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(54) **Title:** APPARATUS, SYSTEM AND METHOD OF USER EQUIPMENT (UE) RELAYING VIA NON-CELLULAR RADIO ACCESS TECHNOLOGY (RAT)

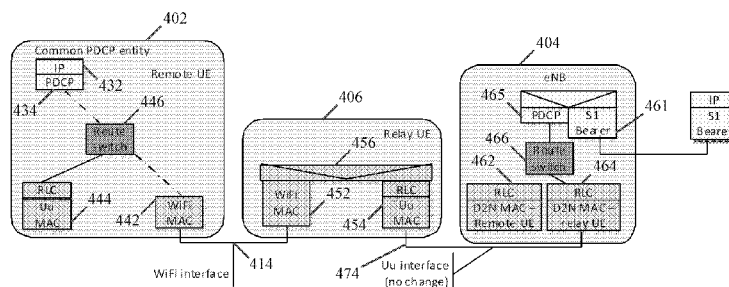


Fig. 4

(57) **Abstract:** Some demonstrative embodiments include devices, systems and/or methods of User Equipment (UE) relaying via non-cellular Radio Access Technology (RAT). For example, a UE may include a Proximity-based Services (ProSe) component to interface with a relay UE over a non-cellular RAT link; a Device to Network (D2N) component to interface with an evolved Node B (eNB) of a cellular network over a cellular RAT link; a Packet Data Convergence Protocol (PDCP) component to process traffic of an Evolved Packet-switched System (EPS) bearer between the UE and the cellular network, the EPS bearer established over the cellular RAT link; and a controller component configured to route an uplink Service Data Unit (SDU) of the EPS bearer to the ProSe component to communicate the uplink SDU to the relay UE over the non-cellular RAT link.

**APPARATUS, SYSTEM AND METHOD OF USER EQUIPMENT (UE) RELAYING
VIA NON-CELLULAR RADIO ACCESS TECHNOLOGY (RAT)**

CROSS REFERENCE

5 [001] This application claims the benefit of and priority from US Provisional Patent Application No. 62/295,930 entitled “Relaying through non-3GPP access for low-power wearable devices”, filed February 16, 2016, the entire disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

10 [002] Some embodiments described herein generally relate to User Equipment (UE) relaying via non-cellular Radio Access Technology (RAT).

BACKGROUND

15 [003] It is becoming more important to be able to provide telecommunication services to fixed and mobile subscribers as efficient and inexpensively as possible. Further, the increased use of mobile applications has resulted in much focus on developing wireless systems capable of delivering large amounts of data at high speed.

20 [004] Currently, as part of the Proximity Services (ProSe) capability introduced in Release 13 of the Long Term Evolution (LTE) Standards, a basic level of functionality has been described to allow network-to-user equipment (UE) relaying. This functionality relies on the reuse of a cellular sidelink radio communication channel between devices to route traffic at an Internet Protocol (IP) layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[005] For simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity of presentation. Furthermore, reference numerals may be repeated among the figures to indicate corresponding or analogous elements. The figures are listed below.

[006] Fig. 1 is a schematic block diagram illustration of a system, in accordance with some demonstrative embodiments.

[007] Fig. 2 is a schematic illustration of elements of a User Equipment (UE), in accordance with some demonstrative embodiments.

[008] Fig. 3 is a schematic illustration of an implementation utilizing UE relaying via a non-cellular Radio Access Technology (RAT), in accordance with some demonstrative embodiments.

[009] Fig. 4 is a schematic illustration of a protocol stack configured for Layer 2 (L2) relaying above a Radio Link Control (RLC) layer, in accordance with some demonstrative embodiments.

[0010] Fig. 5 is a schematic illustration of a protocol stack configured for Layer 2 (L2) relaying above a Medium Access Control (MAC) layer, in accordance with some demonstrative embodiments.

[0011] Fig. 6 is a schematic flow-chart illustration of a method of UE relaying via a non-cellular RAT, in accordance with some demonstrative embodiments.

[0012] Fig. 7 is a schematic flow-chart illustration of a method of UE relaying via a non-cellular RAT, in accordance with some demonstrative embodiments.

[0013] Fig. 8 is a schematic flow-chart illustration of a method of UE relaying via a non-cellular RAT, in accordance with some demonstrative embodiments.

[0014] Fig. 9 is a schematic illustration of a product, in accordance with some demonstrative embodiments.

DETAILED DESCRIPTION

[0015] In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of some embodiments. However, it will be understood by persons of ordinary skill in the art that some embodiments may be practiced without these specific details. In other instances, well-known methods, procedures, components, units and/or circuits have not been described in detail so as not to obscure the discussion.

[0016] Discussions herein utilizing terms such as, for example, “processing”, “computing”, “calculating”, “determining”, “establishing”, “analyzing”, “checking”, or the like, may refer to operation(s) and/or process(es) of a computer, a computing platform, a computing system, or other electronic computing device, that manipulate and/or transform data represented as physical (e.g., electronic) quantities within the computer’s registers and/or memories into other data similarly represented as physical quantities within the computer’s registers and/or memories or other information storage medium that may store instructions to perform operations and/or processes.

[0017] The terms “plurality” and “a plurality”, as used herein, include, for example, “multiple” or “two or more”. For example, “a plurality of items” includes two or more items.

[0018] References to “one embodiment,” “an embodiment,” “demonstrative embodiment,” “various embodiments,” etc., indicate that the embodiment(s) so described may include a particular feature, structure, or characteristic, but not every embodiment necessarily includes the particular feature, structure, or characteristic. Further, repeated use of the phrase “in one embodiment” does not necessarily refer to the same embodiment, although it may.

[0019] As used herein, unless otherwise specified the use of the ordinal adjectives “first,” “second,” “third,” etc., to describe a common object, merely indicate that different instances of like objects are being referred to, and are not intended to imply that the objects so described must be in a given sequence, either temporally, spatially, in ranking, or in any other manner.

[0020] Some embodiments may be used in conjunction with various devices and systems, for example, a Personal Computer (PC), a desktop computer, a mobile computer, a laptop computer, a notebook computer, a tablet computer, a Smartphone device, a server computer, a handheld computer, a handheld device, a Personal Digital Assistant (PDA) device, a handheld PDA device, an on-board device, an off-board device, an Internet of Things (IoT) device, a sensor device, a wearable device, a hybrid device, a vehicular device, a non-

vehicular device, a mobile or portable device, a consumer device, a non-mobile or non-portable device, a wireless communication station, a wireless communication device, a wireless Access Point (AP), a wired or wireless router, a wired or wireless modem, a video device, an audio device, an audio-video (A/V) device, a wired or wireless network, a wireless area network, a cellular network, a cellular node, a cellular device, a Wireless Local Area Network (WLAN), a Multiple Input Multiple Output (MIMO) transceiver or device, a Single Input Multiple Output (SIMO) transceiver or device, a Multiple Input Single Output (MISO) transceiver or device, a device having one or more internal antennas and/or external antennas, Digital Video Broadcast (DVB) devices or systems, multi-standard radio devices or systems, a wired or wireless handheld device, e.g., a Smartphone, a Wireless Application Protocol (WAP) device, vending machines, sell terminals, and the like.

[0021] Some embodiments may be used in conjunction with devices and/or networks operating in accordance with existing 3rd Generation Partnership Project (3GPP) and/or Long Term Evolution (LTE) specifications (including 3GPP TS 23.303 (“3GPP TS 23.303 V13.2.0 (2015-12); Technical Specification; 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Proximity-based services (ProSe); Stage 2 (Release 13)”) and/or future versions and/or derivatives thereof, devices and/or networks operating in accordance with existing IEEE 802.11 standards (including IEEE 802.11-201 (including IEEE 802.11-2012, IEEE Standard for Information technology-- Telecommunications and information exchange between systems Local and metropolitan area networks--Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, March 29, 2012); and/or IEEE802.11REVmcTM (IEEE802.11REVmcTM_D3.0, June 2014, Draft Standard for Information Technology – Telecommunications and Information Exchange Between Systems – Local and Metropolitan Area Networks – Specific Requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications)), and/or future versions and/or derivatives thereof, devices and/or networks operating in accordance with existing IEEE 802.16 standards (IEEE-Std 802.16, 2009 Edition, Air Interface for Fixed Broadband Wireless Access Systems; IEEE-Std 802.16e, 2005 Edition, Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands; amendment to IEEE Std 802.16-2009, developed by Task Group m) and/or future versions and/or derivatives thereof, devices and/or networks operating in accordance with existing WirelessHDTM

specifications and/or future versions and/or derivatives thereof, units and/or devices which are part of the above networks, and the like.

[0022] Some embodiments may be used in conjunction with one or more types of wireless communication signals and/or systems, for example, Radio Frequency (RF), Frequency-Division Multiplexing (FDM), Orthogonal FDM (OFDM), Single Carrier Frequency Division Multiple Access (SC-FDMA), Time-Division Multiplexing (TDM), Time-Division Multiple Access (TDMA), Extended TDMA (E-TDMA), General Packet Radio Service (GPRS), extended GPRS, Code-Division Multiple Access (CDMA), Wideband CDMA (WCDMA), CDMA 2000, single-carrier CDMA, multi-carrier CDMA, Multi-Carrier Modulation (MDM), Discrete Multi-Tone (DMT), Bluetooth®, Global Positioning System (GPS), Wireless Fidelity (Wi-Fi), Wi-Max, ZigBee™, Ultra-Wideband (UWB), Global System for Mobile communication (GSM), second generation (2G), 2.5G, 3G, 3.5G, 4G, Fifth Generation (5G) mobile networks, 3GPP, Long Term Evolution (LTE) cellular system, LTE advance cellular system, High-Speed Downlink Packet Access (HSDPA), High-Speed Uplink Packet Access (HSUPA), High-Speed Packet Access (HSPA), HSPA+, Single Carrier Radio Transmission Technology (1XRTT), Evolution-Data Optimized (EV-DO), Enhanced Data rates for GSM Evolution (EDGE), and the like. Other embodiments may be used in various other devices, systems and/or networks.

[0023] The term “wireless device”, as used herein, includes, for example, a device capable of wireless communication, a communication device capable of wireless communication, a communication station capable of wireless communication, a portable or non-portable device capable of wireless communication, or the like. In some demonstrative embodiments, a wireless device may be or may include a peripheral that is integrated with a computer, or a peripheral that is attached to a computer. In some demonstrative embodiments, the term “wireless device” may optionally include a wireless service.

[0024] The term “communicating” as used herein with respect to a communication signal includes transmitting the communication signal and/or receiving the communication signal. For example, a communication unit, which is capable of communicating a communication signal, may include a transmitter to transmit the communication signal to at least one other communication unit, and/or a communication receiver to receive the communication signal from at least one other communication unit. The verb communicating may be used to refer to the action of transmitting or the action of receiving. In one example, the phrase “communicating a signal” may refer to the action of transmitting the signal by a first device,

and may not necessarily include the action of receiving the signal by a second device. In another example, the phrase “communicating a signal” may refer to the action of receiving the signal by a first device, and may not necessarily include the action of transmitting the signal by a second device.

5 [0025] As used herein, the term "circuitry" may refer to, be part of, or include, an Application Specific Integrated Circuit (ASIC), an integrated circuit, an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group), that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some
10 embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

[0026] The term “logic” may refer, for example, to computing logic embedded in circuitry of a computing apparatus and/or computing logic stored in a memory of a computing apparatus.
15 For example, the logic may be accessible by a processor of the computing apparatus to execute the computing logic to perform computing functions and/or operations. In one example, logic may be embedded in various types of memory and/or firmware, e.g., silicon blocks of various chips and/or processors. Logic may be included in, and/or implemented as part of, various circuitry, e.g. radio circuitry, receiver circuitry, control circuitry, transmitter
20 circuitry, transceiver circuitry, processor circuitry, and/or the like. In one example, logic may be embedded in volatile memory and/or non-volatile memory, including random access memory, read only memory, programmable memory, magnetic memory, flash memory, persistent memory, and the like. Logic may be executed by one or more processors using memory, e.g., registers, stuck, buffers, and/or the like, coupled to the one or more processors,
25 e.g., as necessary to execute the logic.

[0027] The term “antenna”, as used herein, may include any suitable configuration, structure and/or arrangement of one or more antenna elements, components, units, assemblies and/or arrays. In some embodiments, the antenna may implement transmit and receive functionalities using separate transmit and receive antenna elements. In some embodiments,
30 the antenna may implement transmit and receive functionalities using common and/or integrated transmit/receive elements. The antenna may include, for example, a phased array antenna, a single element antenna, a dipole antenna, a set of switched beam antennas, and/or the like.

[0028] The term “cell”, as used herein, may include a combination of network resources, for example, downlink and optionally uplink resources. The resources may be controlled and/or allocated, for example, by a node (also referred to as a “base station”), or the like. The linking between a carrier frequency of the downlink resources and a carrier frequency of the uplink resources may be indicated in system information transmitted on the downlink resources.

[0029] Some demonstrative embodiments are described herein with respect to a LTE network. However, other embodiments may be implemented in any other suitable cellular network or system, e.g., a Universal Mobile Telecommunications System (UMTS) cellular system, a GSM network, a 3G cellular network, a 4G cellular network, a 4.5G network, a 5G cellular network, a WiMAX cellular network, and the like.

[0030] Some demonstrative embodiments are described herein with respect to a WLAN system, a WiFi system, a Bluetooth (BT) system, and/or a short-range communication network. However, other embodiments may be implemented in any other suitable non-cellular network.

[0031] Some demonstrative embodiments may be used in conjunction with a Heterogeneous Network (HetNet), which may utilize a deployment of a mix of technologies, frequencies, cell sizes and/or network architectures, e.g., including cellular, millimeter wave (“mmWave” or “mmW”), and/or the like. In one example, the HetNet may include a radio access network having layers of different-sized cells ranging from large macrocells to small cells, for example, picocells and femtocells. Other embodiments may be used in conjunction with any other suitable wireless communication network.

[0032] Other embodiments may be used in conjunction with any other suitable wireless communication network.

[0033] Reference is now made to Fig. 1, which schematically illustrates a block diagram of a system 100, in accordance with some demonstrative embodiments.

[0034] As shown in Fig. 1, in some demonstrative embodiments, system 100 may include one or more wireless communication devices capable of communicating content, data, information and/or signals via one or more wireless mediums (WM). For example, system 100 may include one or more User Equipment (UE), e.g., UE 102 and/or UE 106, capable of communicating with one or more wireless communication networks, e.g., as described below.

[0035] In some demonstrative embodiments, system 100 may include an access network of a 3rd Generation Partnership Project (3GPP) long-term evolution (LTE) or long-term

evolution- advanced (LTE-A) network such as, for example, an evolved universal mobile telecommunication system (UMTS) terrestrial radio access network (E-UTRAN), and/or any other additional or alternative network.

[0036] In some demonstrative embodiments, elements of system 100 may be capable of communicating over one or more wireless mediums, for example, a radio channel, a cellular channel, an RF channel, a WiFi channel, an IR channel, and the like. One or more elements of system 100 may optionally be capable of communicating over any suitable wired communication links.

[0037] In some demonstrative embodiments, system 100 may include at least one cellular manager 104 to manage communication of a cellular network, e.g., as described below.

[0038] In some demonstrative embodiments, cellular manager 104 may include, may operate as, and/or may perform the functionality of, an Evolved Node B (eNB) 104, e.g., as described below. For example, cellular manager 104 may be configured to perform radio resource management (RRM), radio bearer control, radio admission control (access control), connection mobility management, resource scheduling between UEs and eNB radios, e.g., Dynamic allocation of resources to UEs in both uplink and downlink, header compression, link encryption of user data streams, packet routing of user data towards a destination, e.g., another eNB or an Evolved Packet Core (EPC), scheduling and/or transmitting paging messages, e.g., incoming calls and/or connection requests, broadcast information coordination, measurement reporting, and/or any other operations, communications, and/or functionality.

[0039] In other embodiments, cellular manager 104 may include any other functionality and/or may perform the functionality of any other cellular node, network controller, base station or any other node or network device.

[0040] In some demonstrative embodiments, UE 102 and/or UE 106 may include, for example, a Mobile Device (MD), a Station (STA), a mobile computer, a laptop computer, a notebook computer, a tablet computer, an UltrabookTM computer, an Internet of Things (IoT) device, a wearable device, a sensor device, a mobile internet device, a handheld computer, a handheld device, a storage device, a PDA device, a handheld PDA device, an on-board device, an off-board device, a hybrid device (e.g., combining cellular phone functionalities with PDA device functionalities), a consumer device, a vehicular device, a non-vehicular device, a mobile or portable device, a mobile phone, a cellular telephone, a PCS device, a

mobile or portable GPS device, a DVB device, a relatively small computing device, a non-desktop computer, a “Carry Small Live Large” (CSLL) device, an Ultra Mobile Device (UMD), an Ultra Mobile PC (UMPC), a Mobile Internet Device (MID), an “Origami” device or computing device, a video device, an audio device, an A/V device, a gaming device, a media player, a Smartphone, or the like.

[0041] In some demonstrative embodiments, UE 102, UE 106 and/or eNB 104 may include one or more communication interfaces to perform communication between UE 102, UE 106, eNB 104, and/or with one or more other wireless communication devices, e.g., as described below.

[0042] In some demonstrative embodiments, eNB 104 may include an air interface, for example, a cellular transceiver (TRx) 167, including circuitry and/or logic configured to communicate with UE 102 via a cellular link 133, and/or to communicate with UE 106 via a cellular link 135.

[0043] In some demonstrative embodiments, UE 102 may include a cellular transceiver (TRx) 165 including circuitry and/or logic configured to communicate with a cellular network, for example, via a cellular device, e.g., eNB104, via the cellular link 133.

[0044] In some demonstrative embodiments, UE 106 may include a cellular transceiver (TRx) 166 including circuitry and/or logic configured to communicate with a cellular network, for example, via a cellular device, e.g., eNB104, via the cellular link 135.

[0045] In some demonstrative embodiments, UE 102 may include at least one non-cellular RAT transceiver (TRx) 163, and/or UE 106 may include at least one non-cellular RAT TRx 164, to communicate over a non-cellular RAT network. For example, UE 102 may communicate with UE 106 via at least one non-cellular RAT link 131, e.g., as described below.

[0046] In some demonstrative embodiments, non-cellular TRx 163 and/or non-cellular TRx 164 may include, for example, a WLAN TRx, including circuitry and/or logic configured to communicate via a WLAN link 131.

[0047] In some demonstrative embodiments, non-cellular TRx 163 and/or non-cellular TRx 164 may include, for example, a Bluetooth (BT) TRx, including circuitry and/or logic configured to communicate via a BT link 131.

[0048] Some embodiments are described below with respect to a UE, e.g., UE 102 and/or UE 106, including a WLAN TRx to communicate over a WLAN and/or a BT TRx to communicate over a BT link. In other embodiments, the UE, e.g., UE 102 and/or UE 106, may include any additional or alternative non-cellular RAT TRx to communicate over any additional or alternative non-cellular RAT network.

[0049] In some demonstrative embodiments, non-cellular TRx 163, cellular TRx 165, cellular TRx 167, cellular TRx 166, and/or non-cellular TRx 164 may include one or more wireless transmitters, receivers and/or transceivers including circuitry and/or logic to process, encode, decode, send and/or receive wireless communication signals, RF signals, frames, blocks, transmission streams, packets, messages, data items, and/or data.

[0050] In some demonstrative embodiments, non-cellular TRx 163, cellular TRx 165, cellular TRx 167, cellular TRx 166, and/or non-cellular TRx 164 may include one or more wireless receivers (Rx) including circuitry and/or logic to receive wireless communication signals, RF signals, frames, blocks, transmission streams, packets, messages, data items, and/or data; and/or one or more wireless transmitters (Tx) including circuitry and/or logic to send wireless communication signals, RF signals, frames, blocks, transmission streams, packets, messages, data items, and/or data. For example, non-cellular TRx 163, cellular TRx 165, cellular TRx 167, cellular TRx 166, and/or non-cellular TRx 164 may include circuitry; logic; Radio Frequency (RF) elements, circuitry and/or logic; baseband elements, circuitry and/or logic; modulation elements, circuitry and/or logic; demodulation elements, circuitry and/or logic; amplifiers; analog to digital and/or digital to analog converters; filters; and/or the like.

[0051] In some demonstrative embodiments, cellular TRx 167, cellular TRx 165, and/or cellular TRx 166 may include a multiple input multiple output (MIMO) transmitters receivers system (not shown), which may be capable of performing antenna beamforming methods, if desired. In other embodiments, cellular TRx 167, cellular TRx 165, and/or cellular TRx 166 may include any other transmitters and/or receivers.

