



(51) International Patent Classification:
H04W 56/00 (2009.01)

(21) International Application Number:
PCT/US2019/045529

(22) International Filing Date:
07 August 2019 (07.08.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/715,664 07 August 2018 (07.08.2018) US

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(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,

(54) Title: METHODS AND APPARATUSES FOR SYNCHRONIZATION IN WIRELESS SYSTEM

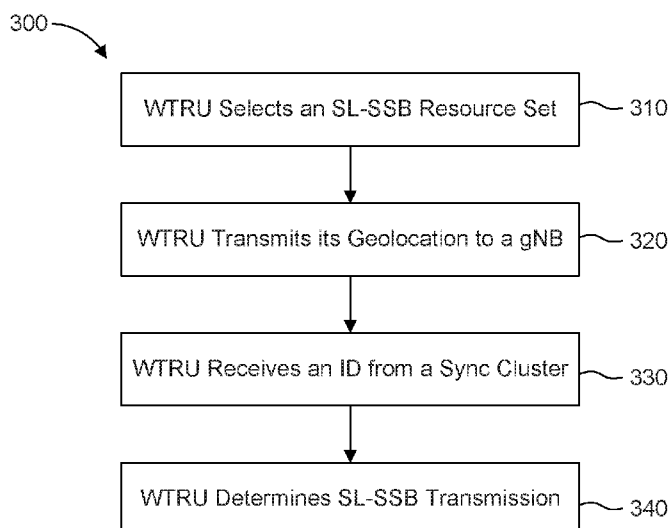


FIG. 3

(57) Abstract: Methods and apparatuses for synchronization in wireless systems includes a wireless transmit/receive unit (WTRU) where the WTRU selects a side-link synchronization signal and physical side-link broadcast channel (SL-SSB) resource-set, based on the the WTRU's properties. Thereafter, the WTRU may transmit its properties, like geolocation, to a base station (gNB). Following this, the WTRU may receive an identification (ID) to be a part of a group of other WTRUs and to be distinguished from other WTRUs in the group by the ID, where the group is created based on similar properties between each WTRU in the group. After this, the WTRU may receive from a gNB, network layer, or other WTRU, a SL-SSB to transmit, based on the WTRU's ID.

SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

METHODS AND APPARATUSES FOR SYNCHRONIZATION IN WIRELESS SYSTEM**CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims the benefit of U.S. Provisional Application No. 62/715,664, filed August 07, 2018, the contents of which are incorporated herein by reference.

BACKGROUND

[0002] In long term evolution (LTE) vehicle-to-everything (V2X) synchronization procedures, prior to transmitting and/or receiving data on a sidelink, a wireless transmit/receive unit (WTRU) needs to be synchronized in time and frequency with other sidelink WTRUs. A WTRU may select a synchronization reference source from which the timing and frequency is derived. Depending on the pre-configuration of the synchronization source priority and the reference signal received power (RSRP) measured from base station reliability, the WTRU may prioritize one synchronization source over another. LTE supports a configuration using a higher layer parameter typeTxSync which indicates the prioritized synchronization for performing V2X sidelink communication on the carrier frequency on which this field is broadcast.

[0003] In 5G new radio (NR), a WTRU may use a synchronization signal block (SS block) to acquire time and frequency synchronization. The SS block may comprise of a primary synchronization signal, a secondary synchronization signal, and physical broadcasting channel (PBCH). In NR, V2X communication is targeting different types of traffic with different characteristics, for example, periodic traffic, aperiodic traffic, small packet size and large packet size. To meet such characteristics, large system bandwidth is needed for V2X transmissions.

