensing position and/or velocity, control motors for moving and/or adjusting components and/or quantities). A typical data processing system may be implemented utilizing any suitable commercially available components, such as those typically found in data computing/communication and/or network computing/communication systems.

[0219] The herein described subject matter sometimes illustrates different components included within, or connected with, different other components. It is to be understood that such depicted architectures are merely examples, and that in fact many other architectures may be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively "associated" such that the desired functionality may

be achieved. Hence, any two components herein combined to achieve a particular functionality may be seen as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermedial components. Likewise, any two components so associated may also be viewed as being "operably connected", or "operably coupled", to each other to achieve the desired functionality, and any two components capable of being so associated may also be viewed as being "operably couplable" to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically mateable and/or physically interacting components and/or wirelessly interactable and/or wirelessly interacting components and/or logically interacting and/or logically interactable components.

[0220] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0221] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, where only one item is intended, the term "single" or similar language may be used. As an aid to understanding, the following appended claims and/or the descriptions herein may include usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim including such introduced claim recitation to embodiments including only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should be interpreted to mean "at least one" or "one or more"). The same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having

skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B." Further, the terms "any of" followed by a listing of a plurality of items and/or a plurality of categories of items, as used herein, are intended to include "any of," "any combination of," "any multiple of," and/or "any combination of multiples of" the items and/or the categories of items, individually or in conjunction with other items and/or other categories of items. Moreover, as used herein, the term "set" is intended to include any number of items, including zero. Additionally, as used herein, the term "number" is intended to include any number, including zero. And the term "multiple", as used herein, is intended to be synonymous with "a plurality".

[0222] In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[0223] As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, etc. As a non-limiting example, each range discussed herein may be readily broken down into a lower third, middle third and upper third, etc. As will also be understood by one skilled in the art all language such as "up to," "at least," "greater than," "less than," and the like includes the number recited and refers to ranges which can be subsequently broken down into subranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual member. Thus, for example, a group having 1-3 cells refers to groups having 1, 2, or 3 cells. Similarly, a group having 1-5 cells refers to groups having 1, 2, 3, 4, or 5 cells, and so forth.

[0224] Moreover, the claims should not be read as limited to the provided order or elements unless stated to that effect. In addition, use of the terms "means for" in any claim is intended to invoke 35 U.S.C. §112, ¶ 6 or means-plus-function claim format, and any claim without the terms "means for" is not so intended.

CLAIMS

What is claimed is:

1. A method at a wireless transfer/receive unit, WTRU, comprising:
 - transmitting, to a node in a radio access network, first information indicative of a type of service to invoke for the WTRU;
 - receiving, from the node in the radio access network, second information indicative of an identifier of a connection established between the node in the radio access network and a user plane node, and of control function contact information;
 - transmitting, to the node in the radio access network, a connection request intended for the user plane node;
 - receiving, from the node in the radio access network, third information indicative of one or more rules related to the connection; and
 - transmitting, using one or more resources determined using the one or more rules, uplink data to the radio access network.
2. The method of claim 1, wherein the first information is indicative of at least one of a data network name identifier, a permanent identifier of the WTRU, and a user identifier identifying an application, a device or a user that will use the service to send and receive data.
3. The method of claim 1 or 2, wherein the first information comprises service selection assistance information to use to select a service instance to invoke.
4. The method of any one of claims 1-3, wherein the second information comprises at least one of an identifier of the user plane node, control function contact information for the user plane node, a session key for the WTRU, information indicating one or more resources that may be used to send data to the user plane node.
5. The method of any one of claims 1-4, wherein the data is indicative of a type of application that will use the connection.
6. A wireless transfer/receive unit, WTRU, comprising at least one hardware processor configured to:
 - transmit, to a node in a radio access network, first information indicative of a type of service to invoke for the WTRU;

receive, from the node in the radio access network, second information indicative of an identifier of a connection established between the node in the radio access network and a user plane node;

transmit, to the node in the radio access network, a connection request intended for the user plane node;

receive, from the node in the radio access network, third information indicative of one or more rules related to the connection; and

transmit, using one or more resources determined using the one or more rules, uplink data to the radio access network.

7. The WTRU of claim 6, wherein the first information is indicative of at least one of a data network name identifier, a permanent identifier of the WTRU, and a user identifier identifying an application, a device or a user that will use the service to send and receive data.

8. The WTRU of claim 6 or 7, wherein the first information comprises service selection assistance information to use to select a service instance to invoke.

9. The WTRU of any one of claims 6-8, wherein the second information comprises at least one of an identifier of the user plane node, control function contact information for the user plane node, a session key for the WTRU, information indicating one or more resources that may be used to send data to the user plane node.

10. The WTRU of any one of claims 6-9, wherein the data is indicative of a type of application that will use the connection.

11. A method at a node in a radio access network, comprising:

receiving, from a wireless transfer/receive unit, WTRU, first information indicative of a type of service to invoke for the WTRU;

transmitting, to a user plane function selection node, a request indicative of a service of the type of service to invoke for the WTRU and of an identifier of the WTRU;

receiving, from the user plane function selection node, a first response indicative of a selected user plane node;

establishing with the selected user plane node a connection for sending and receiving control plane information and data related to the connection; and

transmitting, to the WTRU, a second response indicative of an identifier of the connection.

12. The method of claim 11, wherein the first information is indicative of at least one of a data network name identifier, a permanent identifier of the WTRU, and a user identifier identifying an application, a device or a user that will use the service to send and receive data.
13. The method of claim 11 or 12, wherein the first information comprises service selection assistance information to use to select a service instance to invoke.
14. The method of claim 13, further comprising:
selecting the service based on the service selection assistance information.
15. The method of any one of claims 11-14, wherein the first response comprises at least one of a session key for the WTRU, an identifier of a network slice and a session key for the node.
16. The method of claim 15, wherein the connection is established using the session key for the node.
17. The method of any one of claims 11-16, further comprising:
receiving, from the WTRU, user plane data together with the identifier of the connection.
18. The method of claim 17, further comprising:
transmitting the user plane data to the selected user plane node.
19. The method of any one of claims 11-18, further comprising:
transmitting, to the WTRU, information indicative of one or more radio access channel resources to use to establish the connection, the one or more radio access channel resources based on the connection.
20. The method of any one of claims 11-19, further comprising:
transmitting session management information over the connection.
21. A node in a radio access network, comprising at least one hardware processor configured to:
receive, from a wireless transfer/receive unit, WTRU, first information indicative of a type of service to invoke for the WTRU;
transmit, to a user plane function selection node, a request indicative of a service of the type of service to invoke for the WTRU and of an identifier of the WTRU;
receive, from the user plane function selection node, a first response indicative of a selected user plane node;

establish with the selected user plane node a connection for sending and receiving control plane information and data related to the connection; and

transmit, to the WTRU, a second response indicative of an identifier of the connection.