[0052] In some demonstrative embodiments, cellular TRx 167, cellular TRx 165, and/or cellular TRx 166 may include LTE, WCDMA and/or TD-SCDMA modulator and/or demodulator circuitry (not shown) configured to modulate and/or demodulate downlink signals to be communicated over downlink channels, e.g., between eNB and UE 102 and/or UE 106, and/or uplink signals to be communicated over uplink channels, e.g., from UE 102

and/or UE 106 to eNB 106 104. In other embodiments, cellular TRx 167, cellular TRx 165, and/or cellular TRx 166 may include any other modulators and/or demodulators.

[0053] In some demonstrative embodiments, cellular TRx 167, cellular TRx 165, and/or cellular TRx 166 may include a turbo decoder and/or a turbo encoder (not shown) including circuitry and/or logic for encoding and/or decoding data bits into data symbols, if desired. In some demonstrative embodiments, cellular TRx 167, cellular TRx 165, and/or cellular TRx 166 may include OFDM and/or SC-FDMA modulators and/or demodulators (not shown) configured to communicate OFDM signals over downlink (DL) channels, and/or SC-FDMA signals over uplink (UL) channels.

[0054] In some demonstrative embodiments, UE 102 may establish a WLAN link with UE 106. For example, non-cellular TRx 163 and/or non-cellular TRx 164 may perform the functionality of one or more STAs, e.g., one or more WiFi STAs, WLAN STAs, and/or DMG STAs.

[0055] In some demonstrative embodiments, UE 102 may establish a BT link with UE 106. For example, non-cellular TRx 163 and/or non-cellular TRx 164 may perform the functionality of one or more BT STAs or devices, e.g., a BT master device, a BT slave device, and/or a Bluetooth Low Energy (BLE) device.

[0056] In some demonstrative embodiments, UE 102, UE 106, and/or eNB 104, may include, or may be associated with, one or more antennas. In one example, cellular TRx 167 may be associated with at least two antennas, e.g., antennas 132 and 134, or any other number of antennas, e.g., one antenna or more than two antennas; cellular TRx 165 may be associated with at least two antennas, e.g., antennas 114, or any other number of antennas, e.g., one antenna or more than two antennas; cellular TRx 166 may be associated with at least two antennas, e.g., antennas 115, or any other number of antennas, e.g., one antenna or more than two antennas; non-cellular TRx 163 may be associated with one or more antennas 112; and/or non-cellular TRx 164 may be associated with one or more antennas 113.

[0057] In some demonstrative embodiments, antennas 112, 113, 114, 115, 132, and/or 134 may include any type of antennas suitable for transmitting and/or receiving wireless communication signals, blocks, frames, transmission streams, packets, messages and/or data. For example, antennas 112, 113, 114, 115, 132, and/or 134 may include any suitable configuration, structure and/or arrangement of one or more antenna elements, components, units, assemblies and/or arrays. For example, antennas 112, 113, 114, 115, 132, and/or 134

may include a phased array antenna, a dipole antenna, a single element antenna, a set of switched beam antennas, and/or the like.

[0058] In some embodiments, antennas 112, 113, 114, 115, 132, and/or 134 may implement transmit and receive functionalities using separate transmit and receive antenna elements. In some embodiments, antennas 112, 113, 114, 115, 132, and/or 134 may implement transmit and receive functionalities using common and/or integrated transmit/receive elements.

[0059] In some demonstrative embodiments, eNB 104 may include at least one controller component 182, UE 102 may include at least one controller component 197, and/or UE 106 may include at least one controller component 192. Controllers 182, 197, and/or 192 may be configured to trigger one or more communications, may generate and/or trigger communication of one or more messages and/or transmissions, and/or may perform one or more functionalities, operations and/or procedures, e.g., as described below.

[0060] In some demonstrative embodiments, controllers 182, 197, and/or 192 may include circuitry and/or logic, e.g., one or more processors including circuitry and/or logic, memory circuitry and/or logic, Media-Access Control (MAC) circuitry and/or logic, Physical Layer (PHY) circuitry and/or logic, and/or any other circuitry and/or logic, configured to perform the functionality of controllers 182, 197, and/or 192, respectively. Additionally or alternatively, one or more functionalities of controllers 182, 197, and/or 192 may be implemented by logic, which may be executed by a machine and/or one or more processors, e.g., as described below.

[0061] In one example, controller 182 may include circuitry and/or logic, for example, one or more processors including circuitry and/or logic, configured to cause, request and/or trigger eNB 104 to perform one or more operations, communications and/or functionalities, e.g., as described herein. In one example, controller 197 may include circuitry and/or logic, for example, one or more processors including circuitry and/or logic, configured to cause, request and/or trigger UE 102 to perform one or more operations, communications and/or functionalities, e.g., as described herein. In one example, controller 192 may include circuitry and/or logic, for example, one or more processors including circuitry and/or logic, configured to cause, request and/or trigger UE 106 to perform one or more operations, communications and/or functionalities, e.g., as described herein.

[0062] In some demonstrative embodiments, eNB 104 may include a message processor 144 configured to generate, process and/or access one or messages communicated by eNB 104. In

one example, message processor 144 may be configured to generate one or more messages to be transmitted by eNB 104, and/or message processor 144 may be configured to access and/or to process one or more messages received by eNB 104, e.g., as described below.

[0063] In some demonstrative embodiments, UE 102 may include a message processor 198 configured to generate, process and/or access one or messages communicated by UE 102. In one example, message processor 198 may be configured to generate one or more messages to be transmitted by UE 102, and/or message processor 198 may be configured to access and/or to process one or more messages received by UE 102, e.g., as described below.

[0064] In some demonstrative embodiments, UE 106 may include a message processor 196 configured to generate, process and/or access one or messages communicated by UE 106. In one example, message processor 196 may be configured to generate one or more messages to be transmitted by UE 106, and/or message processor 196 may be configured to access and/or to process one or more messages received by UE 106, e.g., as described below.

[0065] In some demonstrative embodiments, message processors 144, 198 and/or 196 may include circuitry, e.g., processor circuitry, memory circuitry, Media-Access Control (MAC) circuitry, Physical Layer (PHY) circuitry, and/or any other circuitry, configured to perform the functionality of message processors 144, 198 and/or 196. Additionally or alternatively, one or more functionalities of message processors 144, 198 and/or 196 may be implemented by logic, which may be executed by a machine and/or one or more processors, e.g., as described below.

[0066] In some demonstrative embodiments, at least part of the functionality of message processor 144 may be implemented as part of cellular TRx 167; at least part of the functionality of message processor 198 may be implemented as part of cellular TRx 165 and/or non-cellular TRx 163; and/or at least part of the functionality of message processor 196 may be implemented as part of cellular TRx 166 and/or non-cellular TRx 164.

[0067] In some demonstrative embodiments, at least part of the functionality of message processor 144 may be implemented as part of controller 182, at least part of the functionality of message processor 198 may be implemented as part of controller 197, and/or at least part of the functionality of message processor 196 may be implemented as part of controller 192.

[0068] In other embodiments, at least part of the functionality of message processor 144 may be implemented as part of any other element of eNB 104, at least part of the functionality of message processor 198 may be implemented as part of any other element of UE 102, and/or

at least part of the functionality of message processor 196 may be implemented as part of any other element of UE 106.

[0069] In some demonstrative embodiments, at least part of the functionality of controller 197, and/or message processor 198 may be implemented by an integrated circuit, for example, a chip, e.g., a System on Chip (SoC). In one example, the chip or SoC may be configured to perform one or more functionalities of cellular transceiver 165 and/or non-cellular TRx 163. For example, the chip or SoC may include one or more elements of controller 197, message processor 198, and/or one or more elements of cellular transceiver 165 and/or non-cellular TRx 163. In one example, controller 197, message processor 198, cellular transceiver 165, and non-cellular TRx 163 may be implemented as part of the chip or SoC. In other embodiments, controller 197, message processor 198, cellular transceiver 165 and/or non-cellular TRx 163 may be implemented by one or more additional or alternative elements of UE 102.

[0070] In some demonstrative embodiments, at least part of the functionality of controller 192, and/or message processor 196 may be implemented by an integrated circuit, for example, a chip, e.g., a System on Chip (SoC). In one example, the chip or SoC may be configured to perform one or more functionalities of cellular transceiver 166 and/or non-cellular TRx 164. For example, the chip or SoC may include one or more elements of controller 192, message processor 196, and/or one or more elements of cellular transceiver 166 and/or non-cellular TRx 164. In one example, controller 192, message processor 196, cellular transceiver 166, and non-cellular TRx 164 may be implemented as part of the chip or SoC. In other embodiments, controller 192, message processor 196, cellular transceiver 166 and/or non-cellular TRx 164 may be implemented by one or more additional or alternative elements of UE 106.

[0071] In some demonstrative embodiments, at least part of the functionality of controller 182 and/or message processor 144 may be implemented by an integrated circuit, for example, a chip, e.g., a System on Chip (SoC). In one example, the chip or SoC may be configured to perform one or more functionalities of cellular transceiver 167. For example, the chip or SoC may include one or more elements of controller 182, message processor 144, and/or one or more elements of cellular transceiver 167. In one example, controller 182, message processor 144, and cellular transceiver 167 may be implemented as part of the chip or SoC. In other embodiments, controller 182, message processor 144, and/or cellular transceiver 167 may be implemented by one or more additional or alternative elements of eNB 104.

[0072] In some demonstrative embodiments, eNB 104, UE 102, and/or UE 106 may also include, for example, one or more of a processor, an input unit, an output unit, a memory unit, and/or a storage unit. For example, eNB 104 may include a processor 173 and/or a memory 174; UE 102 may include a memory 151, a processor 152, an input unit 153, an output unit 154, and/or a storage unit 155; and/or UE 106 may include a memory 175, a processor 176, an input unit 178, an output unit 179, and/or a storage unit 177. UE 102, cellular manager 104 and/or UE 106 may optionally include other suitable hardware components and/or software components. In some demonstrative embodiments, some or all of the components of UE 102 may be enclosed in a common housing or packaging, and may be interconnected or operably associated using one or more wired or wireless links; some or all of the components of UE 106 may be enclosed in a common housing or packaging, and may be interconnected or operably associated using one or more wired or wireless links; and/or some or all of the components of eNB 104 may be enclosed in a common housing or packaging, and may be interconnected or operably associated using one or more wired or wireless links. In other embodiments, components of UE 102 may be distributed among multiple or separate devices, components of UE 106 may be distributed among multiple or separate devices, and/or components of eNB 104 may be distributed among multiple or separate devices.

[0073] In some demonstrative embodiments, processors 173, 152, and/or 176 may include, for example, a Central Processing Unit (CPU), a Digital Signal Processor (DSP), one or more processor cores, a single-core processor, a dual-core processor, a multiple-core processor, a microprocessor, a host processor, a controller, a plurality of processors or controllers, a chip, a microchip, one or more circuits, circuitry, a logic unit, an Integrated Circuit (IC), an Application-Specific IC (ASIC), or any other suitable multi-purpose or specific processor or controller. For example, processor 173 may execute instructions, for example, of an Operating System (OS) of eNB 104 and/or of one or more suitable applications; processor 152 may execute instructions of an OS of UE 102 and/or of one or more suitable applications; and/or processor 176 may execute instructions of an OS of UE 106 and/or of one or more suitable applications.

[0074] In some demonstrative embodiments, input unit 153 and/or input unit 178 may include, for example, a keyboard, a keypad, a mouse, a touch-screen, a touch-pad, a trackball, a stylus, a microphone, or other suitable pointing device or input device. Output unit 154 and/or output unit 177 includes, for example, a monitor, a screen, a touch-screen, a flat panel

display, a Light Emitting Diode (LED) display unit, a Liquid Crystal Display (LCD) display unit, a plasma display unit, one or more audio speakers or earphones, or other suitable output devices.

5 [0075] In some demonstrative embodiments, memory units 174, 175 and/or 151 may include, for example, a Random Access Memory (RAM), a Read Only Memory (ROM), a Dynamic RAM (DRAM), a Synchronous DRAM (SD-RAM), a flash memory, a volatile memory, a non-volatile memory, a cache memory, a buffer, a short term memory unit, a long term memory unit, or other suitable memory units. Storage units 155 and/or 177 may include, for example, a hard disk drive, a floppy disk drive, a Compact Disk (CD) drive, a CD-ROM
10 drive, a DVD drive, or other suitable removable or non-removable storage units. For example, memory unit 174 may store data processed by eNB 104; memory unit 151 may store data processed by UE 102; and/or memory unit 175 may store data processed by UE 106.

15 [0076] In some demonstrative embodiments, a first UE, e.g., UE 106 may be configured to operate as a relay UE, which may be able to provide relaying functionality, for example, to forward data received from eNB 104 to a second UE (“the remote UE”), e.g., UE 102, and/or to forward data received from the remote UE to eNB 104, e.g., as described below.

20 [0077] In some demonstrative embodiments, UE 102 may be configured to communicate directly with eNB 104 via cellular link 133, and/or UE 106 may be configured to communicate directly with eNB 104 via cellular link 135. For example, cellular links 133 and/or 135 may include a Uu link.

25 [0078] In some demonstrative embodiments, UE 102 may be configured to establish a bearer, for example, an Evolved Packet-switched System (EPS) bearer between UE 102 and the cellular network. For example, UE 102 may be configured to establish the EPS bearer over the cellular RAT link 133 between UE 102 and eNB 104, e.g., as described below.

[0079] In some demonstrative embodiments, UE 102, UE 106, and/or eNB 104 may be configured to enable relaying traffic of the EPS bearer of UE 102 to the cellular network, for example, via the non-cellular RAT link 131 between UE 102 and UE 106, and via the cellular RAT link between UE 106 and eNB 104, e.g., as described below.

30 [0080] In some demonstrative embodiments, UE 102 may be configured to operate as a remote UE, which may be capable of routing traffic of the EPS of UE 102 via a relay UE. For

example, UE 106 may be configured to operate as the relay UE to relay the traffic of UE 102 between UE 102 and eNB 104, e.g., as described below.

[0081] Reference is made to Fig. 2, which schematically illustrates elements of a UE device 200, in accordance with some demonstrative embodiments. For example, UE 102 (Fig. 1) may include one or more elements of UE device 200, and/or UE 106 (Fig. 1) may include one or more elements of UE device 200. In one example, one or more elements of UE device 200 may be configured to perform the functionality of one or more of cellular TRx 165 (Fig. 1), non-cellular TRx 163 (Fig. 1), controller 197 (Fig., 1), message processor 198 (Fig. 1), and/or one or more other elements of UE 102 (Fig. 1). In one example, one or more elements of UE device 200 may be configured to perform the functionality of one or more of cellular TRx 166 (Fig. 1), non-cellular TRx 164 (Fig. 1), controller 192 (Fig., 1), message processor 196 (Fig. 1), and/or one or more other elements of UE 106 (Fig. 1). In some demonstrative embodiments, embodiments of a UE may be implemented into a system using any suitably configured hardware and/or software. Fig. 2 illustrates, for one embodiment, example components of UE device 200.

[0082] In some demonstrative embodiments, UE device 200 may include application circuitry 202, baseband circuitry 204, Radio Frequency (RF) circuitry 206, front-end module (FEM) circuitry 208, and one or more antennas 210, coupled together at least as shown.

[0083] In one example, application circuitry 202 may be configured to perform at least part of the functionality of controller 197 (Fig. 1), and/or message processor 198 (Fig. 1); and/or baseband circuitry 204, RF circuitry 206, and/or FEM circuitry 208 may be configured to perform at least part of the functionality of cellular TRx 165 (Fig. 1), non-cellular TRx 163 (Fig. 1), controller 197 (Fig. 1), and/or message processor 198 (Fig. 1).

[0084] In another example, application circuitry 202 may be configured to perform at least part of the functionality of controller 192 (Fig. 1), and/or message processor 196 (Fig. 1); and/or baseband circuitry 204, RF circuitry 206, and/or FEM circuitry 208 may be configured to perform at least part of the functionality of cellular TRx 166 (Fig. 1), non-cellular TRx 164 (Fig. 1), controller 192 (Fig. 1), and/or message processor 196 (Fig. 1).

[0085] In some demonstrative embodiments, the application circuitry 202 may include one or more application processors. For example, the application circuitry 202 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated

processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include memory/storage and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system.

5 [0086] In some demonstrative embodiments, the baseband circuitry 204 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 204 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 206 and to generate baseband signals for a transmit signal path of the RF circuitry 206. Baseband
10 processing circuitry 204 may interface with the application circuitry 202, for example, for generation and processing of the baseband signals and for controlling operations of the RF circuitry 206. For example, in some embodiments, the baseband circuitry 204 may include a second generation (2G) baseband processor 204a, a third generation (3G) baseband processor 204b, a fourth generation (4G) baseband processor 204c, and/or other baseband processor(s)
15 204d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 204 (e.g., one or more of baseband processors 204a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 206. The radio control functions may include, but are not limited to, signal modulation/demodulation,
20 encoding/decoding, radio frequency shifting, etc. In some embodiments, modulation/demodulation circuitry of the baseband circuitry 204 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 204 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check
25 (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

[0087] In some demonstrative embodiments, the baseband circuitry 204 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial
30 radio access network (EUTRAN) protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 204e of the baseband circuitry 204 may be configured, for example, to run elements of the protocol stack

for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal processor(s) (DSP) 204f. The audio DSP(s) 204f may include elements for compression/decompression and echo cancellation, and/or may include other suitable processing elements in other embodiments.

5 Components of the baseband circuitry 204 may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 204 and the application circuitry 202 may be implemented together such as, for example, on a system on a chip (SOC).

10 [0088] In some demonstrative embodiments, the baseband circuitry 204 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 204 may support communication with an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network
15 (WPAN), and/or one or more additional or alternative networks. Embodiments in which the baseband circuitry 204 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

[0089] In some demonstrative embodiments, RF circuitry 206 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid
20 medium. In various embodiments, the RF circuitry 206 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 206 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 208, and to provide baseband signals to the baseband circuitry 204. RF circuitry 206 may also include a transmit signal path which may include
25 circuitry to up-convert baseband signals provided by the baseband circuitry 204 and provide RF output signals to the FEM circuitry 208 for transmission.

[0090] In some demonstrative embodiments, the RF circuitry 206 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 206 may include mixer circuitry 206a, amplifier circuitry 206b, and filter circuitry 206c. The transmit
30 signal path of the RF circuitry 206 may include filter circuitry 206c and mixer circuitry 206a. RF circuitry 206 may also include synthesizer circuitry 206d for synthesizing a frequency for use by the mixer circuitry 206a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 206a of the receive signal path may be configured to

down-convert RF signals received from the FEM circuitry 208 based on the synthesized frequency provided by synthesizer circuitry 206d. The amplifier circuitry 206b may be configured to amplify the down-converted signals and the filter circuitry 206c may be, for example, a low-pass filter (LPF) or a band-pass filter (BPF), configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to the baseband circuitry 204 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 206a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

[0091] In some demonstrative embodiments, the mixer circuitry 206a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 206d to generate RF output signals for the FEM circuitry 208. The baseband signals may be provided by the baseband circuitry 204 and may be filtered by filter circuitry 206c. The filter circuitry 206c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

[0092] In some demonstrative embodiments, the mixer circuitry 206a of the receive signal path and the mixer circuitry 206a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 206a of the receive signal path and the mixer circuitry 206a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 206a of the receive signal path and the mixer circuitry 206a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 206a of the receive signal path and the mixer circuitry 206a of the transmit signal path may be configured for super-heterodyne operation.

[0093] In some demonstrative embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 206 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry, and the baseband circuitry 204 may include a digital baseband interface to communicate with the RF circuitry 206.

[0094] In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

[0095] In some demonstrative embodiments, the synthesizer circuitry 206d may be a fractional-N synthesizer or a fractional $N/N+1$ synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 206d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

[0096] In some demonstrative embodiments, the synthesizer circuitry 206d may be configured to synthesize an output frequency for use by the mixer circuitry 206a of the RF circuitry 206 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 206d may be a fractional $N/N+1$ synthesizer.

[0097] In some demonstrative embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 204 or the applications processor 202 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 202.

[0098] In some demonstrative embodiments, synthesizer circuitry 206d of the RF circuitry 206 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or $N+1$ (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into N_d equal packets of phase, where N_d is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

[0099] In some demonstrative embodiments, synthesizer circuitry 206d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the

output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 206 may include an IQ/polar converter.

[00100] In some demonstrative embodiments, FEM circuitry 208 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 210, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 206 for further processing. FEM circuitry 208 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 206 for transmission by one or more of the one or more antennas 210.

[00101] In some demonstrative embodiments, the FEM circuitry 208 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 206). The transmit signal path of the FEM circuitry 208 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 206), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 210).

[00102] In some embodiments, the UE device 200 may include one or more additional or alternative elements such as, for example, memory/storage, display, camera, sensor, and/or input/output (I/O) interface.

[00103] Reference is made to Fig. 3, which schematically illustrates an implementation utilizing UE relaying via a non-cellular Radio Access Technology (RAT), in accordance with some demonstrative embodiments.

