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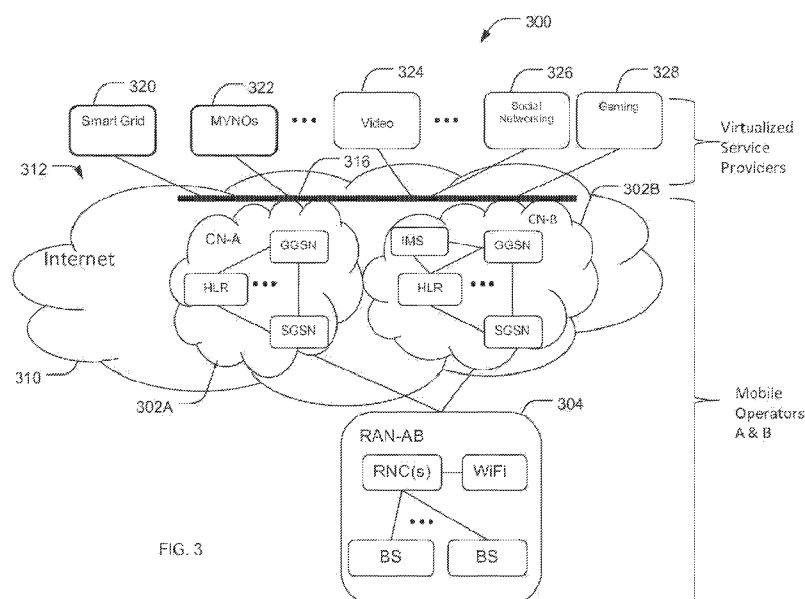


FIG. 3

(57) Abstract: Methods and/or systems for providing a mobile cloud and/or mobile network virtualization may be disclosed. For example, a mobile cloud system may be provided. The mobile cloud system may include a mobile core network that may include at least one node integrated into the Internet. The node may have a public IP address. The mobile cloud system may also include a network interface configured to provide communication between the node and a service provider connected to the Internet using the public IP address. The service provider may dynamically obtain a bulk portion or a per user portion of a capacity associated with the mobile cloud system and/or the mobile network associated therewith using the core network and/or node.

MOBILE NETWORK VIRTUALIZATION

BACKGROUND

[0001] Virtualization may include to a set of techniques for making a physical resource such as a machine, network, and the like appear as multiple logical resources. As a physical resource may appear as multiple logical resources, multiple users may have access to the same underlying physical resource simultaneously, but with potentially different service uses. Such users may also be unaware that they may be sharing the resource such as the computing machine, memory, network, storage and like. An example of such a virtualization, for example, where a physical resource may appear as multiple logical resources that may be used and/or shared by multiple includes cloud computing such as Internet cloud computing. Such cloud computing services typically include SaaS (Software as a Service) where, for example, application servers may be hosted remotely on the Internet, as opposed to locally in an enterprise or home, and accessed by a user with a thin client such as a web browser, PaaS (Platform as a Service) where, for example, a computing environment for development of user software may be hosted remotely on the Internet and accessed by the user for remote SW development, and IaaS (Infrastructure as a Service) where, for example, a computing infrastructure such as storage components, servers, and the like may be hosted remotely on the Internet and accessed by the user on demand. Unfortunately, current cloud computing techniques and or services tend to be limited to or oriented towards a fixed infrastructure for providing various features such as storage and application computing. For example, such cloud computing may be limited to enhanced data storage and/or caching and some application processing using a limited non-virtualized and/or fixed infrastructure in a mobile communication network.

SUMMARY

[0002] Systems and methods for providing a mobile cloud and/or mobile network virtualization may be disclosed. For example, in an embodiment, a mobile cloud system may be provided. The mobile cloud system may include a mobile core network that may include at least one node integrated into the Internet. The node may have a public IP address. The mobile cloud system may also include a network interface configured to provide communication between the node and a service provider connected to the Internet using the public IP address.

[0003] According to an embodiment, a mobile cloud system may include a core network and a radio access network in communication with the core network. The core network may include core network nodes integrated into the Internet. Each of the core network nodes may have a public IP address configured to be used to provide access to the core network nodes. Similarly, the radio access network may include radio access network nodes. In an example embodiment, at least one of the radio access nodes may be external to the Internet. Additionally, the core network nodes may be reachable by the radio access node that may be external to the Internet.

[0004] In an embodiment, a method for using a portion of a capacity provided by a mobile cloud system may be provided. For example, information may be received at a core network from a service provider. According to an example embodiment, the core network may include nodes having a public IP address configured to receive the information. At least one network element of the core network may be configured based on the information and a service from the service provider may be provided to an end user using the network element configured based on the information.

[0005] The Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Furthermore, the claimed subject matter is not limited to any limitations that solve any or all disadvantages noted in any part of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] A more detailed understanding of the embodiments disclosed herein may be had from the following description, given by way of example in conjunction with the accompanying drawings.

[0007] FIG. 1A depicts a diagram of an example communications system in which one or more disclosed embodiments may be implemented.

[0008] FIG. 1B depicts a system diagram of an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A.

[0009] FIG. 1C depicts a system diagram of an example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A.

[0010] FIG. 1D depicts a system diagram of another example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A.

[0011] FIG. 1E depicts a system diagram of another example radio access network and an example core network that may be used within the communications system illustrated in FIG. 1A.

[0012] FIG. 2 illustrates an example embodiment of an architecture of a mobile communications network that includes multiple core networks and multiple radio access networks.

[0013] FIG. 3 illustrates an example embodiment of a mobile cloud architecture or an architecture of a mobile communication network that may provide and/or implement one or more cloud computing techniques disclosed herein.

[0014] FIG. 4 illustrates another example embodiment of a mobile cloud architecture or an architecture of a mobile communication network that may provide and/or implement one or more cloud computing techniques disclosed herein.

[0015] FIG. 5 illustrates an example embodiment of an interconnection scheme of a mobile cloud.

[0016] FIG. 6 illustrates an example embodiment of a service provider using a portion such as a bulk portion of a capacity provided by a mobile cloud.

DETAILED DESCRIPTION

[0017] Systems and/or methods for implementing cloud computing techniques in a mobile communication network such that resources in the mobile communication network may be virtualized may be disclosed herein. In an embodiment, an architecture of a mobile communication network that may implement mobile cloud computing and/or virtualization (e.g. a mobile cloud network) may be provided. In such a mobile cloud network architecture, mobile core network nodes may be moved out of current firewalled operator networks and may be integrated into (e.g. directly into) the open Internet. Additionally, multiple mobile operator core networks may be provided in an integrated mobile cloud that may be global. In an example embodiment, a mobile cloud network and the methods and/or techniques that may enable the mobile cloud network may be recursively virtualized.

[0018] According to additional embodiment, systems and/or methods that may enable a third party virtual service provider (e.g. a third party bulk virtual service provided) such as mobile virtual network operators (MVNOs), smart grid operators, and the like to dynamically obtain a portion such as a bulk portion of a capacity associated with a mobile communication network and/or the mobile cloud thereof (e.g. a “bulk slice”) may be disclosed herein. Such systems and/or methods may include one or more of the following: providing and/or defining one or more network interfaces between a third party service provider and a mobile communication network; providing and/or defining network processing to assign and/or maintain a bulk slice; and the like.

[0019] In an example embodiment, systems and/or methods that may enable a third party virtual service provider (e.g. a third party per user slice virtual service provider) such as gaming, video, and/or social networking sites and/or providers thereof to dynamically obtain a per user portion of a capacity of a mobile communication network and/or the mobile cloud thereof (e.g. a “per user slice”) may also be disclosed. Such systems and/or methods may include one or more of the following: providing and/or defining one or more network interfaces between a third party service provider and the a communication network; providing and/or defining network processing to assign and maintain the per user slice; and the like.

[0020] FIG. 1A depicts a diagram of 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), and the like.

[0021] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, and/or 102d (which generally or collectively may be referred to as WTRU 102), a radio access network (RAN) 103/104/105, a core network 106/107/109, 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, and/or 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, and/or 102d may be configured to transmit and/or receive wireless signals and may include user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, consumer electronics, and the like.

[0022] The communications systems 100 may also include a base station 114a and 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, and/or 102d to facilitate access to one or more communication networks, such as the core network 106/107/109, the Internet 110, and/or the networks 112. By way of example, the base stations 114a and/or 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, 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 103/104/105, 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 within a particular geographic region, which may be referred to as a cell (not shown). 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 one 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, therefore, may utilize multiple transceivers for each sector of the cell.

[0024] The base stations 114a and/or 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, and/or 102d over an air interface 115/116/117, which may be any suitable wireless communication link (e.g., radio frequency (RF), microwave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 115/116/117 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 103/104/105 and the WTRUs 102a, 102b, and/or 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 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, and/or 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 115/116/117 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A).

[0027] In other embodiments, the base station 114a and the WTRUs 102a, 102b, and/or 102c may implement radio technologies such as 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.

[0028] 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, and the like. In one 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 yet 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, etc.) to establish a 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 core network 106/107/109.

[0029] The RAN 103/104/105 may be in communication with the core network 106/107/109, 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, and/or 102d. For example, the core network 106/107/109 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 103/104/105 and/or the core network 106/107/109 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 103/104/105 or a different RAT. For example, in addition to being connected to the RAN 103/104/105, which may be utilizing an E-UTRA radio technology, the core network 106/107/109 may also be in communication with another RAN (not shown) employing a GSM radio technology.

[0030] The core network 106/107/109 may also serve as a gateway for the WTRUs 102a, 102b, 102c, and/or 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 the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another core network connected to one or more RANs, which may employ the same RAT as the RAN 103/104/105 or a different RAT.

[0031] Some or all of the WTRUs 102a, 102b, 102c, and/or 102d in the communications system 100 may include multi-mode capabilities, i.e., the WTRUs 102a, 102b, 102c, and/or 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.

[0032] FIG. 1B depicts a system diagram of 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 other peripherals 138. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment. Also, embodiments contemplate that the base stations 114a and 114b, and/or the nodes that base stations 114a and 114b may represent, such as but not limited to transceiver station (BTS), a Node-B, a site controller, an access point (AP), a home node-B, an evolved home node-B (eNodeB), a home evolved node-B (HeNB), a home evolved node-B gateway, and proxy nodes, among others, may include some or all of the elements depicted in FIG. 1B and described herein.

[0033] 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 Array (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 may be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0034] 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 115/116/117. For example, in one 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 yet an embodiment, the transmit/receive element 122 may be configured to transmit and 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.

[0035] In addition, 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. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one 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 115/116/117.

[0036] 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 UTRA and IEEE 802.11, for example.

[0037] 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).

[0038] 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.

[0039] 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 115/116/117 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.

[0040] The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs 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, and the like.

[0041] FIG. 1C depicts a system diagram of the RAN 103 and the core network 106 according to an embodiment. As noted above, the RAN 103 may employ a UTRA radio

technology to communicate with the WTRUs 102a, 102b, and/or 102c over the air interface 115. The RAN 103 may also be in communication with the core network 106. As shown in FIG. 1C, the RAN 103 may include Node-Bs 140a, 140b, and/or 140c, which may each include one or more transceivers for communicating with the WTRUs 102a, 102b, and/or 102c over the air interface 115. The Node-Bs 140a, 140b, and/or 140c may each be associated with a particular cell (not shown) within the RAN 103. The RAN 103 may also include RNCs 142a and/or 142b. It will be appreciated that the RAN 103 may include any number of Node-Bs and RNCs while remaining consistent with an embodiment.