[0004] Thus, NR V2X may deploy higher frequency (e.g., above 6Ghz) to benefit from the larger bandwidth. In the high frequency region, the channel is characterized by a high free-space path loss and additional non-line-of-sight losses. To compensate for the losses, synchronization signals may be transmitted in a beamformed manner with beam sweeping. Furthermore, to reduce the synchronization latency, sidelink synchronization signals may be transmitted more frequently in time. In V2X, however, WTRUs may not be available all the time to transmit synchronization signals. Thus, there is a need for sidelink synchronization signals transmitted by WTRUs (e.g., V2X WTRUs) to be available with short periodicity in a given area while at the same time reducing the number of transmissions from the WTRU's perspective.

SUMMARY

[0005] Methods and apparatuses for synchronization in wireless systems are disclosed. The method includes a wireless transmit/receive unit (WTRU) where the WTRU selects a side-link synchronization signal and physical side-link broadcast channel (SL-SSB) resource-set, based on the the WTRU's properties. Thereafter, the WTRU may transmit its properties, like geolocation, to a base station (gNB). Following this, the WTRU may receive an identification (ID) to be a part of a group of other WTRUs and to be distinguished from other WTRUs in the group by the ID, where the group is created based on similar properties between each WTRU in the group. After this, the WTRU may receive from a gNB, network layer, or other WTRU, a SL-SSB to transmit, based on the WTRU's ID.

[0006] The WTRU may also be configured to monitor multiple SL-SSB resource sets for different communication types. Additionally, the WTRU may initiate and control a WTRU group by notifying other WTRUs to start or stop transmitting the same SL-SSB. Moreover, the WTRU may be configured to automatically determine SL-SSB transmission opportunities by selection options such as unused transmission opportunities or periodic reselection of time opportunities. Furthermore, the WTRU may be configured to determine if another WTRU should switch WTRU groups based on the other WTRU's properties and notify the other WTRU to switch WTRU groups if so. Finally, the WTRU may be configured with multiple synchronization sources, where each synchronization source is configured with priority.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings, wherein like reference numerals in the figures indicate like elements, and wherein:

[0008] FIG. 1A is a system diagram illustrating an example communications system in which one or more disclosed embodiments may be implemented;

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

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

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

[0012] FIG. 2 is a diagram illustrating an example WTRU synchronization framework in new radio;

[0013] FIG. 3 is a diagram illustrating an example procedure for a WTRU to join a group of other WTRUs assigned to transmit the same synchronization signal and physical sidelink broadcast channel (SL-SSB);

[0014] FIG. 4 is a diagram illustrating an example procedure for a WTRU to lead a group of other WTRUs assigned to transmit the same SL-SSB;

[0015] FIG. 5 is a diagram illustrating an example repetition of an SL-SSB block that occurs every k slot/subframe;

[0016] FIG. 6 a diagram illustrating an example network coordinating SL-SSB transmission where multiple WTRUs are configured to transmit the same SL-SSB in different time or frequency opportunities; and

[0017] FIG. 7 is a diagram illustrating an example inter-cluster coordination between synchronization clusters.

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 discrete Fourier transform Spread OFDM (ZT-UW-DFT-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 radio access network (RAN) 104, a core network (CN) 106, 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 (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 UE.

[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, 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 NodeB, an eNode B (eNB), a Home Node B, a Home eNode B, a next generation NodeB, such as a gNode B (gNB), a new radio (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, 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, and the like. 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 and the WTRUs 102a, 102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 116 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink (DL) Packet Access (HSDPA) and/or High-Speed Uplink (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 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., an 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.

[0029] The RAN 104 may be in communication with the CN 106, 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 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 and/or the CN 106 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104 or a different RAT. For example, in addition to being connected to the RAN 104, which may be utilizing a NR radio technology, the CN 106 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 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 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), 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, a humidity sensor and the like.

[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 DL (e.g., for reception) may be concurrent and/or simultaneous. The full duplex radio may include an interference management unit to reduce and or substantially eliminate self-interference via either hardware (e.g., a choke) or signal processing via a processor (e.g., a separate processor (not shown) or via processor 118). In an embodiment, the WTRU 102 may include a half-duplex radio for which transmission and reception of some or all of the signals (e.g., associated with particular subframes for either the UL (e.g., for transmission) or the DL (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 (PGW) 166. While 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 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. 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 (MTC), such as MTC devices in a macro coverage area. MTC devices may have certain capabilities, for example, limited capabilities including support for (e.g., only support for) certain and/or limited bandwidths. The MTC devices may include a battery with a battery life above a threshold (e.g., to maintain a very long battery life).