22. The node of claim 21, wherein the first information is indicative of at least one of a data network name identifier, a permanent identifier of the WTRU, and a user identifier identifying an application, a device or a user that will use the service to send and receive data.

23. The node of claim 21 or 22, wherein the first information comprises service selection assistance information to use to select a service instance to invoke.

24. The node of claim 23, wherein the at least one hardware processor is configured to:
select the service based on the service selection assistance information.

25. The node of any one of claims 21-24, wherein the first response comprises at least one of a session key for the WTRU, an identifier of a network slice and a session key for the node.

26. The node of claim 25, wherein the connection is established using the session key for the node.

27. The node of any one of claims 21-26, wherein the at least one hardware processor is configured to:

receive, from the WTRU, user plane data together with the identifier of the connection.

28. The node of claim 27, wherein the at least one hardware processor is configured to:
transmit the user plane data to the selected user plane node.

29. The node of any one of claims 21-28, wherein the at least one hardware processor is configured to:

transmit, to the WTRU, information indicative of one or more radio access channel resources to use to establish the connection, the one or more radio access channel resources based on the connection.

30. The node of any one of claims 21-29, wherein the at least one hardware processor is configured to:

transmit session management information over the connection.

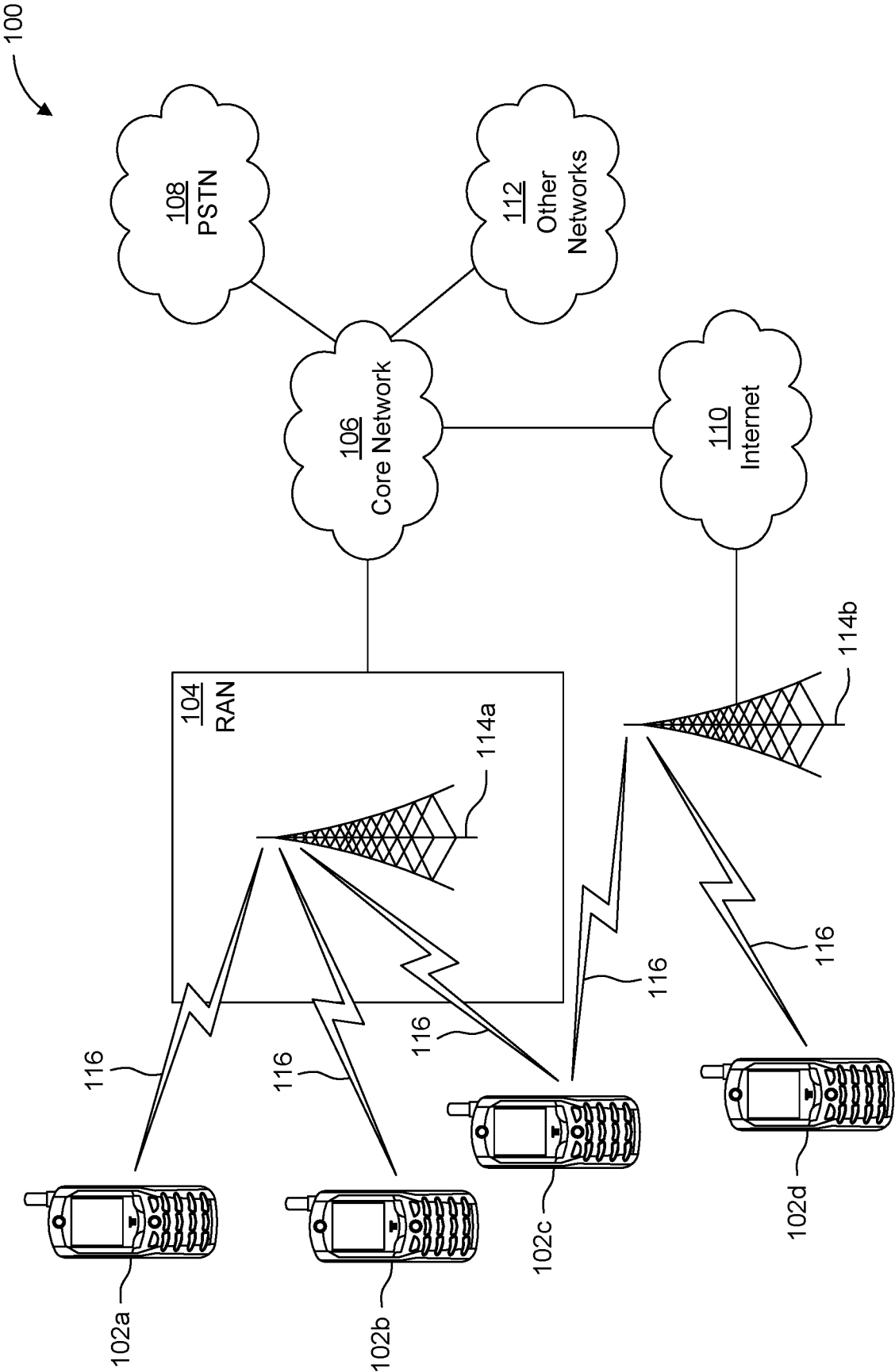


FIG. 1A

2/11

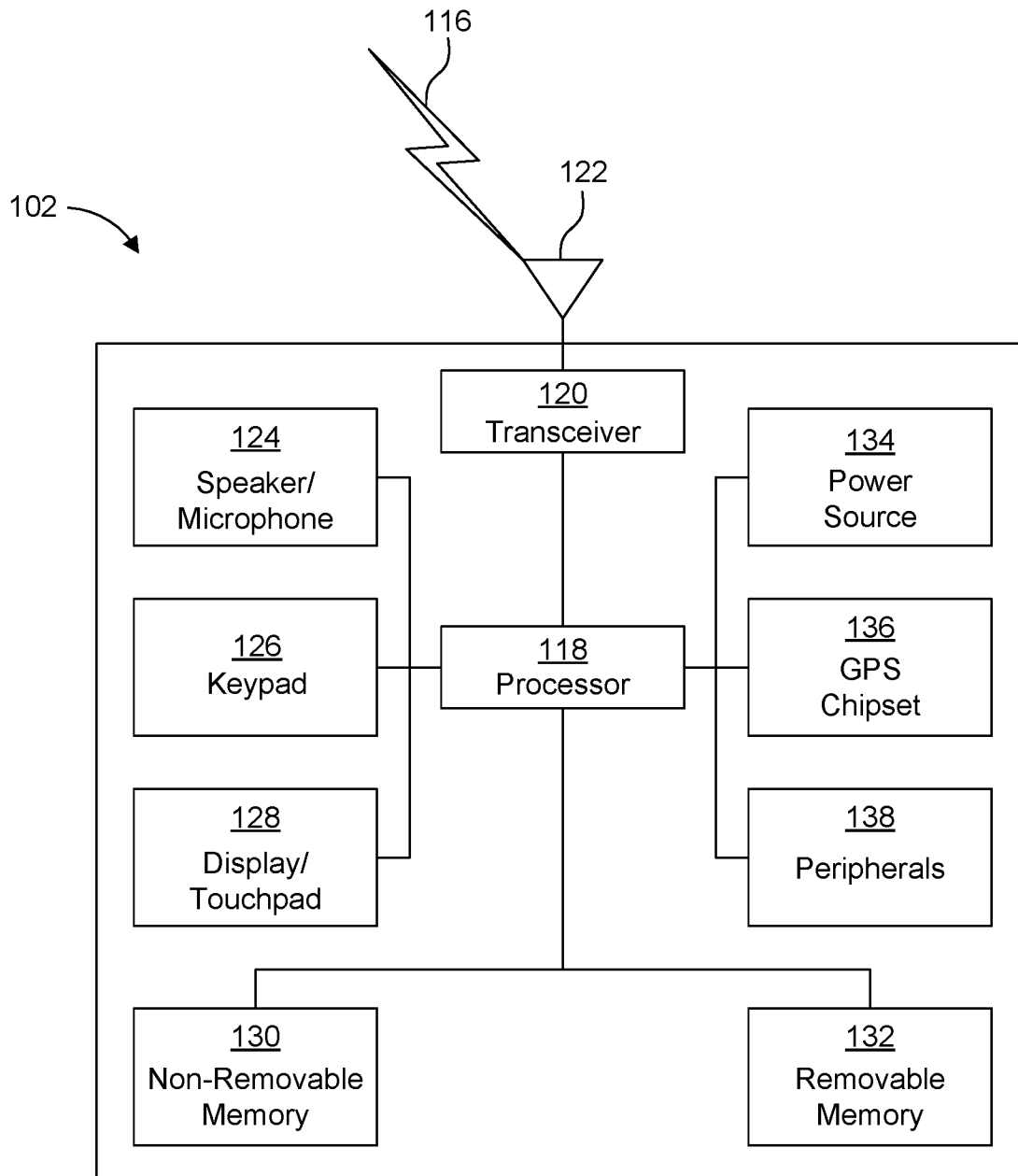


FIG. 1B

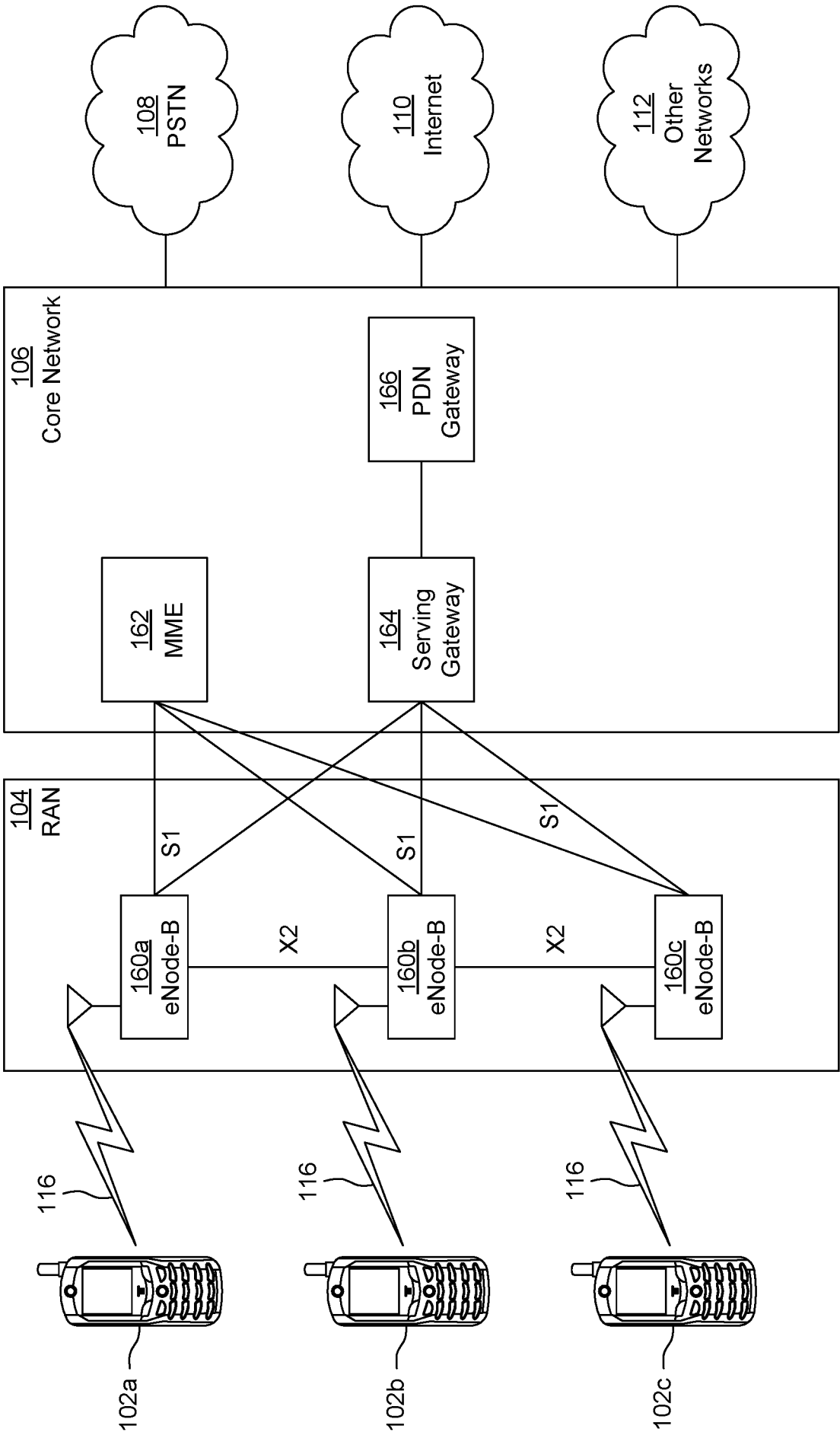


FIG. 1C

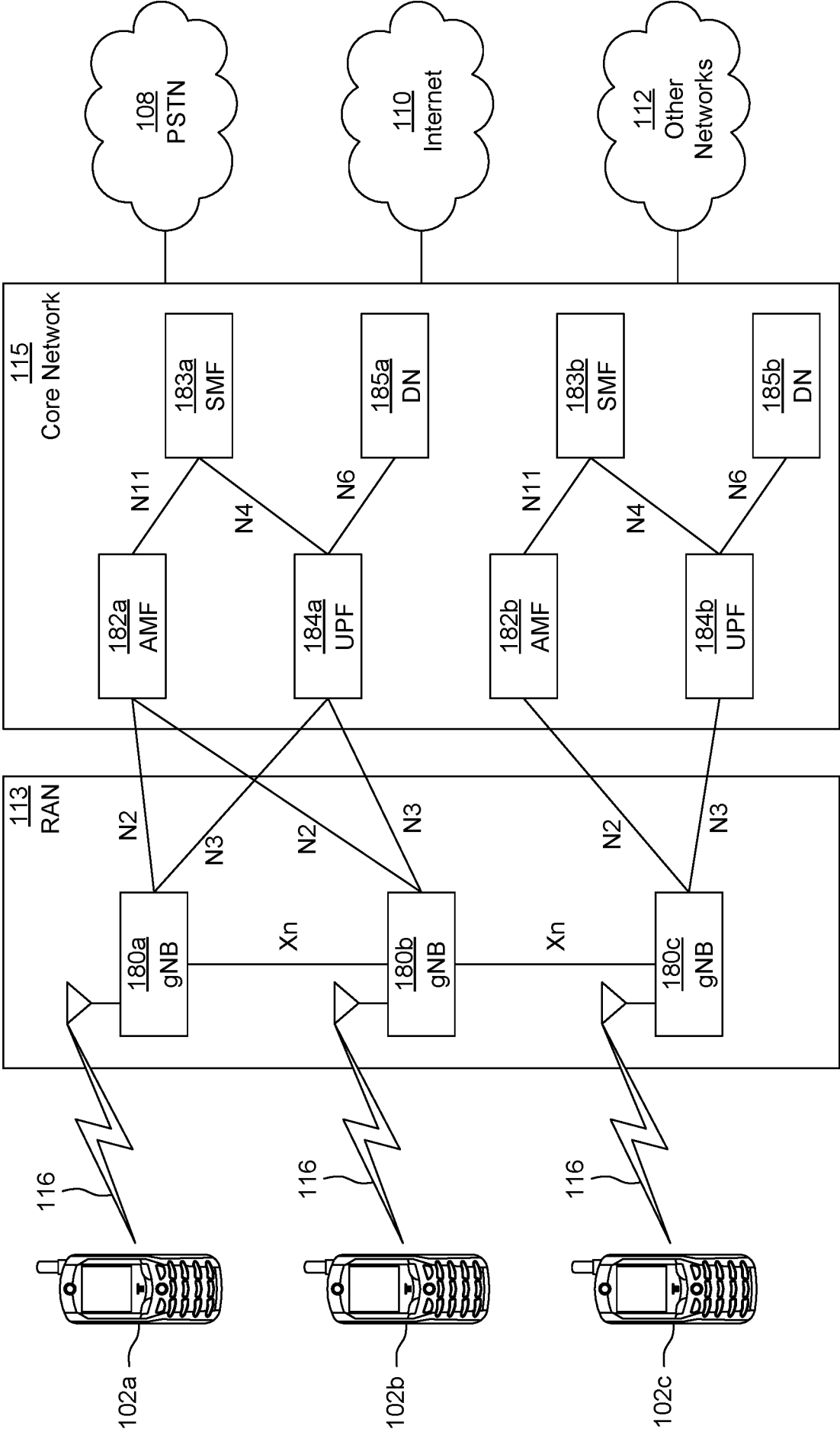


FIG. 1D

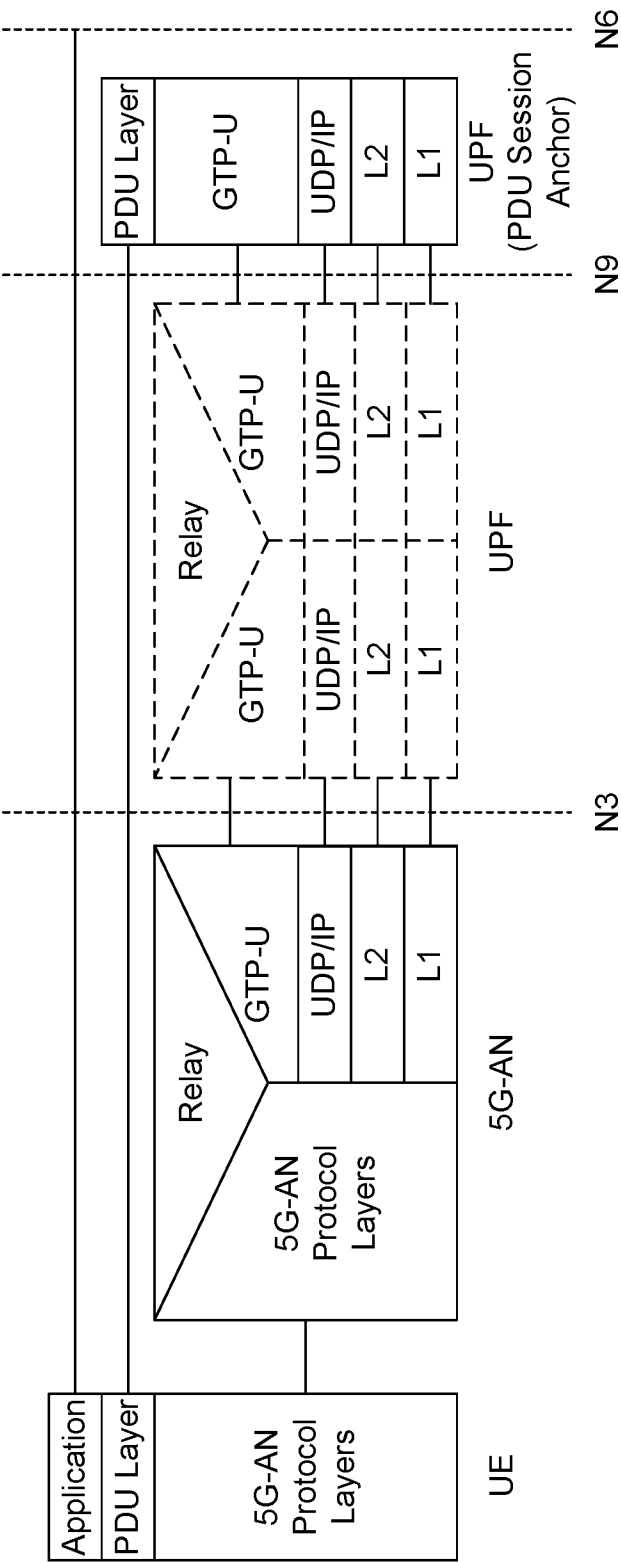


FIG. 2

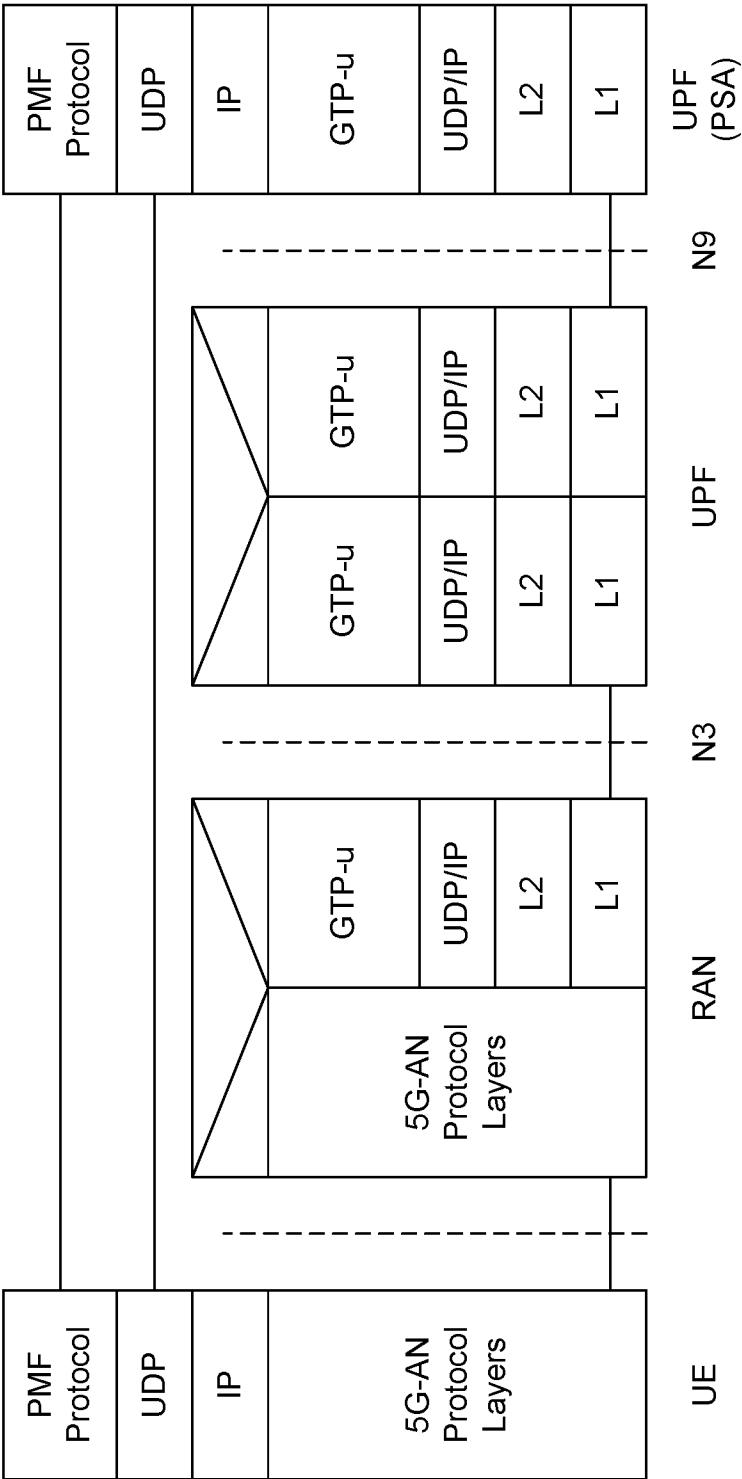


FIG. 3

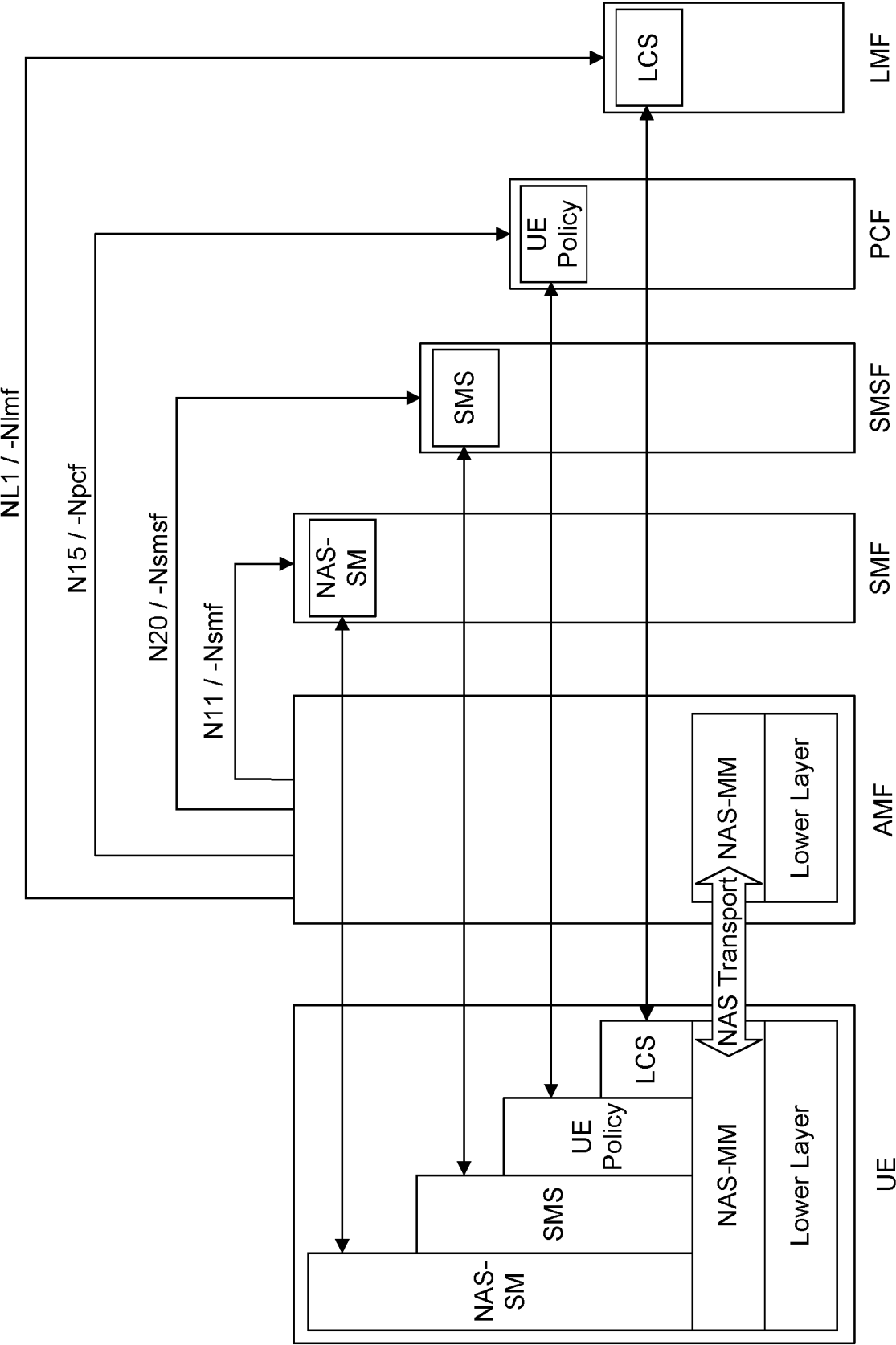


FIG. 4

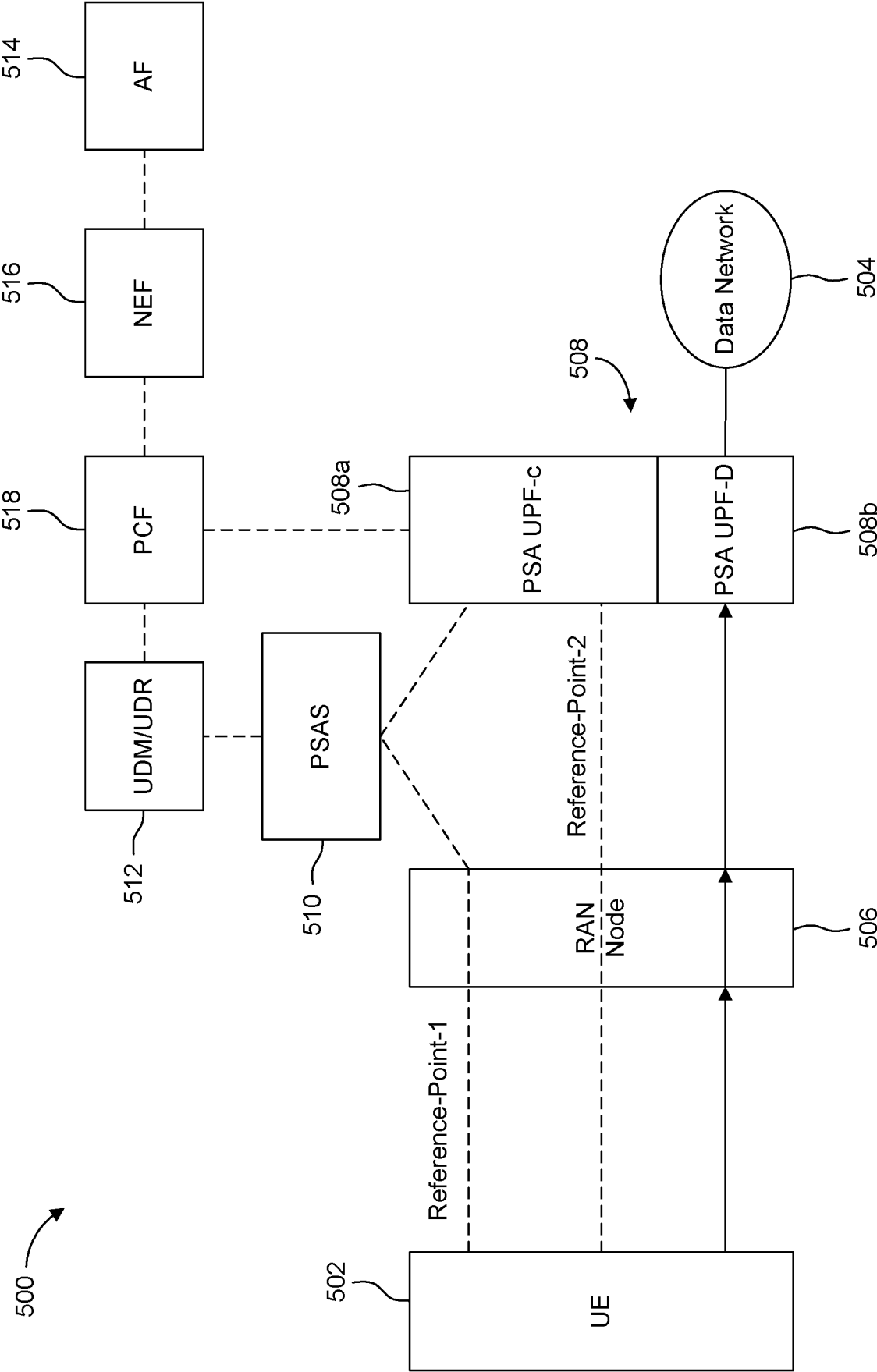


FIG. 5

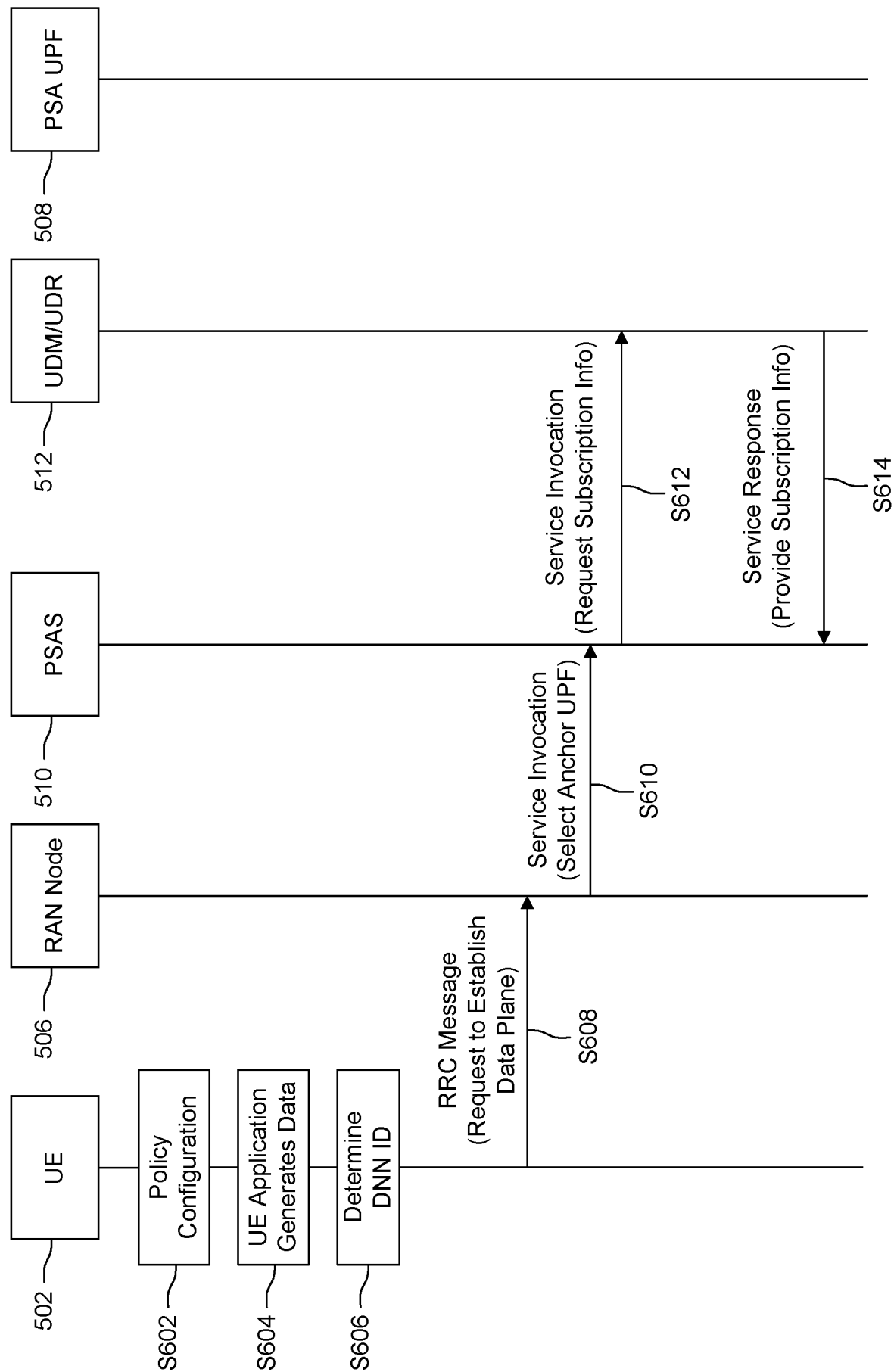


FIG. 6A

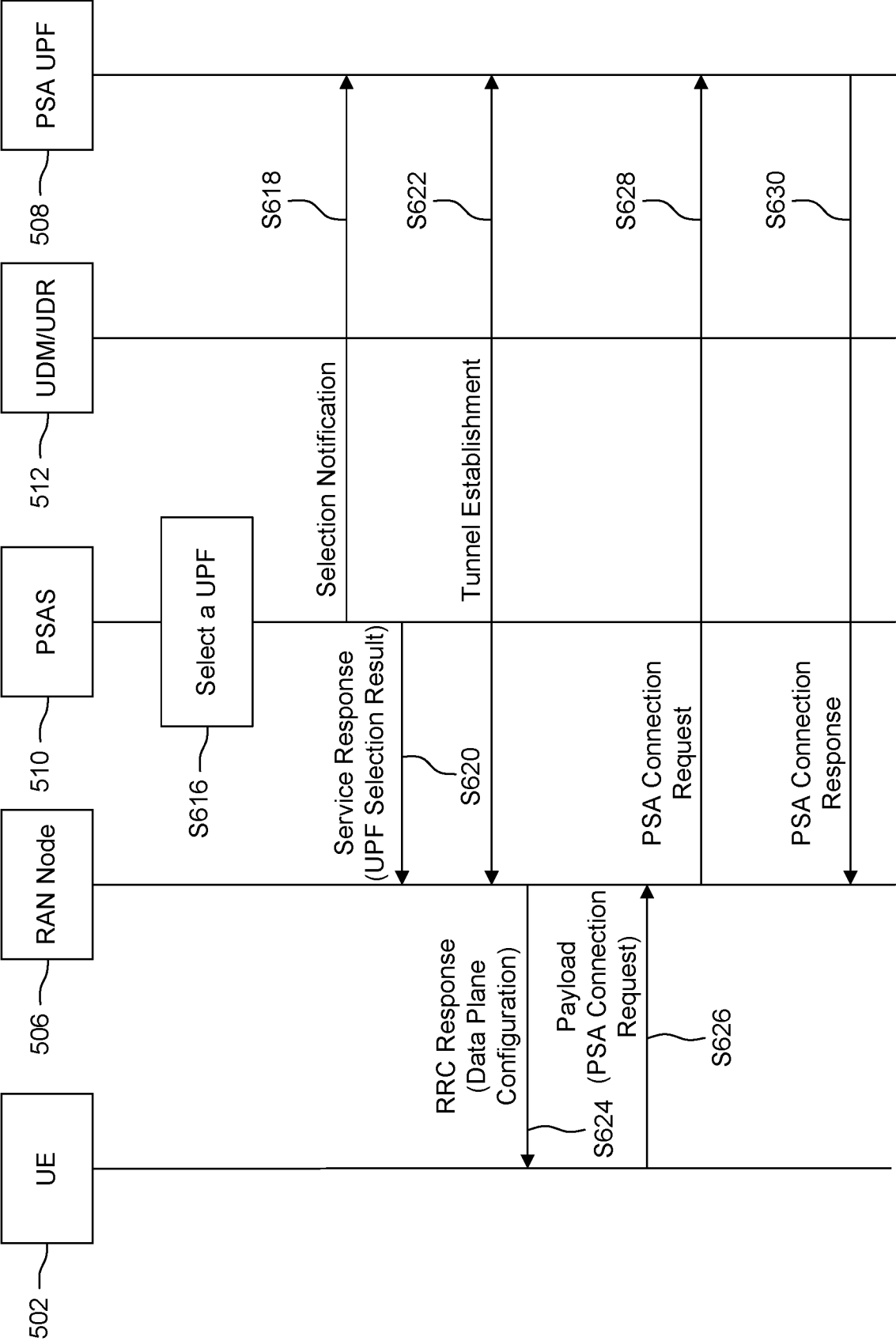


