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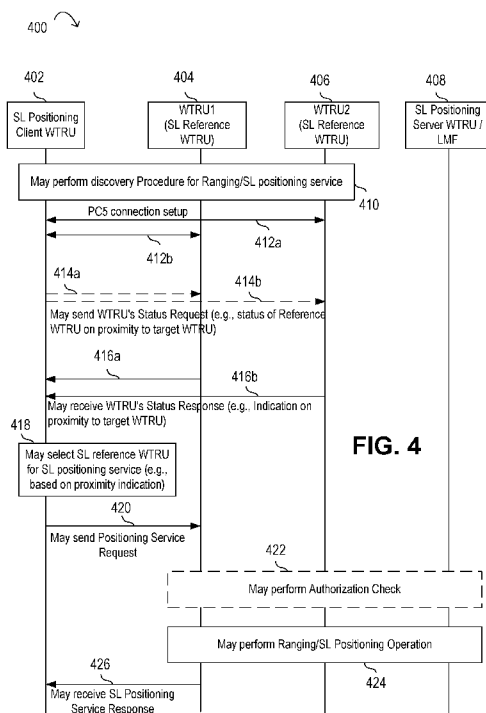
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(57) Abstract: A wireless transmit/receive unit (WTRU) may perform a discovery procedure to discover a plurality of sidelink (SL) reference WTRUs for positioning service with a target WTRU. The WTRU may receive a status message from each of a plurality of discovered SL reference WTRUs that includes a proximity indication for the respective SL reference WTRU. The proximity indication may indicate whether the respective SL reference WTRU is in proximity to the target WTRU. The WTRU may select a SL reference WTRU of the plurality of SL reference WTRUs for the SL positioning service based on the respective proximity indications of the plurality of discovered SL reference WTRUs. The WTRU may send a SL positioning service request to the target WTRU and/or to the selected SL reference WTRU. The SL positioning service request may include an indication of the selected SL reference WTRU.

FIG. 4

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METHODS OF SIDELINK POSITIONING WITH PROXIMITY

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to United States Provisional Patent Application No. 63/518,589 filed in the United States of America on August 10, 2023, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0002] Location service (LCS) (e.g., 5G location service) may provide the functionality to provide the positioning information of a WTRU. The positioning of a WTRU can be supported by radio access technology (RAT) dependent position method, which may rely on, for example, one or more 3GPP RAT measurements obtained by a target WTRU and/or measurement(s) obtained by an Access Network of 3GPP RAT signals transmitted by a target WTRU. Positioning of a WTRU can (e.g., also) be supported by RAT independent position methods which may rely on non-RAT measurements obtained by a WTRU and/or other information. Location information for one or more (e.g., multiple) target WTRUs may be requested by and/or reported to an LCS client and/or an application function (AF) within and/or external to a 3GPP operator network, and/or a control plane network function (NF) within 3GPP system. For location request from LCS client and/or an AF, privacy verification of the target WTRU may be enabled to check whether it is allowed to acquire the WTRU location information.

SUMMARY

[0003] A first wireless transmit/receive unit (WTRU) may receive configuration information. The configuration information may include an indication to discover a second WTRU for sidelink (SL) positioning service to determine a target WTRU. The first WTRU may send a connection message to the second WTRU. The first WTRU may send a status request message to the second WTRU. The first WTRU may receive a status response message from the second WTRU. The status response message may indicate the second WTRU proximity indication to the target WTRU. The first WTRU may determine a SL reference WTRU, for example, based on the proximity indication of the second WTRU. The first WTRU may send a SL positioning service request

message to the SL reference WTRU. The first WTRU may receive a SL positioning service response message.

[0004] A wireless transmit/receive unit (WTRU) may perform a discovery procedure to discover a plurality of sidelink (SL) reference WTRUs for positioning service with a target WTRU. The WTRU may receive a status message from each of a plurality of discovered SL reference WTRUs that includes a proximity indication for the respective SL reference WTRU. The proximity indication may indicate whether the respective SL reference WTRU is in proximity to the target WTRU. The WTRU may select a SL reference WTRU of the plurality of SL reference WTRUs for the SL positioning service based on the respective proximity indications of the plurality of discovered SL reference WTRUs. The WTRU may send a SL positioning service request to the target WTRU and/or to the selected SL reference WTRU. The SL positioning service request may include an indication of the selected SL reference WTRU.

[0005] The WTRU may send a status request to the plurality of SL reference WTRUs to request the proximity of the plurality of SL reference WTRUs to the target WTRU. The WTRU may receive a SL positioning service response from the selected SL reference WTRU. The selected SL reference WTRU may be selected based on respective signal qualities associated with the plurality of SL reference WTRUs. The WTRU may measure link quality of sidelink in which the status messages are transferred to determine the respective signal qualities.

[0006] The WTRU may send a proximity status request to a location management function (LMF). The proximity status request may include the plurality of SL reference WTRUs.

[0007] Sending the solicitation request message may include sending the solicitation to one or more SL reference WTRUs of the plurality of SL reference WTRUs to discover the target WTRU.

[0008] Performing the discovery procedure may include one or more of the following. A WTRU may send a solicitation request message to discover the target WTRU for a SL positioning service. The WTRU may receive a solicitation response message from a plurality of SL reference WTRUs. Receiving the status message may be based on the discovery procedure.

[0009] The status message may include one or more of the following. The status message may include an indication that the target WTRU is in proximity. The status message may include information about one or more possible target WTRUs that are in proximity. The status message may include user information of the target WTRU. The status message may include a layer 2 identification (IDs) of the target WTRU and/or one or more other proximity service (ProSe) IDs of the target WTRU. The status message may include a discovery code of the target WTRU. The status message may include age of time after checking the proximity. The status message may include an affinity.

[0010] The solicitation request may include a proximity request for one or more SL reference WTRUs of the plurality of SL reference WTRUs to perform a discovery procedure associated with the target WTRU. The proximity indication for the respective SL reference WTRU may be based on the proximity request.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1A is a system diagram illustrating an example communications system in which one or more disclosed embodiments may be implemented.

[0012] FIG. 1B is a system diagram illustrating an example wireless transmit/receive unit (WTRU) that may be used within the communications system illustrated in FIG. 1A according to an embodiment.

[0013] FIG. 1C is a system diagram illustrating an example radio access network (RAN) and an example core network (CN) that may be used within the communications system illustrated in FIG. 1A according to an embodiment.

[0014] FIG. 1D is a system diagram illustrating a further example RAN and a further example CN that may be used within the communications system illustrated in FIG. 1A according to an embodiment.

[0015] FIG. 2 depicts an example reference model of a potential architecture (e.g., of 5G and/or NextGen network).

[0016] FIG. 3 depicts an example reference model for location service (e.g., reference model of 5G and/or NextGen network for location service).

[0017] FIG. 4 depicts an example procedure of sidelink (SL) positioning by client WTRU with proximity indication from SL reference WTRU.

DETAILED DESCRIPTION

[0018] FIG. 1A is a diagram illustrating an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), zero-tail unique-word DFT-Spread OFDM (ZT UW DTS-s OFDM), unique word OFDM (UW-OFDM), resource block-filtered OFDM, filter bank multicarrier (FBMC), and the like.

[0019] As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a RAN 104/113, a CN 106/115, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d, any of which may be referred to as a “station” and/or a “STA”, may be configured to transmit and/or receive wireless signals and may include a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a subscription-based unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, a hotspot or Mi-Fi device, an Internet of Things (IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device and applications (e.g., remote surgery), an industrial device and applications (e.g., a robot and/or other

wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. Any of the WTRUs 102a, 102b, 102c and 102d may be interchangeably referred to as a WTRU.

[0020] The communications systems 100 may also include a base station 114a and/or a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the CN 106/115, the Internet 110, and/or the other networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a gNB, a NR NodeB, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

[0021] The base station 114a may be part of the RAN 104/113, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals on one or more carrier frequencies, which may be referred to as a cell (not shown). These frequencies may be in licensed spectrum, unlicensed spectrum, or a combination of licensed and unlicensed spectrum. A cell may provide coverage for a wireless service to a specific geographical area that may be relatively fixed or that may change over time. The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In an embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and may utilize multiple transceivers for each sector of the cell. For example, beamforming may be used to transmit and/or receive signals in desired spatial directions.

[0022] The base stations 114a, 114b may communicate with one or more of the WTRUs 102a, 102b, 102c, 102d over an air interface 116, which may be any suitable

wireless communication link (e.g., radio frequency (RF), microwave, centimeter wave, micrometer wave, infrared (IR), ultraviolet (UV), visible light, etc.). The air interface 116 may be established using any suitable radio access technology (RAT).

[0023] More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104/113 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink (DL) Packet Access (HSDPA) and/or High-Speed UL Packet Access (HSUPA).

[0024] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as Evolved UMTS Terrestrial Radio Access (E-UTRA), which may establish the air interface 116 using Long Term Evolution (LTE) and/or LTE-Advanced (LTE-A) and/or LTE-Advanced Pro (LTE-A Pro).

[0025] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as NR Radio Access, which may establish the air interface 116 using New Radio (NR).

[0026] In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement multiple radio access technologies. For example, the base station 114a and the WTRUs 102a, 102b, 102c may implement LTE radio access and NR radio access together, for instance using dual connectivity (DC) principles. Thus, the air interface utilized by WTRUs 102a, 102b, 102c may be characterized by multiple types of radio access technologies and/or transmissions sent to/from multiple types of base stations (e.g., a eNB and a gNB).

[0027] In other embodiments, the base station 114a and the WTRUs 102a, 102b, 102c may implement radio technologies such as IEEE 802.11 (i.e., Wireless Fidelity (WiFi)), IEEE 802.16 (i.e., Worldwide Interoperability for Microwave Access (WiMAX)), CDMA2000, CDMA2000 1X, CDMA2000 EV-DO, Interim Standard 2000 (IS-2000),

Interim Standard 95 (IS-95), Interim Standard 856 (IS-856), Global System for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE), GSM EDGE (GERAN), and the like.

[0028] The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, an industrial facility, an air corridor (e.g., for use by drones), a roadway, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In an embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g., WCDMA, CDMA2000, GSM, LTE, LTE-A, LTE-A Pro, NR etc.) to establish a picocell or femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the CN 106/115.