[00104] In some demonstrative embodiments, as shown in Fig. 3, a remote UE 302 may be configured to communicate with an Evolved Packet Core (EPC) network 308, for example, over a Uu link 310, e.g., via an eNB 304. For example, UE 102 (Fig. 1) may be configured to operate as, and/or perform one or more functionalities of, remote UE 302, and/or eNB 104

(Fig. 1) may be configured to operate as, and/or perform one or more functionalities of, eNB 304.

[00105] In some demonstrative embodiments, as shown in Fig. 3, a relay UE 306 may be configured to relay traffic between eNB 304 and one or more remote UEs, e.g., including remote UE 302. For example, UE 106 (Fig. 1) may be configured to operate as, and/or perform one or more functionalities of, relay UE 306.

[00106] In some demonstrative embodiments, as shown in Fig. 3, relay UE 306 may be configured to communicate with EPC network 308, for example, over a Uu link 318, e.g., via eNB 304.

[00107] In some demonstrative embodiments, as shown in Fig. 3, remote UE 302 and relay UE 306 may be configured to communicate over one or more non-cellular RAT links, for example, a BT link 316 and/or a WiFi link 314.

[00108] In some demonstrative embodiments, relay UE 306 may be configured to operate as a Proximity Services (ProSe) UE-to-Network Relay, e.g., according to a 3GPP Specification.

[00109] In some demonstrative embodiments, as shown in Fig. 3, remote UE 302 and relay UE 306 may be configured to communicate over a cellular interface, for example, a PC5 interface 312.

[00110] In some demonstrative embodiments, remote UE 302 may include a low power device, for example, a low power wearable device, e.g., as described below. In other embodiments, remote UE 304 may include any other device, for example, a sensor device, an IoT device, a mobile device, and/or any other device, which may or may not have power constraints.

[00111] In some demonstrative embodiments, cellular technology, for example, LTE technology of one or more 3GPP Standards, e.g., releases 8-12 of the 3GPP standards, may be enhanced, for example, to connect and/or manage the low-power wearable devices. For example, some use cases for utilizing wearable devices may include use cases ranging from low data rate delay tolerant monitoring to high data rate delay sensitive virtual reality, and/or any other use case or implementation, which may require various communication capabilities.

[00112] In some demonstrative embodiments, a cellular solution, e.g., utilizing cellular RAT links, may provide support of Layer-3 UE to network (UE-to-NW) relaying, for example, by

applying LTE PC5 technology to support some wearable use cases. However, this type of solution may not be suitable for, and/or efficient for, some use cases, implementations, deployments and/or scenarios.

[00113] In some demonstrative embodiments, a ProSe framework may be enhanced to target long-range and/or relatively low-rate broadcast communication, which may be robust to interference, for example, by analyzing how wearable as a subset of Machine Type Communications (MTC) use cases can benefit from Device-to-Device (D2D) technology, and/or by identifying enhancements to the cellular and/or sidelink air-interface jointly with UE-to-NW relaying functionality, for example, in order to support a broad range of wearable use cases.

[00114] In some demonstrative embodiments, UE 302, e.g., a wearable device, may support non-3GPP capabilities such as, for example, WiFi, BT, short-range communication, and/or any other non-cellular RAT. The UE 302 may be configured to use the non-cellular RAT capabilities as alternatives to communicate with the cellular network, for example, via relay UE 306, e.g., as described below.

[00115] Some demonstrative embodiments, e.g., as described below, may be implemented to provide solutions, which may enable having a form of tight integration between the non-cellular RAT and existing Uu and/or relay UE 302, for example, to enable transferring data between the remote UE 302 and the network 308. These solutions may enable, for example, at least smooth switching between direct Uu and non-3GPP access for the remote UE 302, e.g., as described below.

[00116] In some demonstrative embodiments, remote UE 302, relay UE 306 and/or eNB 304 may be configured to enable relaying of traffic between remote UE 302 and eNB 304 via the non-cellular RAT link between remote UE 302 and relay UE 306, for example, using Layer 2 (L2) relaying between the different access technologies, e.g., as described below.

[00117] In some demonstrative embodiments, the remote UE 302 may be configured to use the relay UE 306, e.g., only relay UE 306, for communication via the non-3GPP access, e.g., via non-cellular RAT links 314 and/or 316.

[00118] In some demonstrative embodiments, as shown in Fig. 3, relay UE 306 may be in coverage of the cellular network of eNB 304. For example, it may be assumed that relay UE 306 remains, e.g., always, in coverage of eNB 304, for example, at least for the duration of a relaying operation (also referred to as “relay session”) with a remote UE, e.g., UE 302.

[00119] In some demonstrative embodiments, as shown in Fig. 3, remote UE 302 may be out of a coverage (“out of network”) of the cellular network of eNB 304, for example, after establishing an EPS bearer between remote UE 306 and EPC 308. For example, remote UE 302 may be configured to use the Uu link 310 to establish an EPS bearer between remote UE 302 and EPC 308 via eNB 304, and to switch to use the non-cellular RAT links 314 and/or 316 with relay UE 306 to communicate traffic of the EPS bearer with EPC 308, e.g., as described below.

[00120] In some demonstrative embodiments, the remote UE 302 to be served by a relay path via relay UE 306 may be in coverage of the eNB 304. For example, remote UE 302 may be in connected mode, or may have been in connected mode, for example, such that UE context corresponding to remote UE 302 may be available at eNB 304. For example, signaling radio bearers (SRBs), data radio bearers (DRBs), and/or security may be established between remote UE 302 and eNB 304, an S1 connection may be established between remote UE 302 and eNB 304, and/or an S1 connection may be established between eNB 304 and EPC 308.

[00121] In some demonstrative embodiments, remote UE 302, relay UE 306, and/or eNB 304 may be configured to support one or more advanced relaying operations, for example, by using relay UE 306 to relay (transfer) traffic between remote UE 302 and eNB 304, for example, via L2 routing over a non-3GPP interface between the remote UE 302 and relay UE 306, e.g., via non-cellular RAT links 314 and/or 316.

[00122] In some demonstrative embodiments, using an L2 routing scheme, e.g., as described herein, may be advantageous, for example, compared to a Layer 3 (L3) relay, e.g., of an eProSe work item of LTE Release 13, which may be configured for an LTE PC5 interface supporting direct communication via LTE. For example, the Layer 2 routing scheme described herein may enable to perform relaying below the L3 layer, e.g., even right above a MAC layer.

[00123] In some demonstrative embodiments, L3 relaying, e.g., Internet Protocol (IP) based relaying, may be disadvantageous and/or inefficient, for example, since service continuity may be dependent on an application level to be maintained, e.g., when an IP address may change during a relay change or a direct relay path change.

[00124] In some demonstrative embodiments, remote UE 302 may be configured to use a common Packet Data Convergence Protocol (PDCP) layer/entity to process both

communications of a direct link between UE 302 and eNB 304, as well as communications with the cellular network through a UE-to-Network relay, e.g., as described below.

[00125] In some demonstrative embodiments, remote UE 302 may be configured to send to relay UE 306 one or more uplink data units, e.g., one or more uplink Service Data Units (SDUs) and/or Protocol Data Units (PDUs), via non-cellular RAT links 314 and/or 316, and relay UE 306 may be configured to transfer the uplink data units to EPC 308 via Uu interface 316, e.g., as described below.

[00126] In some demonstrative embodiments, eNB 304 may be configured to send to relay UE 306 one or more downlink data units, e.g., downlink SDUs and/or PDUs, via Uu interface 318, and relay UE 306 may be configured to transfer the downlink data units to remote UE 302 via non-cellular RAT links 314 and/or 316, e.g., as described below.

[00127] In some demonstrative embodiments, remote UE 302 may be configured to interface, via a Device to Device (D2D) component, with relay UE 306 over a non-cellular RAT link, e.g., link 314 and/or link 316, e.g., as described below.

[00128] In some demonstrative embodiments, remote UE 302 may be configured to interface, via a Device to Network (D2N) component, with eNB 304 of a cellular network, e.g., EPC 308, over a cellular RAT link, e.g., Uu link 310, as described below.

[00129] In some demonstrative embodiments, remote UE 302 may be configured to perform PDCP processing of traffic of an EPS bearer between remote UE 302 and the cellular network, e.g., as described below. For example, the EPS bearer may be established over the cellular RAT link, e.g., Uu link 310.

[00130] In some demonstrative embodiments, remote UE 302 may be configured to route an uplink SDU of the EPS bearer to the D2D component to communicate the uplink SDU to the relay UE 306 over the non-cellular RAT link, e.g., link 314 and/or link 316, e.g., as described below.

[00131] In some demonstrative embodiments, relay UE 306 may be configured to interface, via a D2D component, with at least one remote UE, e.g., remote UE 302, over at least one non-cellular RAT link, e.g., link 314 and/or link 316, as described below.

[00132] In some demonstrative embodiments, the D2D component may include, may operate as, and/or may perform one or more functionalities of, a ProSe component, e.g., a ProSe interface, communication component, controller, and/or processor. For example, remote UE

302 may include a ProSe component to communicate with relay UE 306, and/or relay UE 306 may include a ProSe component to communicate with remote UE 302, e.g., as described below.

[00133] Some demonstrative embodiments are described herein with respect to a UE, e.g., relay UE 306 and/or remote UE 302, including a ProSe component to communicate over a non-cellular RAT link, e.g., link 314. In other embodiments, the UE, e.g., relay UE 306 and/or remote UE 302, may include any additional or alternative component, e.g., a D2D component, configured to communicate over a non-cellular RAT link, e.g., link 314.

[00134] In some demonstrative embodiments, relay UE 306 may be configured to interface, via a D2N component, with eNB 304 over a cellular RAT link, e.g., Uu link 318, as described below.

[00135] In some demonstrative embodiments, relay UE 306 may receive from the D2D component an uplink SDU from the remote UE, e.g., the uplink SDU from remote UE 302.

[00136] In some demonstrative embodiments, relay UE 306 may be configured to transfer the uplink SDU to the D2N component to communicate the uplink SDU to the eNB 304 over the cellular RAT link, e.g., Uu link 318, as described below.

[00137] In some demonstrative embodiments, eNB 304 may be configured to interface, via a first D2N component, with a remote UE, e.g., remote UE 302, over a first cellular Radio RAT link, e.g., Uu link 310, as described below.

[00138] In some demonstrative embodiments, eNB 304 may be configured to interface, via a second D2N component, with a relay UE, e.g., relay UE 306, over a second cellular RAT link, e.g., Uu link 318, as described below.

[00139] In some demonstrative embodiments, eNB 304 may be configured to receive an indication of establishment of a non-cellular RAT link between the remote UE and the relay UE, for example, the non-cellular RAT links 314 and/316. For example, eNB 304 may receive the indication of establishment of the non-cellular RAT links 314 and/or 316 between UE 302 and UE 306, for example, from UE 302 and/or from UE 306.

[00140] In some demonstrative embodiments, eNB 304 may be configured to, based on the indication, route a downlink SDU for the remote UE 302 to the second D2N component to communicate the downlink SDU to the relay UE 306, e.g., as described below.

[00141] Fig. 4 is a schematic illustration of a protocol stack configured for L2 relaying above a Radio Link Control (RLC) layer, in accordance with some demonstrative embodiments.

[00142] In some demonstrative embodiments, a relay UE 406 may be configured to relay communications between an eNB 404 and a remote UE 402, for example, via a non-cellular RAT link 414 between the remote UE 402 and the relay UE 406, e.g., as described below.

[00143] For example, UE 106 (Fig. 1) may be configured to operate as, and/or perform one or more functionalities of, relay UE 406; UE 102 (Fig. 1) may be configured to operate as, and/or perform one or more functionalities of, remote UE 402; and/or eNB 104 (Fig. 1) may be configured to operate as, and/or perform one or more functionalities of, eNB 404.

[00144] In some demonstrative embodiments, UE 402, UE 406, and/or eNB 404 may be configured to implement a protocol stack configured to support forwarding or relaying of traffic within relay UE 406 above an RLC layer, e.g., just above the RLC layer, as described below.

[00145] In some demonstrative embodiments, as shown in Fig. 4, remote UE 402 may include a Device to Device (D2D) component 442, e.g., a ProSe component, configured to interface with relay UE 406 over a non-cellular RAT link 414.

[00146] In one example, as shown in Fig. 4, ProSe component 442 may include a WLAN communication component to interface with UE 406 over a WLAN link 414. For example, as shown in Fig. 4, ProSe component 442 may include at least a WLAN MAC layer.

[00147] In another example, D2D component 442 may include any other additional or alternative non-cellular communication component to interface with UE 406 over any other additional or alternative non-cellular RAT link 414. For example, D2D component 442 may include at least a BT communication component to communicate over a BT link.

[00148] In some demonstrative embodiments, as shown in Fig. 4, remote UE 402 may include a Device to Network (D2N) component 444 configured to interface with eNB 404 over a cellular RAT link, e.g., over a Uu link. For example, as shown in Fig. 4, D2N component 444 may include at least a RLC component and a Uu MAC.

[00149] In some demonstrative embodiments, as shown in Fig. 4, remote UE 402 may include a Packet Data Convergence Protocol (PDCP) component 434 configured to process traffic communicated between UE 402 and the cellular network, e.g., as described below.

[00150] In some demonstrative embodiments, PDCP component 434 may be configured to process traffic of an EPS bearer between UE 402 and the cellular network. For example, the EPS bearer may be established over the cellular RAT link between UE 402 and eNB 404, e.g., as described above.

5 [00151] In some demonstrative embodiments, as shown in Fig. 4, relay UE 406 may include a D2D component 452, e.g., a ProSe component, configured to interface with one or more remote UEs, e.g., including remote UE 402, over one or more non-cellular RAT links, e.g., including non-cellular RAT link 414.

10 [00152] In one example, as shown in Fig. 4, D2D component 452 may include a WLAN communication component to interface with UE 402 over a WLAN link 414. For example, as shown in Fig. 4, D2D component 452 may include at least a WLAN MAC layer.

[00153] In another example, D2D component 452 may include any other additional or alternative non-cellular communication component to interface with UE 402 over any other additional or alternative non-cellular RAT link 414. For example, D2D component 452 may
15 include at least a BT communication component to communicate over a BT link.

[00154] In some demonstrative embodiments, as shown in Fig. 4, relay UE 406 may include a D2N component 454 configured to interface with eNB 404 over a cellular RAT link 474, e.g., over a Uu link. For example, as shown in Fig. 4, D2N component 454 may include at least a RLC component and a Uu MAC.

20 [00155] In some demonstrative embodiments, as shown in Fig. 4, eNB 404 may include a plurality of D2N components to communicate with a plurality of UEs. For example, eNB 404 may include at least a first D2N component 462 configured to interface with remote UE 402 over a cellular RAT link, e.g., over a Uu link, and a second D2N component 464 configured to interface with relay UE 406 over cellular RAT link 474. For example, as shown in Fig. 4,
25 D2N components 462 and/or 464 may include at least a RLC component and a Uu MAC.

[00156] In some demonstrative embodiments, as shown in Fig. 4, eNB 404 may include a PDCP component 465 configured to process traffic communicated between eNB 404 and a plurality of UEs, including UE 402 and/or UE 406, e.g., as described below.

[00157] In some demonstrative embodiments, PDCP component 465 may be configured to
30 process traffic of the EPS bearer between the cellular network and UE 402, e.g., as described above.

[00158] In some demonstrative embodiments, as shown in Fig. 4, UE 402 and/or UE 406 may be configured to utilize a common PDCP entity, which may be shared and/or tightly integrated between the WLAN MAC and D2D MAC protocol stack, e.g., a ProSe MAC protocol stack.

- 5 [00159] In some demonstrative embodiments, implementing the common PDCP entity may allow, for example, at least to ensure end-to-end security between remote UE 402 and eNB 404, and/or to have a common pathway between non-3GPP and Uu protocols, e.g., to enable transferring messages between the two technologies.

[00160] In some demonstrative embodiments, remote UE 402, relay UE 406, and/or eNB
10 404 may be configured to support L2 relaying below the PDCP layer, e.g., as described below.

[00161] In some demonstrative embodiments, the L2 relaying may be advantageous, for example, at least since the L2 relaying may allow traffic of EPS bearers to be switched between a direct path, e.g., via a direct cellular link, or a relay path, e.g., via relay UE 406,
15 for example, while preserving an Internet Protocol (IP) address, e.g., regardless of which path is used to carry the traffic.

[00162] In some demonstrative embodiments, the L2 relaying may be advantageous, for example, at least since the L2 relaying may allow traffic relaying between the direct path and the relay path, for example, even without the core network and/or upper protocol layers being
20 aware that relaying is performed.

[00163] In some demonstrative embodiments, the L2 relaying may be advantageous, for example, at least since the L2 relaying may allow maintaining security, e.g., provided within the PDCP layer, between remote UE 402 and eNB 404, for example, regardless of the path used to carry the traffic, e.g., between the Uu path and the relay path or between one relay
25 path and another relay path. For example, a PDCP entity of UE 402, e.g., PDCP component 434, may be configured as a common PDCP entity to be shared between cellular, e.g., 3GPP, and non-cellular, e.g., non-3GPP, entities, for example, to support end-to-end security between remote UE 402 and eNB 404.

[00164] In some demonstrative embodiments, the L2 relaying may be advantageous, for
30 example, at least since the L2 relaying may allow maintaining a header compression, e.g., provided within the PDCP layer, between remote UE 402 and eNB 406, e.g., regardless of the path used to carry the traffic.

[00165] In some demonstrative embodiments, UE 402 may include a controller component 446 configured to route traffic between remote UE 402 and eNB 404 via D2D component 442, e.g., to communicate the traffic via a relay path over the non-cellular RAT link 414, and/or via D2N component 444, e.g., to communicate the traffic via a direct path over the cellular RAT link between remote UE 402 and eNB 404, e.g., as described below.

[00166] In some demonstrative embodiments, eNB 404 may include a controller component 466 configured to route the traffic between remote UE 402 and eNB 404 via D2N component 464, e.g., to communicate the traffic via relay UE 406, and/or via D2N component 462, e.g., to communicate the traffic via the cellular RAT link between remote UE 402 and eNB 404, e.g., as described below.

[00167] In some demonstrative embodiments, relay UE 406 may include a controller component 456 configured to transfer traffic D2D component 452 and D2N component 454, e.g., to relay the traffic between eNB 404 and remote UE 402, e.g., as described below.

[00168] In some demonstrative embodiments, D2N component 444, and/or D2N component 462 may be configured to support communication over a direct Uu path between eNB 404 and remote UE 402; D2D component 442, D2D component 452, controller component 456, D2N component 454, and D2N component 464 may be configured to support communication over a relay path between eNB 404 and remote UE 402 via relay UE 406; and/or PDCP component 434, an IP component 432, PDCP component 465, and at least an S1 bearer interface 461 of eNB 404 may be configured to support communication over both the direct path and the relay path, e.g., as described below.

[00169] In some demonstrative embodiments, remote UE 402 may be configured to route uplink data to eNB 404 via relay UE 406, for example, by delivering uplink SDUs, for example, PDCP PDUs from PDCP component 434, to D2D component 442, e.g., to the WLAN MAC, for example, if the relaying functionality is to be used, e.g., as described below.

[00170] In some demonstrative embodiments, the uplink data may include, for example, traffic of the EPS bearer of remote UE 402 with the cellular network, e.g., which may be established before the uplink data is to be transmitted via the relay path.

[00171] In some demonstrative embodiments, remote UE 402 may be configured to setup the EPS bearer via the direct path between D2N component 444 and eNB 404, e.g., using the Uu interface. For example, remote UE 402 may be configured to establish the EPS bearer

according to a cellular protocol, e.g., an LTE control protocol, for example, using one or more Radio Resource Control (RRC) and/or Non-Access Stratum (NAS) layer messages.

[00172] In some demonstrative embodiments, relay UE 406 may receive the uplink SDUs from remote UE 402, for example, at D2D component 452, e.g., at the WLAN MAC.

5 [00173] In some demonstrative embodiments, controller component 456 may be configured to recognize the received uplink SDUs as received with the common PDCP entity, for example, based on header information in the PDCP PDUs, e.g., as described below. For example, controller component 456 may route the received uplink SDUs to the D2N component 454, for example, to the Uu MAC, to communicate the uplink traffic to the
10 network, e.g., via cellular RAT link 474.

[00174] In some demonstrative embodiments, eNB 404 may be configured to route downlink data to remote UE 403 via relay UE 406, for example, by delivering downlink SDUs, for example, PDCP PDUs from PDCP component 465, to D2N component 464, for example, if the relaying functionality is to be used, e.g., as described below. For example, D2N
15 component 464 may send to relay UE 406 MAC SDUs corresponding to the PDCP PDUs, e.g., via link 474.