[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, all available frequency bands may be considered busy even though a majority of the available frequency bands remains idle.

[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 104 and the CN 106 according to an embodiment. As noted above, the RAN 104 may employ an NR 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.

[0060] The RAN 104 may include gNBs 180a, 180b, 180c, though it will be appreciated that the RAN 104 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 a 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, DC, 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 106 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 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.

[0065] The AMF 182a, 182b may be connected to one or more of the gNBs 180a, 180b, 180c in the RAN 104 via an N2 interface and may serve as a control node. For example, the AMF 182a, 182b may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, support for network slicing (e.g., handling of different protocol data unit (PDU) sessions with different requirements), selecting a particular SMF 183a, 183b, management of the registration area, termination of non-access stratum (NAS) signaling, mobility management, and the like. Network slicing may be used by the AMF 182a, 182b 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 MTC access, and the like. The AMF 182a, 182b may provide a control plane function for switching between the RAN 104 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 106 via an N11 interface. The SMF 183a, 183b may also be connected to a UPF 184a, 184b in the CN 106 via an N4 interface. The SMF 183a, 183b may select and control the UPF 184a, 184b and configure the routing of traffic through the UPF 184a, 184b. The SMF 183a, 183b may perform other functions, such as managing and allocating UE IP address, managing PDU sessions, controlling policy enforcement and QoS, providing DL 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 104 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 DL packets, providing mobility anchoring, and the like.

[0068] The CN 106 may facilitate communications with other networks. 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. In one embodiment, the WTRUs 102a, 102b, 102c may be connected to a local 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 FIGs. 1A-1D, and the corresponding description of FIGs. 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-b, 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 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] In long term evolution (LTE) vehicle-to-everything (V2X) synchronization procedure, prior to receiving and/or transmitting data on a sidelink, a WTRU may need to be synchronized in time and frequency with other sidelink WTRUs. At first, the WTRU may select a synchronization reference source from which the timing and frequency can be derived. There are three synchronization sources types in LTE V2X.

[0073] The first synchronization source type is an eNB where sidelink timing is derived from primary synchronization signal (PSS)/secondary synchronization signal (SSS) transmitted by an eNB base station. The second synchronization sources type is a global navigation satellite system (GNSS) where sidelink timing is derived from the GNSS. The third synchronization source type is a sync reference WTRU where sidelink timing is derived from sidelink synchronization signals (SLSS) transmitted by the synchronization reference WTRU.

[0074] Depending on the pre-configuration of the synchronization source priority and the reference signal received power (RSRP) measured from the eNB and GNSS reliability, the WTRU may prioritize one synchronization source over another synchronization source. LTE supports a configuration using RRC signaling (e.g., typeTxSync) which indicates the prioritized synchronization type (i.e. eNB or GNSS) for performing V2X sidelink communication on the carrier frequency on which this field is broadcasted.

[0075] Furthermore, the network may configure or preconfigure a WTRU to SLSS to extend the coverage of synchronization signals. A WTRU, in out-of-coverage, may also transmit SLSS in some scenarios. For example, an out-of-coverage WTRU that is closer to an in-coverage WTRU transmitting the SLSS may start transmitting the SLSS. In LTE, SLSS may be transmitted along with side link master information block (SL-MIB) with a periodicity of 160ms as an example. The SL-MIB may include SL-bandwidth, time division duplex (TDD) configuration, direct frame number (DFN), direct sub-frame number and an indication of whether the WTRU transmitting the SL-MIB is in coverage or out-of-coverage of E-UTRAN. The network may pre-configure up to three subframes to be used by different WTRUs for SLSS/SL-MIB transmission. DFN and a direct subframe number value in the SL-MIB may indicate the frame number and subframe number in which SLSS/SL-MIB are transmitted.