[0029] The RAN 104/113 may be in communication with the CN 106/115, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. The data may have varying quality of service (QoS) requirements, such as differing throughput requirements, latency requirements, error tolerance requirements, reliability requirements, data throughput requirements, mobility requirements, and the like. The CN 106/115 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 104/113 and/or the CN 106/115 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104/113 or a different RAT. For example, in addition to being connected to the RAN 104/113, which may be utilizing a NR radio technology, the CN 106/115 may also be in communication

with another RAN (not shown) employing a GSM, UMTS, CDMA 2000, WiMAX, E-UTRA, or WiFi radio technology.

[0030] The CN 106/115 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or the other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and/or the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired and/or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another CN connected to one or more RANs, which may employ the same RAT as the RAN 104/113 or a different RAT.

[0031] Some or all of the WTRUs 102a, 102b, 102c, 102d in the communications system 100 may include multi-mode capabilities (e.g., the WTRUs 102a, 102b, 102c, 102d may include multiple transceivers for communicating with different wireless networks over different wireless links). For example, the WTRU 102c shown in FIG. 1A may be configured to communicate with the base station 114a, which may employ a cellular-based radio technology, and with the base station 114b, which may employ an IEEE 802 radio technology.

[0032] FIG. 1B is a system diagram illustrating an example WTRU 102. As shown in FIG. 1B, the WTRU 102 may include a processor 118, a transceiver 120, a transmit/receive element 122, a speaker/microphone 124, a keypad 126, a display/touchpad 128, non-removable memory 130, removable memory 132, a power source 134, a global positioning system (GPS) chipset 136, and/or other peripherals 138, among others. It will be appreciated that the WTRU 102 may include any sub-combination of the foregoing elements while remaining consistent with an embodiment.

[0033] The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field

Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

[0034] The transmit/receive element 122 may be configured to transmit signals to, or receive signals from, a base station (e.g., the base station 114a) over the air interface 116. For example, in one embodiment, the transmit/receive element 122 may be an antenna configured to transmit and/or receive RF signals. In an embodiment, the transmit/receive element 122 may be an emitter/detector configured to transmit and/or receive IR, UV, or visible light signals, for example. In yet another embodiment, the transmit/receive element 122 may be configured to transmit and/or receive both RF and light signals. It will be appreciated that the transmit/receive element 122 may be configured to transmit and/or receive any combination of wireless signals.

[0035] Although the transmit/receive element 122 is depicted in FIG. 1B as a single element, the WTRU 102 may include any number of transmit/receive elements 122. More specifically, the WTRU 102 may employ MIMO technology. Thus, in one embodiment, the WTRU 102 may include two or more transmit/receive elements 122 (e.g., multiple antennas) for transmitting and receiving wireless signals over the air interface 116.

[0036] The transceiver 120 may be configured to modulate the signals that are to be transmitted by the transmit/receive element 122 and to demodulate the signals that are received by the transmit/receive element 122. As noted above, the WTRU 102 may have multi-mode capabilities. Thus, the transceiver 120 may include multiple transceivers for enabling the WTRU 102 to communicate via multiple RATs, such as NR and IEEE 802.11, for example.

[0037] The processor 118 of the WTRU 102 may be coupled to, and may receive user input data from, the speaker/microphone 124, the keypad 126, and/or the

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

[0038] The processor 118 may receive power from the power source 134, and may be configured to distribute and/or control the power to the other components in the WTRU 102. The power source 134 may be any suitable device for powering the WTRU 102. For example, the power source 134 may include one or more dry cell batteries (e.g., nickel-cadmium (NiCd), nickel-zinc (NiZn), nickel metal hydride (NiMH), lithium-ion (Li-ion), etc.), solar cells, fuel cells, and the like.

[0039] The processor 118 may also be coupled to the GPS chipset 136, which may be configured to provide location information (e.g., longitude and latitude) regarding the current location of the WTRU 102. In addition to, or in lieu of, the information from the GPS chipset 136, the WTRU 102 may receive location information over the air interface 116 from a base station (e.g., base stations 114a, 114b) and/or determine its location based on the timing of the signals being received from two or more nearby base stations. It will be appreciated that the WTRU 102 may acquire location information by way of any suitable location-determination method while remaining consistent with an embodiment.

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

(for photographs and/or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, a Virtual Reality and/or Augmented Reality (VR/AR) device, an activity tracker, and the like. The peripherals 138 may include one or more sensors, the sensors may be one or more of a gyroscope, an accelerometer, a hall effect sensor, a magnetometer, an orientation sensor, a proximity sensor, a temperature sensor, a time sensor, a geolocation sensor, an altimeter, a light sensor, a touch sensor, a magnetometer, a barometer, a gesture sensor, a biometric sensor, and/or a humidity sensor.

[0041] The WTRU 102 may include a full duplex radio for which transmission and reception of some or all of the signals (e.g., associated with particular subframes for both the UL (e.g., for transmission) and downlink (e.g., for reception) may be concurrent and/or simultaneous. The full duplex radio may include an interference management unit 139 to reduce and or substantially eliminate self-interference via either hardware (e.g., a choke) or signal processing via a processor (e.g., a separate processor (not shown) or via processor 118). In an embodiment, the WTRU 102 may include a half-duplex radio for which transmission and reception of some or all of the signals (e.g., associated with particular subframes for either the UL (e.g., for transmission) or the downlink (e.g., for reception)).

[0042] FIG. 1C is a system diagram illustrating the RAN 104 and the CN 106 according to an embodiment. As noted above, the RAN 104 may employ an E-UTRA radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 104 may also be in communication with the CN 106.

[0043] The RAN 104 may include eNode-Bs 160a, 160b, 160c, though it will be appreciated that the RAN 104 may include any number of eNode-Bs while remaining consistent with an embodiment. The eNode-Bs 160a, 160b, 160c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the eNode-Bs 160a, 160b, 160c may implement MIMO technology. Thus, the eNode-B 160a, for example, may use multiple antennas to transmit wireless signals to, and/or receive wireless signals from, the WTRU 102a.

[0044] Each of the eNode-Bs 160a, 160b, 160c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the UL and/or DL, and the like. As shown in FIG. 1C, the eNode-Bs 160a, 160b, 160c may communicate with one another over an X2 interface.

[0045] The CN 106 shown in FIG. 1C may include a mobility management entity (MME) 162, a serving gateway (SGW) 164, and a packet data network (PDN) gateway (or PGW) 166. While each of the foregoing elements are depicted as part of the CN 106, it will be appreciated that any of these elements may be owned and/or operated by an entity other than the CN operator.

[0046] The MME 162 may be connected to each of the eNode-Bs 162a, 162b, 162c in the RAN 104 via an S1 interface and may serve as a control node. For example, the MME 162 may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, bearer activation/deactivation, selecting a particular serving gateway during an initial attach of the WTRUs 102a, 102b, 102c, and the like. The MME 162 may provide a control plane function for switching between the RAN 104 and other RANs (not shown) that employ other radio technologies, such as GSM and/or WCDMA.

[0047] The SGW 164 may be connected to each of the eNode Bs 160a, 160b, 160c in the RAN 104 via the S1 interface. The SGW 164 may generally route and forward user data packets to/from the WTRUs 102a, 102b, 102c. The SGW 164 may perform other functions, such as anchoring user planes during inter-eNode B handovers, triggering paging when DL data is available for the WTRUs 102a, 102b, 102c, managing and storing contexts of the WTRUs 102a, 102b, 102c, and the like.

[0048] The SGW 164 may be connected to the PGW 166, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices.

[0049] The CN 106 may facilitate communications with other networks. For example, the CN 106 may provide the WTRUs 102a, 102b, 102c with access to circuit-switched networks, such as the PSTN 108, to facilitate communications between the WTRUs 102a, 102b, 102c and traditional land-line communications devices. For example, the

CN 106 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the CN 106 and the PSTN 108. In addition, the CN 106 may provide the WTRUs 102a, 102b, 102c with access to the other networks 112, which may include other wired and/or wireless networks that are owned and/or operated by other service providers.

[0050] Although the WTRU is described in FIGS. 1A-1D as a wireless terminal, it is contemplated that in certain representative embodiments that such a terminal may use (e.g., temporarily or permanently) wired communication interfaces with the communication network.

[0051] In representative embodiments, the other network 112 may be a WLAN.

[0052] A WLAN in Infrastructure Basic Service Set (BSS) mode may have an Access Point (AP) for the BSS and one or more stations (STAs) associated with the AP. The AP may have an access or an interface to a Distribution System (DS) or another type of wired/wireless network that carries traffic in to and/or out of the BSS. Traffic to STAs that originates from outside the BSS may arrive through the AP and may be delivered to the STAs. Traffic originating from STAs to destinations outside the BSS may be sent to the AP to be delivered to respective destinations. Traffic between STAs within the BSS may be sent through the AP, for example, where the source STA may send traffic to the AP and the AP may deliver the traffic to the destination STA. The traffic between STAs within a BSS may be considered and/or referred to as peer-to-peer traffic. The peer-to-peer traffic may be sent between (e.g., directly between) the source and destination STAs with a direct link setup (DLS). In certain representative embodiments, the DLS may use an 802.11e DLS or an 802.11z tunneled DLS (TDLS). A WLAN using an Independent BSS (IBSS) mode may not have an AP, and the STAs (e.g., all of the STAs) within or using the IBSS may communicate directly with each other. The IBSS mode of communication may sometimes be referred to herein as an “ad-hoc” mode of communication.

[0053] When using the 802.11ac infrastructure mode of operation or a similar mode of operations, the AP may transmit a beacon on a fixed channel, such as a primary channel. The primary channel may be a fixed width (e.g., 20 MHz wide bandwidth) or a dynamically set width via signaling. The primary channel may be the operating channel

of the BSS and may be used by the STAs to establish a connection with the AP. In certain representative embodiments, Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) may be implemented, for example in 802.11 systems. For CSMA/CA, the STAs (e.g., every STA), including the AP, may sense the primary channel. If the primary channel is sensed/detected and/or determined to be busy by a particular STA, the particular STA may back off. One STA (e.g., only one station) may transmit at any given time in a given BSS.

[0054] High Throughput (HT) STAs may use a 40 MHz wide channel for communication, for example, via a combination of the primary 20 MHz channel with an adjacent or nonadjacent 20 MHz channel to form a 40 MHz wide channel.