[0042] As shown in FIG. 1C, the Node-Bs 140a and/or 140b may be in communication with the RNC 142a. Additionally, the Node-B 140c may be in communication with the RNC 142b. The Node-Bs 140a, 140b, and/or 140c may communicate with the respective RNCs 142a, 142b via an Iub interface. The RNCs 142a, 142b may be in communication with one another via an Iur interface. Each of the RNCs 142a, 142b may be configured to control the respective Node-Bs 140a, 140b, and/or 140c to which it is connected. In addition, each of the RNCs 142a, 142b may be configured to carry out or support other functionality, such as outer loop power control, load control, admission control, packet scheduling, handover control, macrodiversity, security functions, data encryption, and the like.

[0043] The core network 106 shown in FIG. 1C may include a media gateway (MGW) 144, a mobile switching center (MSC) 146, a serving GPRS support node (SGSN) 148, and/or a gateway GPRS support node (GGSN) 150. While each of the foregoing elements are depicted as part of the core network 106, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0044] The RNC 142a in the RAN 103 may be connected to the MSC 146 in the core network 106 via an IuCS interface. The MSC 146 may be connected to the MGW 144. The MSC 146 and the MGW 144 may provide the WTRUs 102a, 102b, and/or 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, and/or 102c and traditional land-line communications devices.

[0045] The RNC 142a in the RAN 103 may also be connected to the SGSN 148 in the core network 106 via an IuPS interface. The SGSN 148 may be connected to the GGSN 150.

The SGSN 148 and the GGSN 150 may provide the WTRUs 102a, 102b, and/or 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between and the WTRUs 102a, 102b, and/or 102c and IP-enabled devices.

[0046] As noted above, the core network 106 may also be connected to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0047] FIG. 1D depicts a system diagram of the RAN 104 and the core network 107 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/or 102c over the air interface 116. The RAN 104 may also be in communication with the core network 107.

[0048] The RAN 104 may include eNode-Bs 160a, 160b, and/or 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, and/or 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, and/or 102c over the air interface 116. In one embodiment, the eNode-Bs 160a, 160b, and/or 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.

[0049] Each of the eNode-Bs 160a, 160b, and/or 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 and/or downlink, and the like. As shown in FIG. 1D, the eNode-Bs 160a, 160b, and/or 160c may communicate with one another over an X2 interface.

[0050] The core network 107 shown in FIG. 1D may include a mobility management gateway (MME) 162, a serving gateway 164, and a packet data network (PDN) gateway 166. While each of the foregoing elements are depicted as part of the core network 107, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0051] The MME 162 may be connected to each of the eNode-Bs 160a, 160b, and/or 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, and/or

102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, and/or 102c, and the like. The MME 162 may also provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM or WCDMA.

[0052] The serving gateway 164 may be connected to each of the eNode-Bs 160a, 160b, and/or 160c in the RAN 104 via the S1 interface. The serving gateway 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, and/or 102c. The serving gateway 164 may also perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when downlink data is available for the WTRUs 102a, 102b, and/or 102c, managing and storing contexts of the WTRUs 102a, 102b, and/or 102c, and the like.

[0053] The serving gateway 164 may also be connected to the PDN gateway 166, which may provide the WTRUs 102a, 102b, and/or 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, and/or 102c and IP-enabled devices.

[0054] The core network 107 may facilitate communications with other networks. For example, the core network 107 may provide the WTRUs 102a, 102b, and/or 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, and/or 102c and traditional land-line communications devices. For example, the core network 107 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the core network 107 and the PSTN 108. In addition, the core network 107 may provide the WTRUs 102a, 102b, and/or 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0055] FIG. 1E depicts a system diagram of the RAN 105 and the core network 109 according to an embodiment. The RAN 105 may be an access service network (ASN) that employs IEEE 802.16 radio technology to communicate with the WTRUs 102a, 102b, and/or 102c over the air interface 117. As will be further discussed below, the communication links between the different functional entities of the WTRUs 102a, 102b, and/or 102c, the RAN 105, and the core network 109 may be defined as reference points.

[0056] As shown in FIG. 1E, the RAN 105 may include base stations 180a, 180b, and/or 180c, and an ASN gateway 182, though it will be appreciated that the RAN 105 may include any number of base stations and ASN gateways while remaining consistent with an embodiment. The base stations 180a, 180b, and/or 180c may each be associated with a particular cell (not shown) in the RAN 105 and may each include one or more transceivers for communicating with the WTRUs 102a, 102b, and/or 102c over the air interface 117. In one embodiment, the base stations 180a, 180b, and/or 180c may implement MIMO technology. Thus, the base station 180a, for example, may use multiple antennas to transmit wireless signals to, and receive wireless signals from, the WTRU 102a. The base stations 180a, 180b, and/or 180c may also provide mobility management functions, such as handoff triggering, tunnel establishment, radio resource management, traffic classification, quality of service (QoS) policy enforcement, and the like. The ASN gateway 182 may serve as a traffic aggregation point and may be responsible for paging, caching of subscriber profiles, routing to the core network 109, and the like.

[0057] The air interface 117 between the WTRUs 102a, 102b, and/or 102c and the RAN 105 may be defined as an R1 reference point that implements the IEEE 802.16 specification. In addition, each of the WTRUs 102a, 102b, and/or 102c may establish a logical interface (not shown) with the core network 109. The logical interface between the WTRUs 102a, 102b, and/or 102c and the core network 109 may be defined as an R2 reference point, which may be used for authentication, authorization, IP host configuration management, and/or mobility management.

[0058] The communication link between each of the base stations 180a, 180b, and/or 180c may be defined as an R8 reference point that includes protocols for facilitating WTRU handovers and the transfer of data between base stations. The communication link between the base stations 180a, 180b, and/or 180c and the ASN gateway 182 may be defined as an R6 reference point. The R6 reference point may include protocols for facilitating mobility management based on mobility events associated with each of the WTRUs 102a, 102b, and/or 102c.

[0059] As shown in FIG. 1E, the RAN 105 may be connected to the core network 109. The communication link between the RAN 105 and the core network 109 may be defined as an R3 reference point that includes protocols for facilitating data transfer and mobility management capabilities, for example. The core network 109 may include a mobile IP home

agent (MIP-HA) 184, an authentication, authorization, accounting (AAA) server 186, and a gateway 188. While each of the foregoing elements are depicted as part of the core network 109, it will be appreciated that any one of these elements may be owned and/or operated by an entity other than the core network operator.

[0060] The MIP-HA may be responsible for IP address management, and may enable the WTRUs 102a, 102b, and/or 102c to roam between different ASNs and/or different core networks. The MIP-HA 184 may provide the WTRUs 102a, 102b, and/or 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, and/or 102c and IP-enabled devices. The AAA server 186 may be responsible for user authentication and for supporting user services. The gateway 188 may facilitate interworking with other networks. For example, the gateway 188 may provide the WTRUs 102a, 102b, and/or 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, and/or 102c and traditional land-line communications devices. In addition, the gateway 188 may provide the WTRUs 102a, 102b, and/or 102c with access to the networks 112, which may include other wired or wireless networks that are owned and/or operated by other service providers.

[0061] Although not shown in FIG. 1E, it should, may, and/or will be appreciated that the RAN 105 may be connected to other ASNs and the core network 109 may be connected to other core networks. The communication link between the RAN 105 the other ASNs may be defined as an R4 reference point, which may include protocols for coordinating the mobility of the WTRUs 102a, 102b, and/or 102c between the RAN 105 and the other ASNs. The communication link between the core network 109 and the other core networks may be defined as an R5 reference, which may include protocols for facilitating interworking between home core networks and visited core networks.

[0062] As described above, current cloud computing such as Internet cloud computing may be limited to or oriented towards a fixed infrastructure and enterprise related features such as storage and application computing. For example, such cloud computing may be limited to enhanced data storage and/or caching and some application processing using a limited non-virtualized and/or fixed infrastructure (e.g. in a mobile communication network). As such, systems and/or methods described herein may expand the functionality of cloud computing to include various aspects of a mobile communication network. For example, in embodiments, components or portions of a mobile communication network may be virtualized

to generate a mobile cloud. The mobile cloud may be used to provide features and functionalities of enhanced data storage, caching, and/or application processing in a mobile communication network as well as virtualization and/or a flexible architecture as described herein.

[0063] For example, an overall architecture of a mobile cloud network (e.g. a mobile communication network that may implement, provide, and/or include a mobile cloud) may be provided. In an embodiment, at least some of the mobile core network nodes may be moved out of current firewalled operator networks and integrated into (e.g. directly into) the Internet (e.g. the open Internet). Additionally, a single integrated global mobile cloud may replace at least a portion of a mobile operator core network or multiple mobile operator core networks. As described herein, the systems and/or methods that may enable the mobile cloud network to be recursively virtualized (e.g., the HLRs, SGSNs, and the like) may also be provided.

[0064] As described herein, the systems and methods described below may also allow or enable a third party virtual service provider to dynamically obtain a bulk portion of a mobile networks capacity (e.g. a “bulk slice”) and/or a per user portion of a mobile networks capacity (e.g. a “per user slice”).

[0065] FIG. 2 illustrates an example architecture of a mobile communications network such as a mobile communications network 200. As shown in FIG. 2, the mobile communications network (e.g. 200) may include one or more operators such as a first mobile operator (e.g. or mobile operator A) and a second mobile operator (e.g. or mobile operator B). In an example embodiment, each of operators (e.g. the first and second mobile operators or mobile operator A and B) may have their own (e.g. separate) infrastructure. For example, as shown in FIG. 2, the mobile communications network may include one or more core networks (CNs) such as a first core network (e.g. or core network-A) 202A and a second core network (e.g. or core network-B) 202B. The one or more core networks may be any suitable CN including, for example, a 3G CN, a LTE CN, a LTE-Advanced CN, and the like. According to an example embodiment, the first mobile operator or mobile operator-A may include, have, maintain, and/or be associated with the first core network (e.g. or core network-A) 202A and the second mobile operator or mobile operator-B may include, have, maintain, and/or be associated with the second core network (e.g. or core network-B) 202B. Additionally, the mobile communications network (e.g. 200) may further include one or more radio access networks (RANs) such as a first radio access network (e.g. or RAN-A) 204A and

a second radio access network (e.g. or RAN-B) 204B. According to an example embodiment, the first mobile operator or mobile operator-A may include, have, maintain, and/or be associated with the first radio access network (e.g. or RAN-A) 204A and the second mobile operator or mobile operator-B may include, have, maintain, and/or be associated with the second radio access network (e.g. RAN-B) 204B. As such, as shown in FIG. 2, in an embodiment, the core networks and/or radio access networks may be included in an infrastructure provided by the operators where the first operator may operate CN 202A and RAN 204A and a second operator may operate CN 202B and RAN 204B.

[0066] In an embodiment, the CNs and RANs between operators may have different configurations and/or infrastructures. For example, as shown in FIG. 2, WiFi may be provided and supported by the first operator in the first RAN 204A while WiFi may not be provided and supported by the second operator in the second RAN 204B. Similarly, the CN 202B that may be provided by the second operator may provide or support an IP Multimedia Subsystem (IMS) infrastructure while the CN 202A that may be provided by the first operator may not provide or support an IMS infrastructure.