[00175] In some demonstrative embodiments, relay UE 406 may receive, e.g., at D2N component 454, the downlink MAC SDUs from eNB 404, for example, on a downlink (DL) of the Uu interface between eNB 404 and relay UE 406, e.g., over link 474.

20 [00176] In some demonstrative embodiments, controller component 456 may be configured to transfer, e.g., to directly submit, the downlink MAC SDUs to D2D component 452, for example, as MAC SDUs on the non-cellular RAT interface, e.g., the WLAN interface between relay UE 406 and remote UE 402.

[00177] In some demonstrative embodiments, a relaying function implemented by controller
25 456 at relay UE 406 may include a buffer mechanism, for example, to enable queuing the downlink traffic from eNB 404 and/or the uplink traffic from remote UE 402, for example, until a convenient time for transmission e.g. until resource is scheduled.

[00178] In some demonstrative embodiments, controller component 446 of remote UE 402 and/or controller component 466 of eNB 404 may be configured to perform one or more
30 route switching operations and/or functions, e.g., as described below.

[00179] In some demonstrative embodiments, controller component 446 of remote UE 402 may be configured to implement a switching functionality, which may enable, for example, RLC PDUs, e.g., the uplink MAC SDUs and/or the downlink MAC SDUs, to be switched between the MAC of the D2D component 442, e.g., the WLAN MAC interface, and the D2N component 444, e.g., the MAC of the Uu interface.

[00180] In some demonstrative embodiments, controller component 466 of eNB 404 may be configured to implement a switching functionality, which may enable, for example, RLC PDUs, e.g., the uplink MAC SDUs and/or the downlink MAC SDUs, to be switched between the MAC of the D2N component 462, e.g., the MAC of the Uu interface between eNB 404 and remote UE 402, and the MAC of the D2N component 464, e.g., the MAC of the Uu interface between eNB 404 and relay UE 406.

[00181] In some demonstrative embodiments, controller component 446 of remote UE 402 and/or controller component 466 of eNB 404 may implement one or more switching criteria and/or switching schemes to switch traffic between the direct path and the relay path.

[00182] In some demonstrative embodiments, controller component 446 of remote UE 402 and/or controller component 466 of eNB 404 may be configured to switch traffic based on a logical channel from which the traffic is received.

[00183] In one example, when remote UE 402 is configured for transmission via relay UE 406 or if remote UE 402 is already associated with a certain relay UE 406, e.g., based on paired association, data may arrive at remote UE 402 from a certain configured logical channel. According to this example, controller component 446 of remote UE 402 may be configured to select, for example, based on the logical channel from which the data is received, between transmitting the data via the relay path, e.g., through D2D component 442, or via the direct path, e.g., through the Uu interface of D2N component 444.

[00184] In another example, controller component 446 of remote UE 402 may be configured to transmit data via relay UE 406, e.g., by sending the data via the WLAN MAC of D2D component 442, for example, when remote UE 402 is configured for transmission via relay UE 406 or if remote UE 402 is already associated with a certain relay UE 406, e.g., based on paired association, for example, regardless of which logical channel the data arrives.

[00185] In another example, controller component 446 of remote UE 402 may be configured to select between transmitting the data via the relay path, e.g., through D2D component 442,

or via the direct path, e.g., through the Uu interface of D2N component 444, for example, on a per packet by packet basis, for example, derived by a packet filtering function.

[00186] In some demonstrative embodiments, a switching functionality may be located above the MAC layer, e.g., as shown in Fig. 4. However, in other embodiments, the switching functionality may be implemented in any other location and/or layer, e.g., in an upper or a lower layer.

[00187] In some demonstrative embodiments, remote UE 402 may be configured to support an internal status indication from the D2D component 442 to the D2N component 444 and/or to the controller component 446 to indicate a status of the non-cellular RAT link 414 between remote UE and relay UE 406. The status indication may indicate, for example, whether or not the non-cellular RAT link 414 is successfully established, whether the or not the non-cellular RAT link 414 is disconnected, a quality of the non-cellular RAT link 414, and/or one or more additional or alternative parameters and/or attributes corresponding to the non-cellular RAT link 414.

[00188] In some demonstrative embodiments, relay UE 406 may be configured to support an internal status indication from the D2D component 452 to the D2N component 454 and/or to the controller component 456 to indicate a status of the non-cellular RAT link 414 between remote UE and relay UE 406. The status indication may indicate, for example, whether or not the non-cellular RAT link 414 is successfully established, whether or not the non-cellular RAT link 414 is disconnected, a quality of the non-cellular RAT link 414, and/or one or more additional or alternative parameters and/or attributes corresponding to the non-cellular RAT link 414.

[00189] In some demonstrative embodiments, D2D component 442 may be configured to provide an indication to an LTE RRC entity, e.g., implemented by controller component 446 and/or D2N component 444, for example, when non-cellular RAT link 414 is established between the remote UE 402 and the relay UE 406.

[00190] In some demonstrative embodiments, D2D component 452 may be configured to provide an indication to an LTE RRC entity, e.g., implemented by controller component 456 and/or D2N component 454, for example, when non-cellular RAT link 414 is established between the remote UE 402 and the relay UE 406.

[00191] In some demonstrative embodiments, controller component 446 and/or D2N component 444 may be configured to initiate EPS bearer establishment, e.g., between remote

UE 402 and eNB 404, and/or to trigger a relay session to switch path from the direct path over the Uu link of remote UE 402 to the relaying path via non-cellular RAT link 414.

[00192] In some demonstrative embodiments, remote UE 402 and relay UE 406 may be configured to support a control plane notification, which may be exchanged between remote
5 UE 402 and relay UE 406, for example, to signal an indication to switch to or from the relay path, for example, to enable the relay link or the Uu link.

[00193] In some demonstrative embodiments, remote UE 402 and/or relay UE 406 may be configured to send a notification of the status of non-cellular RAT link 414 to eNB 404, for example, via RRC signaling, e.g., to indicate that the connection between remote UE 402 and
10 relay UE 406 via non-cellular RAT link 414 is established, for example, to enable eNB 404 to transmit and/or receive traffic for remote UE 402 via relay UE 406.

[00194] In some demonstrative embodiments, remote UE 402, relay UE 406 and/or eNB 404 may be configured to implement one or more non-3GPP Connection management operations and/or functionalities, for example, to manage the relaying via the non-cellular RAT link 414,
15 e.g., as described below.

[00195] In some demonstrative embodiments, D2D component 442 may be configured to provide an indication to an LTE RRC entity, e.g., implemented by controller component 446 and/or D2N component 444, for example, when non-cellular RAT link 414 is disconnected, or if a quality of the non-cellular RAT link 414 is degraded, e.g., below a quality threshold.

[00196] In some demonstrative embodiments, D2D component 452 may be configured to provide an indication to an LTE RRC entity, e.g., implemented by controller component 456 and/or D2N component 454, for example, when non-cellular RAT link 414 is disconnected, or if a quality of the non-cellular RAT link 414 is degraded, e.g., below a quality threshold.

[00197] In some demonstrative embodiments, controller component 446 and/or D2N
25 component 444 may be configured to initiate an EPS bearer release, e.g., to release the EPS bearer between remote UE 402 and eNB 404, and/or to trigger a path switch to switch from the relaying path via non-cellular RAT link 414 to the direct path over the Uu link of remote UE 402. For example, controller component 446 and/or D2N component 444 may be configured to prepare the direct path and initiate a connection switch to switch from the relay
30 path to the direct path.

[00198] In some demonstrative embodiments, remote UE 402 and relay UE 406 may be configured to support a control plane notification, which may be exchanged between remote

UE 402 and relay UE 406, for example, to signal an indication to switch to or from the relay path, for example, to enable the relay link or the Uu link.

[00199] In some demonstrative embodiments, remote UE 402 and/or relay UE 406 may be configured to send a notification of the status of non-cellular RAT link 414 to eNB 404, for example, via RRC signaling, e.g., to indicate that the connection between remote UE 402 and relay UE 406 via non-cellular RAT link 414 is unavailable, e.g., disconnected, or that the quality of the connection over non-cellular RAT link 414 is degraded, for example, to enable eNB 404 to switch from the relay path to the direct path with remote UE 502.

[00200] In some demonstrative embodiments, controller component 446 may be configured to route an uplink SDU of the EPS bearer of UE 402 to the D2D component 442 to communicate the uplink SDU to the relay UE 406 over the non-cellular RAT link 414.

[00201] In some demonstrative embodiments, the uplink SDU may include a Medium Access Control (MAC) SDU.

[00202] In some demonstrative embodiments, as shown in Fig. 4, the uplink SDU may include a PDCP SDU provided by the PDCP component 434, for example, if controller component 446 is implemented to perform relaying below the PDCP layer and above the RLC layer.

[00203] In some demonstrative embodiments, the uplink SDU may include an RLC SDU processed by an RLC component, for example, if controller component 446 is implemented to perform relaying below the RLC layer, e.g., as described below with reference to Fig. 5.

[00204] In some demonstrative embodiments, controller component 446 may be configured to select between routing the uplink SDU to the D2D component 442 to communicate the uplink SDU to the relay UE 406, and routing the uplink SDU to the D2N component 444 to communicate the uplink SDU to the eNB 404 via the cellular RAT link, e.g., as described above.

[00205] In some demonstrative embodiments, controller component 446 may be configured to provide to the D2D component 442 an uplink Protocol Data Unit (PDU) including the uplink SDU and a relay protocol header including an identifier of the remote UE 402. For example, the identifier of remote UE 402 may include a MAC address of remote UE 402 and/or any other identifier configured to identify remote UE 402 to one or more other elements, e.g., including relay UE 406 and/or eNB 404.

- [00206] In some demonstrative embodiments, controller component 446 may be configured to receive from the D2D component 442 a status indication of a status of the non-cellular RAT link 414. For example, controller component 446 may be configured to select, based at least on the status indication, between routing the uplink SDU to the D2D component 442 and routing the uplink SDU to the D2N component 444, e.g., as described above. The status indication may indicate, for example, whether or not the non-cellular RAT link 414 is successfully established, whether the or not the non-cellular RAT link 414 is disconnected, a quality of the non-cellular RAT link 414, and/or one or more additional or alternative parameters and/or attributes corresponding to the non-cellular RAT link 414.
- [00207] In some demonstrative embodiments, controller component 446 may be configured to receive a downlink SDU from the D2D component 442, and to provide the downlink SDU to be processed by at least the PDCP component 434. For example, the downlink SDU may include a downlink SDU of the EPS bearer of UE 402, which may be sent from eNB 404 to UE 406 via relay UE 406, e.g., as described above.
- [00208] In some demonstrative embodiments, controller component 456 may include, for example, a relay controller, which may be configured to receive from the D2D component 452 the uplink SDU from the remote UE 402, and to transfer the uplink SDU to the D2N component 454 to communicate the uplink SDU to the eNB 404 over the cellular RAT link 474.
- [00209] In some demonstrative embodiments, controller component 456 may be configured to receive from the D2D component 452 the uplink PDU including the uplink SDU from remote UE 402 and the relay protocol header including the identifier of the remote UE 402.
- [00210] In some demonstrative embodiments, controller component 456 may be configured to map the uplink SDU to a radio bearer, e.g., to communicate the uplink SDU to eNB 404, based at least on the identifier of the remote UE 402. For example, controller component 456 may be configured to map a MAC PDU from D2D component 452 to the Uu interface of D2N component 454, for example, based on the header information.
- [00211] In some demonstrative embodiments, relay UE 406 may be configured to relay traffic between eNB 404 and a plurality of remote UEs, e.g., including remote UE 402.
- [00212] In some demonstrative embodiments, controller component 456 may be configured to multiplex uplink SDUs from the plurality of remote UEs to a radio bearer from the D2N component 454 to the eNB 404.

[00213] In some demonstrative embodiments, controller component 456 may be configured to receive from the D2N component 454 the downlink SDU from the eNB 404, and to transfer the downlink SDU to the D2D component 452 to communicate the downlink SDU to the remote UE 402 over the non-cellular RAT link 414.

5 [00214] In some demonstrative embodiments, controller component 456 may be configured to receive from the D2D component 452 a status indication of a status of the non-cellular RAT link 414. For example, controller component 456 may be configured to cause the D2N component 454 to signal the status indication to the eNB 404. The status indication may indicate, for example, whether or not the non-cellular RAT link 414 is successfully
10 established, whether or not the non-cellular RAT link 414 is disconnected, a quality of the non-cellular RAT link 414, and/or one or more additional or alternative parameters and/or attributes corresponding to the non-cellular RAT link 414.

[00215] In some demonstrative embodiments, controller component 466 of eNB 404 may be configured to receive an indication of establishment of the non-cellular RAT link 414
15 between the remote UE 402 and the relay UE 406, and, based on the indication, to route a downlink SDU for the remote UE 402 to the second D2N component 464 to communicate the downlink SDU to the relay UE 406.

[00216] In some demonstrative embodiments, the second D2N component 464 may be configured to send to the relay UE 406 a downlink PDU via the cellular RAT link 474. For
20 example, the downlink PDU may include the downlink SDU and a relay protocol header including the identifier of the remote UE 402.

[00217] In some demonstrative embodiments, the first D2N component 462 may be configured to receive a first uplink SDU of the remote UE 402 via the first cellular RAT link between eNB 404 and remote UE 402, and the second D2N component 464 may be
25 configured to receive a second uplink SDU of the remote UE 402 via the second cellular RAT link 474.

[00218] In some demonstrative embodiments, the first and second uplink SDUs may both be associated with a same EPS bearer between remote UE 402 and a cellular network, e.g., the EPS bearer established via the cellular RAT link between UE 402 and eNB 404.

30 [00219] In some demonstrative embodiments, controller component 466 may be configured to provide the first and second uplink SDUs to be processed by at least PDCP component 465.

[00220] In some demonstrative embodiments, controller component 466 may be configured to receive a status indication of the non-cellular RAT link 414, and, based on the status indication, to select whether to switch to route traffic for the remote UE 402 to the second D2N component 464 to communicate the traffic via the first cellular RAT link between eNB 404 and remote UE 402.

[00221] In some demonstrative embodiments, the first D2N component 462 may receive the indication of establishment of the non-cellular RAT link 414 from the remote UE 402, e.g., via the cellular RAT link between eNB 404 and remote UE 402.

[00222] In some demonstrative embodiments, the second D2N component 464 may receive the indication of establishment of the non-cellular RAT link from the relay UE 406, e.g., via the cellular RAT link between eNB 404 and relay UE 406.

[00223] In some demonstrative embodiments, relaying traffic via a relay UE over a non-cellular RAT link may be performed above an RLC layer, e.g., as described above. In other embodiments, relaying the traffic via the relay UE over the non-cellular RAT link may be performed below the RLC layer, e.g., as described below with reference to Fig. 5.

[00224] Fig. 5 is a schematic illustration of a protocol stack configured for L2 relaying above a MAC layer, in accordance with some demonstrative embodiments.

[00225] In some demonstrative embodiments, a relay UE 506 may be configured to relay communications between an eNB 504 and a remote UE 502, for example, via a non-cellular RAT link 514 between the remote UE 502 and the relay UE 504, e.g., as described below.

[00226] For example, UE 106 (Fig. 1) may be configured to operate as, and/or perform one or more functionalities of, relay UE 506; UE 102 (Fig. 1) may be configured to operate as, and/or perform one or more functionalities of, remote UE 502; and/or eNB 104 (Fig. 1) may be configured to operate as, and/or perform one or more functionalities of, eNB 504.

[00227] In some demonstrative embodiments, UE 502, UE 506, and/or eNB 504 may be configured to implement a protocol stack configured to support forwarding or relaying of traffic within relay UE 506 below an RLC layer, e.g., just above the MAC layer, as described below.

[00228] In some demonstrative embodiments, as shown in Fig. 5, remote UE 502 may include a D2D component 542, e.g., a ProSe component, configured to interface with relay UE 506 over a non-cellular RAT link 514.

[00229] In one example, as shown in Fig. 5, D2D component 542 may include a WLAN communication component to interface with UE 506 over a WLAN link 514. For example, as shown in Fig. 5, D2D component 542 may include at least a WLAN MAC layer.

[00230] In another example, D2D component 542 may include any other additional or alternative non-cellular communication component to interface with UE 506 over any other additional or alternative non-cellular RAT link 514. For example, D2D component 542 may include at least a BT communication component to communicate over a BT link.

[00231] In some demonstrative embodiments, as shown in Fig. 5, remote UE 502 may include a D2N component 544 configured to interface with eNB 504 over a cellular RAT link, e.g., over a Uu link. For example, as shown in Fig. 5, D2N component 544 may include at least a Uu MAC.

[00232] In some demonstrative embodiments, as shown in Fig. 5, remote UE 502 may include a PDCP component 434 and an RLC component 545 configured to process traffic communicated between UE 502 and the cellular network.

[00233] In some demonstrative embodiments, PDCP component 534 and RLC component 545 may be configured to process traffic of an EPS bearer between UE 502 and the cellular network. For example, the EPS bearer may be established over the cellular RAT link between UE 502 and eNB 504, e.g., as described above.

[00234] In some demonstrative embodiments, as shown in Fig. 5, relay UE 506 may include a D2D component 552, e.g., a ProSe component, configured to interface with one or more remote UEs, e.g., including remote UE 502, over one or more non-cellular RAT links, e.g., including non-cellular RAT link 514.

[00235] In one example, as shown in Fig. 5, D2D component 552 may include a WLAN communication component to interface with UE 502 over a WLAN link 514. For example, as shown in Fig. 5, D2D component 552 may include at least a WLAN MAC layer.

[00236] In another example, D2D component 552 may include any other additional or alternative non-cellular communication component to interface with UE 502 over any other additional or alternative non-cellular RAT link 514. For example, D2D component 552 may include at least a BT communication component to communicate over a BT link.

[00237] In some demonstrative embodiments, as shown in Fig. 5, relay UE 506 may include a D2N component 554 configured to interface with eNB 504 over a cellular RAT link 574,

e.g., over a Uu link. For example, as shown in Fig. 5, D2N component 554 may include at least a Uu MAC.

[00238] In some demonstrative embodiments, as shown in Fig. 5, eNB 504 may include a plurality of D2N components to communicate with a plurality of UEs. For example, eNB 504 may include at least a first D2N component 562 configured to interface with remote UE 502 over a cellular RAT link, e.g., over a Uu link, and a second D2N component 564 configured to interface with relay UE 506 over cellular RAT link 574. For example, as shown in Fig. 5, D2N components 562 and/or 564 may include at least a Uu MAC.

[00239] In some demonstrative embodiments, as shown in Fig. 5, eNB 504 may include a PDCCP component 565 and an RLC component 567 configured to process traffic communicated between eNB 504 and a plurality of UEs, including UE 502 and/or UE 506.

[00240] In some demonstrative embodiments, PDCCP component 565 and RLC component 567 may be configured to process traffic of the EPS bearer between the cellular network and UE 502, e.g., as described above.

[00241] In some demonstrative embodiments, as shown in Fig. 5, UE 502 and/or UE 506 may be configured to utilize a common PDCCP entity and a common RLC entity, which may be shared and/or tightly integrated between the WLAN MAC and D2D MAC protocol stack.

[00242] In some demonstrative embodiments, UE 502 may include a controller component 546 configured to route traffic between remote UE 502 and eNB 504 via D2D component 542, e.g., to communicate the traffic via a relay path over the non-cellular RAT link 514, and/or via D2N component 544, e.g., to communicate the traffic via a direct path over the cellular RAT link between remote UE 502 and eNB 504.

[00243] In some demonstrative embodiments, eNB 504 may include a controller component 566 configured to route the traffic between remote UE 502 and eNB 504 via D2N component 564, e.g., to communicate the traffic via relay UE 506, and/or via D2N component 562, e.g., to communicate the traffic via the cellular RAT link between remote UE 502 and eNB 504.

[00244] In some demonstrative embodiments, relay UE 506 may include a controller component 556 configured to transfer traffic D2D component 552 and D2N component 554, e.g., to relay the traffic between eNB 504 and remote UE 504.

[00245] In some demonstrative embodiments, D2N component 544, and/or D2N component 562 may be configured to support communication over a direct Uu path between eNB 504

and remote UE 502; D2D component 542, D2D component 552, controller component 556, D2N component 554, and D2N component 564 may be configured to support communication over a relay path between eNB 504 and remote UE 502 via relay UE 506; and/or PDCP component 534, an IP component 532, RLC component 534, PDCP component 565, RLC component 567, and at least an S1 bearer interface 561 of eNB 504 may be configured to support communication over both the direct path and the relay path.

[00246] In some demonstrative embodiments, UE 502, UE 506 and/or eNB 504 may be configured to support relaying below the RLC layer, e.g., just above the MAC layer.

[00247] In some demonstrative embodiments, in an uplink direction from remote UE 502 to the cellular network, MAC SDUs received on the WLAN interface, e.g., of D2D component 552, between the remote UE 502 and the relay UE 506 may be directly submitted as MAC SDUs on an uplink (UL) of the Uu interface, e.g., of D2N component 554, between relay UE 506 and eNB 506.