[0055] Very High Throughput (VHT) STAs may support 20MHz, 40 MHz, 80 MHz, and/or 160 MHz wide channels. The 40 MHz, and/or 80 MHz, channels may be formed by combining contiguous 20 MHz channels. A 160 MHz channel may be formed by combining 8 contiguous 20 MHz channels, or by combining two non-contiguous 80 MHz channels, which may be referred to as an 80+80 configuration. For the 80+80 configuration, the data, after channel encoding, may be passed through a segment parser that may divide the data into two streams. Inverse Fast Fourier Transform (IFFT) processing, and time domain processing, may be done on each stream separately. The streams may be mapped on to the two 80 MHz channels, and the data may be transmitted by a transmitting STA. At the receiver of the receiving STA, the above described operation for the 80+80 configuration may be reversed, and the combined data may be sent to the Medium Access Control (MAC).

[0056] Sub 1 GHz modes of operation are supported by 802.11af and 802.11ah. The channel operating bandwidths, and carriers, are reduced in 802.11af and 802.11ah relative to those used in 802.11n, and 802.11ac. 802.11af supports 5 MHz, 10 MHz and 20 MHz bandwidths in the TV White Space (TVWS) spectrum, and 802.11ah supports 1 MHz, 2 MHz, 4 MHz, 8 MHz, and 16 MHz bandwidths using non-TVWS spectrum. According to a representative embodiment, 802.11ah may support Meter Type Control/Machine-Type Communications, such as MTC devices in a macro coverage area. MTC devices may have certain capabilities, for example, limited capabilities including support for (e.g., only support for) certain and/or limited bandwidths. The MTC

devices may include a battery with a battery life above a threshold (e.g., to maintain a very long battery life).

[0057] WLAN systems, which may support multiple channels, and channel bandwidths, such as 802.11n, 802.11ac, 802.11af, and 802.11ah, include a channel which may be designated as the primary channel. The primary channel may have a bandwidth equal to the largest common operating bandwidth supported by all STAs in the BSS. The bandwidth of the primary channel may be set and/or limited by a STA, from among all STAs in operating in a BSS, which supports the smallest bandwidth operating mode. In the example of 802.11ah, the primary channel may be 1 MHz wide for STAs (e.g., MTC type devices) that support (e.g., only support) a 1 MHz mode, even if the AP, and other STAs in the BSS support 2 MHz, 4 MHz, 8 MHz, 16 MHz, and/or other channel bandwidth operating modes. Carrier sensing and/or Network Allocation Vector (NAV) settings may depend on the status of the primary channel. If the primary channel is busy, for example, due to a STA (which supports only a 1 MHz operating mode), transmitting to the AP, the entire available frequency bands may be considered busy even though a majority of the frequency bands remains idle and may be available.

[0058] In the United States, the available frequency bands, which may be used by 802.11ah, are from 902 MHz to 928 MHz. In Korea, the available frequency bands are from 917.5 MHz to 923.5 MHz. In Japan, the available frequency bands are from 916.5 MHz to 927.5 MHz. The total bandwidth available for 802.11ah is 6 MHz to 26 MHz depending on the country code.

[0059] FIG. 1D is a system diagram illustrating the RAN 113 and the CN 115 according to an embodiment. As noted above, the RAN 113 may employ an NR radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 113 may also be in communication with the CN 115.

[0060] The RAN 113 may include gNBs 180a, 180b, 180c, though it will be appreciated that the RAN 113 may include any number of gNBs while remaining consistent with an embodiment. The gNBs 180a, 180b, 180c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the gNBs 180a, 180b, 180c may implement MIMO technology. For example, gNBs 180a, 180b may utilize beamforming to transmit signals to and/or

receive signals from the gNBs 180a, 180b, 180c. Thus, the gNB 180a, for example, may use multiple antennas to transmit wireless signals to, and/or receive wireless signals from, the WTRU 102a. In an embodiment, the gNBs 180a, 180b, 180c may implement carrier aggregation technology. For example, the gNB 180a may transmit multiple component carriers to the WTRU 102a (not shown). A subset of these component carriers may be on unlicensed spectrum while the remaining component carriers may be on licensed spectrum. In an embodiment, the gNBs 180a, 180b, 180c may implement Coordinated Multi-Point (CoMP) technology. For example, WTRU 102a may receive coordinated transmissions from gNB 180a and gNB 180b (and/or gNB 180c).

[0061] The WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c using transmissions associated with a scalable numerology. For example, the OFDM symbol spacing and/or OFDM subcarrier spacing may vary for different transmissions, different cells, and/or different portions of the wireless transmission spectrum. The WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c using subframe or transmission time intervals (TTIs) of various or scalable lengths (e.g., containing varying number of OFDM symbols and/or lasting varying lengths of absolute time).

[0062] The gNBs 180a, 180b, 180c may be configured to communicate with the WTRUs 102a, 102b, 102c in a standalone configuration and/or a non-standalone configuration. In the standalone configuration, WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c without also accessing other RANs (e.g., such as eNode-Bs 160a, 160b, 160c). In the standalone configuration, WTRUs 102a, 102b, 102c may utilize one or more of gNBs 180a, 180b, 180c as a mobility anchor point. In the standalone configuration, WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c using signals in an unlicensed band. In a non-standalone configuration WTRUs 102a, 102b, 102c may communicate with/connect to gNBs 180a, 180b, 180c while also communicating with/connecting to another RAN such as eNode-Bs 160a, 160b, 160c. For example, WTRUs 102a, 102b, 102c may implement DC principles to communicate with one or more gNBs 180a, 180b, 180c and one or more eNode-Bs 160a, 160b, 160c substantially simultaneously. In the non-standalone configuration, eNode-Bs 160a, 160b, 160c may serve as a mobility anchor for WTRUs 102a, 102b, 102c and gNBs

180a, 180b, 180c may provide additional coverage and/or throughput for servicing WTRUs 102a, 102b, 102c.

[0063] Each of the gNBs 180a, 180b, 180c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the UL and/or DL, support of network slicing, dual connectivity, interworking between NR and E-UTRA, routing of user plane data towards User Plane Function (UPF) 184a, 184b, routing of control plane information towards Access and Mobility Management Function (AMF) 182a, 182b and the like. As shown in FIG. 1D, the gNBs 180a, 180b, 180c may communicate with one another over an Xn interface.

[0064] The CN 115 shown in FIG. 1D may include at least one AMF 182a, 182b, at least one UPF 184a, 184b, at least one Session Management Function (SMF) 183a, 183b, and possibly a Data Network (DN) 185a, 185b. While each of the foregoing elements are depicted as part of the CN 115, it will be appreciated that any of these elements may be owned and/or operated by an entity other than the CN operator.

[0065] The AMF 182a, 182b may be connected to one or more of the gNBs 180a, 180b, 180c in the RAN 113 via an N2 interface and may serve as a control node. For example, the AMF 182a, 182b may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, support for network slicing (e.g., handling of different PDU sessions with different requirements), selecting a particular SMF 183a, 183b, management of the registration area, termination of NAS signaling, mobility management, and the like. Network slicing may be used by the AMF 182a, 182b in order to customize CN support for WTRUs 102a, 102b, 102c based on the types of services being utilized WTRUs 102a, 102b, 102c. For example, different network slices may be established for different use cases such as services relying on ultra-reliable low latency (URLLC) access, services relying on enhanced massive mobile broadband (eMBB) access, services for machine type communication (MTC) access, and/or the like. The AMF 162 may provide a control plane function for switching between the RAN 113 and other RANs (not shown) that employ other radio technologies, such as LTE, LTE-A, LTE-A Pro, and/or non-3GPP access technologies such as WiFi.

[0066] The SMF 183a, 183b may be connected to an AMF 182a, 182b in the CN 115 via an N11 interface. The SMF 183a, 183b may also be connected to a UPF 184a, 184b in the CN 115 via an N4 interface. The SMF 183a, 183b may select and control the UPF 184a, 184b and configure the routing of traffic through the UPF 184a, 184b. The SMF 183a, 183b may perform other functions, such as managing and allocating WTRU IP address, managing PDU sessions, controlling policy enforcement and QoS, providing downlink data notifications, and the like. A PDU session type may be IP-based, non-IP based, Ethernet-based, and the like.

[0067] The UPF 184a, 184b may be connected to one or more of the gNBs 180a, 180b, 180c in the RAN 113 via an N3 interface, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The UPF 184a, 184b may perform other functions, such as routing and forwarding packets, enforcing user plane policies, supporting multi-homed PDU sessions, handling user plane QoS, buffering downlink packets, providing mobility anchoring, and the like.

[0068] The CN 115 may facilitate communications with other networks. For example, the CN 115 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the CN 115 and the PSTN 108. In addition, the CN 115 may provide the WTRUs 102a, 102b, 102c with access to the other networks 112, which may include other wired and/or wireless networks that are owned and/or operated by other service providers. In one embodiment, the WTRUs 102a, 102b, 102c may be connected to a local Data Network (DN) 185a, 185b through the UPF 184a, 184b via the N3 interface to the UPF 184a, 184b and an N6 interface between the UPF 184a, 184b and the DN 185a, 185b.

[0069] In view of Figures 1A-1D, and the corresponding description of Figures 1A-1D, one or more, or all, of the functions described herein with regard to one or more of: WTRU 102a-d, Base Station 114a-b, eNode-B 160a-c, MME 162, SGW 164, PGW 166, gNB 180a-c, AMF 182a-ab, UPF 184a-b, SMF 183a-b, DN 185a-b, and/or any other device(s) described herein, may be performed by one or more emulation devices (not shown). The emulation devices may be one or more devices configured to emulate one

or more, or all, of the functions described herein. For example, the emulation devices may be used to test other devices and/or to simulate network and/or WTRU functions.

[0070] The emulation devices may be designed to implement one or more tests of other devices in a lab environment and/or in an operator network environment. For example, the one or more emulation devices may perform the one or more, or all, functions while being fully or partially implemented and/or deployed as part of a wired and/or wireless communication network in order to test other devices within the communication network. The one or more emulation devices may perform the one or more, or all, functions while being temporarily implemented/deployed as part of a wired and/or wireless communication network. The emulation device may be directly coupled to another device for purposes of testing and/or may performing testing using over-the-air wireless communications.

[0071] The one or more emulation devices may perform the one or more, including all, functions while not being implemented/deployed as part of a wired and/or wireless communication network. For example, the emulation devices may be utilized in a testing scenario in a testing laboratory and/or a non-deployed (e.g., testing) wired and/or wireless communication network in order to implement testing of one or more components. The one or more emulation devices may be test equipment. Direct RF coupling and/or wireless communications via RF circuitry (e.g., which may include one or more antennas) may be used by the emulation devices to transmit and/or receive data.