[0067] As shown in FIG. 2, a mobile communications network (e.g. 200) may be IP based such that components of the mobile communications network (e.g. 200) that may be provided and/or supported by the first and second operators such as the first core network 202A and the second core network 202B may be connected to the Internet (e.g. for user traffic) by one or more Internet connections such as Internet connections 206A and 206B, but may otherwise be maintained as an isolated (e.g. private) operator controlled network. For example, components of a mobile communications network (e.g. 200) may be connected to the Internet, but may be an isolated (e.g. private) operator controlled network by surrounding the core network (CN) such as the first core network or CN-A (e.g. 202A) and the second core network or CN-B (e.g. 202B) with a firewall that may prevent external IP packets from reaching one or more of the nodes of the CN directly. According to an example embodiment, one or more the nodes within the CN may also be assigned private IP addresses to isolate them from the public Internet.

[0068] In an embodiment, value added services such as value added services 208 that may be tailored for a mobile communication system (e.g. 200) and a mobile environment may also be provided. As shown in FIG. 2, value added services (e.g. 208) may include streaming video, social networking, instant messaging services, and the like, for example,

may be provided by the operator themselves or third party providers (e.g. closely cooperating third party providers or companies). Such third party providers may use custom or proprietary interfaces (e.g. special interfaces) to the CNs (e.g. 202A and/or 202B) associated with the operators such as the mobile operator A and/or B and may have a pre-defined business relationship with the operator such as the mobile operator A and/or B. As such, typical mobile value added services (e.g. 208 shown in FIG. 2) may be agreed to and customized per operator. Additionally, video and other services may be offered “over the top” through the Internet connections to the mobile networks, but such over the top services may not (e.g. by definition) be fully optimized for a mobile communications network (e.g. 200) and/or a mobile environment that may have more stringent and demanding operating characteristics than a fixed Internet.

[0069] As such, as described herein, the CN such as the first and second core networks or CN-A and CN-B (e.g. 202A and 202B) and the first and second radio access networks or RAN-A and RAN-B (e.g. 204A and 204B) may be isolated from the Internet except for a limited or fixed pipeline, interface, or point (e.g. a special interface such as 206A and/or 206B) in the mobile network where access to data or information may be funneled, which may be cumbersome and expensive. For example, an application on a device such as user equipment (UE) may be executed to initiate a service such as value added services (e.g. 208). Currently, to access information associated a mobile network for the service and/or the application, the application may use or establish a special interface and/or agreement as described above with the operator of the components of the mobile network. Additionally, even with such a special interface and/or agreement, the information accessible may be limited, for example, to or by a location of an operator, to information associated with a billing system that may be maintained by the operator, by SMS, and the like.

[0070] FIG. 3 illustrates an example embodiment of a mobile cloud architecture or, for example, an architecture of a mobile communication network (e.g. 300) that may provide and/or implement one or more cloud computing techniques disclosed herein. As shown in FIG. 3, in an embodiment, one or more components of an operator such as mobile operator A and/or mobile operator B may be virtualized and integrated into the Internet, which collectively may be a mobile cloud where a “Network as a Service” may be established. For example, a first core network (e.g. CN-A) such as a first core network or CN-A 302A and a second core network (e.g. CN-B) such as a second core network or CN-B 302B may be

virtualized and integrated into the Internet such as the Internet 310, which collectively may be referred to as a mobile cloud such as a mobile cloud 312 where a “Network as a Service” may be established. In such an embodiment (e.g. as shown in FIG. 3), the operators such as the first and/or second mobile operators (e.g. or mobile operators A and/or B) associated with or that may provide the various CNs (e.g. 302A and/or 302B) may continue to maintain separate CNs within the Internet (e.g. 310).

[0071] As shown in FIG. 3, in an example embodiment, the first and second core networks or CN-A and CN-B (e.g. 302A and 302B) may be integrated into the Internet (e.g. 310) rather than being maintained as stand-alone private IP networks. As such, nodes associated with the first and second core networks or CN-A and CN-B may be assigned a public IP address and may send and/or receive IP packets with one or more other components, nodes, service providers, or services in the Internet (e.g. 310) or in communication with the Internet (e.g. 310). For example, as shown in FIG. 3, one or more nodes such as a HLR, GGSN, SGSN, and the like associated with the first core network or CN-A (e.g. 302A) may be assigned a public IP address and may send and/or receive IP packets between each other or with other nodes in the Internet (e.g. 310) such as one or more nodes associated with the second core network or CN-B (e.g. 302B) and/or other components in communication with the Internet (e.g. 310) such as one or more service providers or services as described below. Similarly, one or more nodes such as components, modules, or boxes of HLR, GGSN, and/or SGSN, and the like associated with the second core network or CN-B (e.g. 302B) may be assigned a public IP address and may send and/or receive IP packets between each other or with other nodes in the Internet (e.g. 310) such as one or more nodes associated with the first core network or CN-A (e.g. 302A) and/or other components in communication with the Internet (e.g. 310) such as one or more service providers or services as described below. In an example embodiment, integrating or moving one or more components such as a core network (e.g. 302A and/or 302B) of mobile network or operator such as operator A and B to the Internet (e.g. 310) to form a mobile cloud (e.g. 312) may enable additional services and features to be used and may make a mobile cloud (e.g. 312) in line with Internet concepts such as Web 2.0 rather than current or traditional telecommunications or mobile communication network concepts.

[0072] According to an example embodiment, the operators such as the first and/or second mobile operators (e.g. mobile operators A and/or B) may also share a radio access

network such as a RAN 304 or may continue to operate separately maintained RANs. As shown in FIG. 3, in an embodiment, the radio access network or RAN-AB (e.g. RAN 304) may be connected to the first and second core network or CN-A and CN-B (e.g. 302A and 302B) and/or nodes such as RNCs, BSs, WiFi, and the like associated therewith, but may be an isolated (e.g. private) operator controlled network by being surrounded with a firewall that may prevent IP packets not associated with the first or second core network or CN-A or CN-B (e.g. 302A and 302B) or nodes associated therewith from reaching one or more of the nodes of the radio access network or RAN-AB (e.g. 304) directly. According to an example embodiment, one or more the nodes within the radio access network or RAN-AB (e.g. 304) may further be assigned private IP addresses to isolate them from the public Internet (e.g. components or nodes that may not be associated with or provided by the first and second core networks or CN-A and CN-B (e.g. 302A and 302B)). In an embodiment, one or more nodes such as a RNC included in or associated with the random access network or RAN-AB (e.g. 304) may also be moved or integrated into the Internet (e.g. 310) and may be assigned public IP addresses and, thus, may be included in the mobile cloud (e.g. 312). While FIG. 3 illustrates one random access network or RAN-AB (e.g. 304) additional random access networks or RANs may be provided and/or used herein. For example, there may be several RANs talking to several CNs (e.g. with some CNs being in the mobile cloud 312 and others still deployed as stand-alone traditional CNs). Additionally, a plurality of RANs (e.g. grouped by operator) may be provided where each RAN may be in communication with a core network or CN (e.g. 302A and/or 302B) that may be included in a mobile cloud (e.g. 312). Additionally, in embodiments, one or more layers of a device such as user equipment (UE) (not shown) may be moved or integrated into the Internet (e.g. 310) and the mobile cloud (e.g. 312).

[0073] A variety of service providers or services associated therewith (e.g. third party service providers and services associated therewith) may communicate with one or more components or nodes associated with the first or second operators that may be included in the Internet (e.g. 310) and may form the mobile cloud (e.g. 312). For example, as shown in FIG. 3, various service providers and or services such as a smart grid operator or service 320, one or more MVNOs or services 322, video content providers or services 324, social networking providers or services 326, gaming providers or services 328, and the like may communicate with (e.g. be in communication with) the first and second core networks or CN-A and CN-B (e.g. 302A and 302B) and one or more nodes associated therewith that may be included in the

Internet (e.g. 310) and may form the mobile cloud (e.g. 312). Other types of service providers or services (e.g. not shown) may communicate with the mobile cloud (e.g. 312) and the components included therein such as the first and second core networks or CN-A and CN-B (e.g. 302A and 302B) and the nodes associated therewith. Unlike the typical mobile value added services (e.g. 208 shown in FIG. 2), value added service providers (e.g. the smart grid operator or service 320, one or more MVNOs or services 322, video content providers or services 324, social networking providers or services 326, gaming providers or services 328, and the like) that may be used in the systems and methods described herein may be independent from an operator such as mobile operator A and B.

[0074] The service providers or services (e.g. the smart grid operator or service 320, one or more MVNOs or services 322, video content providers or services 324, social networking providers or services 326, gaming providers or services 328, and the like) may be independent of the operator such as the first and second operators or mobile operators A and B (e.g. may be “virtual” service providers or services) and may access the first and second core network or CN-A and CN-B (e.g. 302A and 302B) via open network interfaces such as a network interface 316. The network interfaces (e.g. 316) may be uniform across the operators such as the first and second operators or mobile operator A and B and may segregated, for example, into “bulk service” network interfaces and “per user” network interfaces. While network interfaces 316 may be uniform across the operators, some network interfaces may return a null response or other type of response if the respective core network such as the CN-A or CN-B (e.g. 302A and 302B) may not support the functionality of the service provider. In one embodiment, for example, a network interface call from a service provider to an IMS feature in a core network such as the first core network or CN-A (e.g. 302A) shown in FIG. 3 may be return a null response since the first core network or CN-A (e.g. 302A) may not include IMS functionality. In comparison, the same call to an IMS feature in a core network such as the second core network or CN-B (e.g. 302B) may return a positive response since the second core network or CN-B (e.g. 302B) may include and/or support IMS functionality.

[0075] Additionally, according to an example embodiment, the service providers or services may communicate with the components that may be included in the mobile cloud (e.g. 312) such as the first and second core networks or CN-A and CN-B (e.g. 302A and 302B) and the nodes included therein (e.g. a HLR, GGSN, SGSN, IMS components,

modules, or boxes, and the like) via a HTTP Request such as GET, PUT, POST, DELETE, HEAD, TRACE, OPTIONS, CONNECT, PATCH, and the like over the network interface (e.g. 316). For example, the service providers or services may send an HTTP request to the components or nodes included in the mobile cloud (e.g. 312) such as the first and second core networks or CN-A and CN-B (e.g. 302A and 302B) and the nodes associated therewith via the network interface (e.g. 316). The components or nodes may then respond by giving the service providers or services an open application programming interface (API) or another interface via the network interface (e.g. 316) to exchange information without a special agreement or interface being used.

[0076] In an embodiment, mobile network protocols such as 3GPP Mobility Management, 3GPP Call Control, and the like may run unchanged inside a mobile cloud (e.g. 312). Alternatively or additionally, other mobile network protocols may be used (e.g. 3GPP Mobility Management protocols may be replaced by other IP centric mobility management protocols). As such, according to example embodiment, the mobile cloud (e.g. 312) and the flexibility of the architecture thereof may enable multiple models to be handled.

[0077] Additionally, in example embodiments, service providers or services may request capacity from a mobile cloud (e.g. 312). For example, the service providers or services may not use dedicated servers to add new services when a mobile cloud such as the mobile cloud (e.g. 312) shown in FIG. 3 may be provided. As such, the mobile cloud (e.g. 312) may allow or enable accelerated service roll-out schedules with operators and/or service providers adding or removing capacity by dynamically provisioning.