[0076] In new radio (NR), a WTRU may use a synchronization signal (SS) block (or SSB) to acquire time and frequency synchronization. SS block may comprise a primary synchronization signal (PSS), secondary synchronization signal (SSS) and physical sidelink broadcasting channel (PBCH). Multiple SS blocks can be transmitted, for example, in a half frame and may be indexed in an ascending order in time.

[0077] Furthermore, multiple SS blocks may be transmitted in the frequency domain and the frequency location of an SS block within a carrier may not be fixed. During initial access, while searching for an SS block, a WTRU assumes an SS Block periodicity of 5 ms (half a frame). A WTRU, after reading the MIB and determining initial bandwidth part (BWP), may be configured to use higher layer signaling with different SSB periodicity. Beam sweeping can be used by the network to transmit an SS block in different directions and a WTRU may select the suitable SSB and perform beam paring.

[0078] The 3rd Generation Partnership Project (3GPP) has established that there may be two frequency ranges on which NR can operate. The first is frequency range 1 (FR1), which operates at a frequency between 450 MHz – 6000 MHz. The second is frequency range 2 (FR2), which operates at a frequency between 24250 MHz – 52600 MHz. FR2 is characterized by high free

space path loss. Beam based transmission may be used to mitigate the channel losses and increase the reliability of transmission. To cover multiple directions, multiple beams and beam sweeping may be used. To ensure that multiple SSBs are available for WTRUs initially searching for the cell, up to 64 SS blocks may be transmitted, for example, in a half-frame.

[0079] Generally, NR V2X may be used for different types of traffic with different characteristics (e.g., periodic traffic, aperiodic traffic, small packet size, and large packet size). For example, a traffic model may include an inter-packet arrival time of 30 ms with a size in the range between 30000 bytes and 60000 bytes. To meet such high traffic intensity, a large system bandwidth may be needed for V2X transmissions. Thus, it is expected that NR V2X will be deployed in higher frequencies above 6Ghz as stated in NR Rel-15 to benefit from the larger bandwidth. In high frequency region, the channel is characterized by a high free space path loss and additional non-line-of-sight losses.

[0080] To compensate for the losses, synchronization signals should be transmitted in a beamformed manner with beam sweeping. Furthermore, to reduce the synchronization latency, sidelink synchronization signals may be transmitted more frequently in time (e.g., as in NR, half frame periodicity is assumed by the WTRU during initial access). The WTRU may not always be available to transmit synchronization signals (e.g., a WTRU may be receiving/transmitting in Uu interface and also receiving from other WTRUs in sidelink, or a WTRU may be moving to another area). Thus, sidelink synchronization signals transmitted by V2X WTRUs may need to be available with short periodicity in a given area while at the same time reducing the transmissions from WTRU perspective.

[0081] FIG. 2 is an example synchronization framework in NR. As illustrated in FIG. 2, WTRU_N 210 and WTRU₁ 220 are in-coverage of gNB 200. Both WTRU_N 210 and WTRU₁ 220 may transmit via SLSS/SL-MIB and may utilize beam sweeping and transmit in the time opportunities as shown in frame 260 where WTRU_N 210 and WTRU₁ 220 may acquire certain network time and frequency synchronizations.

[0082] For matter of consistency and clarification, sidelink primary synchronization signal, sidelink secondary signal and physical sidelink broadcast channel (PSBCH) may be referred to as sidelink synchronization signals and PSBCH (SL-SSB).

[0083] FIG. 3 is a diagram illustrating an example procedure for a WTRU to join a group of other WTRUs assigned to transmit the same SL-SSB through process 300.