[0072] Systems, methods, and/or apparatuses are provided herein with respect to sidelink (SL) positioning operation with proximity indication from SL reference WTRU. When SL positioning client WTRU discovers SL Reference WTRU for a target UE, for example, the client WTRU may request SL reference WTRU to indicate whether it is in proximity to the target WTRU. The SL reference WTRU may respond with indication of proximity to the target WTRU to the client WTRU. Based on indication information and/or one or more other parameters, for example, the client WTRU may select a SL reference WTRU and/or may trigger SL positioning service request to the selected SL reference WTRU.

[0073] FIG. 2 depicts an example reference model of a potential architecture 200 (e.g., of 5G and/or NextGen network). Radio access network (RAN) may refer to a radio access network based on the (e.g., 5G) RAT and/or Evolved E-UTRA that connects to the NextGen core network. The Access Control and Mobility Management Function (AMF) may include one or more of the following functionalities: Registration management, Connection management, Reachability management, Mobility Management, and/or the like. The Session Management Function (SMF) may include one or more of the following functionalities: session management (e.g., including session establishment, modify and/or release); WTRU internet protocol (IP) address allocation, selection and/or control of user plane (UP) function; and/or the like.

[0074] The user plane function (UPF) may include one or more of the following functionalities: packet routing & forwarding; packet inspection; traffic usage reporting; and/or the like.

[0075] Location service (LCS) (e.g., 5G location service) may provide the functionality to provide the positioning information of a WTRU. The positioning of a WTRU can be supported by radio access technology (RAT) dependent position method, which may rely on, for example, one or more 3GPP RAT measurements obtained by a target WTRU and/or measurement(s) obtained by an Access Network of 3GPP RAT signals transmitted by a target WTRU. Positioning of a WTRU can (e.g., also) be supported by RAT independent position methods which may rely on non-RAT measurements obtained by a WTRU and/or other information. Location information for one or more (e.g., multiple) target WTRUs may be requested by and/or reported to an LCS client and/or an application function (AF) within and/or external to a 3GPP operator network, and/or a control plane network function (NF) within 3GPP system. For location request from LCS client and/or an AF, privacy verification of the target WTRU may be enabled to check whether it is allowed to acquire the WTRU location information.

[0076] FIG. 3 depicts an example reference model of a potential architecture 300 for location service (e.g., of 5G and/or NextGen network). (R)AN here may represent next generation (NG)-RAN, trusted non-3GPP access, and/or untrusted non-3GPP access. The Network (e.g., 5G Network) may work with wired network. In this case, it may be referred to as Access Network. (R)AN may represent Access Network and/or Radio

Access Network. Access network may be involved in the handling of one or more (e.g., various) positioning procedures including positioning of a target WTRU, provision of location related information not associated with a particular target WTRU, and/or transfer of positioning messages between an AMF or location management function (LMF) and a target WTRU.

[0077]AFs and/or NFs may access LCS services from a gateway mobile location centre (GMLC) in the same 3GPP operator network. LCS clients may access LCS services from a GMLC and/or External AF may access LCS service from a network exposure function (NEF). The GMLC may handle the request from external LCS client, AF (e.g., via NEF if AF is external AF), and/or may forward the location request to the (e.g., proper) NF.

[0078]The location retrieval function (LRF) may retrieve and/or validate location information and/or may be collocated with an GMLC or separate. The LMF may manage the (e.g., overall) co-ordination and/or scheduling of resources required for the location of a WTRU that is registered with and/or accessing (e.g., 5G) core network (CN). The LMF may calculate and/or verify a final location related information and/or achieved accuracy.

[0079]SL positioning (e.g., SL based positioning) service may be provided herein. SL positioning may be referred to as positioning WTRU using device-to-device direct communication (e.g., PC5) to obtain absolute position, relative position, and/or ranging information. Ranging may refer to the determination of the distance between two WTRUs and/or two or more WTRUs, and/or the direction of one WTRU (e.g., Target WTRU) from another WTRU (e.g., Reference WTRU) via PC5 interface.

[0080]SL positioning, target WTRU, SL Reference WTRU, SL positioning client WTRU and located UE may be include the following.

[0081]A target WTRU may include a WTRU whose distance, direction, and/or position is measured with the support from one or more (e.g., multiple) SL Reference WTRUs using Sidelink in the Ranging based service and/or Sidelink positioning. For example, the SL positioning client WTRU may measure link quality of sidelink in which the status messages (e.g., as described herein) are transferred to determine the respective signal

qualities (e.g., associated with the plurality of SL reference WTRUs as described herein).

[0082] A located WTRU may include a SL Reference WTRU of which the location is known and/or is able to be known using radio interface (e.g., Uu) based positioning. A located WTRU can be used to determine the location of a Target WTRU using Sidelink Positioning.

[0083] A SL Reference WTRU may support positioning of the target WTRU (e.g., by transmitting and/or receiving reference signals for positioning), for example, using sidelink. A SL Reference WTRU may provide positioning-related information and/or the like, for example, using sidelink.

[0084] A SL Positioning Client WTRU may include a third-party WTRU, other than SL Reference WTRU and/or Target WTRU, which initiates Ranging and/or Sidelink positioning service request on behalf of the application residing on it.

[0085] A LMF (Location Management Function), which may be a Network Function within a mobile operator network, may manage the (e.g., overall) coordination and/or scheduling of resources for location of a WTRU using Sidelink. LMF may communicate with other network entity(ies) for authorization of location request from a SL Positioning Client.

[0086] A SL Positioning server WTRU may be a WTRU which manages the (e.g., overall) coordination for location of a WTRU using Sidelink, when SL Positioning operation is performed without involving mobile operator network (example.g.,, when target WTRU and/or SL Reference WTRU are out of network coverage). When a SL Positioning server WTRU is involved, for example, authorization of location request from a SL Positioning Client may be handled by checking the stored information at the target WTRU and/or SL Reference WTRU and/or SL Positioning server WTRU.

[0087] The operation of Ranging and/or Sidelink Positioning can be performed with either Network-assisted Operation or WTRU-only Operation: In the Network-assisted Operation, 5GC NF(s) may be involved for the service request handling and/or the result calculation. In the WTRU-only Operation, the service request handling and/or result calculation may be performed by WTRU.

[0088] When Network-assisted operation is used, for example, LMF defined in the (e.g., 5G) Location Service may be used to support triggering SL positioning, coordination of SL positioning operation, and/or delivering the result to the client. The Ranging and/or Sidelink Positioning service request can be initiated by a WTRU (e.g., SL Positioning Client WTRU, Target WTRU, SL Reference WTRU), a 5GC NF, an LCS Client, and/or an AF.

[0089] When WTRU-only operation is used, for example, one or more WTRUs may interact with each other over PC5 (e.g., as necessary) in order to perform SL positioning operation. SL positioning server WTRU may coordinate SL positioning operation and/or calculate the positioning result.

[0090] A SL Positioning Server WTRU may offer method determination, assistant data distribution, location calculation functionalities, and/or location calculation functionalities for Sidelink Positioning and/or Ranging based service.

[0091] A WTRU (e.g., SL positioning client WTRU) may request SL positioning through PC5 and/or through the network (NW). When the SL positioning client WTRU requests SL positioning service through PC5 connection, for example, it can discover one of Reference WTRU and Target WTRU, and/or it may invoke the Ranging and/or SL Positioning service request to the discovered Reference WTRU and/or Target WTRU for obtaining the Ranging and/or SL positioning result between the Reference WTRU and the Target WTRU. This request may include the user information of SL Positioning Client WTRU, the Reference WTRU, and/or the Target WTRU.

[0092] SL positioning client WTRU selecting the SL reference WTRU in proximity of the target WTRU for SL positioning operation may be addressed herein.

[0093] When SL positioning client WTRU invokes the Ranging and/or SL positioning service request, for example (e.g., at first), it may discover the target WTRU and/or SL reference WTRU and/or it may initiate SL positioning service request to the discovered target WTRU and/or discovered SL reference WTRU.

[0094] In examples, the client WTRU may discover (e.g., only) SL reference WTRU(s) but not the target WTRU. In this case, for example, SL positioning client WTRU may select a WTRU among the discovered WTRU for initiating SL positioning service request. For successful SL positioning operation, for example, the selected SL

reference WTRU may be in proximity to the target WTRU, otherwise, SL positioning operation may not (e.g., cannot) be performed between the SL reference WTRU and the target WTRU over PC5 connection.

[0095] How the SL positioning client WTRU ensures the selected SL reference WTRU is in proximity to the target WTRU for SL positioning operation may be addressed herein.

[0096] Embodiments provided herein may determine (e.g., assume) that the WTRU supports PC5 connection. The WTRUs in embodiments may have capability of ranging and/or sidelink positioning. Sidelink positioning may refer to the positioning via PC5 interface and/or ranging may refer to the determination of the distance between two WTRUs and/or two or more WTRUs, and/or the direction and/or relative positioning of one WTRU from another WTRU.

[0097] FIG. 4 depicts an example procedure of SL positioning operation with Proximity indication from the SL Reference WTRU 400.

[0098] At 410, a SL positioning client WTRU 402 may perform a discovery procedure. For example, the SL positioning WTRU 402 may perform a discovery procedure to discover a plurality of SL reference WTRUs for SL positioning service with a target WTRU. For example, the SL positioning Client WTRU 402 may be triggered to discover target WTRU(s) and/or one or more SL reference WTRUs (e.g., 404, 406) for SL positioning service. The SL positioning client WTRU 402 may send a Solicitation request message including indication of SL positioning service and/or information of target WTRU(s). The SL positioning client WTRU 402 may send the Solicitation request message to one or more SL reference WTRUs of the plurality of SL Reference WTRUs to discover the target WTRU. One or more (e.g., some) SL reference WTRUs (e.g., SL Reference WTRU1 404 and/or SL Reference WTRU 2 406) may respond to the solicitation message. The solicitation request message may include a proximity request for one or more SL Reference WTRUs of the plurality of SL reference WTRUs to perform a discovery procedure associated with the target WTRU. The proximity indication for the respective SL reference WTRU may be based on the proximity request. Performing the discovery procedure may include one or more of the following. Performing the discovery procedure may include the SL positioning client WTRU 402 sending a solicitation request message to discover the target WTRU for a SL positioning

service. Performing the discovery procedure may include the SL positioning client WTRU 402 receiving a solicitation response message from a plurality of SL Reference WTRUs.