[00248] In some demonstrative embodiments, in a downlink direction from the cellular network to remote UE 502, MAC SDUs received on a downlink (DL) of the Uu interface, e.g., of D2N component 554, between eNB 504 and relay UE 506 may be directly submitted as MAC SDUs on the WLAN interface, e.g., of D2D component 552, between relay UE 506 and remote UE 502.

[00249] In some demonstrative embodiments, a relaying function implemented by controller 556 at relay UE 506 may include a buffer mechanism, for example, to enable queuing the downlink traffic from eNB 504 and/or the uplink traffic from remote UE 502, for example, until a convenient time for transmission e.g. until resource is scheduled.

[00250] In some demonstrative embodiments, controller component 556 of remote UE 502 and/or controller component 566 of eNB 504 may be configured to perform one or more route switching operations and/or functions, e.g., as described below.

[00251] In some demonstrative embodiments, controller component 546 of remote UE 502 may be configured to implement a switching functionality, which may enable, for example, RLC PDUs, e.g., the uplink MAC SDUs and/or the downlink MAC SDUs, to be switched between the MAC of the D2D component 542, e.g., the WLAN MAC interface, and the D2N component 544, e.g., the MAC of the Uu interface.

[00252] In some demonstrative embodiments, controller component 566 of eNB 504 may be configured to implement a switching functionality, which may enable, for example, RLC

PDU's, e.g., the uplink MAC SDUs and/or the downlink MAC SDUs, to be switched between the MAC of the D2N component 562, e.g., the MAC of the Uu interface between eNB 504 and remote UE 502, and the MAC of the D2N component 564, e.g., the MAC of the Uu interface between eNB 504 and relay UE 506.

5 [00253] Fig. 6 is a schematic flow-chart illustration of a method of UE relaying via a non-cellular RAT, in accordance with some demonstrative embodiments. In some embodiments, one or more of the operations of the method of Fig. 6 may be performed by one or more components of a remote UE, e.g., UE 102 (Fig. 1), remote UE 302 (Fig. 3), remote UE 402 (Fig. 4), and/or remote UE 502 (Fig. 5).

10 [00254] As indicated at block 602, the method may include interfacing, via a D2D component, e.g., a ProSe component, with a relay UE over a non-cellular RAT link. For example, UE 102 (Fig. 1) may interface, e.g., via D2D component 442 (Fig. 4), with relay UE 106 (Fig. 1) over non-cellular RAT link 131 (Fig. 1), e.g., as described above.

[00255] As indicated at block 604, the method may include interfacing, via a D2N
15 component, with an eNB of a cellular network over a cellular RAT link. For example, UE 102 (Fig. 1) may interface, e.g., via D2N component 444 (Fig. 4), with eNB 104 (Fig. 1) over cellular RAT link 133 (Fig. 1), e.g., as described above.

[00256] As indicated at block 606, the method may include performing PDCP processing of traffic of an EPS bearer between the UE and the cellular network, the EPS bearer established
20 over the cellular RAT link. For example, UE 102 (Fig. 1) may perform PDCP processing of traffic of an EPS bearer established over cellular RAT link 133 (Fig. 1), e.g., as described above.

[00257] As indicated at block 608, the method may include routing an uplink SDU of the EPS bearer to the D2D component to communicate the uplink SDU to the relay UE over the non-
25 cellular RAT link. For example, controller component 446 (Fig. 4) may route an uplink SDU of the EPS bearer to D2D component 442 (Fig. 4) to communicate the uplink SDU to relay UE 406 (Fig. 4) over non-cellular RAT link 414 (Fig. 4), e.g., as described above.

[00258] Fig. 7 is a schematic flow-chart illustration of a method of UE relaying via a non-cellular RAT, in accordance with some demonstrative embodiments. In some embodiments,
30 one or more of the operations of the method of Fig. 7 may be performed by one or more components of a relay UE, e.g., UE 106 (Fig. 1), relay UE 306 (Fig. 3), relay UE 406 (Fig. 4), and/or relay UE 506 (Fig. 5).

[00259] As indicated at block 702, the method may include interfacing, via a D2D component, e.g., a ProSe component, with at least one remote UE over at least one non-cellular RAT link. For example, UE 106 (Fig. 1) may interface, e.g., via D2D component 452 (Fig. 4), with remote UE 102 (Fig. 1) over non-cellular RAT link 131 (Fig. 1), e.g., as described above.

[00260] As indicated at block 704, the method may include interfacing, via a D2N component, with an eNB of a cellular network over a cellular RAT link. For example, UE 106 (Fig. 1) may interface, e.g., via D2N component 454 (Fig. 4), with eNB 104 (Fig. 1) over cellular RAT link 135 (Fig. 1), e.g., as described above.

[00261] As indicated at block 706, the method may include receiving from the D2D component an uplink SDU from the remote UE. For example, controller component 456 (Fig. 4) may receive from D2D component 452 (Fig. 4) the uplink SDU from remote UE 402 (Fig. 4), e.g., as described above.

[00262] As indicated at block 708, the method may include transferring the uplink SDU to the D2N component to communicate the uplink SDU to the eNB over the cellular RAT link. For example, controller component 456 (Fig. 4) may transfer the uplink SDU to D2N component 454 (Fig. 4) to communicate the uplink SDU to eNB 404 (Fig. 4), e.g., as described above.

[00263] Fig. 8 is a schematic flow-chart illustration of a method of UE relaying via a non-cellular RAT, in accordance with some demonstrative embodiments. In some embodiments, one or more of the operations of the method of Fig. 8 may be performed by one or more components of an eNB, e.g., eNB 104 (Fig. 1), eNB 304 (Fig. 3), eNB 404 (Fig. 4), and/or eNB 504 (Fig. 5).

[00264] As indicated at block 802, the method may include interfacing, via a first D2N component, with a remote UE over a first cellular RAT link. For example, eNB 104 (Fig. 1) may interface, e.g., via D2N component 462 (Fig. 4), with remote UE 102 (Fig. 1) over cellular RAT link 133 (Fig. 1), e.g., as described above.

[00265] As indicated at block 804, the method may include interfacing, via a second D2N component, with a relay UE over a second cellular RAT link. For example, eNB 104 (Fig. 1) may interface, e.g., via D2N component 464 (Fig. 4), with relay UE 106 (Fig. 1) over cellular RAT link 135 (Fig. 1), e.g., as described above.

[00266] As indicated at block 806, the method may include receiving an indication of establishment of a non-cellular RAT link between the remote UE and the relay UE. For example, eNB 104 (Fig. 1) may receive an indication of establishment of non-cellular RAT link 131 (Fig. 1) between the remote UE 102 (Fig. 1) and the relay UE 106 (Fig. 1), e.g., as described above.

[00267] As indicated at block 808, the method may include, based on the indication, routing a downlink SDU for the remote UE to the second D2N component to communicate the downlink SDU to the relay UE. For example, controller component 466 (Fig. 4) may route a downlink SDU for the remote UE 402 (Fig. 4) to the second D2N component 464 (Fig. 4) to communicate the downlink SDU to the relay UE 406 (Fig. 4), e.g., as described above.

[00268] Reference is made to Fig. 9, which schematically illustrates a product of manufacture 900, in accordance with some demonstrative embodiments. Product 900 may include a non-transitory machine-readable storage medium 902 to store logic 904, which may be used, for example, to perform at least part of the functionality of one or more components of a cellular manager, for example, an eNB, e.g., eNB 104 (Fig. 1), eNB 304 (Fig. 3), eNB 404 (Fig. 4), and/or eNB 504 (Fig. 5); one or more components of a UE, e.g., UE 102 (Fig. 1), UE 106 (Fig. 1), UE 200 (Fig. 2), UE 302 (Fig. 3), UE 306 (Fig. 3), UE 402 (Fig. 4), UE 406 (Fig. 4), UE 502 (Fig. 5), and/or UE 506 (Fig. 5); a controller, e.g., controller 182 (Fig. 1), controller 197 (Fig. 1), controller 192 (Fig. 1), controller component 446 (Fig. 4), controller component 456 (Fig. 4), controller component 466 (Fig. 4), controller component 546 (Fig. 5), controller component 556 (Fig. 5), and/or controller component 566 (Fig. 5); and/or a message processor, e.g., message processor 144 (Fig. 1), message processor 198 (Fig. 1), and/or message processor 196 (Fig. 1), and/or to perform one or more operations and/or functionalities described with reference to Figs 1, 2, 3, 4, 5, 6, 7, and/or 8. The phrase “non-transitory machine-readable medium” is directed to include all computer-readable media, with the sole exception being a transitory propagating signal.

[00269] In some demonstrative embodiments, product 900 and/or machine-readable storage medium 902 may include one or more types of computer-readable storage media capable of storing data, including volatile memory, non-volatile memory, removable or non-removable memory, erasable or non-erasable memory, writeable or re-writable memory, and the like. For example, machine-readable storage medium 902 may include, RAM, DRAM, Double-Data-Rate DRAM (DDR-DRAM), SDRAM, static RAM (SRAM), ROM, programmable ROM (PROM), erasable programmable ROM (EPROM), electrically erasable programmable

ROM (EEPROM), Compact Disk ROM (CD-ROM), Compact Disk Recordable (CD-R), Compact Disk Rewriteable (CD-RW), flash memory (e.g., NOR or NAND flash memory), content addressable memory (CAM), polymer memory, phase-change memory, ferroelectric memory, silicon-oxide-nitride-oxide-silicon (SONOS) memory, a disk, a floppy disk, a hard drive, an optical disk, a magnetic disk, a card, a magnetic card, an optical card, a tape, a cassette, and the like. The computer-readable storage media may include any suitable media involved with downloading or transferring a computer program from a remote computer to a requesting computer carried by data signals embodied in a carrier wave or other propagation medium through a communication link, e.g., a modem, radio or network connection.

[00270] In some demonstrative embodiments, logic 904 may include instructions, data, and/or code, which, if executed by a machine, may cause the machine to perform a method, process and/or operations as described herein. The machine may include, for example, any suitable processing platform, computing platform, computing device, processing device, computing system, processing system, computer, processor, or the like, and may be implemented using any suitable combination of hardware, software, firmware, and the like.

[00271] In some demonstrative embodiments, logic 904 may include, or may be implemented as, software, a software module, an application, a program, a subroutine, instructions, an instruction set, computing code, words, values, symbols, and the like. The instructions may include any suitable type of code, such as source code, compiled code, interpreted code, executable code, static code, dynamic code, and the like. The instructions may be implemented according to a predefined computer language, manner or syntax, for instructing a processor to perform a certain function. The instructions may be implemented using any suitable high-level, low-level, object-oriented, visual, compiled and/or interpreted programming language, such as C, C++, Java, BASIC, Matlab, Pascal, Visual BASIC, assembly language, machine code, and the like.

EXAMPLES

[00272] The following examples pertain to further embodiments.

[00273] Example 1 includes an apparatus of a User Equipment (UE), the apparatus comprising a Proximity-based Services (ProSe) component to interface with a relay UE over a non-cellular Radio Access Technology (RAT) link; a Device to Network (D2N) component to interface with an evolved Node B (eNB) of a cellular network over a cellular RAT link; a Packet Data Convergence Protocol (PDCP) component to process traffic of an Evolved

Packet-switched System (EPS) bearer between the UE and the cellular network, the EPS bearer established over the cellular RAT link; and a controller component configured to route an uplink Service Data Unit (SDU) of the EPS bearer to the ProSe component to communicate the uplink SDU to the relay UE over the non-cellular RAT link.

5 [00274] Example 2 includes the subject matter of Example 1, and optionally, wherein the controller component is configured to select between routing the uplink SDU to the ProSe component to communicate the uplink SDU to the relay UE, and routing the uplink SDU to the D2N component to communicate the uplink SDU to the eNB via the cellular RAT link.

[00275] Example 3 includes the subject matter of Example 2, and optionally, wherein the
10 controller component is to receive from the ProSe component a status indication of a status of the non-cellular RAT link, the controller component to select, based at least on the status indication, between routing the uplink SDU to the ProSe component and routing the uplink SDU to the D2N component.

[00276] Example 4 includes the subject matter of any one of Examples 1-3, and optionally,
15 wherein the controller component is to receive a downlink SDU from the ProSe component, and to provide the downlink SDU to be processed by at least the PDCP component.

[00277] Example 5 includes the subject matter of any one of Examples 1-4, and optionally, wherein the uplink SDU comprises a PDCP SDU provided by the PDCP component.

[00278] Example 6 includes the subject matter of any one of Examples 1-4, and optionally,
20 wherein the uplink SDU comprises a Radio Link Control (RLC) SDU processed by an RLC component.

[00279] Example 7 includes the subject matter of any one of Examples 1-4, and optionally, wherein the uplink SDU comprises a Medium Access Control (MAC) SDU.

[00280] Example 8 includes the subject matter of any one of Examples 1-7, and optionally,
25 wherein the controller component is to provide to the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the UE.

[00281] Example 9 includes the subject matter of any one of Examples 1-8, and optionally, wherein the ProSe component comprises a Medium Access Control (MAC) component of the
30 non-cellular RAT.

[00282] Example 10 includes the subject matter of any one of Examples 1-9, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

[00283] Example 11 includes the subject matter of any one of Examples 1-10, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

5 [00284] Example 12 includes the subject matter of any one of Examples 1-11, and optionally, comprising one or more antennas, a memory and a processor.

[00285] Example 13 includes an apparatus comprising circuitry and logic configured to trigger a User Equipment (UE) to interface, via a Proximity-based Services (ProSe) component, with a relay UE over a non-cellular Radio Access Technology (RAT) link; interface, via a Device to Network (D2N) component, with an evolved Node B (eNB) of a cellular network over a cellular RAT link; perform Packet Data Convergence Protocol (PDCP) processing of traffic of an Evolved Packet-switched System (EPS) bearer between the UE and the cellular network, the EPS bearer established over the cellular RAT link; and route an uplink Service Data Unit (SDU) of the EPS bearer to the ProSe component to communicate the uplink SDU to the relay UE over the non-cellular RAT link.

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[00286] Example 14 includes the subject matter of Example 13, and optionally, wherein the apparatus is configured to trigger the UE to select between routing the uplink SDU to the ProSe component to communicate the uplink SDU to the relay UE, and routing the uplink SDU to the D2N component to communicate the uplink SDU to the eNB via the cellular RAT link.

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[00287] Example 15 includes the subject matter of Example 14, and optionally, wherein the apparatus is configured to trigger the UE to receive from the ProSe component a status indication of a status of the non-cellular RAT link, and to select, based at least on the status indication, between routing the uplink SDU to the ProSe component and routing the uplink SDU to the D2N component.

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[00288] Example 16 includes the subject matter of any one of Examples 13-15, and optionally, wherein the apparatus is configured to trigger the UE to receive a downlink SDU from the ProSe component, and to provide the downlink SDU to be processed by at least the PDCP component.

30 [00289] Example 17 includes the subject matter of any one of Examples 13-16, and optionally, wherein the uplink SDU comprises a PDCP SDU provided by the PDCP component.

[00290] Example 18 includes the subject matter of any one of Examples 13-16, and optionally, wherein the uplink SDU comprises a Radio Link Control (RLC) SDU processed by an RLC component.

5 [00291] Example 19 includes the subject matter of any one of Examples 13-16, and optionally, wherein the uplink SDU comprises a Medium Access Control (MAC) SDU.

[00292] Example 20 includes the subject matter of any one of Examples 13-19, and optionally, wherein the apparatus is configured to trigger the UE to provide to the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the UE.

10 [00293] Example 21 includes the subject matter of any one of Examples 13-20, and optionally, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.

[00294] Example 22 includes the subject matter of any one of Examples 13-21, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network
15 (WLAN) RAT.

[00295] Example 23 includes the subject matter of any one of Examples 13-22, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

[00296] Example 24 includes the subject matter of any one of Examples 13-23, and optionally, comprising one or more antennas, a memory and a processor.

20 [00297] Example 25 includes a system of cellular communication comprising a User Equipment (UE), the UE comprising one or more antennas; a memory; a processor; a Proximity-based Services (ProSe) component to interface with a relay UE over a non-cellular Radio Access Technology (RAT) link; a Device to Network (D2N) component to interface with an evolved Node B (eNB) of a cellular network over a cellular RAT link; a Packet Data
25 Convergence Protocol (PDCP) component to process traffic of an Evolved Packet-switched System (EPS) bearer between the UE and the cellular network, the EPS bearer established over the cellular RAT link; and a controller component configured to route an uplink Service Data Unit (SDU) of the EPS bearer to the ProSe component to communicate the uplink SDU to the relay UE over the non-cellular RAT link.

30 [00298] Example 26 includes the subject matter of Example 25, and optionally, wherein the controller component is configured to select between routing the uplink SDU to the ProSe

component to communicate the uplink SDU to the relay UE, and routing the uplink SDU to the D2N component to communicate the uplink SDU to the eNB via the cellular RAT link.

[00299] Example 27 includes the subject matter of Example 26, and optionally, wherein the controller component is to receive from the ProSe component a status indication of a status of the non-cellular RAT link, the controller component to select, based at least on the status indication, between routing the uplink SDU to the ProSe component and routing the uplink SDU to the D2N component.

[00300] Example 28 includes the subject matter of any one of Examples 25-27, and optionally, wherein the controller component is to receive a downlink SDU from the ProSe component, and to provide the downlink SDU to be processed by at least the PDCP component.

[00301] Example 29 includes the subject matter of any one of Examples 25-28, and optionally, wherein the uplink SDU comprises a PDCP SDU provided by the PDCP component.

[00302] Example 30 includes the subject matter of any one of Examples 25-28, and optionally, wherein the uplink SDU comprises a Radio Link Control (RLC) SDU processed by an RLC component.

[00303] Example 31 includes the subject matter of any one of Examples 25-28, and optionally, wherein the uplink SDU comprises a Medium Access Control (MAC) SDU.

[00304] Example 32 includes the subject matter of any one of Examples 25-31, and optionally, wherein the controller component is to provide to the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the UE.

[00305] Example 33 includes the subject matter of any one of Examples 25-32, and optionally, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.

[00306] Example 34 includes the subject matter of any one of Examples 25-33, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

[00307] Example 35 includes the subject matter of any one of Examples 25-34, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

[00308] Example 36 includes a method to be performed at a User Equipment (UE), the method comprising interfacing, via a Proximity-based Services (ProSe) component, with a relay UE over a non-cellular Radio Access Technology (RAT) link; interfacing, via a Device to Network (D2N) component, with an evolved Node B (eNB) of a cellular network over a cellular RAT link; performing Packet Data Convergence Protocol (PDCP) processing of traffic of an Evolved Packet-switched System (EPS) bearer between the UE and the cellular network, the EPS bearer established over the cellular RAT link; and routing an uplink Service Data Unit (SDU) of the EPS bearer to the ProSe component to communicate the uplink SDU to the relay UE over the non-cellular RAT link.

[00309] Example 37 includes the subject matter of Example 36, and optionally, comprising selecting between routing the uplink SDU to the ProSe component to communicate the uplink SDU to the relay UE, and routing the uplink SDU to the D2N component to communicate the uplink SDU to the eNB via the cellular RAT link.

[00310] Example 38 includes the subject matter of Example 37, and optionally, comprising receiving from the ProSe component a status indication of a status of the non-cellular RAT link, and selecting, based at least on the status indication, between routing the uplink SDU to the ProSe component and routing the uplink SDU to the D2N component.

[00311] Example 39 includes the subject matter of any one of Examples 36-38, and optionally, comprising receiving a downlink SDU from the ProSe component, and providing the downlink SDU to be processed by at least the PDCP component.

[00312] Example 40 includes the subject matter of any one of Examples 36-39, and optionally, wherein the uplink SDU comprises a PDCP SDU provided by the PDCP component.

[00313] Example 41 includes the subject matter of any one of Examples 36-39, and optionally, wherein the uplink SDU comprises a Radio Link Control (RLC) SDU processed by an RLC component.

[00314] Example 42 includes the subject matter of any one of Examples 36-39, and optionally, wherein the uplink SDU comprises a Medium Access Control (MAC) SDU.

[00315] Example 43 includes the subject matter of any one of Examples 36-42, and optionally, comprising providing to the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the UE.

[00316] Example 44 includes the subject matter of any one of Examples 36-43, and optionally, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.

5 [00317] Example 45 includes the subject matter of any one of Examples 36-44, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

[00318] Example 46 includes the subject matter of any one of Examples 36-45, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

10 [00319] Example 47 includes an product comprising one or more tangible computer-readable non-transitory storage media comprising computer-executable instructions operable to, when executed by at least one computer processor, enable the at least one computer processor to implement operations at a User Equipment (UE), the operations comprising interfacing, via a Proximity-based Services (ProSe) component, with a relay UE over a non-cellular Radio Access Technology (RAT) link; interfacing, via a Device to Network (D2N) component, with
15 an evolved Node B (eNB) of a cellular network over a cellular RAT link; performing Packet Data Convergence Protocol (PDCP) processing of traffic of an Evolved Packet-switched System (EPS) bearer between the UE and the cellular network, the EPS bearer established over the cellular RAT link; and routing an uplink Service Data Unit (SDU) of the EPS bearer to the ProSe component to communicate the uplink SDU to the relay UE over the non-
20 cellular RAT link.