[0084] As illustrated in FIG. 3, to create such a WTRU group, process 300 shows that a WTRU may select a particular SL-SSB resource set at 310. After that, the WTRU may transmit its geolocation information to a base station (gNB) at 320. Following that, a WTRU may receive a particular identification (ID) from a sync cluster, where a sync cluster may be multiple WTRUs in the same group, transmitting the same SL-SSB, at 330. Finally, the WTRU may determine its SL-SSB possibly based on its ID within the group, or other relevant factors or properties, at 340.

[0085] FIG. 4 is a diagram illustrating an example procedure for a WTRU to lead a group of other WTRUs assigned to transmit the same SL-SSB through process 400. As illustrated in FIG. 4, a WTRU may be assigned as a sync cluster leader or an inter-cluster coordinator, at 410. After that, the WTRU may instruct other WTRUs to join a sync cluster or switch sync clusters, at 420. Finally, the WTRU, once forming a WTRU group, may instruct other WTRUs in the group to perform SL-SSB transmission with certain parameters (e.g., time and frequency), at 430.

[0086] In an embodiment, a WTRU may determine NR SLSS/SL-MIB resources. Such embodiment is described as follows.

[0087] An SL-SSB may be defined, configured, or preconfigured based on any one of a combination of the following parameter so: a bandwidth part (BWP) on which SL-SSB is transmitted/received; a slot/subframe number on which SL-SSB is transmitted or received; a sequence that is used to generate primary or secondary SLSS; a demodulation reference signal (DMRS) sequence that is used for PSBCH; a symbol index within a slot/subframe on which SL-SSB is transmitted/received; a subcarrier spacing of the SL-SSB; a periodicity and offset of the SL-SSB; the periodicity and the offset of the SL-SSB; a number of SL-SSB repetitions, (i.e., an SL-SSB may be repeated over time by multiple WTRUs or the same WTRU and the repetition of SL-SSB may occur every k slot/subframe where k can be preconfigured or fixed on the specification); and a priority associated with SL-SSB. For example, a WTRU may prioritize the transmission of a SL-SBB with high priority over the transmission of a SL-SBB with lower priority. In another example, a WTRU may prioritize decoding a SL-SBB with high priority.

[0088] Accordingly, multiple SL-SSBs may be grouped into a SL-SSB resource set. Each SL-SSB resource set can have one or more SL-SSBs and the SL-SSB resource set may be identified by an identifier (ID) as well as the SL-SSB within the SL-SSB resource set. An SL-SSB resource set may be configurable from the network or fixed (e.g., in the specification). An SL-SSB within an SL-SSB resource set may have some common parameters. For example, all SL-SSBs within an SL-SSB resource set may have the same subcarrier spacing or the same periodicity the same DMRS sequence, as the case may be.

[0089] A WTRU may associate itself with an SL-SSB resource set by one, or a combination of, the following possibilities.

[0090] A WTRU may be configured with one or more SL-SSB resource set(s) using higher layer signaling. The higher layer configuration may be dedicated to the WTRU or received via common signaling (e.g., received in the system information block (SIB) transmission, or can be preconfigured to the WTRU).

[0091] A WTRU may be configured to determine a SL-SSB resource set to monitor or transmit based on geolocation information. For example, a WTRU may be preconfigured with multiple SL-SSB resource sets and determine a set of synchronization signals to monitor/transmit based on its geolocation.

[0092] A WTRU may be configured to determine an SL-SSB resource set based on the type of service that is configured or used for the WTRU. For example, each SL-SSB resource set may be associated with a type of service (e.g., URLLC). Such association may be pre-configured, semi-statically configured or dynamically configured or indicated by the network. The dynamic configuration or indication may be determined based on the active BWP.

[0093] A WTRU may determine an SL-SSB resource set based on frequency range of V2X carrier frequency that is being used. For example, carrier frequencies belonging to FR2 may be configured with a different SL-SSB resource set(s) than frequencies of FR1.

[0094] A WTRU may determine an SL-SSB resource set based on a WTRU ID and/or group ID. For example, a WTRU may be configured with a group ID or unique ID within a group of WTRUs. The group ID and/or WTRU ID may be associated with the SL-SSB resource set.