[0099] At 412a and/or 412b, the SL positioning client WTRU 402 may setup PC5 connection(s) with the discovered WTRU (e.g., SL Reference WTRU1 404 and/or SL Reference WTRU2 406). For example, at 412a, the SL positioning client WTRU 402 may establish a PC5 connection with SL reference WTRU2 406. For example, at 412b, the SL positioning client WTRU 402 may establish a PC5 connection with SL reference WTRU1 404.

[0100] At 414a and/or 414b, based on (e.g., after) PC5 connection setup, the SL positioning client WTRU 402 may request the discovered SL reference WTRU's (e.g., SL reference WTRU1 404, SL reference WTRU2 406) status information on proximity to the target WTRU. For example, the SL positioning client WTRU 402 may send a status request to the plurality of SL Reference WTRUs (e.g., SL reference WTRU1 404, SL reference WTRU2 406) to request the proximity of the plurality of SL reference WTRUs to the target WTRU. The status information may be requested using an existing PC5 message, e.g., PC5 discovery solicitation message with the proximity to target WTRU status query indication message, and/or another (e.g., new) PC5 message.

[0101] Additionally or alternatively, during PC5 connection setup, the SL reference WTRU may indicate the proximity to the target WTRU (e.g., indication the proximity to target WTRU status may be included in direct communication accept (DCA) from SL reference WTRU).

[0102] At 416a and/or 416b, each SL reference WTRU may send the SL positioning client WTRU 402 a WTRU status response message. The SL Positioning Client WTRU 402 may receive a status message from each of a plurality of discovered SL reference WTRUs that includes a proximity indication for the respective SL reference WTRU. The proximity indication may indicate whether the respective SL reference WTRU is in proximity to the target WTRU. For example, the SL reference WTRU(s) (e.g., 404, 406) may send the respective WTRU's status response. The status response message may include indication on proximity to the target WTRU. For example, SL reference WTRU1 404 may send, at 416a, a status response message. The status response message

416a may include an indication on the proximity to the target WTRU for the SL reference WTRU1 404. At 416b, a SL reference WTRU2 406 may send a status response message. The status response message 416b may include an indication on the proximity to the target WTRU for the SL reference WTRU2 406.

[0103] The status response message (e.g., 416a, 416b) may be sent as a response to the PC5 message received, as described herein (e.g., at 410) (e.g., Discovery response message) and/or as another (e.g., new) PC5 message. For example, reception of the status message may be based on the discovery procedure (e.g., as described herein).

[0104] The status response message (e.g., 416a, 416b) in the PC5 message may include one or more of the following. The status response (e.g., 416a, 416b) in the PC5 message may include indication that the target WTRU is in proximity. The status response (e.g., 416a, 416b) in the PC5 message may include information about one or more other (e.g., possible) target WTRU(s) which are in proximity. The status response (e.g., 416a, 416b) in the PC5 message may include user information of target WTRU. The status response (e.g., 416a, 416b) in the PC5 message may include Layer 2 identification (ID) of the target and/or other Prose ID of the target WTRU. The status response (e.g., 416a, 416b) in the PC5 message may include a discovery code of the target WTRU. The status response (e.g., 416a, 416b) in the PC5 message may include a discovery message received by the SL Reference WTRU(s) from the target WTRU. The status response (e.g., 416a, 416b) in the PC5 message may include accuracy of the result(s) (e.g., proximity of the target WTRU). The status response (e.g., 416a, 416b) in the PC5 message may include age of time after checking the proximity. The status response (e.g., 416a, 416b) in the PC5 message may include an affinity. Affinity may indicate the degree to which the discovered WTRU may be suitable to be used for measuring target WTRU's position. Affinity may be specified by one or more (e.g., various) means. For example, affinity may be specified as the time the discovered WTRU has been in proximity of the target WTRU and/or the change in range and/or proximity between the discovered WTRU and the target WTRU, within a period of time. In examples, affinity may be an application layer parameter indicating a positioning relationship between the two WTRUs (e.g., two cars that had planned to drive from city A to city B through the same route).

[0105] The SL reference WTRU may determine it is in proximity to the target WTRU, for example, when it received an announcement message from the target WTRU, performed successful discovery procedure with the target WTRU based on model B discovery, and/or it has an existing PC5 connection with the target WTRU.

[0106] The SL reference WTRU may perform model B discovery procedure to discover the target WTRU (e.g., as needed).

[0107] Additionally or alternatively, the SL reference WTRU 402 may perform discovery procedure for the target WTRU after a receiving solicitation message from SL positioning client WTRU (e.g., as described herein, during the discovery procedure 410, based on the discover procedure 410). The SL reference WTRU may send WTRU's status response report, which may include indication on proximity to the target WTRU without receiving WTRU's Status request from the client WTRU in step 3.

[0108] At 418, the SL positioning client WTRU 402 may select a SL reference WTRU (e.g., SL reference WTRU1 404, SL reference WTRU2 406). The SL positioning client WTRU 402 may select the SL reference WTRU based on the WTRU's status response (e.g., at 416a, 416b) from the SL reference WTRU (e.g., 404, 406) and/or one or more other parameter(s) (e.g. signal quality of received message from SL reference WTRU). The SL positioning client WTRU 402 may select the SL Reference WTRU (e.g., the SL Positioning Client WTRU 402 may receive a SL positioning service response from the selected SL reference WTRU (e.g., SL reference WTRU1 404, SL reference WTRU2 406) based on respective signal qualities associated with the plurality of SL Reference WTRUs. For example, the client WTRU may select a SL reference WTRU which is in proximity to the target WTRU (e.g., SL reference WTRU1 404) for SL positioning operation with the target WTRU. The SL positioning client WTRU 402 may select a SL reference WTRU of the plurality of discovered SL reference WTRUs for the SL positioning service, for example, based on the respective proximity indications of the plurality of discovered SL reference WTRUs. The client WTRU may select a SL reference WTRU based on one or more of: one or more respective signal quality(ies); a ProSe service code to indicate supporting SL positioning; a PLMN in which each SL reference WTRU is registered (e.g., it may be included because same operator domain may be better for coordination of operation); and/or a supported SL positioning method.

[0109] If it is determined that there is no SL reference WTRU discovered (e.g., as described herein), at 410, 416a, 416b) in proximity to the target WTRU, the SL positioning client WTRU 402 may repeatedly perform procedures 410, 412a, 412b, 414a, 414b, 416a, and/or 416b until the SL positioning client WTRU 402 discovers the target WTRU and/or the SL reference WTRU (e.g., 404, 406) in proximity to the target WTRU.

[0110] At 420, the SL positioning client WTRU 402 may send a positioning service request. The SL positioning client WTRU 402 may send a positioning service request to the target WTRU and/or to the selected SL reference WTRU (e.g., SL reference WTRU1 404, SL reference WTRU2 406). The SL positioning service request may include an indication of the selected SL reference WTRU (e.g., SL reference WTRU1 404, SL reference WTRU2 406). For example, the indication may be included if the SL positioning request is sent to the selected SL reference WTRU (e.g., and not to the target WTRU). The indication of the selected SL reference WTRU may be included (e.g., needed) to indicate the entity to perform SL positioning. The SL positioning client WTRU 402 may send the SL positioning service request to the selected SL reference WTRU (e.g., SL Reference WTRU1 404). The positioning service request may include the target WTRU information and/or the selected SL reference WTRU.

[0111] At 422, the SL Reference WTRU (e.g., SL Reference WTRU 1 404, SL Reference WTRU 2 406) may determine authorization. For example, based on (e.g., after) receiving the SL positioning service request 420, the SL Reference WTRU1 404 and/or target WTRU may check their local database whether the SL Positioning client WTRU 402 is authorized for positioning information of the target WTRU and/or may request SL Positioning Server WTRU/LMF 408 to verify authorization of SL Positioning Client WTRU.

[0112] At 424, the SL Reference WTRU (e.g., SL Reference WTRU1 404, SL Reference WTRU 406) and/or Target WTRU (e.g., not shown in figure 4) may perform SL positioning operation (e.g. sending Reference Signal at target WTRU using Sidelink, measuring Reference Signal at SL Reference WTRU(s) using Sidelink, and/or collecting the measured Reference Signal and calculating location of target WTRU at SL

Positioning Server WTRU/LMF) as requested by the SL positioning client WTRU with coordination of SL Positioning Server WTRU/LMF 408.

[0113] At 426, the SL Reference WTRU (e.g., SL Reference WTRU1 402, SL Reference WTRU2 406) may send a SL positioning service response to the SL positioning client WTRU with the result of SL positioning operation. For example, the SL Positioning Client WTRU 402 may receive a SL positioning service response from the selected SL reference WTRU (e.g., SL reference WTRU1 404, SL reference WTRU2 406).

[0114] In examples, the SL client WTRU (e.g., SL positioning client WTRU) may send a proximity status request to the LMF for the target WTRU. For example, the SL client WTRU may send the proximity status request to the LMF after discovering the SL reference WTRUs. The proximity status request may include a list of discovered SL reference WTRUs. The proximity status request may include (e.g., an indication of) the plurality of SL reference WTRUs. For example, the SL positioning client WTRU. The LMF may (e.g., then) determine which SL reference WTRU(s) are the closest and/or may select them. The LMF may (e.g., then) send a response with a proximity status corresponding to the selected WTRU ID(s). The proximity status could also be tracked by an LMF, and/or the LMF may notify the client WTRU as soon as the status changes.

[0115] In examples, if the proximity status of the SL reference WTRU changes due to mobility (e.g., SL reference WTRU and/or the target WTRU has moved apart), then following step 5, the selected SL reference WTRU may indicate status change as soon as it is triggered based on radio parameters (e.g., such as signal strength).

CLAIMS:

1. A wireless transmit/receive unit (WTRU) comprising:
a processor configured to:
perform a discovery procedure to discover a plurality of sidelink (SL) reference WTRUs for SL positioning service with a target WTRU;
receive a status message from each of a plurality of discovered sidelink (SL) reference WTRUs that includes a proximity indication for the respective SL reference WTRU, wherein the proximity indication indicates whether the respective SL reference WTRU is in proximity to the target WTRU;
select a SL reference WTRU of the plurality of discovered SL reference WTRUs for the SL positioning service based on the respective proximity indications of the plurality of discovered SL reference WTRUs; and
send a SL positioning service request to the target WTRU or to the selected SL reference WTRU, wherein the SL positioning service request comprises an indication of the selected SL reference WTRU.
2. The WTRU of claim 1, wherein the processor is further configured to send a status request to the plurality of SL reference WTRUs to request the proximity of the plurality of SL reference WTRUs to the target WTRU.
3. The WTRU of claim 1 or 2, wherein the processor is further configured to receive a SL positioning service response from the selected SL reference WTRU.
4. The WTRU of any of claims 1 to 3, wherein the selected SL reference WTRU is selected based on respective signal qualities associated with the plurality of SL reference WTRUs.
5. The WTRU of claim 4, wherein the processor is further configured to measure link quality of Sidelink in which the status messages are transferred to determine the respective signal qualities.