[0078] FIG. 4 illustrates an example embodiment of a mobile cloud architecture or an architecture of a mobile communication network (e.g. 400) that may provide and/or implement one or more cloud computing techniques disclosed herein. As shown in FIG. 4, a core network or CN such as the core network or CN 402 and/or a radio access network or RAN such as the radio access network or RAN 404 may be shared between operators to create a global mobile cloud such as a global mobile cloud 412. The global mobile cloud (e.g. 412) may be formed in a variety of ways. For example, in one embodiment, a core network or CN (e.g. 402) and nodes associated therewith may be moved or integrated into the Internet such that the core network or CN may stretch across the world to form a unified global mobile cloud (e.g. as illustrated in FIG. 4). Such an implementation may be similar to and/or a subset of the Global Internet. Additionally, in such an implementation, the core

network or CN (e.g. 402) and/or the nodes associated therewith may have a public IP address, and the like associated therewith such that the core network or CN (e.g. 402) and the one or more nodes associated therewith (e.g. IMS, HLRs, GGSNs, SGSNs, and the like) may send and/or receive IP packets with one or more other components, nodes, service providers, or services in the Internet or in communication with the internet as described above.

[0079] In an embodiment, a relatively small number of core networks or CNs and nodes associated therewith may be moved or integrated into the Internet and may form regional mobile clouds (e.g. European, Asian, North American, and the like) (not shown) that may be used to provide the functionality of the mobile cloud described herein to particular geographical areas. For example, in such an implementation, the core networks or CNs and/or the nodes associated therewith may have a public IP address, and the like associated therewith such that the core networks or CNs and the one or more nodes associated therewith (e.g. IMS, HLRs, GGSNs, SGSNs, and the like) may send and/or receive IP packets with one or more other components, nodes, service providers, or services in the Internet or in communication with the Internet as described above.

[0080] According to additional embodiments, one or more radio access networks or RANs (e.g. 404) and/or one or more nodes associated therewith may be moved or integrated into the Internet in, for example, the unified global mobile cloud (e.g. 412 shown in FIG. 4) or the regional mobile clouds (not shown). In such an embodiment, the one or more radio access networks or RANs (e.g. 404) and/or the one or more nodes associated therewith may also have may have a public IP address, and the like associated therewith such that the radio access networks or RANs and the one or more nodes associated therewith (e.g. RNCs, BSs, WiFi, and the like) may send and/or receive IP packets with one or more other components, nodes, service providers, or services in the Internet or in communication with the Internet as described above.

[0081] Similar to FIG. 3, common mobile or open network interfaces such as a network interface 416 across operators may be provided and used. The network interfaces (e.g. 416) may be uniform across the operators and may be segregated into “bulk service” network interfaces and “per user” network interfaces, for example.

[0082] A variety of service providers may communicate with the global mobile cloud (e.g. 412) or regional global clouds as described above. Various service providers may

include, without limitation, a smart grid operator 420, one or more MVNOs 422, video content providers 424, social networking providers 426, and gaming providers 428. As it to be appreciated, numerous other types of service providers and/or entities may communicate with the global mobile cloud 412. For example, as shown in FIG.4, various service providers and or services such as a smart grid operator or service 420, one or more MVNOs or services 422, video content providers or services 424, social networking providers or services 426, gaming providers or services 428, and the like may communicate with (e.g. be in communication with) the core network or CN (e.g. 402) and one or more nodes associated therewith that may be included in the Internet and may form the mobile cloud (e.g. 412). Other types of service providers or services (e.g. not shown) may communicate with the mobile cloud (e.g. 412) and the components included therein such as the core network or CN (e.g. 402) and the nodes associated therewith. Unlike the typical mobile value added services (e.g. 208 shown in FIG. 2), value added service providers (e.g. the smart grid operator or service 420, one or more MVNOs or services 422, video content providers or services 424, social networking providers or services 426, gaming providers or services 428, and the like) that may be used in the systems and methods described herein may be independent from an operator such as mobile operator A and B. Additionally, in an embodiment, the service providers or services may request capacity from the mobile cloud as described herein.

[0083] Still referring to FIG. 4, in one embodiment, costs and/or profits for the global mobile cloud 412 may be divided between the respective operators. For example, the operators may form a partnership, consortium, association, or some other business relationship to run and manage the global mobile cloud (e.g. 412). As such, the global mobile cloud (e.g. 412) may allow or enable cost savings and increases in efficiency, for example, due to economies of scale and/or other benefits.

[0084] Although FIG. 4 illustrates an embodiment of a global mobile cloud with a core network or CN integrated therein, additional components may be included or integrated into the mobile cloud (e.g. 412). For example, there may be several RANs talking to several CNs where one or more CNs may be integrated into the mobile cloud and one or more CNs may be still deployed as stand-alone traditional CNs. Additionally, operators may believe that their competitor advantage may be coverage rather than the CN. As such, there may be several RANs, but a single mobile cloud CN.

[0085] FIG. 5 illustrates an example embodiment of an interconnection scheme such as an interconnection scheme 500 of a mobile cloud such as a mobile cloud 512. As shown in FIG. 5, a global core network or CN such as a core network or CN 502 may be shared by the operators in the world or at least a subset of the operators in the world. Similarly, a global radio access network or RAN such as a radio access network or RAN 504 may be shared by the operators in the world or at least a subset of the operators in the world. As described above, the global core network or CN (e.g. 502) and one or more nodes associated therewith may have public IP addresses. Because the global core network or CN (e.g. 502) and the one or more nodes associated therewith may have reachable public IP addresses, a network interface call may be terminated and processed in any suitable or appropriate node of the global core network or CN (e.g. 502). As such, one or more nodes in the global core network or CN (e.g. 502) such as a SGSN, GGSN, HLR, IMS, and the like may be fully integrated into the Internet such as the Internet 510 and may, therefore, send and/or receive IP packets from any other node in the Internet or connected to the Internet as described above. According to an example embodiment, the global core network or CN (e.g. 502) and one or more nodes associated therewith may not be isolated by firewalls and other components, mechanisms, or techniques from the Internet with specific gateways acting as connection points to the Internet (e.g. as shown and described above with respect to FIG. 2).

[0086] In example embodiments, one or more components such as the global core network or CN (e.g. 502) and/or a radio access network or RAN or nodes within a global mobile cloud (e.g. 512) may be connected via tunnels 540, such as VPN tunnels or other encapsulating tunnels, for example, to protect and control the mobile traffic moving between these nodes. The tunnels 540 may run over the general Internet 510 such that dedicated links or other hardware may not be used between the nodes. As such, even though a component such as core network or CN (e.g. 502, 402, 302A and/or 302B) or a radio access network or RAN and one or more nodes associated therewith may be moved or integrated into the Internet and the mobile cloud (e.g. may have public IP addresses), the data or information included in or provided by the core network(s) or CN(s) or the radio access network or RAN and the one or more nodes associated therewith may be protected. To protect such data or information, virtual private networks (VPNs) may be established and/or an encrypted tunnel or interface may be used. For example, mobility protocols such as MIP, PMIP, DSMIP or other suitable distributed mobility management protocol and/or its IPV6 variant may be used and/or provided to enable the mobile communications network to operate as normal. As the

core network or CN(s) and/or the radio access network(s) or RANs may be integrated into the Internet and mobile cloud, such mobility protocols may run in the mobile cloud (e.g. 512, 412, and/or 312) using the VPN or encrypted tunnel or interface that may be provided and/or used to protect the data or information and the protocols. When running in the VPN or encrypted tunnel or interface, such protocols may be unchanged and may be unaware they may be running in the open Internet.

[0087] Additionally, a variety of service providers or services may communicate with the global core network or CN (e.g. 502) and the nodes associated therewith of the global mobile cloud (e.g. 512) via common network interfaces such as a common network interface 516. Various service providers may include, for example, a smart grid operator or service 520, one or more MVNOs or services 522, video content providers or services 524, social networking providers or services 526, gaming providers or services 528, and the like. Additionally, numerous other types of service providers and/or entities may communicate with the mobile cloud 512 via the common network interfaces (e.g. 516).

[0088] According to embodiments, portions or parts of the mobile cloud (e.g. 512) may be recursively virtualized to provide automatic scalability. For example, nodes such as HLRs and/or SGSNs associated with a core network or CN (e.g. 502) in the mobile cloud (e.g. 512) may not be dedicated servers. Rather, one or more virtual nodes such as virtual nodes 550 may be requested automatically and dynamically provisioned (e.g. on demand) by the global mobile cloud (e.g. 512) from cloud computing providers such as GOOGLE, AMAZON (AMAZON EC2) and/or other third party cloud computing providers such as a third party server farm 552, for example.

[0089] As described above, in example embodiments, there may be a variety of network interfaces that may allow or enable different types of network services. For example, “bulk service” network interfaces, the “per user slice” network interfaces and/or other or additional the network interfaces may be provided and or used.

[0090] The bulk service network interfaces may enable service providers or services such as MVNOs (e.g. 522, 422, and/or 322) and smart grid service providers (e.g. 520, 420, and/or 320), for example, to dynamically obtain a bulk portion of a mobile networks capacity (e.g. a “bulk slice”). Such a bulk slice may be defined based on an intended use (e.g. a relatively long term reservation or lease such as weeks, months, and the like) of the resources

of the mobile cloud (e.g. 512, 412, and/or 312) for use by the customers of the service provider or service. Additional details regarding bulk slicing may be described below (e.g. with respect to FIG. 6).

[0091] In various embodiments, various types of optimization and/or segregation may be used to improve the performance of the mobile cloud (e.g. 512, 412, and/or 312). For example, services providing HD streaming services may be segregated to a high performance control and data path in a mobile cloud (e.g. 512, 412, and/or 312) while lower bandwidth services (e.g., social networking services) may be segregated to a lower performance control and data path through the mobile cloud (e.g. 512, 412, and/or 312). In embodiments, each service provider or type of service provider may be allotted a particular data and control plane through the mobile cloud (e.g. 512, 412, and/or 312). Such techniques may improve various performance parameters, such as processing time and queuing delay, as compared to traditional core network architectures.

[0092] Moreover, in embodiments, some of the user equipment (UE) or wireless transmit and receive unit (WTRU) components, applications, or functionality (e.g. upper device layers of the WTRU 102 shown in FIG. 1B) may be integrated or moved into a mobile cloud (e.g. 512, 412, and/or 312) such that the components, applications, or functionality (e.g. the upper device layers) or at least a portion thereof may be integrated into the Internet and may have public IP addresses that may be configured to be used to access (e.g. via a network interface) the components, applications and/or functionality (e.g. the upper device layers) by the service provider and/or nodes of the core network. For example, upper layer processing such as application processing and/or control processing (e.g. 3GPP control processing) of a UE or WTRU (e.g. the WTRU 102 shown in FIG. 1B) may be integrated or moved into a mobile cloud (e.g. 512, 412, and/or 312). In an embodiment, storage of at least a portion of 3GPP NAS signaling state data may be integrated or moved into the mobile cloud (e.g. 512, 412, and/or 312) from the UE or WTRU. Migrating functionality from the user equipment into the mobile cloud (e.g. 512, 412, and/or 312) may, among other benefits, reduce re-boot time for the user equipment and/or reduce network registration time.