[00320] Example 48 includes the subject matter of Example 47, and optionally, wherein the operations comprise selecting between routing the uplink SDU to the ProSe component to communicate the uplink SDU to the relay UE, and routing the uplink SDU to the D2N component to communicate the uplink SDU to the eNB via the cellular RAT link.

25 [00321] Example 49 includes the subject matter of Example 48, and optionally, wherein the operations comprise receiving from the ProSe component a status indication of a status of the non-cellular RAT link, and selecting, based at least on the status indication, between routing the uplink SDU to the ProSe component and routing the uplink SDU to the D2N component.

30 [00322] Example 50 includes the subject matter of any one of Examples 47-49, and optionally, wherein the operations comprise receiving a downlink SDU from the ProSe component, and providing the downlink SDU to be processed by at least the PDCP component.

[00323] Example 51 includes the subject matter of any one of Examples 47-50, and optionally, wherein the uplink SDU comprises a PDCP SDU provided by the PDCP component.

5 [00324] Example 52 includes the subject matter of any one of Examples 47-50, and optionally, wherein the uplink SDU comprises a Radio Link Control (RLC) SDU processed by an RLC component.

[00325] Example 53 includes the subject matter of any one of Examples 47-50, and optionally, wherein the uplink SDU comprises a Medium Access Control (MAC) SDU.

10 [00326] Example 54 includes the subject matter of any one of Examples 47-53, and optionally, wherein the operations comprise providing to the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the UE.

15 [00327] Example 55 includes the subject matter of any one of Examples 47-54, and optionally, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.

[00328] Example 56 includes the subject matter of any one of Examples 47-55, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

20 [00329] Example 57 includes the subject matter of any one of Examples 47-56, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

25 [00330] Example 58 includes an apparatus of cellular communication by a User Equipment (UE), the apparatus comprising means for interfacing, via a Proximity-based Services (ProSe) component, with a relay UE over a non-cellular Radio Access Technology (RAT) link; means for interfacing, via a Device to Network (D2N) component, with an evolved Node B (eNB) of a cellular network over a cellular RAT link; means for performing Packet Data Convergence Protocol (PDCP) processing of traffic of an Evolved Packet-switched System (EPS) bearer between the UE and the cellular network, the EPS bearer established over the cellular RAT link; and means for routing an uplink Service Data Unit (SDU) of the EPS bearer to the ProSe component to communicate the uplink SDU to the relay UE over the non-cellular RAT link.

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[00331] Example 59 includes the subject matter of Example 58, and optionally, comprising means for selecting between routing the uplink SDU to the ProSe component to communicate the uplink SDU to the relay UE, and routing the uplink SDU to the D2N component to communicate the uplink SDU to the eNB via the cellular RAT link.

- 5 [00332] Example 60 includes the subject matter of Example 59, and optionally, comprising means for receiving from the ProSe component a status indication of a status of the non-cellular RAT link, and selecting, based at least on the status indication, between routing the uplink SDU to the ProSe component and routing the uplink SDU to the D2N component.

- [00333] Example 61 includes the subject matter of any one of Examples 58-60, and
10 optionally, comprising means for receiving a downlink SDU from the ProSe component, and providing the downlink SDU to be processed by at least the PDCP component.

[00334] Example 62 includes the subject matter of any one of Examples 58-61, and optionally, wherein the uplink SDU comprises a PDCP SDU provided by the PDCP component.

- 15 [00335] Example 63 includes the subject matter of any one of Examples 58-61, and optionally, wherein the uplink SDU comprises a Radio Link Control (RLC) SDU processed by an RLC component.

[00336] Example 64 includes the subject matter of any one of Examples 58-61, and optionally, wherein the uplink SDU comprises a Medium Access Control (MAC) SDU.

- 20 [00337] Example 65 includes the subject matter of any one of Examples 58-64, and optionally, comprising means for providing to the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the UE.

- [00338] Example 66 includes the subject matter of any one of Examples 58-65, and
25 optionally, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.

[00339] Example 67 includes the subject matter of any one of Examples 58-66, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

- 30 [00340] Example 68 includes the subject matter of any one of Examples 58-67, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

[00341] Example 69 includes an apparatus of a User Equipment (UE), the apparatus comprising a Proximity-based Services (ProSe) component to interface with at least one remote UE over at least one non-cellular Radio Access Technology (RAT) link; a Device to Network (D2N) component to interface with an evolved Node B (eNB) of a cellular network over a cellular RAT link; and a controller component configured to receive from the ProSe component an uplink Service Data Unit (SDU) from the remote UE, and to transfer the uplink SDU to the D2N component to communicate the uplink SDU to the eNB over the cellular RAT link.

[00342] Example 70 includes the subject matter of Example 69, and optionally, wherein the controller component is to receive from the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the remote UE, the controller component to map the uplink SDU to a radio bearer based on the identifier of the remote UE.

[00343] Example 71 includes the subject matter of Example 69 or 70, and optionally, wherein the controller component is to receive from the D2N component a downlink SDU from the eNB, and to transfer the downlink SDU to the ProSe component to communicate the downlink SDU to the remote UE over the non-cellular RAT link.

[00344] Example 72 includes the subject matter of any one of Examples 69-71, and optionally, wherein the at least one remote UE comprises a plurality of remote UEs, the controller component configured to multiplex uplink SDUs from the plurality of remote UEs to a radio bearer from the D2N component to the eNB.

[00345] Example 73 includes the subject matter of any one of Examples 69-72, and optionally, wherein the controller component is to receive from the ProSe component a status indication of a status of the non-cellular RAT link, the controller component to cause the D2N component to signal the status indication to the eNB.

[00346] Example 74 includes the subject matter of any one of Examples 69-73, and optionally, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.

[00347] Example 75 includes the subject matter of any one of Examples 69-74, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

[00348] Example 76 includes the subject matter of any one of Examples 69-75, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

[00349] Example 77 includes the subject matter of any one of Examples 69-76, and optionally, comprising one or more antennas, a memory and a processor.

5 [00350] Example 78 includes an apparatus comprising circuitry and logic configured to trigger a User Equipment (UE) to interface, via a Proximity-based Services (ProSe) component, with at least one remote UE over at least one non-cellular Radio Access Technology (RAT) link; interface, via a Device to Network (D2N) component, with an evolved Node B (eNB) of a cellular network over a cellular RAT link; receive from the ProSe
10 component an uplink Service Data Unit (SDU) from the remote UE; and transfer the uplink SDU to the D2N component to communicate the uplink SDU to the eNB over the cellular RAT link.

[00351] Example 79 includes the subject matter of Example 78, and optionally, wherein the apparatus is configured to trigger the UE to receive from the ProSe component an uplink
15 Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the remote UE, and to map the uplink SDU to a radio bearer based on the identifier of the remote UE.

[00352] Example 80 includes the subject matter of Example 78 or 79, and optionally, wherein the apparatus is configured to trigger the UE to receive from the D2N component a
20 downlink SDU from the eNB, and to transfer the downlink SDU to the ProSe component to communicate the downlink SDU to the remote UE over the non-cellular RAT link.

[00353] Example 81 includes the subject matter of any one of Examples 78-80, and optionally, wherein the at least one remote UE comprises a plurality of remote UEs, the apparatus configured to trigger the UE to multiplex uplink SDUs from the plurality of remote
25 UEs to a radio bearer from the D2N component to the eNB.

[00354] Example 82 includes the subject matter of any one of Examples 78-81, and optionally, wherein the apparatus is configured to trigger the UE is to receive from the ProSe component a status indication of a status of the non-cellular RAT link, and to cause the D2N component to signal the status indication to the eNB.

30 [00355] Example 83 includes the subject matter of any one of Examples 78-82, and optionally, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.

[00356] Example 84 includes the subject matter of any one of Examples 78-83, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

5 [00357] Example 85 includes the subject matter of any one of Examples 78-84, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

[00358] Example 86 includes the subject matter of any one of Examples 78-85, and optionally, comprising one or more antennas, a memory and a processor.

[00359] Example 87 includes a system of cellular communication comprising a User Equipment (UE), the UE comprising one or more antennas; a memory; a processor; a
10 Proximity-based Services (ProSe) component to interface with at least one remote UE over at least one non-cellular Radio Access Technology (RAT) link; a Device to Network (D2N) component to interface with an evolved Node B (eNB) of a cellular network over a cellular RAT link; and a controller component configured to receive from the ProSe component an uplink Service Data Unit (SDU) from the remote UE, and to transfer the uplink SDU to the
15 D2N component to communicate the uplink SDU to the eNB over the cellular RAT link.

[00360] Example 88 includes the subject matter of Example 87, and optionally, wherein the controller component is to receive from the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the remote UE, the controller component to map the uplink SDU to a radio bearer based on the
20 identifier of the remote UE.

[00361] Example 89 includes the subject matter of Example 87 or 88, and optionally, wherein the controller component is to receive from the D2N component a downlink SDU from the eNB, and to transfer the downlink SDU to the ProSe component to communicate the downlink SDU to the remote UE over the non-cellular RAT link.

25 [00362] Example 90 includes the subject matter of any one of Examples 87-89, and optionally, wherein the at least one remote UE comprises a plurality of remote UEs, the controller component configured to multiplex uplink SDUs from the plurality of remote UEs to a radio bearer from the D2N component to the eNB.

[00363] Example 91 includes the subject matter of any one of Examples 87-90, and
30 optionally, wherein the controller component is to receive from the ProSe component a status indication of a status of the non-cellular RAT link, the controller component to cause the D2N component to signal the status indication to the eNB.

[00364] Example 92 includes the subject matter of any one of Examples 87-91, and optionally, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.

5 [00365] Example 93 includes the subject matter of any one of Examples 87-92, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

[00366] Example 94 includes the subject matter of any one of Examples 87-93, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

10 [00367] Example 95 includes a method to be performed at a User Equipment (UE), the method comprising interfacing, via a Proximity-based Services (ProSe) component, with at least one remote UE over at least one non-cellular Radio Access Technology (RAT) link; interfacing, via a Device to Network (D2N) component, with an evolved Node B (eNB) of a cellular network over a cellular RAT link; receiving from the ProSe component an uplink Service Data Unit (SDU) from the remote UE; and transferring the uplink SDU to the D2N
15 component to communicate the uplink SDU to the eNB over the cellular RAT link.

[00368] Example 96 includes the subject matter of Example 95, and optionally, comprising receiving from the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the remote UE, and mapping the uplink SDU to a radio bearer based on the identifier of the remote UE.

20 [00369] Example 97 includes the subject matter of Example 95 or 96, and optionally, comprising receiving from the D2N component a downlink SDU from the eNB, and transferring the downlink SDU to the ProSe component to communicate the downlink SDU to the remote UE over the non-cellular RAT link.

25 [00370] Example 98 includes the subject matter of any one of Examples 95-97, and optionally, wherein the at least one remote UE comprises a plurality of remote UEs, the method comprising multiplexing uplink SDUs from the plurality of remote UEs to a radio bearer from the D2N component to the eNB.

30 [00371] Example 99 includes the subject matter of any one of Examples 95-98, and optionally, comprising receiving from the ProSe component a status indication of a status of the non-cellular RAT link, and causing the D2N component to signal the status indication to the eNB.

[00372] Example 100 includes the subject matter of any one of Examples 95-99, and optionally, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.

5 [00373] Example 101 includes the subject matter of any one of Examples 95-100, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

[00374] Example 102 includes the subject matter of any one of Examples 95-101, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

10 [00375] Example 103 includes a product comprising one or more tangible computer-readable non-transitory storage media comprising computer-executable instructions operable to, when executed by at least one computer processor, enable the at least one computer processor to implement operations at a User Equipment (UE), the operations comprising interfacing, via a Proximity-based Services (ProSe) component, with at least one remote UE over at least one non-cellular Radio Access Technology (RAT) link; interfacing, via a Device to Network
15 (D2N) component, with an evolved Node B (eNB) of a cellular network over a cellular RAT link; receiving from the ProSe component an uplink Service Data Unit (SDU) from the remote UE; and transferring the uplink SDU to the D2N component to communicate the uplink SDU to the eNB over the cellular RAT link.

[00376] Example 104 includes the subject matter of Example 103, and optionally, wherein
20 the operations comprise receiving from the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the remote UE, and mapping the uplink SDU to a radio bearer based on the identifier of the remote UE.

[00377] Example 105 includes the subject matter of Example 103 or 104, and optionally,
25 wherein the operations comprise receiving from the D2N component a downlink SDU from the eNB, and transferring the downlink SDU to the ProSe component to communicate the downlink SDU to the remote UE over the non-cellular RAT link.

[00378] Example 106 includes the subject matter of any one of Examples 103-105, and optionally, wherein the at least one remote UE comprises a plurality of remote UEs, the
30 operations comprising multiplexing uplink SDUs from the plurality of remote UEs to a radio bearer from the D2N component to the eNB.

[00379] Example 107 includes the subject matter of any one of Examples 103-106, and optionally, wherein the operations comprise receiving from the ProSe component a status indication of a status of the non-cellular RAT link, and causing the D2N component to signal the status indication to the eNB.

- 5 [00380] Example 108 includes the subject matter of any one of Examples 103-107, and optionally, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.

[00381] Example 109 includes the subject matter of any one of Examples 103-108, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network
10 (WLAN) RAT.

[00382] Example 110 includes the subject matter of any one of Examples 103-109, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

[00383] Example 111 includes an apparatus of cellular communication by a User Equipment (UE), the apparatus comprising means for interfacing, via a Proximity-based Services (ProSe)
15 component, with at least one remote UE over at least one non-cellular Radio Access Technology (RAT) link; means for interfacing, via a Device to Network (D2N) component, with an evolved Node B (eNB) of a cellular network over a cellular RAT link; means for receiving from the ProSe component an uplink Service Data Unit (SDU) from the remote UE; and means for transferring the uplink SDU to the D2N component to communicate the
20 uplink SDU to the eNB over the cellular RAT link.

[00384] Example 112 includes the subject matter of Example 111, and optionally, comprising means for receiving from the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the remote UE, and mapping the uplink SDU to a radio bearer based on the identifier of the
25 remote UE.

[00385] Example 113 includes the subject matter of Example 111 or 112, and optionally, comprising means for receiving from the D2N component a downlink SDU from the eNB, and transferring the downlink SDU to the ProSe component to communicate the downlink SDU to the remote UE over the non-cellular RAT link.

30 [00386] Example 114 includes the subject matter of any one of Examples 111-113, and optionally, wherein the at least one remote UE comprises a plurality of remote UEs, the

apparatus comprising means for multiplexing uplink SDUs from the plurality of remote UEs to a radio bearer from the D2N component to the eNB.

[00387] Example 115 includes the subject matter of any one of Examples 111-114, and optionally, comprising means for receiving from the ProSe component a status indication of a status of the non-cellular RAT link, and causing the D2N component to signal the status indication to the eNB.

[00388] Example 116 includes the subject matter of any one of Examples 111-115, and optionally, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.

[00389] Example 117 includes the subject matter of any one of Examples 111-116, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

[00390] Example 118 includes the subject matter of any one of Examples 111-117, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

[00391] Example 119 includes an apparatus of an evolved Node B (eNB), the apparatus comprising a first Device to Network (D2N) component to interface with a remote User Equipment (UE) over a first cellular Radio Access Technology (RAT) link; a second D2N component to interface with a relay UE over a second cellular RAT link; and a controller component configured to receive an indication of establishment of a non-cellular RAT link between the remote UE and the relay UE, and, based on the indication, to route a downlink Service Data Unit (SDU) for the remote UE to the second D2N component to communicate the downlink SDU to the relay UE.

[00392] Example 120 includes the subject matter of Example 119, and optionally, wherein the second D2N component is to send to the relay UE a downlink Protocol Data Unit (PDU) via the second cellular RAT link, the downlink PDU comprising the downlink SDU and a relay protocol header comprising an identifier of the remote UE.

[00393] Example 121 includes the subject matter of Example 119 or 120, and optionally, wherein the first D2N component is to receive a first uplink SDU of the remote UE via the first cellular RAT link, and the second D2N component is to receive a second uplink SDU of the remote UE via the second cellular RAT link, the controller component to provide the first and second uplink SDUs to be processed by at least a Packet Data Convergence Protocol (PDCP) component of the eNB.

[00394] Example 122 includes the subject matter of Example 121, and optionally, wherein the first and second uplink SDUs are both associated with a same Evolved Packet-switched System (EPS) bearer between the remote UE and a cellular network.

[00395] Example 123 includes the subject matter of any one of Examples 119-122, and optionally, wherein the controller component is to receive a status indication of the non-cellular RAT link, and, based on the status indication, to select whether to switch to route traffic for the remote UE to the second D2N component to communicate the traffic via the first cellular RAT link.

[00396] Example 124 includes the subject matter of any one of Examples 119-123, and optionally, wherein the first D2N component is to receive the indication of establishment of the non-cellular RAT link from the remote UE.

[00397] Example 125 includes the subject matter of any one of Examples 119-124, and optionally, wherein the second D2N component is to receive the indication of establishment of the non-cellular RAT link from the relay UE.

[00398] Example 126 includes the subject matter of any one of Examples 119-125, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

[00399] Example 127 includes the subject matter of any one of Examples 119-126, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

[00400] Example 128 includes the subject matter of any one of Examples 119-127, and optionally, comprising one or more antennas, a memory and a processor.

[00401] Example 129 includes an apparatus comprising circuitry and logic configured to trigger an evolved Node B (eNB) to interface, via a first Device to Network (D2N) component, with a remote User Equipment (UE) over a first cellular Radio Access Technology (RAT) link; interface, via a second D2N component, with a relay UE over a second cellular RAT link; receive an indication of establishment of a non-cellular RAT link between the remote UE and the relay UE; and based on the indication, route a downlink Service Data Unit (SDU) for the remote UE to the second D2N component to communicate the downlink SDU to the relay UE.

[00402] Example 130 includes the subject matter of Example 129, and optionally, wherein the second D2N component is to send to the relay UE a downlink Protocol Data Unit (PDU)

via the second cellular RAT link, the downlink PDU comprising the downlink SDU and a relay protocol header comprising an identifier of the remote UE.

[00403] Example 131 includes the subject matter of Example 129 or 130, and optionally, wherein the first D2N component is to receive a first uplink SDU of the remote UE via the first cellular RAT link, and the second D2N component is to receive a second uplink SDU of the remote UE via the second cellular RAT link, the apparatus configured to trigger the eNB to provide the first and second uplink SDUs to be processed by at least a Packet Data Convergence Protocol (PDCP) component of the eNB.

[00404] Example 132 includes the subject matter of Example 131, and optionally, wherein the first and second uplink SDUs are both associated with a same Evolved Packet-switched System (EPS) bearer between the remote UE and a cellular network.

[00405] Example 133 includes the subject matter of any one of Examples 129-132, and optionally, wherein the apparatus is configured to receive a status indication of the non-cellular RAT link, and, based on the status indication, to select whether to switch to route traffic for the remote UE to the second D2N component to communicate the traffic via the first cellular RAT link.

[00406] Example 134 includes the subject matter of any one of Examples 129-133, and optionally, wherein the first D2N component is to receive the indication of establishment of the non-cellular RAT link from the remote UE.

[00407] Example 135 includes the subject matter of any one of Examples 129-134, and optionally, wherein the second D2N component is to receive the indication of establishment of the non-cellular RAT link from the relay UE.

[00408] Example 136 includes the subject matter of any one of Examples 129-135, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

[00409] Example 137 includes the subject matter of any one of Examples 129-136, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

[00410] Example 138 includes the subject matter of any one of Examples 129-137, and optionally, comprising one or more antennas, a memory and a processor.

[00411] Example 139 includes a system of cellular communication comprising an evolved Node B (eNB), the eNB comprising one or more antennas; a memory; a processor; a first

Device to Network (D2N) component to interface with a remote User Equipment (UE) over a first cellular Radio Access Technology (RAT) link; a second D2N component to interface with a relay UE over a second cellular RAT link; and a controller component configured to receive an indication of establishment of a non-cellular RAT link between the remote UE and the relay UE, and, based on the indication, to route a downlink Service Data Unit (SDU) for the remote UE to the second D2N component to communicate the downlink SDU to the relay UE.

[00412] Example 140 includes the subject matter of Example 139, and optionally, wherein the second D2N component is to send to the relay UE a downlink Protocol Data Unit (PDU) via the second cellular RAT link, the downlink PDU comprising the downlink SDU and a relay protocol header comprising an identifier of the remote UE.