6. The WTRU of any of claims 1 to 5, wherein the processor is further configured to send a proximity status request to a location management function (LMF), wherein the proximity status request comprises the plurality of SL reference WTRUs.

7. The WTRU of any of claims 1 to 6, wherein the processor being configured to perform the discovery procedure comprises the processor being configured to:

send a solicitation request message to discover the target WTRU for a SL positioning service; and

receive a solicitation response message from a plurality of SL reference WTRUs; and

wherein the processor being configured to receive the status message is based on the discovery procedure.

8. The WTRU of claim 7, wherein the processor being configured to send the solicitation request message comprises the processor being configured to send the solicitation to one or more SL reference WTRUs of the plurality of SL reference WTRUs to discover the target WTRU.

9. The WTRU of claim 7 or 8, wherein the solicitation request message comprises a proximity request for one or more SL reference WTRUs of the plurality of SL reference WTRUs to perform a discovery procedure associated with the target WTRU, wherein the proximity indication for the respective SL reference WTRU is based on the proximity request.

10. The WTRU of any of claims 1 to 9, wherein the status message comprises one or more of:

an indication that the target WTRU is in proximity, information about one or more other possible target WTRUs that are in proximity, user information of the target WTRU, a layer 2 identification (IDs) of the target WTRU or one or more other proximity service (ProSe) IDs of the target WTRU, a discovery code of the target WTRU, an age of time after checking the proximity, or an affinity.

11. A method performed by a wireless transmit/receive unit (WTRU), the method comprising:

performing a discovery procedure to discover a plurality of sidelink (SL) reference WTRUs for SL positioning service with a target WTRU;

receiving a status message from each of a plurality of discovered sidelink (SL) reference WTRUs that includes a proximity indication for the respective SL reference WTRU, wherein the proximity indication indicates whether the respective SL reference WTRU is in proximity to the target WTRU;

selecting a SL reference WTRU of the plurality of discovered SL reference WTRUs for the SL positioning service based on the respective proximity indications of the plurality of discovered SL reference WTRUs; and

sending a SL positioning service request to the target WTRU or to the selected SL reference WTRU, wherein the SL positioning service request comprises an indication of the selected SL reference WTRU.

12. The method of claim 11, further comprising sending a status request to the plurality of SL reference WTRUs to request the proximity of the plurality of SL reference WTRUs to the target WTRU.

13. The method of claim 11 or 12, further comprising receiving a SL positioning service response from the selected SL reference WTRU.

14. The method of any of claims 11 to 13, wherein the selected SL reference WTRU is selected based on respective signal qualities associated with the plurality of SL reference WTRUs.

15. The method of claim 14, further comprising measuring link quality of sidelink in which the status messages are transferred to determine the respective signal qualities.

16. The method of any of claims 11 to 15, further comprising sending a proximity status request to a location management function (LMF), wherein the proximity status request comprises the plurality of SL reference WTRUs.

17. The method of any of claims 11 to 16, wherein performing the discovery procedure comprises:

- sending a solicitation request message to discover the target WTRU for a SL positioning service; and

- receiving a solicitation response message from a plurality of SL reference WTRUs; and

- wherein reception of the status message is based on the discovery procedure.

18. The method of claim 17, wherein sending the solicitation request message comprises sending the solicitation to one or more SL reference WTRUs of the plurality of SL reference WTRUs to discover the target WTRU.

19. The method of any of claims 17 or 18, wherein the solicitation request comprises a proximity request for one or more SL reference WTRUs of the plurality of SL reference WTRUs to perform a discovery procedure associated with the target WTRU, wherein the proximity indication for the respective SL reference WTRU is based on the proximity request.

20. The method of any of claims 11 to 19, wherein the status message comprises one or more of:

- an indication that the target WTRU is in proximity, information about one or more other possible target WTRUs that are in proximity, user information of the target WTRU, a layer 2 identification (IDs) of the target WTRU or one or more other proximity service (ProSe) IDs of the target WTRU, a discovery code of the target WTRU, age of time after checking the proximity, or an affinity.

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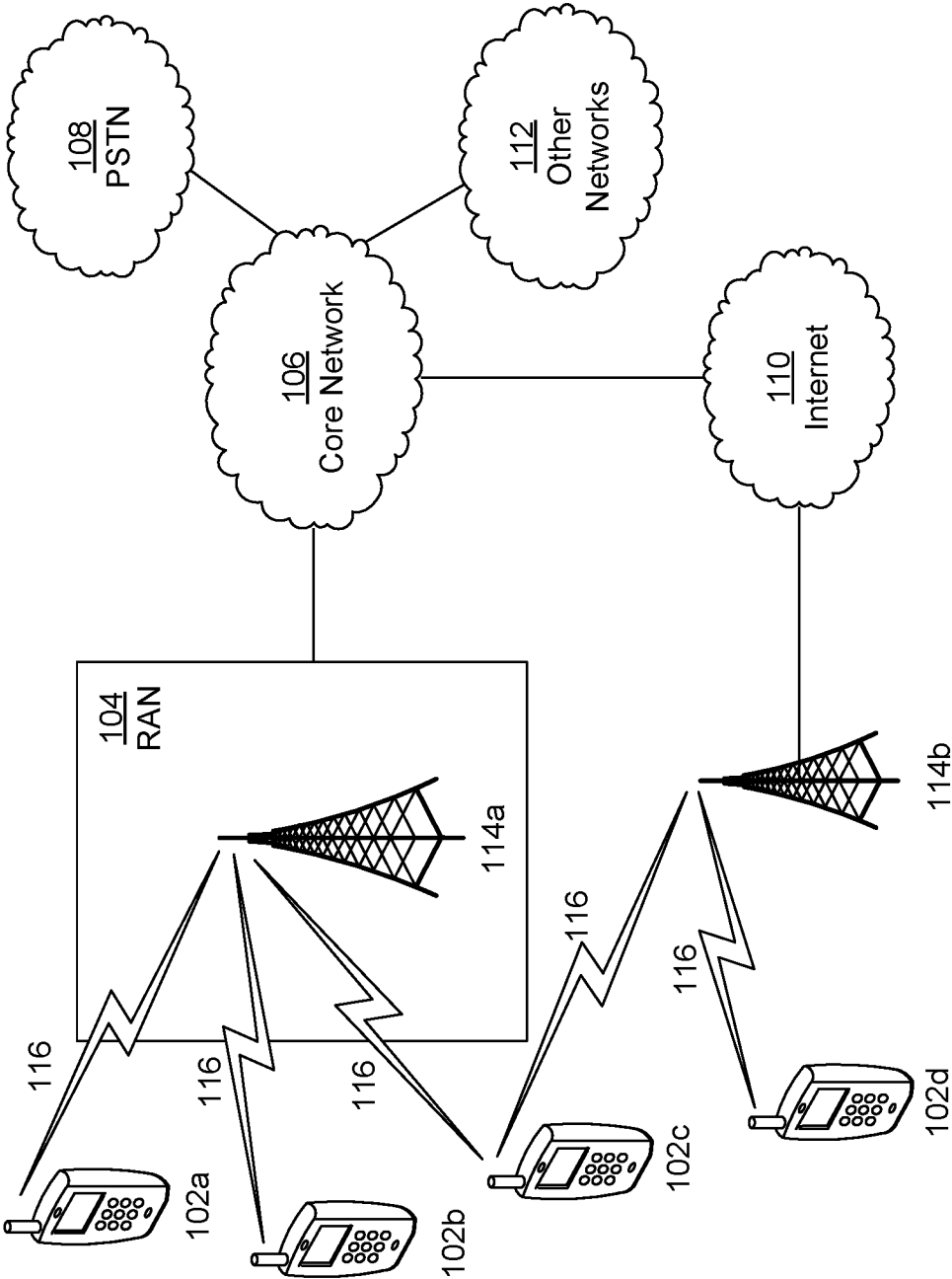