[0093] FIG. 6 illustrates an example embodiment of a service provider using a portion such as a bulk portion of a capacity provided by a mobile cloud. As shown in FIG. 6, one or more modems such as mobile modems 602A-m where m may be a positive integer may be installed in a number of buildings such as buildings 604A-m of customers of an amenity

provider such as an electric utility 606. The number of modems, which may be cellular, WiFi, and the like, that may be installed may be a large number such as 2 million. In such an embodiment, the amenity provider (e.g. the electric utility 606) may want a low bit-rate (e.g. 1 kb/sec) access (e.g. a guaranteed low bit-rate access) to each of the modems (e.g. 602A-m) for smart grid services (e.g. to monitor the consumption rate and send certain control information to each building (e.g. 604A-m)). To accommodate such a request, a smart grid application server such as an electric utility smart grid application server 620 may formulate a request (e.g. an electronic request) that may be sent to a network interface such as a network interface 616 of a mobile cloud such as a global mobile cloud 612. According to an example embodiment, the request may be sent via an API such as a mobile network API. The request may include a variety of information. For example, the information may include a request for new mobile connections (e.g. 2 million connections associated with the number of modems and/or customers), a particular bit rate (e.g., a bit-rate of 1 kb/sec maximum per connection), a term (e.g. the connections may be guaranteed for a term of 12 months). The request may also include, for example, authentication keys to be used by the modems (e.g. 602A-m) when accessing the mobile cloud (e.g. 612) via a radio access network or RAN such as RAN 608. The request may also include, for example, banking account information of the amenity provider such as the electric utility (e.g. 606) from which the global mobile cloud 612 may automatically charge for the service. The request may also include a wide variety of other information.

[0094] In one embodiment, the smart grid application server (e.g. 620) may trigger the network interface (e.g. 616) by sending an IP message such as a HTTP request that may include the above information directly, for example, to a node, for example, a HLR such as a global mobile cloud HLR 618 that may be associated with a core network such as a core network 634 included in a mobile cloud (e.g. 612) that may be located in the USA. The HLR (e.g. 618) may receive the request that may include the above information. The smart grid application server (e.g. 620) may determine the IP address of the HLR (e.g. 618) by using a standard IP address resolution process like Domain Name System (DNS) lookup, for example. As described above, such direct messaging may be possible, because a node such as the HLR (e.g. 618) in the core network or CN (e.g. 634) may be directly integrated into the Internet numbering and naming systems.

[0095] Once the HLR (e.g. 618) may receive the request and the information, the HLR (e.g. 618) may then process the request by communicating with other appropriate nodes in the mobile cloud (e.g. 612). For example, the HLR (e.g. 618) may first reserve enough capacity within itself to support the smart grid request. The HLR (e.g. 618) then may communicate with SGSN(s) such as a SSGN 630 and GGSN(s) such as a GGSN 632 to receive processor capacity in the core network or CN (e.g. 634) for the smart grid modems (e.g. 602A-m). The SGSNs (e.g. 630) may then be triggered to communicate with nodes of the radio access network or RANs (e.g. 608) to reserve RAN capacity. For example, the SGSNs (e.g. 630) may be triggered to communicate with RNCs such as a RNC 636 to reserve RAN capacity for the smart grid modems (e.g. 602A-m). In embodiments, nodes of the radio access network or RAN (e.g. 608) may be integrated into the mobile cloud (e.g. 612). When or if, for example, a SGSN (e.g. 630) may determine that it may not have enough capacity to handle the request, the SGSN (e.g. 630) may dynamically request a third party server farm (e.g. 552 shown in FIG. 5) to provide additional SGSN capacity. The HLR (e.g. 618) may also communicate with mobile cloud charging and accounting systems such as a global mobile cloud charging and accounting system 638 to provide or send the banking information of the smart grid. The HLR (e.g. 618) may further communicate with an authentication system such as an authentication system 640 of the mobile cloud (e.g. 612) to provide the authentication system (e.g. 640) with the authentication keys of the smart grid modems (e.g. 602A-m) (e.g. to send the authentication keys to the authentication system).

[0096] If the internal processing with the mobile cloud (e.g. 612) may be successful, the HLR (e.g. 618) may send back a successful HTTP Response to the smart grid application server (e.g. 620) that may have sent the initial request. The smart grid application server (e.g. 620) may then send an individual activation to each of modems (e.g. 602A-m) by sending a multicast IP message directly to the appropriate mobile cloud node such as a MBMS broadcast server or some other IP multicast distribution mechanism, for example (not shown). The MBMS server or other IP multicast server may then multicast such a message through the mobile cloud (e.g. 612). The smart grid modems (e.g. 602A-m) may be pre-configured to start listening to such an IP address such that the modems (e.g. 602A-m) may receive the message.

[0097] Once the smart grid modems (e.g. 602A-m) may be activated, the smart grid service associated with the amenity provider such as the electric utility (e.g. 606) may be

operable. In the embodiment shown in FIG. 5, pre-defined business relationships may not be setup between the smart grid provider and the mobile operators (e.g. unlike the embodiment shown in FIG. 2). Additionally, no financial or other information may be manually exchanged. The mobile cloud (e.g. 612) may also be able to dynamically scale itself to provide the desired capacity. Finally, custom software coding may not have to be performed to support the mobile operator network interfaces. Instead, the smart grid service may be activated electronically and efficiently by triggering the mobile cloud public network interfaces.

[0098] As described above, another example class of network interfaces are “per user slice” network interfaces that may enable services providers, such as video and gaming service providers, for example, to dynamically obtain a smaller or shorter portion and/or for a shorter duration of the mobile network capacity (i.e. a “per user slice”) to process a given transaction. While the particular transaction may vary, transmitting a streaming video of a given sports event is one example. In some embodiments, the time scale for the per user slice may be short, such as minutes or hours, and. The per user slice network interface processing may be similar to processing described above in the bulk slice processing context except the portion of the capacity may be smaller and/or the duration for using the capacity may be shorter.

[0099] Additionally, the various network interfaces described herein with respect to the mobile cloud (e.g. 612) may be applicable to the other mobile clouds described herein (e.g. 512, 412, and/or 312)

[0100] Furthermore, while the example illustrated in FIG. 6 relates to smart grid technologies, it may be appreciated that the systems and methods described herein may be used across a wide variety of technologies and implementations. For example, the systems and methods described herein may be used in “Internet of Things” applications, such as machine-to-machine communications, health monitoring, manufacturing, retail, other data delivery embodiments or architectures that may directly access a mobile network, for example, and the like.

[0101] Although embodiments described herein may be described or illustrated with respect two mobile operators, the systems and/or methods may be used with one mobile

operator or additional mobile operators (e.g. three mobile operators, four mobile operators, and the like).

[0102] Additionally, although embodiments described herein may show example architectures and example radio access networks or RANs and core networks or CNs, the systems and methods described herein may not be limited to the particular architectures described herein. For example, the RANs and/or CNs may include additional nodes or different nodes than those described herein including, for example, a PCRF, a SGW, a HSS, and the like (e.g. if the mobile network may be 4G or LTE-A) as well as other non-standardized nodes that may be deployed such as components, modules, and/or boxes that may serve as caching resources. Additionally, other nodes or different nodes than those described herein may be moved or integrated into the Internet or mobile cloud. Portions of mobile networks supported or provided by an operator and the architectures associated therewith may be associated with architectures that may also be moved or integrated into the Internet and mobile cloud. For example, legacy equipment associated with a legacy mobile network may be moved or integrated into the Internet and mobile cloud while other equipment (e.g. current network equipment) may not be moved or integrated into the Internet or the mobile cloud.

[0103] Although the terms UE or WTRU may be used herein, it may and should be understood that the use of such terms may be used interchangeably and, as such, may not be distinguishable.

[0104] Additionally, although features and elements are described 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. In addition, the methods described 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 non-transitory computer-readable storage media include, but are not limited to, a read only memory (ROM), 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.

What is claimed is:

1. A mobile cloud system, the mobile cloud system comprising:
a mobile core network (CN) comprising a plurality of nodes integrated into an Internet, the plurality of nodes having public IP addresses; and
a network interface configured to provide communication between the plurality of nodes and a service provider connected to the Internet using the public IP addresses.
2. The mobile cloud system of claim 1, wherein the mobile core network comprises a first core network affiliated with a first mobile operator and a second core network affiliated with a second mobile operator.
3. The mobile cloud system of claim 1, wherein the mobile core network comprises a first core network covering with a first geographic region and a second core network covering a second geographic region.
4. The mobile cloud system of claim 1, wherein the service provider comprises at least one of the following: a bulk service provider and a per user service provider.
5. The mobile cloud system of claim 4, wherein the bulk service provider comprises at least one of the following: a Mobile Virtual Network Operator (MVNO) and a smart grid service provider.
6. The mobile cloud system of claim 4, wherein the per user service provider comprises at least one of the following: a video content provider, a social networking provider, and a gaming provider.
7. The mobile cloud system of claim 1, wherein a first node of the mobile core network is connected to a second node of the mobile core network via an encapsulated tunnel, wherein the encapsulated tunnel is routed via the Internet.

8. The mobile cloud system of claim 1, wherein at least one of the plurality of nodes of the mobile core network is a virtualized node.
9. The mobile cloud system of claim 1, wherein at least one upper layer associated with a wireless transmit and receive unit (WTRU) is integrated into the Internet such that the upper layer comprises a public IP address configured to be used to access the upper layer via the network interface.
10. The mobile cloud system of claim 1, wherein the mobile core network is in communication with at least one radio access network, wherein the at least one radio access network comprises a radio access node external to the Internet.
11. The mobile cloud system of claim 10, wherein the node is reachable by the radio access network node.
12. A mobile cloud system, the mobile cloud system comprising:
 - a core network comprising core network nodes integrated into an Internet, each of the core network nodes having a public IP address configured to be used to provide access to the core network nodes; and
 - a radio access network in communication with the core network, the radio access network comprising radio access network nodes, at least one of the radio access nodes being external to the Internet, and the core network nodes being reachable by the at least one radio access node external to the Internet.
13. The mobile clouds system of claim 12, further comprising:
 - a network interface in communication with the core network, the network interface configured to provide communication between the core network nodes and a service provider connected to the Internet using the public IP address

14. The mobile cloud system of claim 13, wherein the service provider comprises at least one of the following: a Mobile Virtual Network Operator (MVNO), a smart grid service provider, a video content provider, a social networking provider, and a gaming provider.

15. The mobile cloud system of claim 12, wherein at least one core network node is connected to another core network node via an encapsulated tunnel, the encapsulated tunnel being routed via the Internet.