[00413] Example 141 includes the subject matter of Example 139 or 140, and optionally, wherein the first D2N component is to receive a first uplink SDU of the remote UE via the first cellular RAT link, and the second D2N component is to receive a second uplink SDU of the remote UE via the second cellular RAT link, the controller component to provide the first and second uplink SDUs to be processed by at least a Packet Data Convergence Protocol (PDCP) component of the eNB.

[00414] Example 142 includes the subject matter of Example 141, and optionally, wherein the first and second uplink SDUs are both associated with a same Evolved Packet-switched System (EPS) bearer between the remote UE and a cellular network.

[00415] Example 143 includes the subject matter of any one of Examples 139-142, and optionally, wherein the controller component is to receive a status indication of the non-cellular RAT link, and, based on the status indication, to select whether to switch to route traffic for the remote UE to the second D2N component to communicate the traffic via the first cellular RAT link.

[00416] Example 144 includes the subject matter of any one of Examples 139-143, and optionally, wherein the first D2N component is to receive the indication of establishment of the non-cellular RAT link from the remote UE.

[00417] Example 145 includes the subject matter of any one of Examples 139-144, and optionally, wherein the second D2N component is to receive the indication of establishment of the non-cellular RAT link from the relay UE.

[00418] Example 146 includes the subject matter of any one of Examples 139-145, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

5 [00419] Example 147 includes the subject matter of any one of Examples 139-146, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

[00420] Example 148 includes a method to be performed at an evolved Node B (eNB), the method comprising interfacing, via a first Device to Network (D2N) component, with a remote User Equipment (UE) over a first cellular Radio Access Technology (RAT) link; interfacing, via a second D2N component, with a relay UE over a second cellular RAT link;
10 receiving an indication of establishment of a non-cellular RAT link between the remote UE and the relay UE; and based on the indication, routing a downlink Service Data Unit (SDU) for the remote UE to the second D2N component to communicate the downlink SDU to the relay UE.

[00421] Example 149 includes the subject matter of Example 148, and optionally,
15 comprising sending to the relay UE a downlink Protocol Data Unit (PDU) via the second cellular RAT link, the downlink PDU comprising the downlink SDU and a relay protocol header comprising an identifier of the remote UE.

[00422] Example 150 includes the subject matter of Example 148 or 149, and optionally, comprising receiving a first uplink SDU of the remote UE via the first cellular RAT link,
20 receiving a second uplink SDU of the remote UE via the second cellular RAT link, and providing the first and second uplink SDUs to be processed by at least a Packet Data Convergence Protocol (PDCP) component of the eNB.

[00423] Example 151 includes the subject matter of Example 150, and optionally, wherein the first and second uplink SDUs are both associated with a same Evolved Packet-switched
25 System (EPS) bearer between the remote UE and a cellular network.

[00424] Example 152 includes the subject matter of any one of Examples 148-151, and optionally, comprising receiving a status indication of the non-cellular RAT link, and, based on the status indication, selecting whether to switch to route traffic for the remote UE to the second D2N component to communicate the traffic via the first cellular RAT link.

30 [00425] Example 153 includes the subject matter of any one of Examples 148-152, and optionally, comprising receiving the indication of establishment of the non-cellular RAT link from the remote UE.

[00426] Example 154 includes the subject matter of any one of Examples 148-153, and optionally, comprising receiving the indication of establishment of the non-cellular RAT link from the relay UE.

5 [00427] Example 155 includes the subject matter of any one of Examples 148-154, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

[00428] Example 156 includes the subject matter of any one of Examples 148-155, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

10 [00429] Example 157 includes a product comprising one or more tangible computer-readable non-transitory storage media comprising computer-executable instructions operable to, when executed by at least one computer processor, enable the at least one computer processor to implement operations at an evolved Node B (eNB), the operations comprising interfacing, via a first Device to Network (D2N) component, with a remote User Equipment (UE) over a first cellular Radio Access Technology (RAT) link; interfacing, via a second D2N component,
15 with a relay UE over a second cellular RAT link; receiving an indication of establishment of a non-cellular RAT link between the remote UE and the relay UE; and based on the indication, routing a downlink Service Data Unit (SDU) for the remote UE to the second D2N component to communicate the downlink SDU to the relay UE.

20 [00430] Example 158 includes the subject matter of Example 157, and optionally, wherein the operations comprise sending to the relay UE a downlink Protocol Data Unit (PDU) via the second cellular RAT link, the downlink PDU comprising the downlink SDU and a relay protocol header comprising an identifier of the remote UE.

25 [00431] Example 159 includes the subject matter of Example 157 or 158, and optionally, wherein the operations comprise receiving a first uplink SDU of the remote UE via the first cellular RAT link, receiving a second uplink SDU of the remote UE via the second cellular RAT link, and providing the first and second uplink SDUs to be processed by at least a Packet Data Convergence Protocol (PDCP) component of the eNB.

30 [00432] Example 160 includes the subject matter of Example 159, and optionally, wherein the first and second uplink SDUs are both associated with a same Evolved Packet-switched System (EPS) bearer between the remote UE and a cellular network.

[00433] Example 161 includes the subject matter of any one of Examples 157-160, and optionally, wherein the operations comprise receiving a status indication of the non-cellular

RAT link, and, based on the status indication, selecting whether to switch to route traffic for the remote UE to the second D2N component to communicate the traffic via the first cellular RAT link.

[00434] Example 162 includes the subject matter of any one of Examples 157-161, and optionally, wherein the operations comprise receiving the indication of establishment of the non-cellular RAT link from the remote UE.

[00435] Example 163 includes the subject matter of any one of Examples 157-162, and optionally, wherein the operations comprise receiving the indication of establishment of the non-cellular RAT link from the relay UE.

[00436] Example 164 includes the subject matter of any one of Examples 157-163, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

[00437] Example 165 includes the subject matter of any one of Examples 157-164, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

[00438] Example 166 includes an apparatus of cellular communication by an evolved Node B (eNB), the method comprising means for interfacing, via a first Device to Network (D2N) component, with a remote User Equipment (UE) over a first cellular Radio Access Technology (RAT) link; means for interfacing, via a second D2N component, with a relay UE over a second cellular RAT link; means for receiving an indication of establishment of a non-cellular RAT link between the remote UE and the relay UE; and means for, based on the indication, routing a downlink Service Data Unit (SDU) for the remote UE to the second D2N component to communicate the downlink SDU to the relay UE.

[00439] Example 167 includes the subject matter of Example 166, and optionally, comprising means for sending to the relay UE a downlink Protocol Data Unit (PDU) via the second cellular RAT link, the downlink PDU comprising the downlink SDU and a relay protocol header comprising an identifier of the remote UE.

[00440] Example 168 includes the subject matter of Example 166 or 167, and optionally, comprising means for receiving a first uplink SDU of the remote UE via the first cellular RAT link, receiving a second uplink SDU of the remote UE via the second cellular RAT link, and providing the first and second uplink SDUs to be processed by at least a Packet Data Convergence Protocol (PDCP) component of the eNB.

[00441] Example 169 includes the subject matter of Example 168, and optionally, wherein the first and second uplink SDUs are both associated with a same Evolved Packet-switched System (EPS) bearer between the remote UE and a cellular network.

[00442] Example 170 includes the subject matter of any one of Examples 166-169, and optionally, comprising means for receiving a status indication of the non-cellular RAT link, and, based on the status indication, selecting whether to switch to route traffic for the remote UE to the second D2N component to communicate the traffic via the first cellular RAT link.

[00443] Example 171 includes the subject matter of any one of Examples 166-170, and optionally, comprising means for receiving the indication of establishment of the non-cellular RAT link from the remote UE.

[00444] Example 172 includes the subject matter of any one of Examples 166-171, and optionally, comprising means for receiving the indication of establishment of the non-cellular RAT link from the relay UE.

[00445] Example 173 includes the subject matter of any one of Examples 166-172, and optionally, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.

[00446] Example 174 includes the subject matter of any one of Examples 166-173, and optionally, wherein the non-cellular RAT comprises a Bluetooth (BT) RAT.

[00447] Functions, operations, components and/or features described herein with reference to one or more embodiments, may be combined with, or may be utilized in combination with, one or more other functions, operations, components and/or features described herein with reference to one or more other embodiments, or vice versa.

[00448] While certain features have been illustrated and described herein, many modifications, substitutions, changes, and equivalents may occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the disclosure.

CLAIMS

What is claimed is:

1. An apparatus of a User Equipment (UE), the apparatus comprising:
 - a Proximity-based Services (ProSe) component to interface with a relay UE over a
5 non-cellular Radio Access Technology (RAT) link;
 - a Device to Network (D2N) component to interface with an evolved Node B (eNB)
of a cellular network over a cellular RAT link;
 - a Packet Data Convergence Protocol (PDCP) component to process traffic of an
Evolved Packet-switched System (EPS) bearer between the UE and the cellular network, the
10 EPS bearer established over the cellular RAT link; and
 - a controller component configured to route an uplink Service Data Unit (SDU) of
the EPS bearer to the ProSe component to communicate the uplink SDU to the relay UE over
the non-cellular RAT link.
2. The apparatus of claim 1, wherein the controller component is configured to select
15 between routing the uplink SDU to the ProSe component to communicate the uplink SDU to
the relay UE, and routing the uplink SDU to the D2N component to communicate the uplink
SDU to the eNB via the cellular RAT link.
3. The apparatus of claim 2, wherein the controller component is to receive from the
ProSe component a status indication of a status of the non-cellular RAT link, the controller
20 component to select, based at least on the status indication, between routing the uplink SDU
to the ProSe component and routing the uplink SDU to the D2N component.
4. The apparatus of claim 1, wherein the controller component is to receive a downlink
SDU from the ProSe component, and to provide the downlink SDU to be processed by at
least the PDCP component.
- 25 5. The apparatus of claim 1, wherein the uplink SDU comprises a PDCP SDU provided
by the PDCP component.
6. The apparatus of claim 1, wherein the uplink SDU comprises a Radio Link Control
(RLC) SDU processed by an RLC component.

7. The apparatus of claim 1, wherein the uplink SDU comprises a Medium Access Control (MAC) SDU.
8. The apparatus of any one of claims 1-7, wherein the controller component is to provide to the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the UE.
9. The apparatus of any one of claims 1-7, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.
10. The apparatus of any one of claims 1-7, wherein the non-cellular RAT comprises a Wireless Local Area Network (WLAN) RAT.
11. The apparatus of any one of claims 1-7 comprising one or more antennas, a memory and a processor.
12. A system of cellular communication comprising an apparatus of a User Equipment (UE), the apparatus comprising:
- a Proximity-based Services (ProSe) component to interface with at least one remote UE over at least one non-cellular Radio Access Technology (RAT) link;
 - a Device to Network (D2N) component to interface with an evolved Node B (eNB) of a cellular network over a cellular RAT link; and
 - a controller component configured to receive from the ProSe component an uplink Service Data Unit (SDU) from the remote UE, and to transfer the uplink SDU to the D2N component to communicate the uplink SDU to the eNB over the cellular RAT link.
13. The system of claim 12, wherein the controller component is to receive from the ProSe component an uplink Protocol Data Unit (PDU) comprising the uplink SDU and a relay protocol header comprising an identifier of the remote UE, the controller component to map the uplink SDU to a radio bearer based on the identifier of the remote UE.
14. The system of claim 12, wherein the controller component is to receive from the D2N component a downlink SDU from the eNB, and to transfer the downlink SDU to the ProSe component to communicate the downlink SDU to the remote UE over the non-cellular RAT link.

15. The system of claim 12, wherein the at least one remote UE comprises a plurality of remote UEs, the controller component configured to multiplex uplink SDUs from the plurality of remote UEs to a radio bearer from the D2N component to the eNB.

16. The system of any one of claims 12-15, wherein the controller component is to receive from the ProSe component a status indication of a status of the non-cellular RAT link, the controller component to cause the D2N component to signal the status indication to the eNB.

17. The system of any one of claims 12-15, wherein the ProSe component comprises a Medium Access Control (MAC) component of the non-cellular RAT.

18. The system of any one of claims 12-15, wherein the apparatus comprises one or more antennas, a memory and a processor.

19. A method to be performed at an evolved Node B (eNB), the method comprising:
interfacing, via a first Device to Network (D2N) component, with a remote User Equipment (UE) over a first cellular Radio Access Technology (RAT) link;

interfacing, via a second D2N component, with a relay UE over a second cellular RAT link;

receiving an indication of establishment of a non-cellular RAT link between the remote UE and the relay UE; and

based on the indication, routing a downlink Service Data Unit (SDU) for the remote UE to the second D2N component to communicate the downlink SDU to the relay UE.

20. The method of claim 19 comprising sending to the relay UE a downlink Protocol Data Unit (PDU) via the second cellular RAT link, the downlink PDU comprising the downlink SDU and a relay protocol header comprising an identifier of the remote UE.

21. The method of claim 19 comprising receiving a first uplink SDU of the remote UE via the first cellular RAT link, receiving a second uplink SDU of the remote UE via the second cellular RAT link, and providing the first and second uplink SDUs to be processed by at least a Packet Data Convergence Protocol (PDCP) component of the eNB.

22. The method of claim 21, wherein the first and second uplink SDUs are both associated with a same Evolved Packet-switched System (EPS) bearer between the remote UE and a cellular network.

23. The method of claim 19 comprising receiving a status indication of the non-cellular RAT link, and, based on the status indication, selecting whether to switch to route traffic for the remote UE to the second D2N component to communicate the traffic via the first cellular RAT link.

24. The method of claim 19 comprising receiving the indication of establishment of the non-cellular RAT link from the remote UE.

25. A product comprising one or more tangible computer-readable non-transitory storage media comprising computer-executable instructions operable to, when executed by at least one computer processor, enable the at least one computer processor to perform the method of any one of claims 19-24.