FIG. 1A

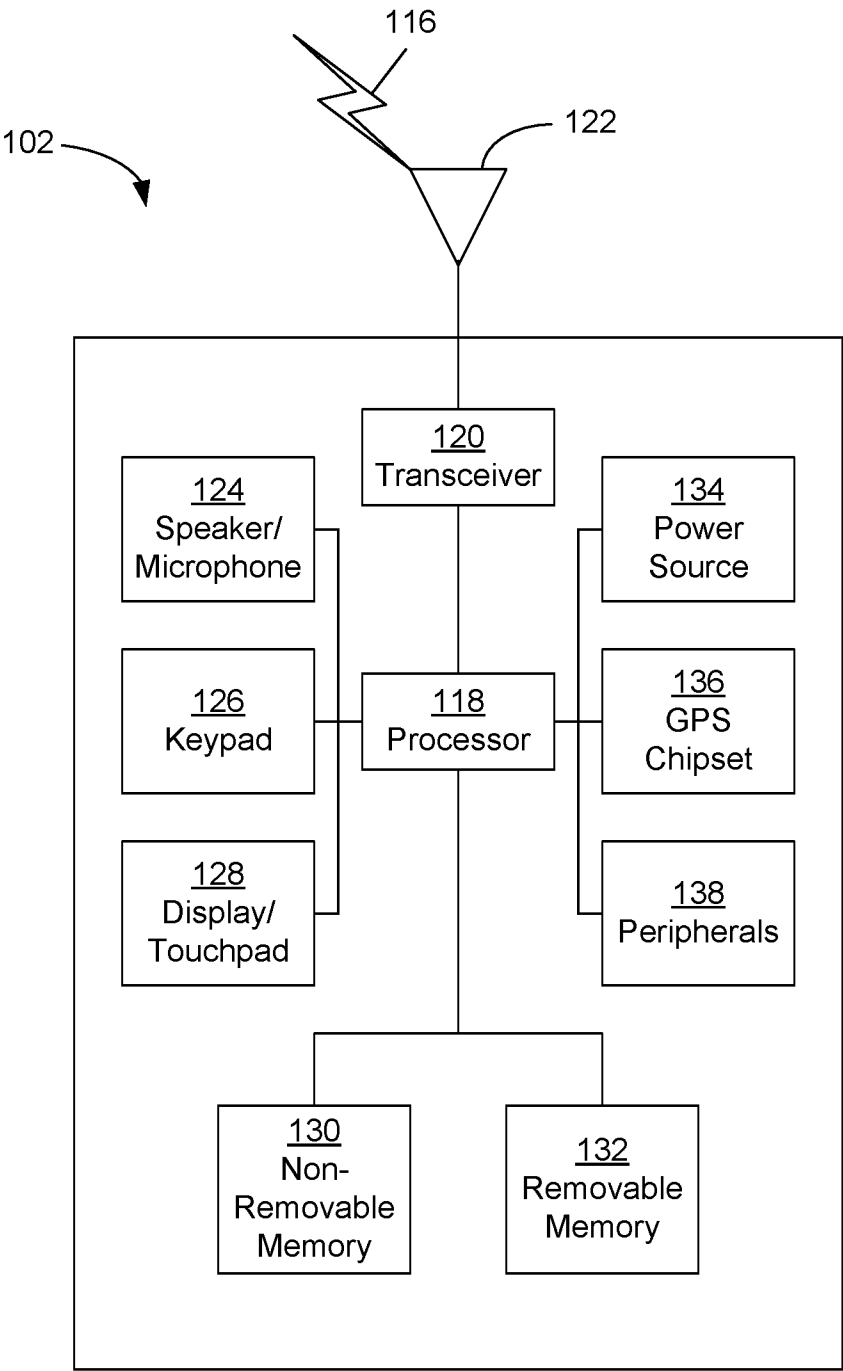


FIG. 1B

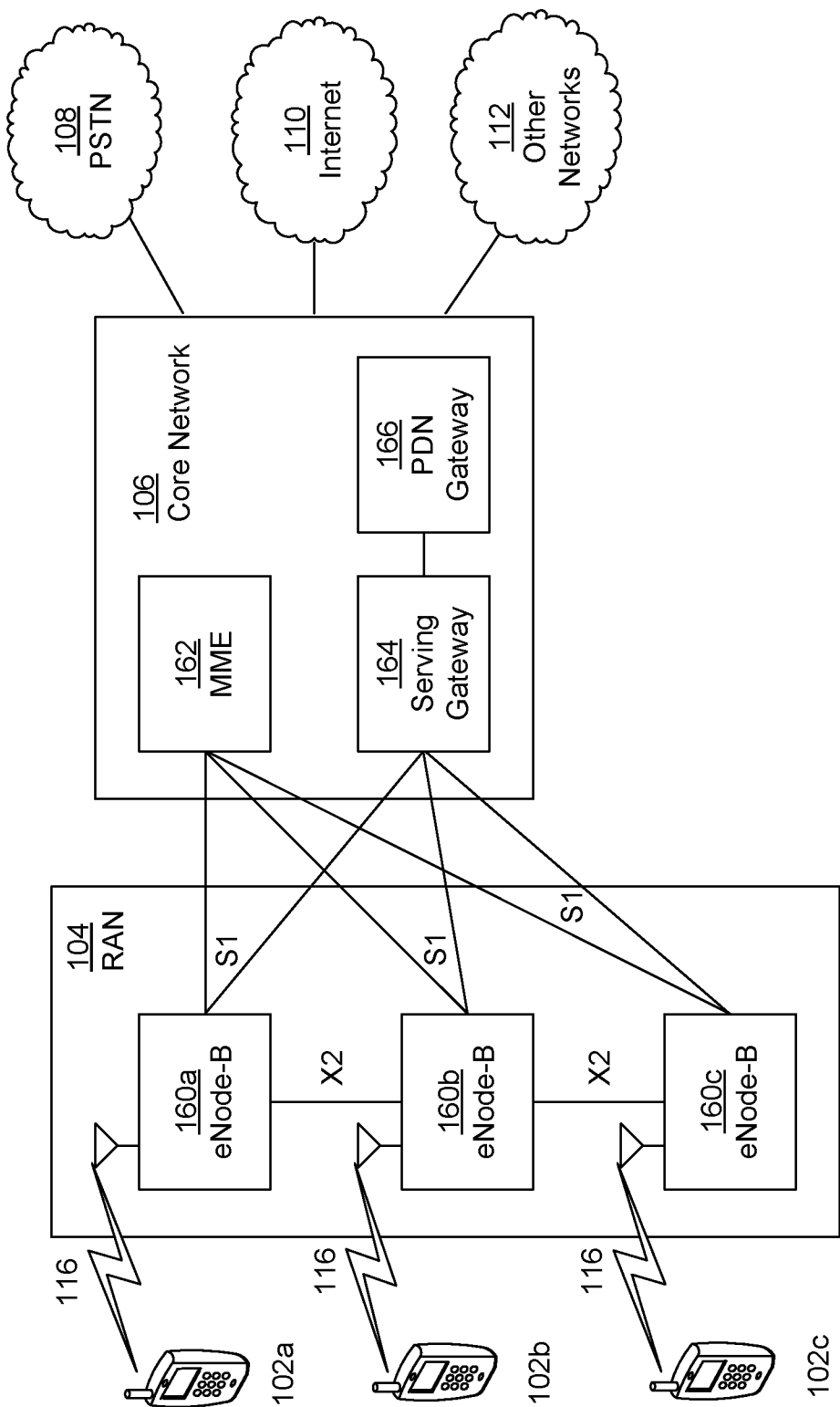


FIG. 1C

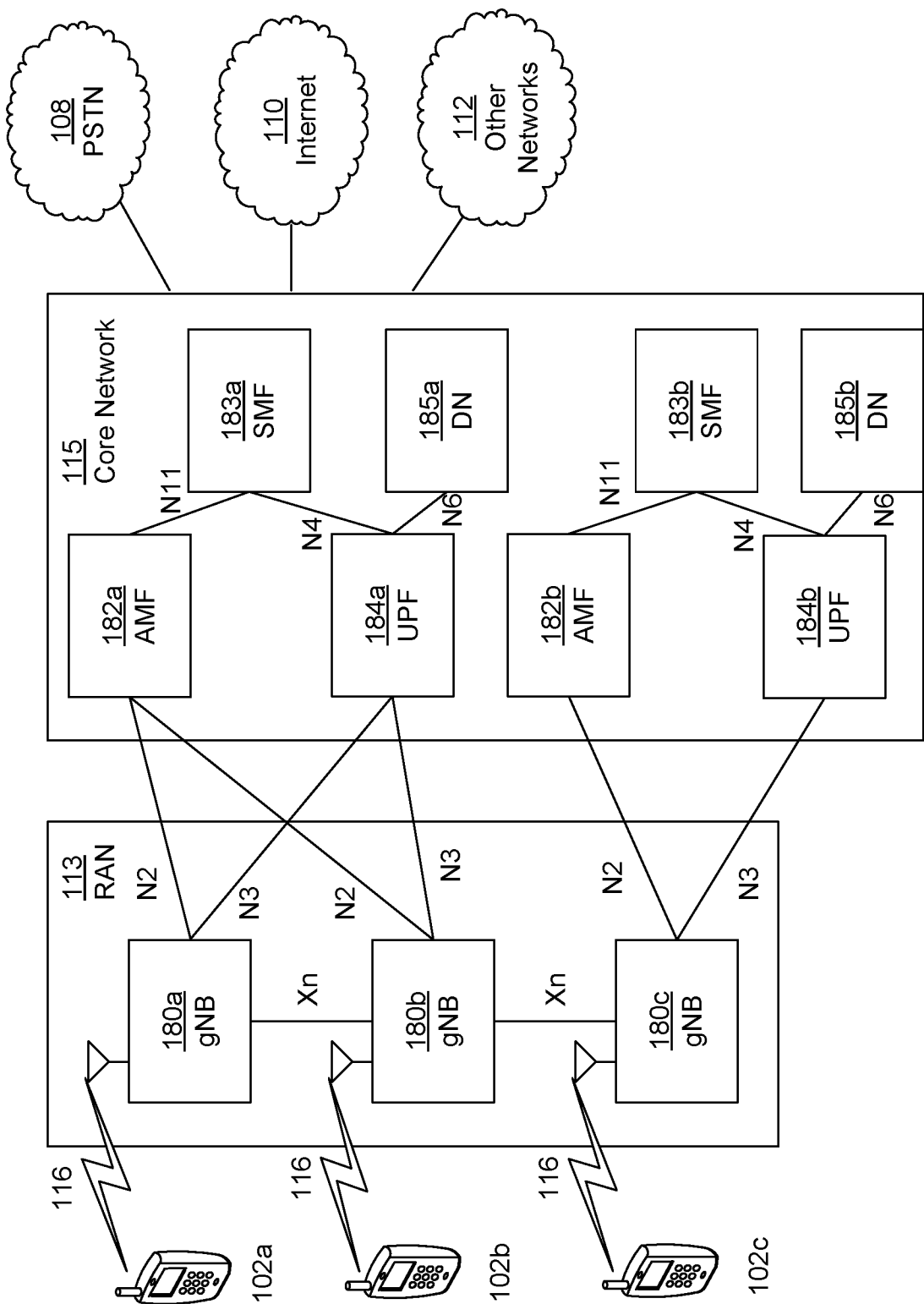


FIG. 1D

200 ↷

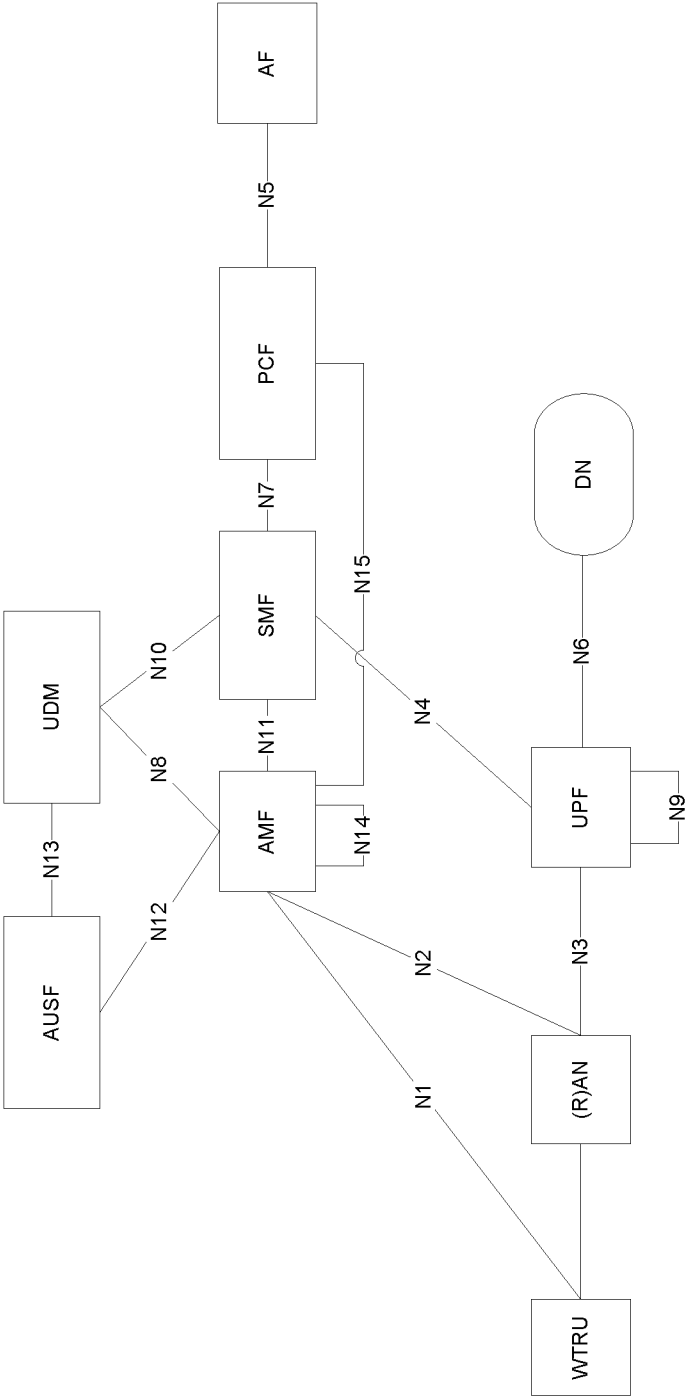


FIG. 2

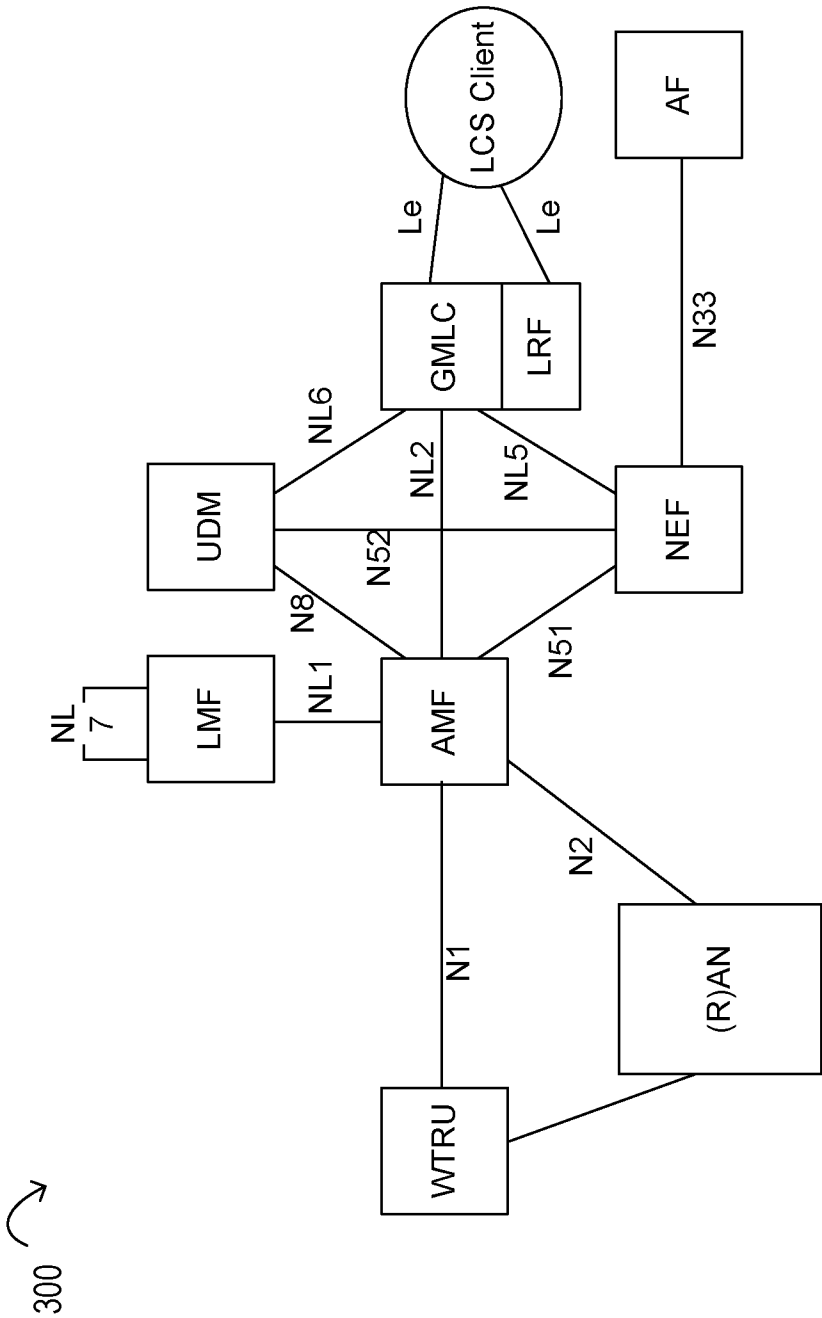
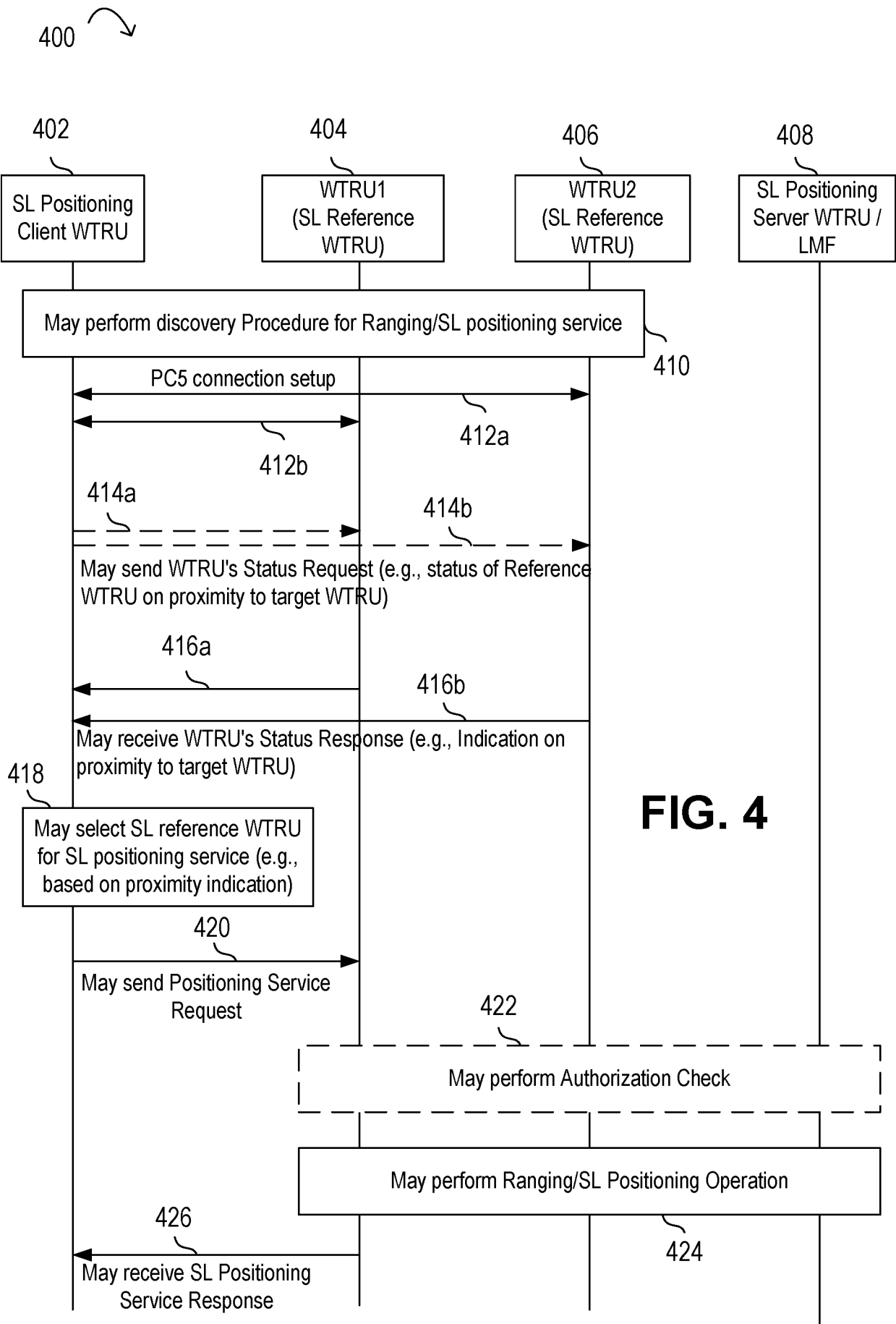


FIG. 3



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/041825

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	G01S5/00	G01S5/02
	H04W4/46	H04W4/40
	H04W64/00	H04W4/44
ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
G01S 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.
Y	WO 2023/062547 A1 (LENOVO SINGAPORE PTE LTD [SG]) 20 April 2023 (2023-04-20) paragraphs [0092] - [0125]; figures 9-15 -----	1-20
Y	WO 2023/048616 A1 (ERICSSON TELEFON AB L M [SE]) 30 March 2023 (2023-03-30) page 4, lines 1-21 page 23, lines 9-11 -----	1-20
Y	WO 2022/272196 A1 (QUALCOMM INC [US]) 29 December 2022 (2022-12-29) paragraphs [0111] - [0118]; figures 9, 10A -----	7-9, 17-19
☐ Further documents are listed in the continuation of Box C.		
☒ See patent family annex.		
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19 November 2024	05/12/2024	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Pariset, Nadia	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2024/041825

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