[0095] Further, concerning SL-SSB resource sets, in another embodiment, a WTRU may monitor multiple SL-SSB resource sets for different communication types. Here, a WTRU may be configured to monitor multiple SL-SSB resource sets for different communication types such as unicast, multicast, and broadcast. For example, a WTRU may establish a unicast or multicast link and may monitor a different SL-SSB resource set for that unicast/multicast link compared to other broadcast traffic. A WTRU may further monitor a different SL-SSB resource set for each unicast/multicast link.

[0096] Also concerning SL-SSB resource sets, in another embodiment, a group of WTRUs may transmit the same SL-SSB. Specifically, a group of WTRUs may be configured to transmit the same SL-SSB. Each WTRU within the group may transmit the same SL SSB in a different time opportunity.

[0097] For example, an SL-SSB may be configured to transmit with periodicity of X ms and k repetition within the period of X ms, as illustrated in FIG. 5. The k WTRUs within the group may be selected by the network, by the upper layers (e.g. NAS layer or ProSe layer) or by another WTRU to transmit the SL-SSB within the resources configured for k repetition. The group of WTRUs that is transmitting the same SL-SSB may be interchangeably referred to as a sync cluster

[0098] FIG. 5 illustrates, through embodiment 500, an example repetition of a SL-SSB block 510 that occurs every k slot/subframe. As illustrated in FIG. 5, each k repetition of SL-SSB 520 represents a period which a WTRU may transmit on SL-SSB block 510 throughout a time period 530.

[0099] Also concerning SL-SSB resource sets, in another embodiment, some WTRUs in a sync cluster may be configured to transmit in the same transmission opportunity and may use a different beam to cover a different spatial area of the sync cluster. A WTRU may determine its transmission beam within one transmission opportunity based on at least one of, or a combination of, the following methods.

[0100] A WTRU may determine its transmission beam based on its ID within a group, which may be setup by a group leader or an application layer. A WTRU may determine its transmission beam based on its location such as a lane ID, a zone ID, or the like. A WTRU may also determine its transmission beam based on its beam transmission direction such as in backward or forward direction. It is also possible that a WTRU may determine its transmission beam using some combination of the above.

[0101] A WTRU may configure multiple WTRUs within the group to transmit in the same transmission opportunity or the same beam direction. A WTRU receiving a SL-SSB may assume that these transmissions have the same SL-SSB information and may perform receiver combining such as maximum ratio combining, selection combining, or the like to improve the detection probability of the SL-SSB.

[0102] In an embodiment, a network may coordinate SL-SSB transmission. In such an embodiment, one or multiple WTRUs may be configured by the network (e.g., a gNB) or from upper layers to transmit an SL-SSB in one transmission opportunity from configured transmission repetitions of a SL-SSB. In order to perform a network coordinating SL-SSB transmission, a WTRU may provide a gNB with its geolocation information, and the network may then assign different time opportunities for different WTRUs to ensure the availability of synchronization signals while reducing the power consumption of WTRUs at the same time. Each WTRU may perform beam

sweeping of a SL-SSB in one transmission opportunity. Alternatively or additionally, a WTRU may change its beam from one period to another period. For example, an SL-SSB may be configured with a periodicity of 10 ms, with three repetitions in time domain.

[0103] FIG. 6 is a diagram illustrating an example network coordinating SL-SSB transmissions where multiple WTRUs are configured to transmit the same SL-SSB in different time or frequency opportunities through embodiment 600. As illustrated in FIG. 6, WTRU1, WTRU2 and WTRU3 are in proximity of each other and are assigned to sync cluster 620, and are also configured to transmit the same SL-SSB but in different time opportunities. Additionally, all WTRUs are in-network with gNB 610. SL-SSB block 630 shows that each WTRU associated with sync cluster 620 may be assigned a different k repetition SL-SSB and may engage in beam sweeping.