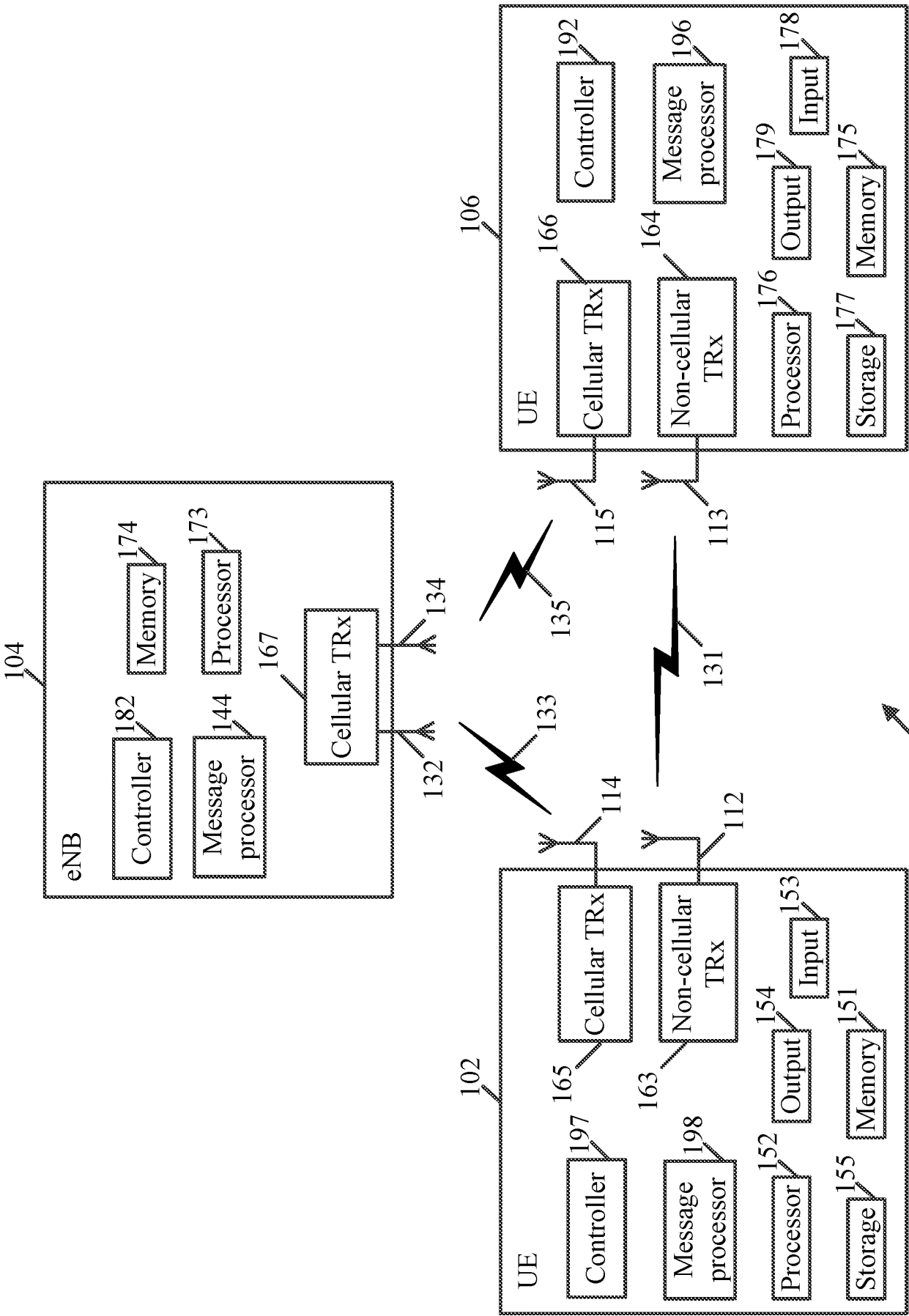


Fig. 1

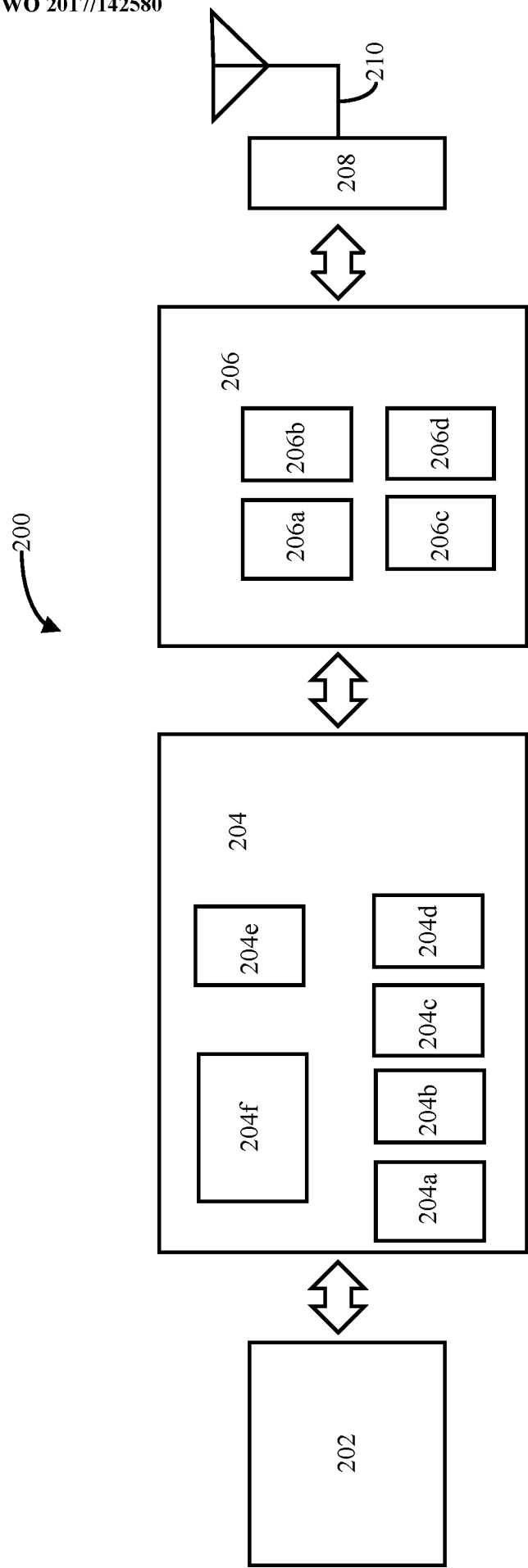


Fig. 2

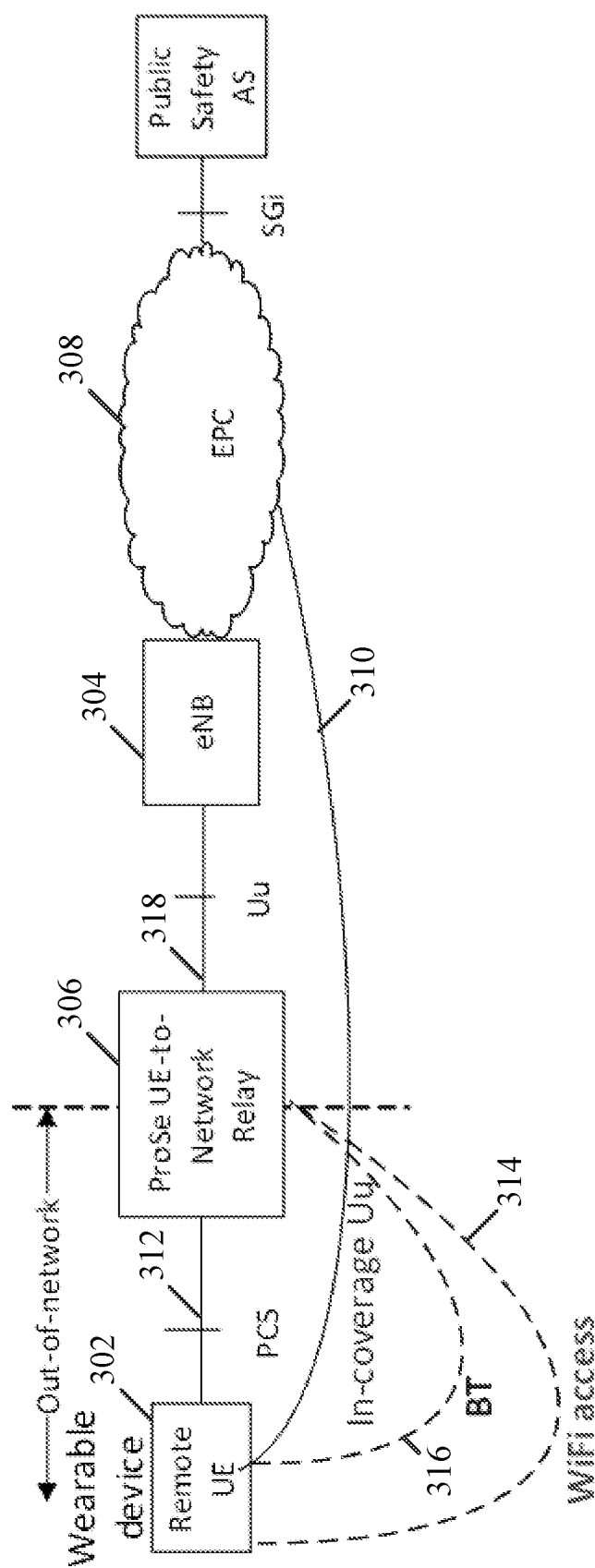


Fig. 3

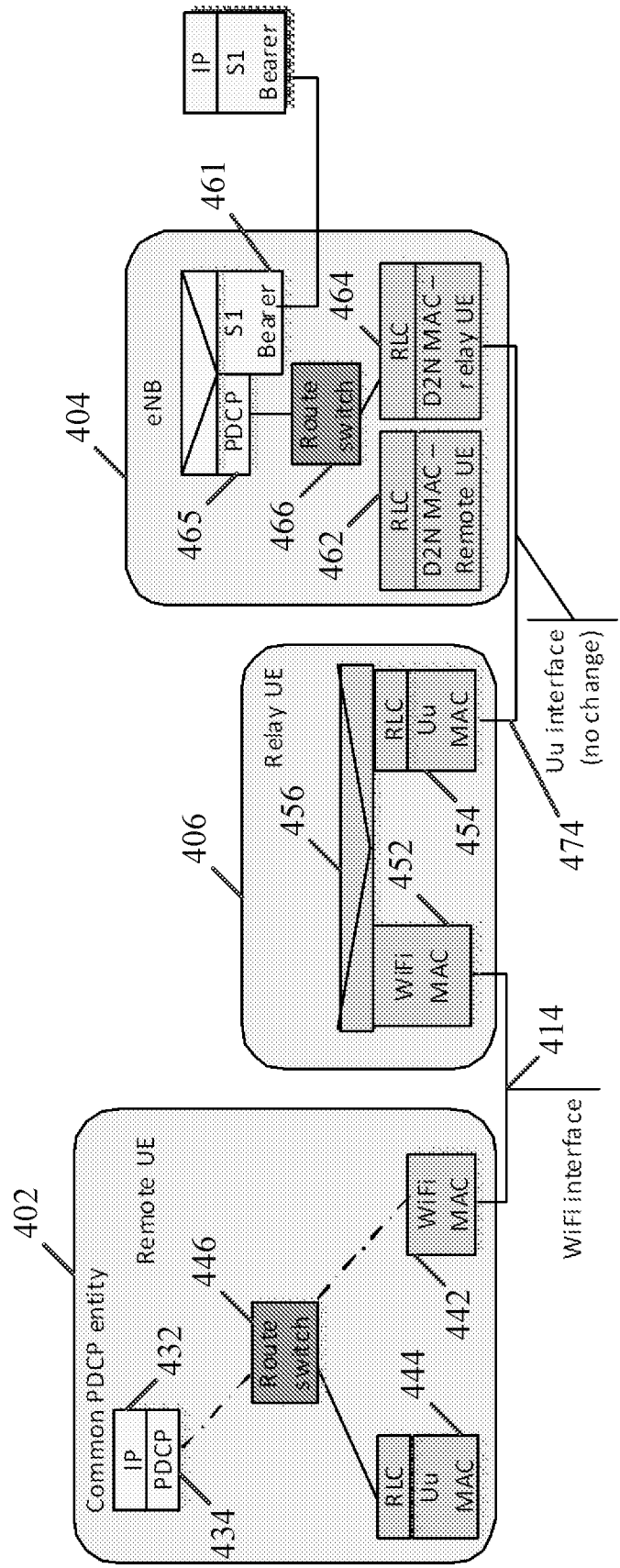


Fig. 4

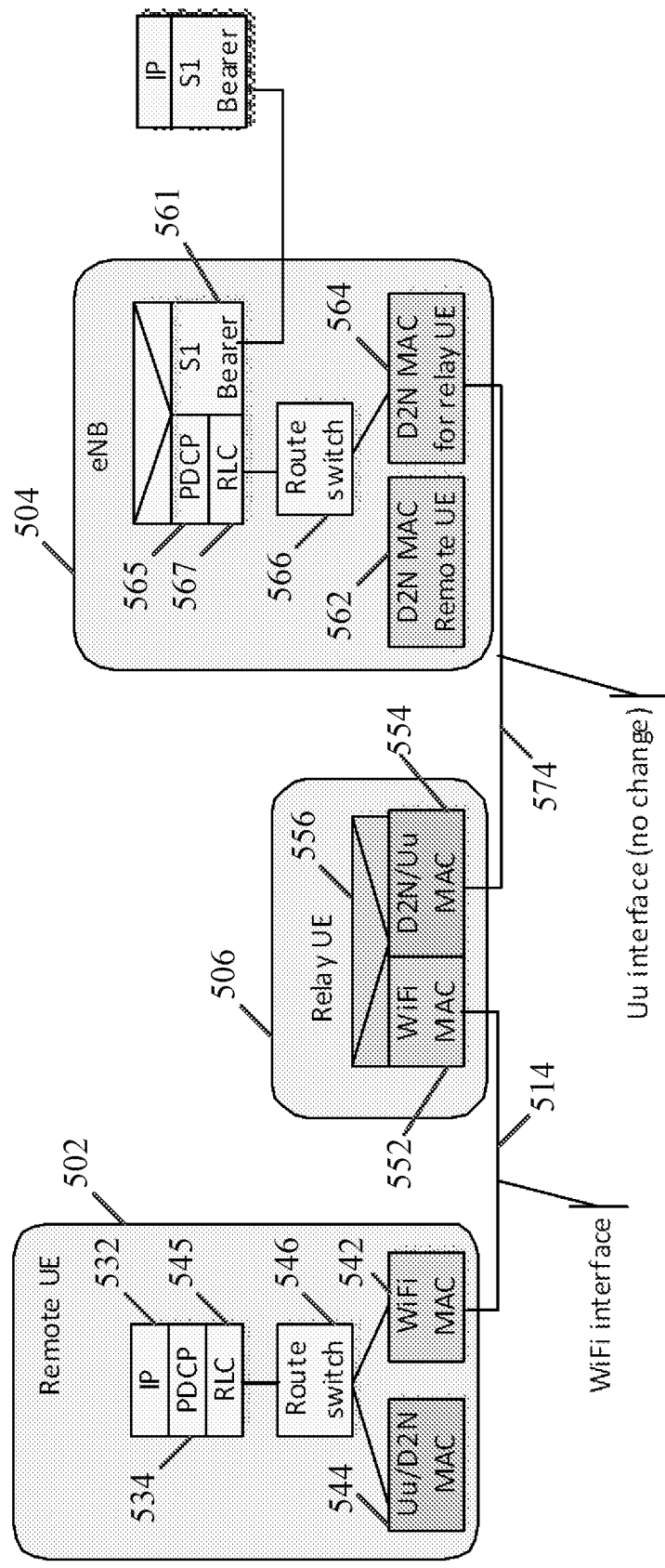


Fig. 5

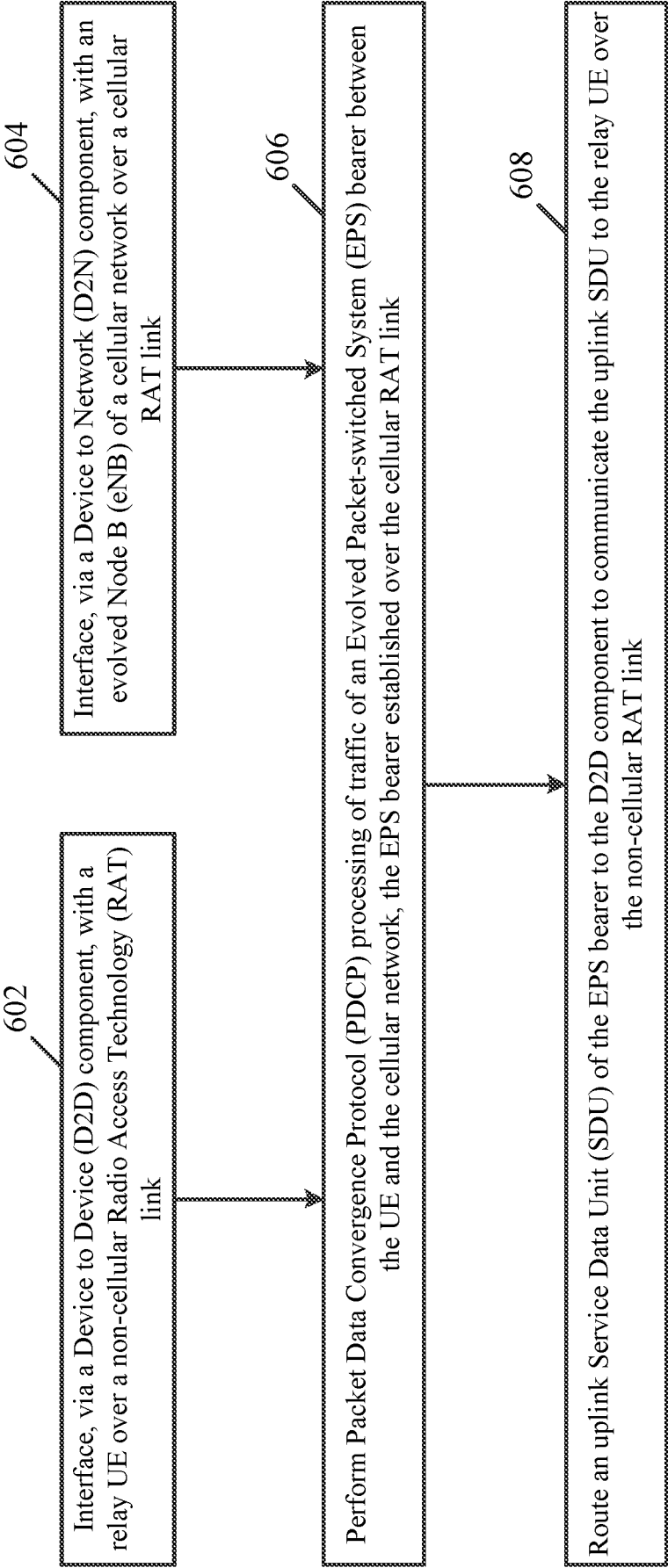


Fig. 6

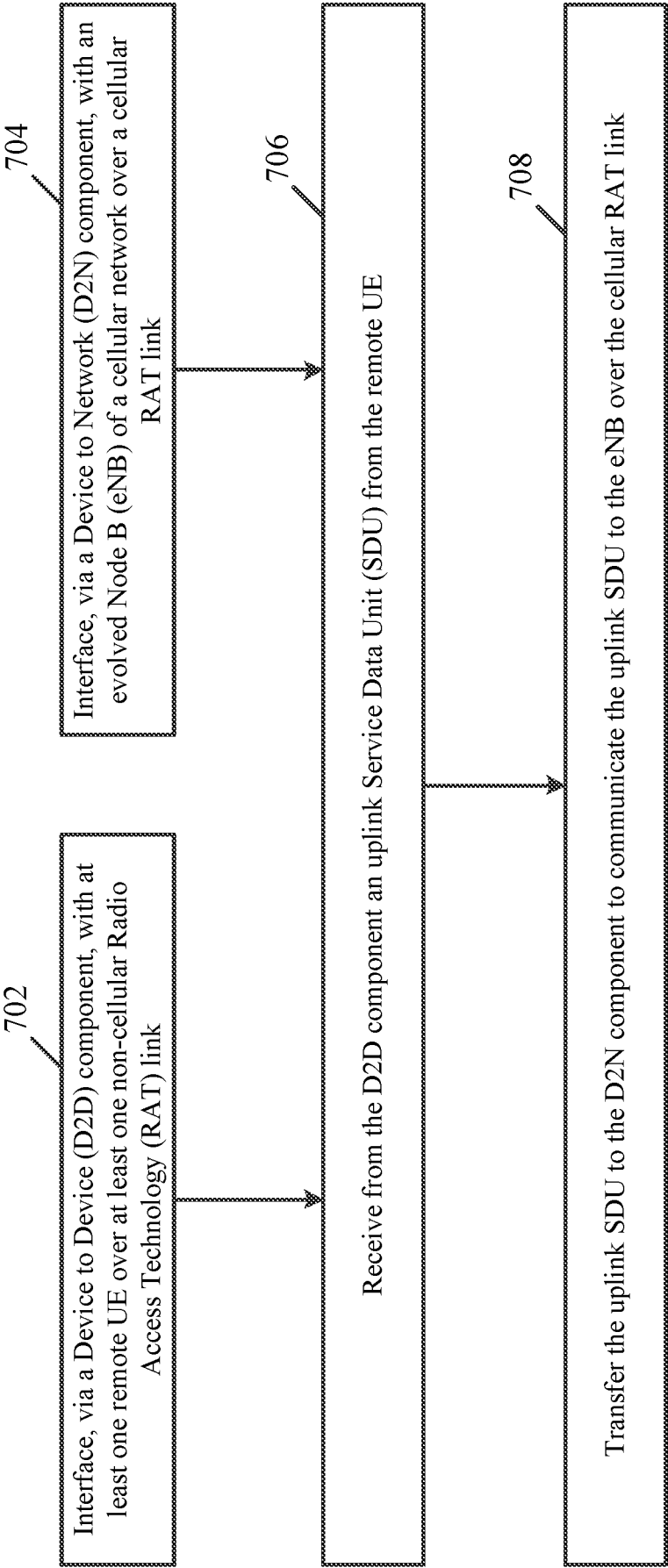


Fig. 7

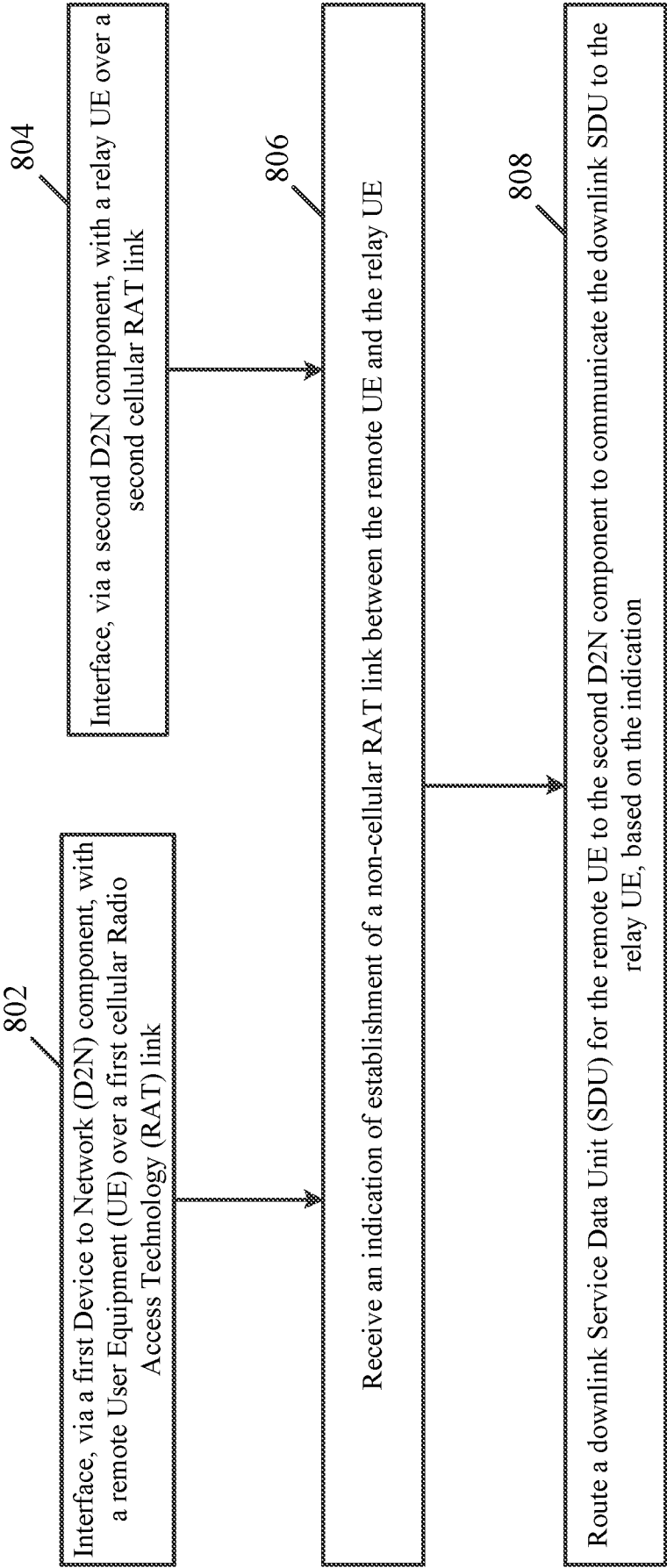


Fig. 8

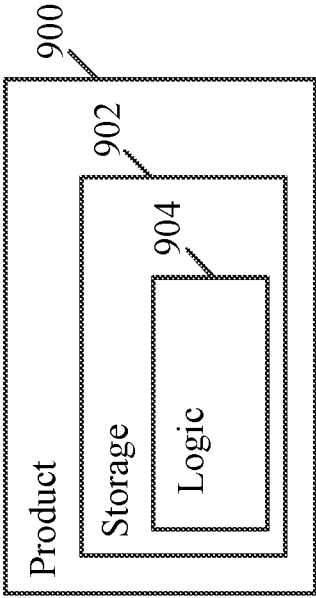


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2016/036835

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W76/02

ADD. H04W76/04

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.
X	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Proximity-based services (ProSe); Stage 2 (Release 13)", 3GPP STANDARD; 3GPP TS 23.303, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. SA WG2, no. V13.2.0, 15 December 2015 (2015-12-15), pages 1-122, XP051046482, [retrieved on 2015-12-15] paragraphs [4.5.4], [05.1], [05.6], [0A.2] ----- -/-	1-25



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

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"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

27 October 2016

Date of mailing of the international search report

04/11/2016

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Bocking, Philip

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/036835

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2015/152785 A1 (ERICSSON TELEFON AB L M [SE]) 8 October 2015 (2015-10-08) paragraphs [0001] - [0018]; figures 2,4 -----	1-25
A	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Study on architecture enhancements to support Proximity-based Services (ProSe) (Release 12)", 3GPP STANDARD; 3GPP TR 23.703, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. SA WG2, no. V2.0.0, 10 March 2014 (2014-03-10), pages 1-324, XP050769634, [retrieved on 2014-03-10] paragraphs [06.3], [AnnexH], [AnnexK] -----	1-25
A	WO 2015/005900 A1 (NOKIA SIEMENS NETWORKS OY [FI]; WOLFNER GYÖRGY TAMAS [HU]; WONG CURT []) 15 January 2015 (2015-01-15) page 12, line 7 - line 11 -----	1,12,19

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/036835

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2015152785	A1	08-10-2015	NONE

WO 2015005900	A1	15-01-2015	US 2016156404 A1 02-06-2016
		WO 2015005900 A1	15-01-2015