16. The mobile cloud system of claim 12, wherein at least one node of the core network is a virtualized node.

17. A method for using a portion of a capacity provided by a mobile cloud system, the method comprising:

receiving, at a core network, information from an external service provider, the core network comprising nodes having a public IP address configured to receive the information;

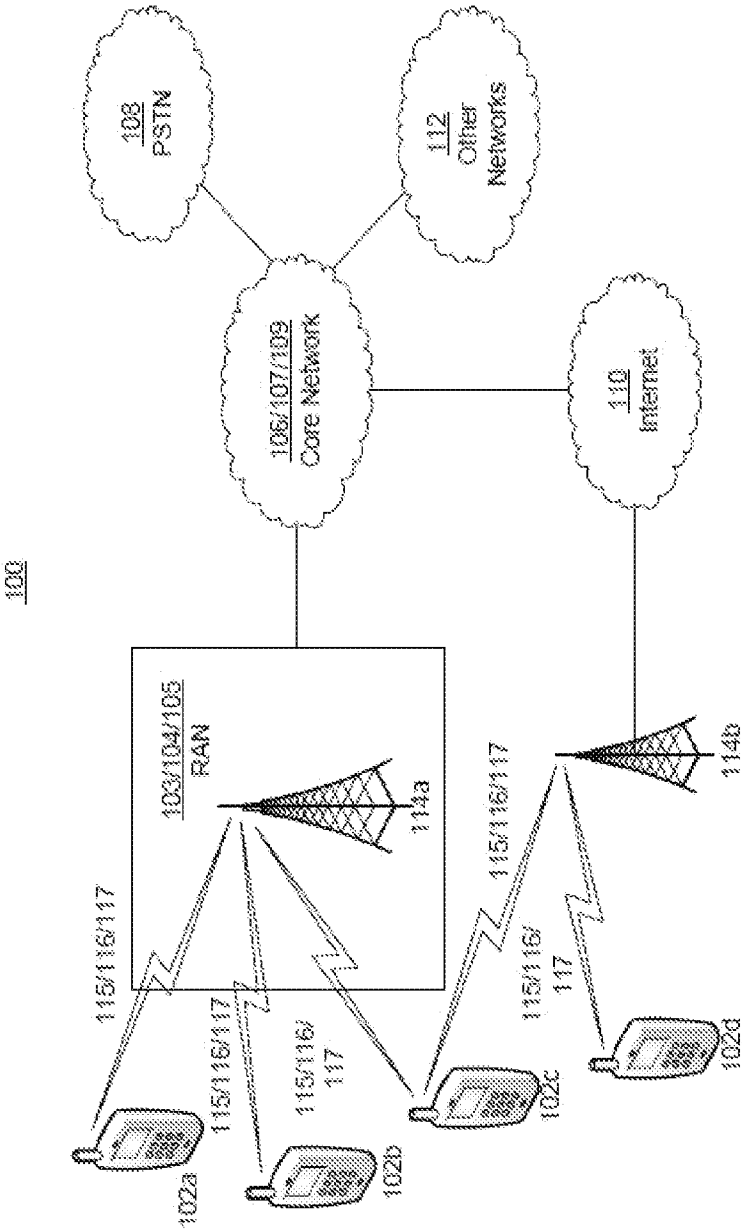
configuring at least one network element of the core network based on the information; and

providing a service from the external service provider to an end user using the at least one network element configured based on the information.

18. The method of claim 17, wherein the information comprises at least one of the following: a request for a number of mobile connections, a request to guarantee the number of mobile connections for a length of time, a request for a bit-rate range, an authentication key for use by the end user to access the core network, and service provider banking information.

19. The method of claim 17, wherein the information is associated with an HTTP request received by at least one of the following nodes of the core network: a Home Location Register (HLR), a serving GPRS support node (SGSN), a gateway GPRS support node (GGSN), a radio network controller (RNC), and an IP multimedia subsystem (IMS).

20. The method of claim 19, further comprising:
- reserving, at least one of the nodes of the core network, capacity to support the HTTP request based on the information and the HTTP request;
 - sending, from at least one of the nodes of the core network, accounting information based on the information and HTTP request to a charging and accounting system of the core network; and
 - sending, from at least one of the nodes of the core network, authentication keys based on the information and HTTP request to an authentication system of the core network.