FIG. 6B

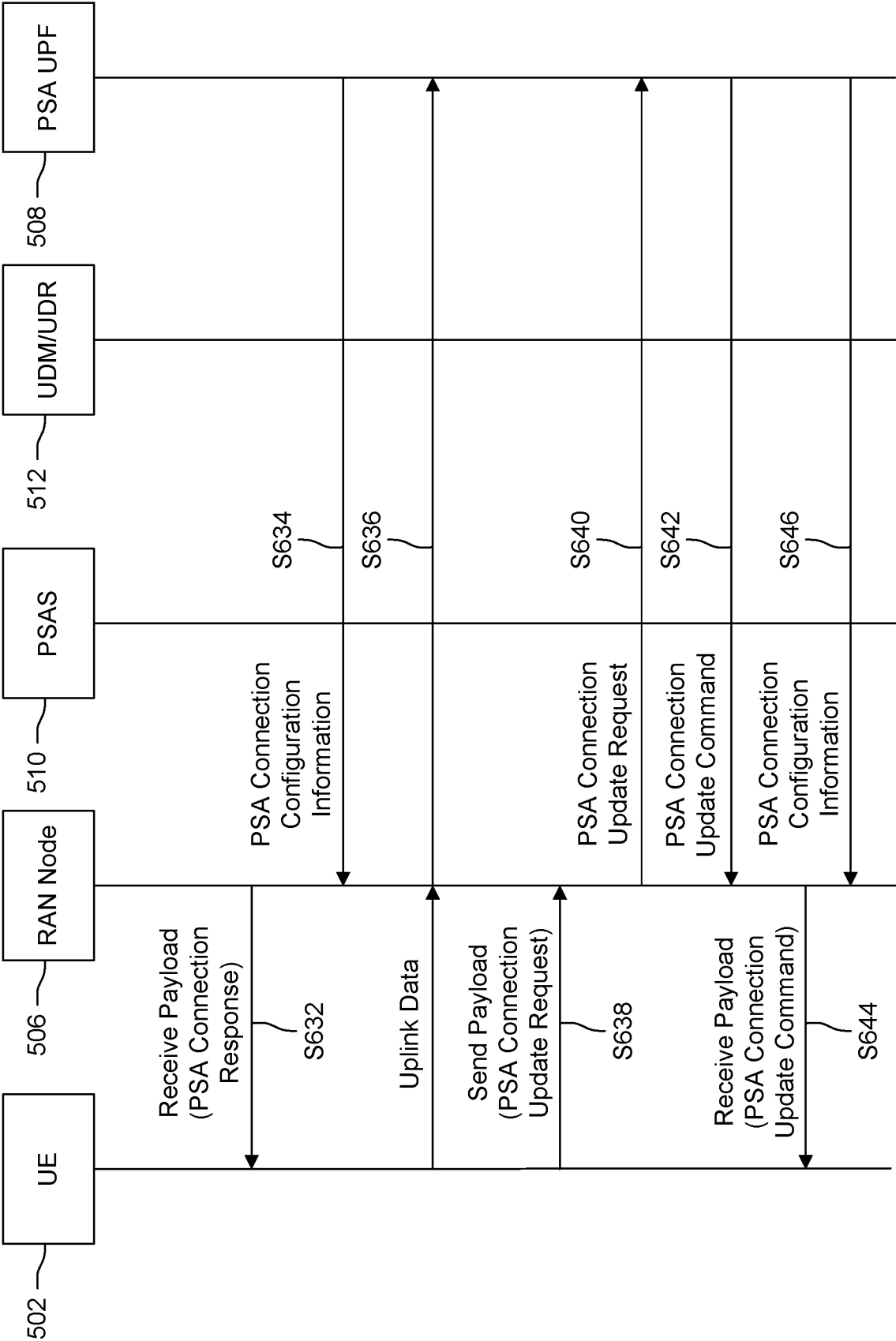


FIG. 6C

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/054837

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W72/543 H04W76/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	HUAWEI ET AL: "TS 23.502: Update on UPF relocation for UE during Service Request", 3GPP DRAFT; S2-174819_4294 UPDATE ON UPF RELOCATION FOR UE IN IDLE_V05, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; , vol. SA WG2, no. San Jose Del Cabo, Mexico; 20170626 - 20170630 3 July 2017 (2017-07-03), XP051309878, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_sa/WG2_Arch/TSGS2_122_Cabo/Docs/ [retrieved on 2017-07-03] point 1; page 6 point 8; - / - -	1 - 30



Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

3 February 2025

Date of mailing of the international search report

10/02/2025

Name and mailing address of the ISA/

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Authorized officer

Lebiedowski, Adam

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2024/054837

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	page 8 point 11; page 9 figures 4.2.3.2-1 ----- US 2019/274181 A1 (ZHU FENQIN [CN] ET AL) 5 September 2019 (2019-09-05) paragraph [0143] - paragraph [0161] -----	1-30

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2024/054837

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		CN 110290471 A	27-09-2019
		EP 3598800 A1	22-01-2020
		EP 3979707 A1	06-04-2022
		JP 6987866 B2	05-01-2022
		JP 2020502928 A	23-01-2020
		KR 20190077514 A	03-07-2019
		US 2019274181 A1	05-09-2019
		US 2022086942 A1	17-03-2022
		WO 2018166336 A1	20-09-2018