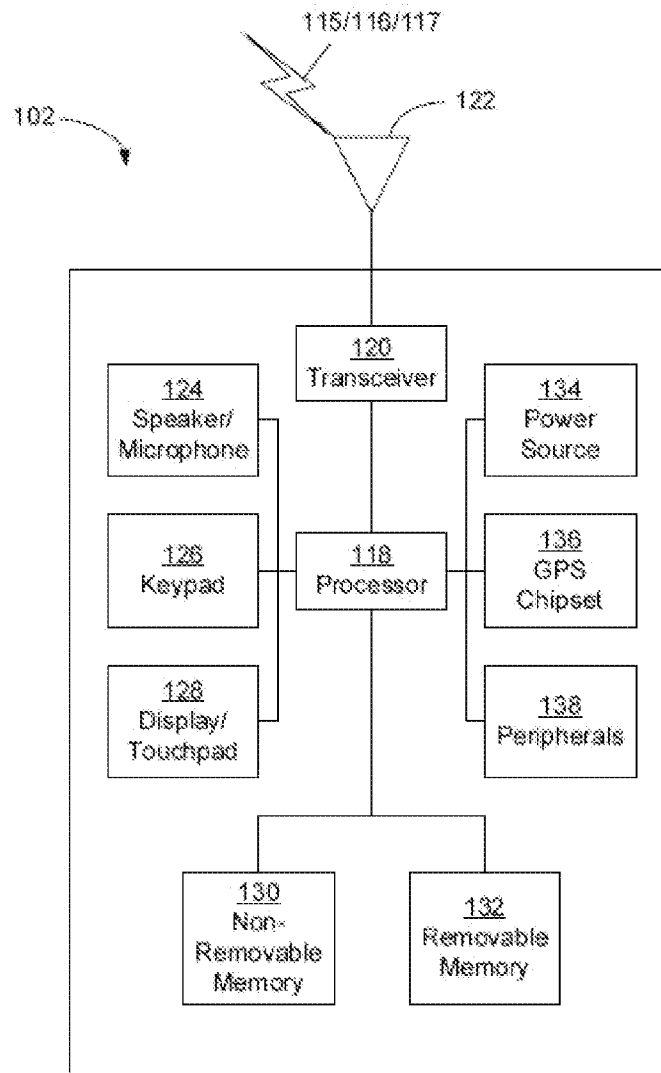


FIG. 1B

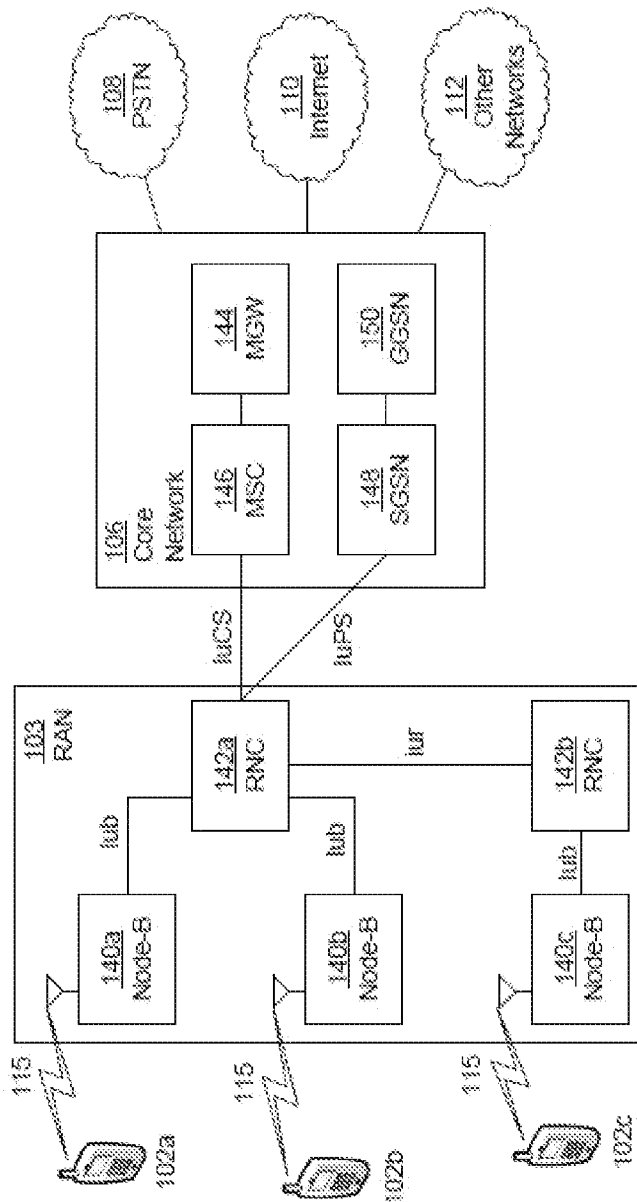


FIG. 1C

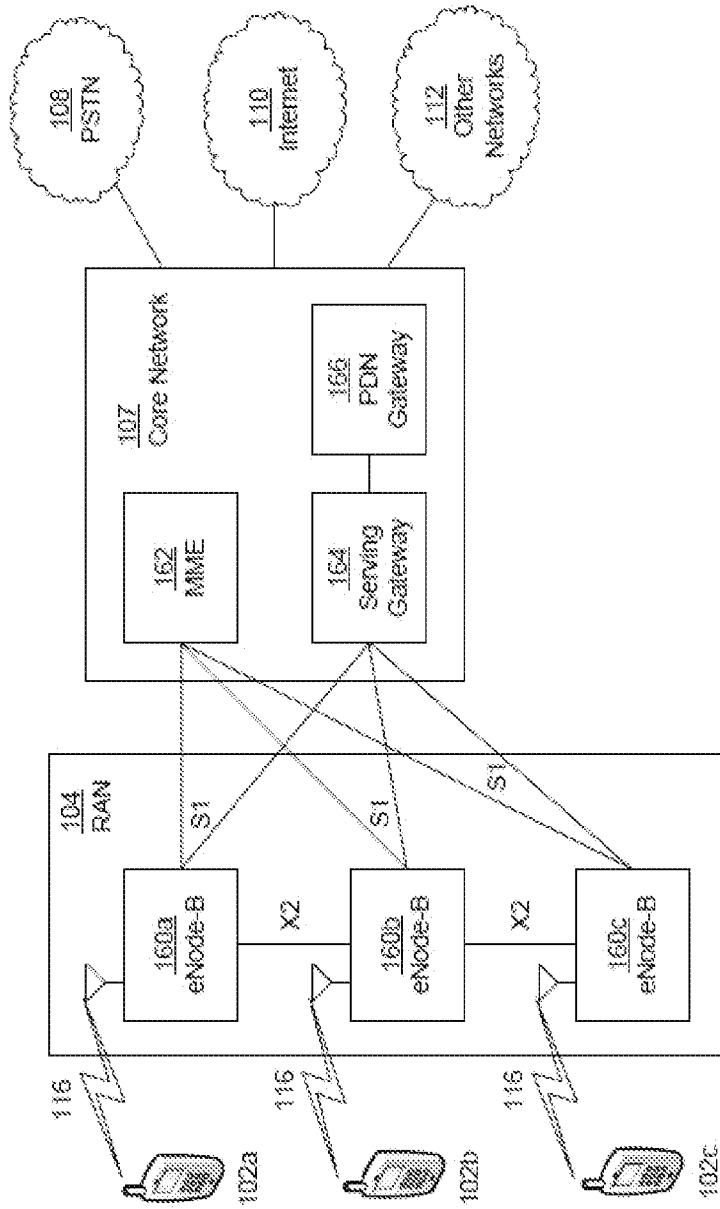


FIG. 1D

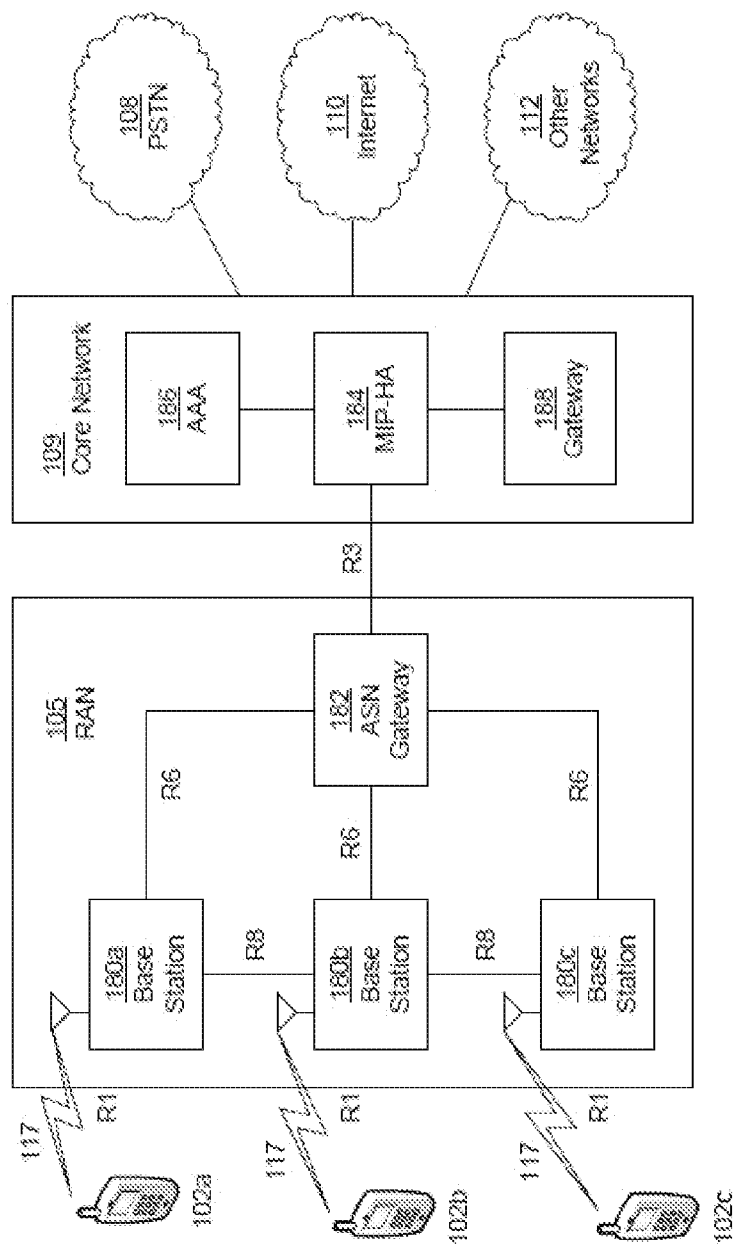


FIG. 1E

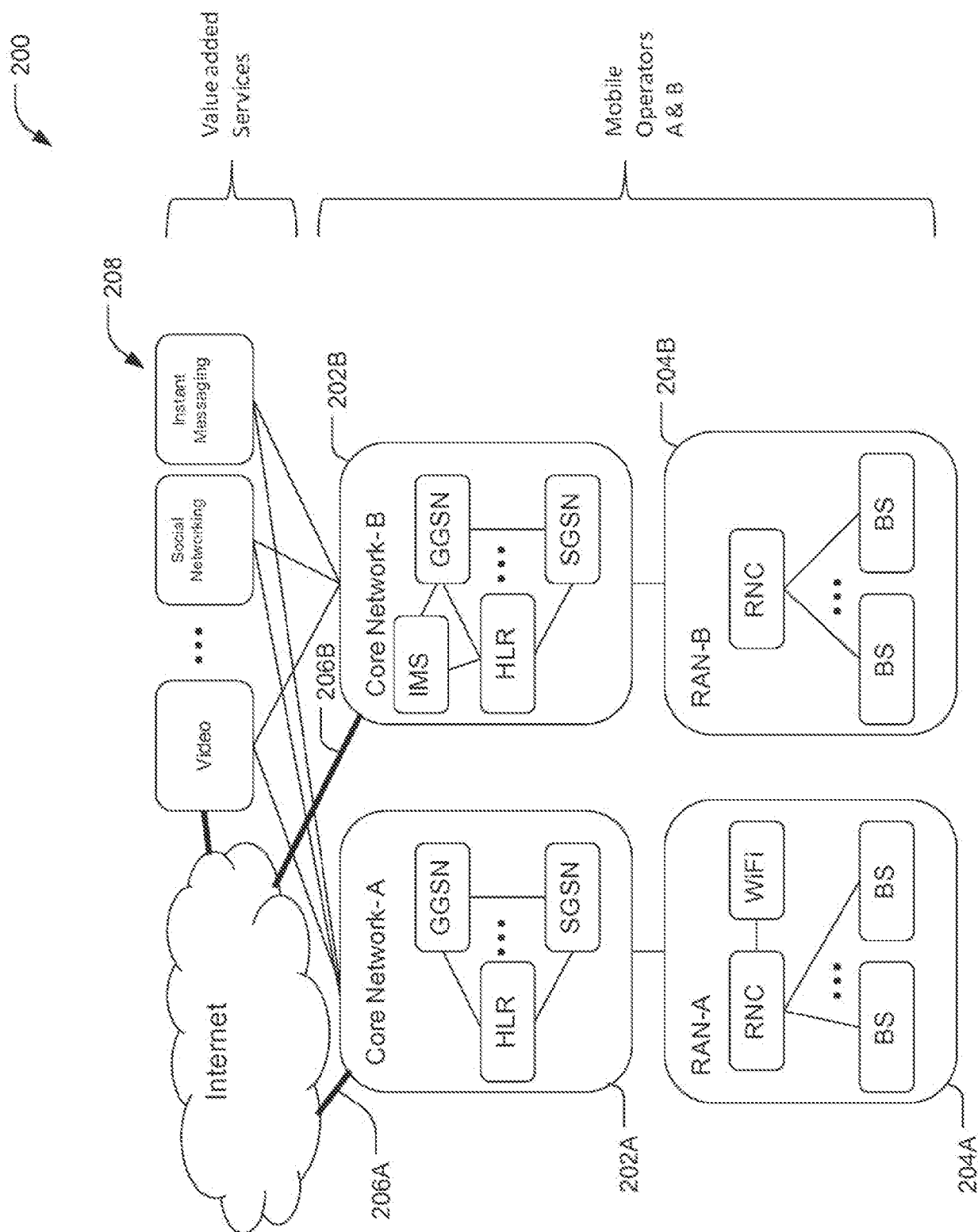


FIG. 2

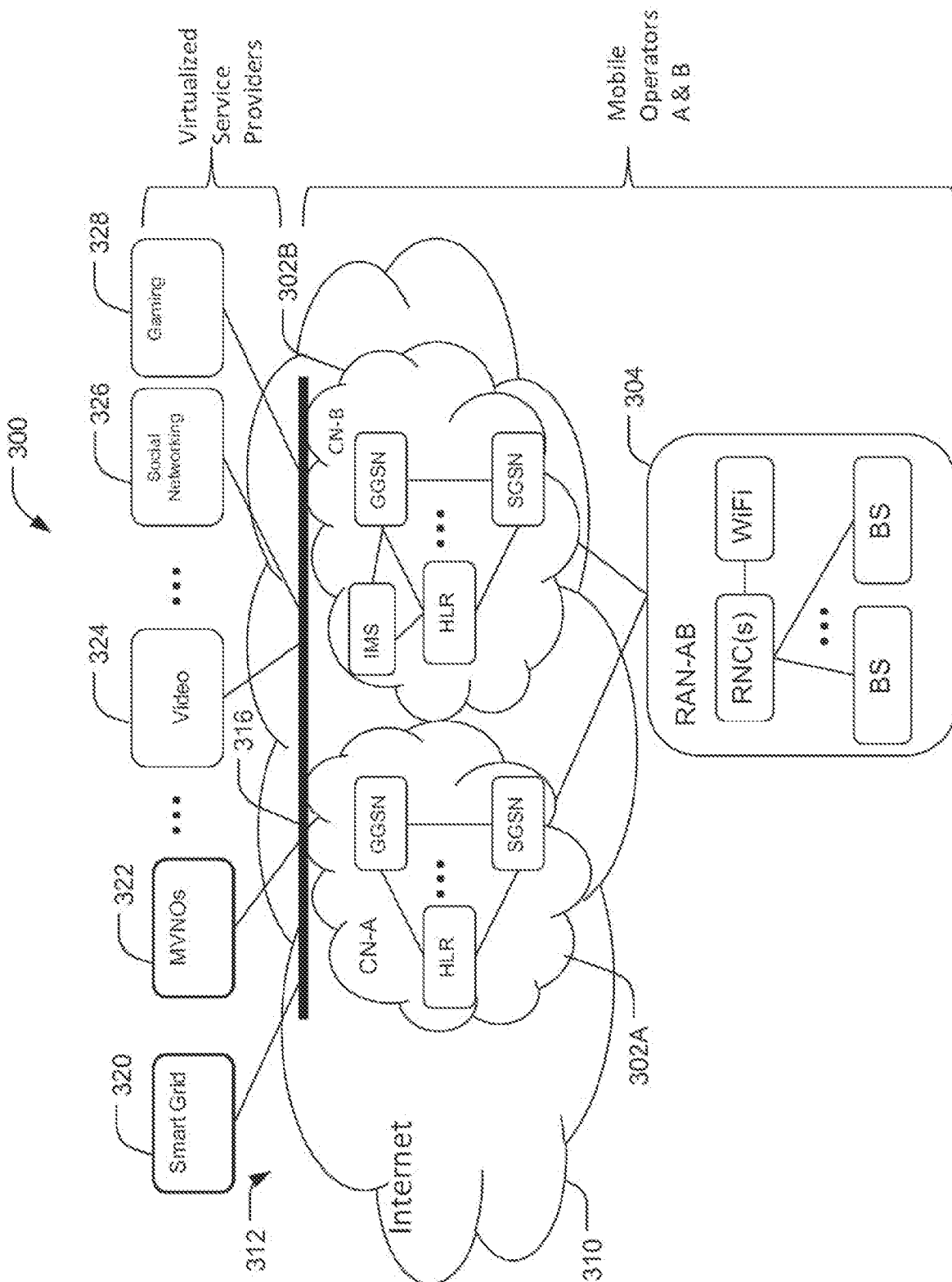


FIG. 3

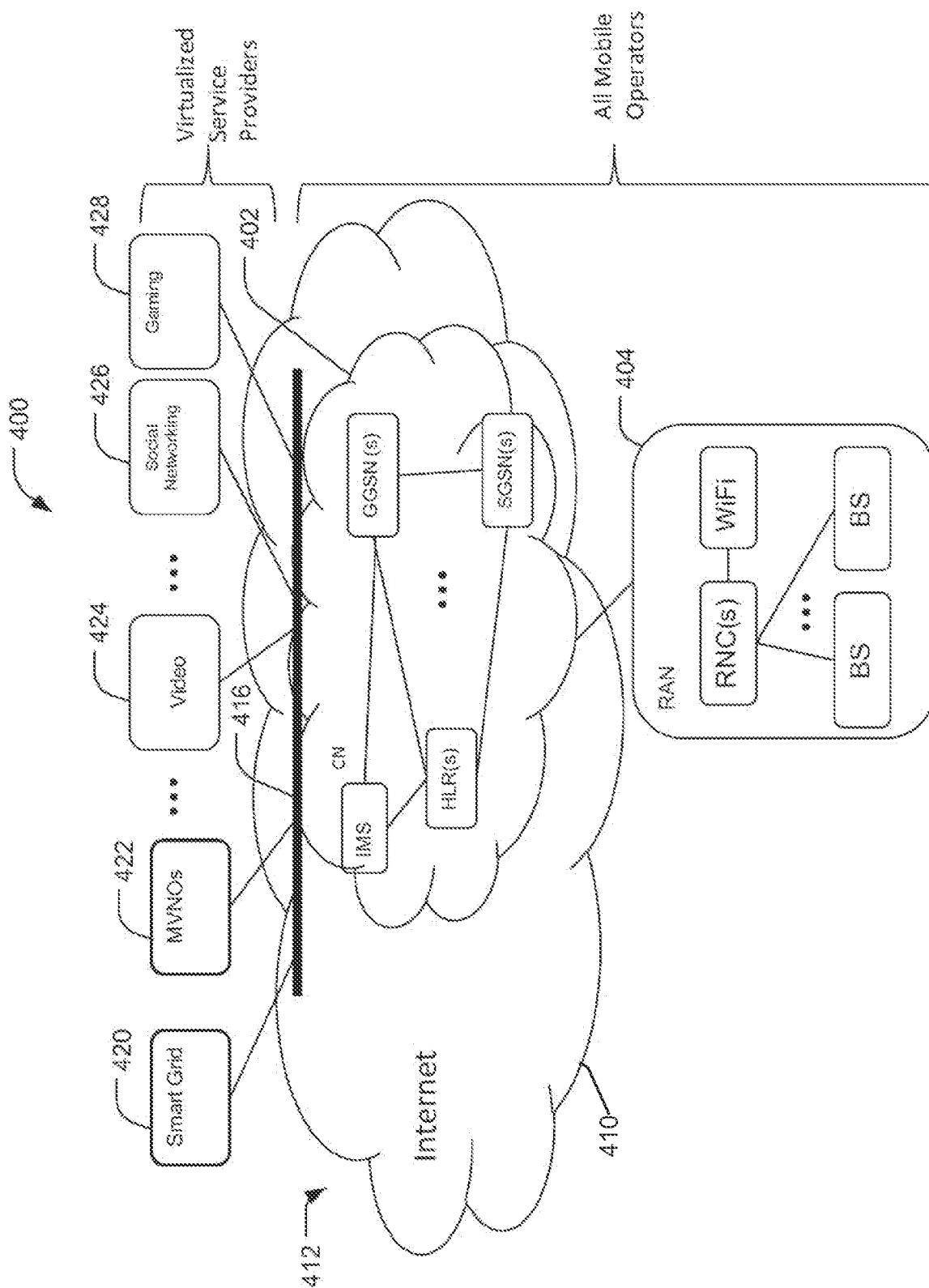


FIG. 4

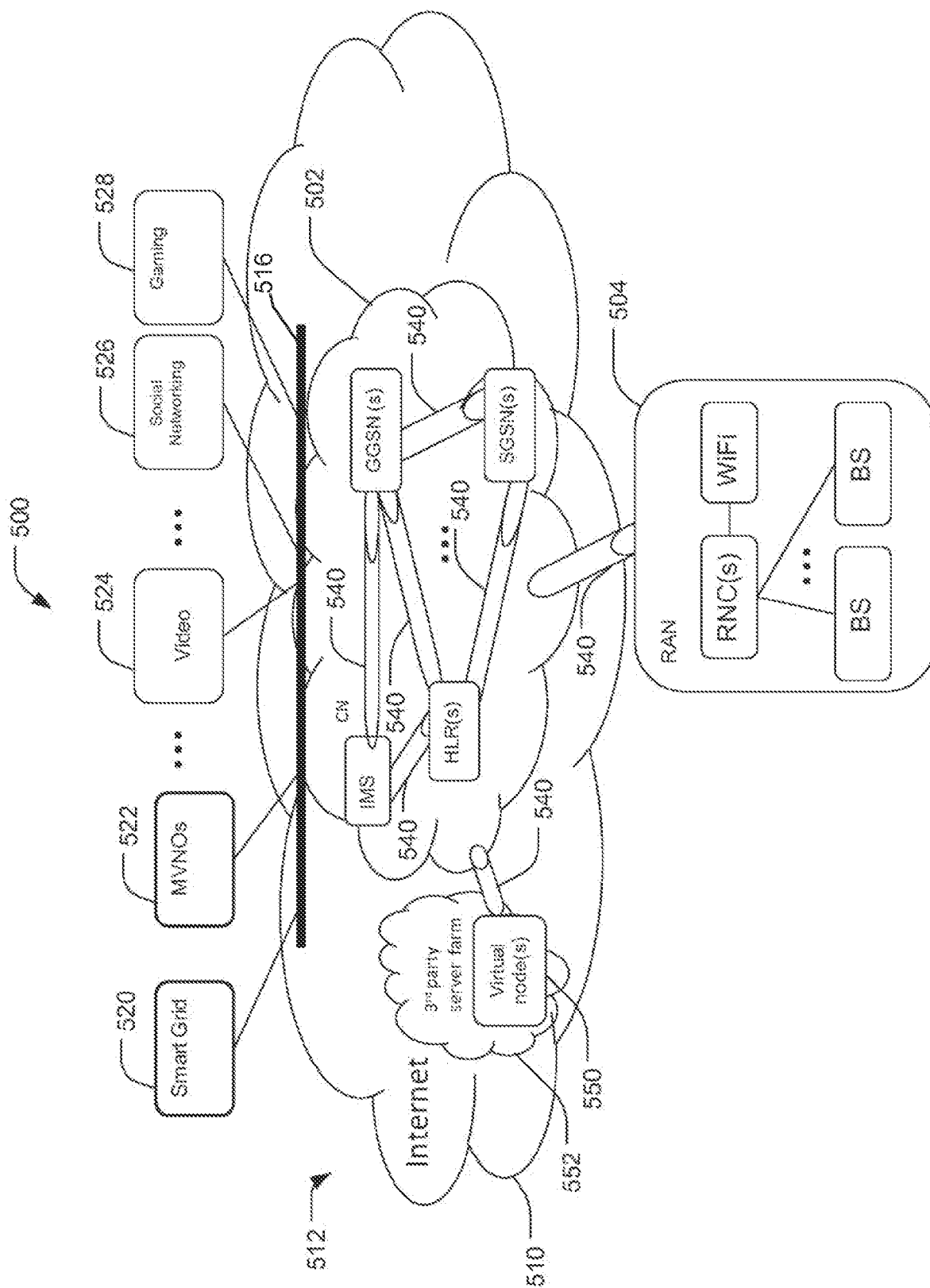


FIG. 5

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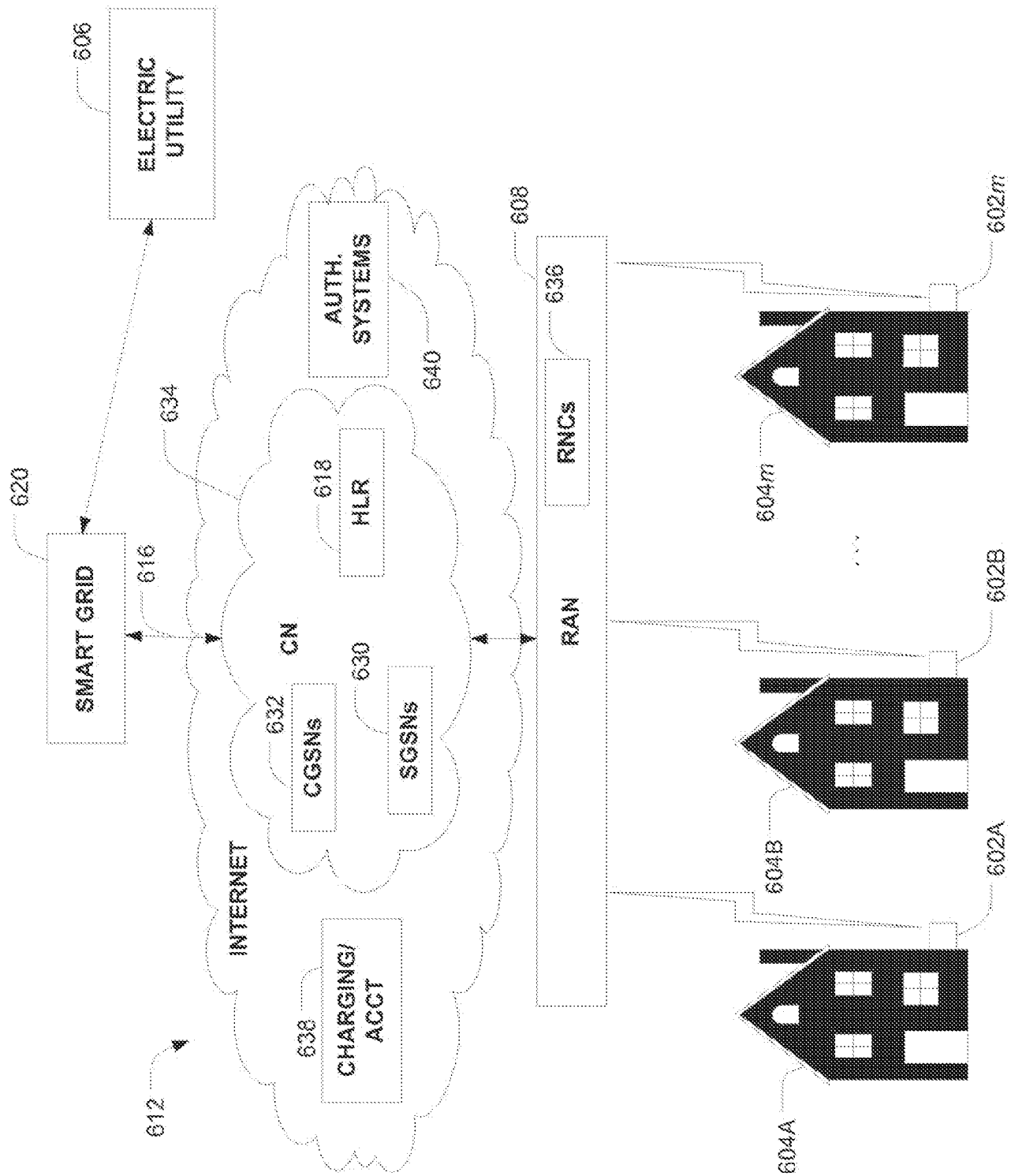


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/043810

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L29/06
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)
H04L

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

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

EP0-Internal, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	MARCO HOFFMANN ET AL: "Network Virtualization for Future Mobile Networks: General Architecture and Applications", COMMUNICATIONS WORKSHOPS (ICC), 2011 IEEE INTERNATIONAL CONFERENCE ON, IEEE, 5 June 2011 (2011-06-05), pages 1-5, XP031909284, DOI: 10.1109/ICCW.2011.5963565 ISBN: 978-1-61284-954-6 the whole document ----- -/-	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

4 September 2012

Date of mailing of the international search report

11/09/2012

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
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Fax: (+31-70) 340-3016

Authorized officer

Brichau, Gert

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/043810

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	TIMOTHY K FORDE ET AL: "Exclusive sharing & virtualization of the cellular network", IEEE INTERNATIONAL SYMPOSIUM ON NEW FRONTIERS IN DYNAMIC SPECTRUM ACCESS NETWORKS ; (AACHEN) : 2011.05.03-06 DYSPAN ; (AACHEN) : 2011.05.03-06 IEEE INTERNATIONAL SYMPOSIUM ON DYNAMIC SPECTRUM ACCESS NETWORKS ; (AACHEN) : 2011.05.03-06, PISCATAWAY, NJ, 3 May 2011 (2011-05-03), pages 337-348, XP031953893, DOI: 10.1109/DYSPAN.2011.5936223 ISBN: 978-1-4577-0177-1	1,12
A	page 343 - page 345 -----	17