[0104] A WTRU may receive one or more indications to start SL-SSB transmission from either the network, from upper layers, or from another WTRU (depending on the case). Examples of such indications may include, but are not limited to, one of the following: an indication of an SL-SSB index within an SL-SSB resource set; a bitmap indicating time opportunities (e.g., indicating slot/subframe index); an offset from the first transmission opportunity of the SL-SSB; an ID within a sync cluster; a BWP switching command; and a WTRU autonomous BWP switch.

[0105] In the case of the ID within a sync cluster received as the indication, the WTRU may derive the transmission opportunity from the configured ID. Alternatively or additionally, the WTRU may derive its ID within the sync cluster based on another ID such as a WTRU's own ID, a unicast or temporary group ID, or the like.

[0106] In the case of the BWP switching command received as the indication, given that NR supports WTRU specific uplink bandwidth part (UL BWP) configuration, sidelink bandwidth part (SL-BWP) may also be WTRU specific since SL-BWP may be in the UL-BWP. To ensure that the location of SL-SSB is fixed in a frequency domain, an SL-BWP may be configured/pre-configured to a WTRU for sidelink synchronization transmission/reception. A WTRU upon receiving SL-BWP switching command to that BWP, may start transmitting the SL-SSB. The BWP switch command may be received from the network or from another WTRU.

[0107] In the case of the WTRU autonomous BWP switch command received as the indication to start SL-SSB transmission, a WTRU may start SL-SSB transmission whenever it decides to switch BWP on its own.

[0108] In an embodiment, WTRUs may autonomously coordinate SL-SSB transmission. In such embodiment, a WTRU may be configured to initiate a sync cluster. For example, a WTRU may be

configured/pre-configured with RSRP threshold to initiate a sync cluster. In this example, the WTRU measures the RSRP from the gNB, and if the RSRP is below the configured threshold, the WTRU may start transmitting the SL-SSB. Moreover, the WTRU may be configured to search for an SL-SSB(s) from a preconfigured/configured SL-SSB resource set(s). If the WTRU cannot receive an SL-SSB with a received power (e.g., RSRP) above a configured threshold, the WTRU may start transmitting an SL-SSB from a SL-SSB resource set(s). A WTRU may select an SL-SSB from an SL-SSB resource set(s) based on the synchronization source type that is used to derive the time/frequency.

[0109] In another embodiment of autonomous SL-SSB transmission coordination, a WTRU may randomly select the time opportunity (i.e. repetition time for the SL-SSB transmission). In another embodiment, a WTRU may start transmitting on the first transmission opportunity configured for the SL-SSB.

[0110] Additionally, a WTRU may be configured to request other WTRUs to transmit the same SL-SSB. The WTRU may transmit such request on the physical sidelink broadcasting channel (PSBCH) associated with the SL-SSB. The request may include the number of WTRUs required for the SL-SSB transmission. Alternatively or additionally, the required number of WTRUs can be derived from the SL-SSB ID.

[0111] In an additional embodiment of autonomous SL-SSB transmission coordination, a WTRU may be configured to join a sync cluster. The WTRU may be pre-configured/configured with one SL-SSB resource set to be monitored or may autonomously select one SL-SSB resource set. The WTRU may be configured to search for all SL-SSBs within the SL-SSB resource set. The WTRU may select an SL-SSB if the WTRU's sidelink-reference signal received power (S-RSRP) to all sync cluster WTRUs is above a configured threshold T_{min} . A minimum S-RSRP threshold may be configured to ensure that all sync cluster members are close to each other and thus can act as one synchronization source.

[0112] Alternatively or additionally, the WTRU may select a SL-SSB if the WTRU's S-RSRP to all sync cluster WTRUs is below a configured threshold T_{max} . A maximum S-RSRP threshold may be configured to ensure that the SL-SSB transmitted by a sync cluster has good coverage. Alternatively or additionally, the WTRU may select an SL-SSB if SL-SSB priority is greater or equal than SL-SSB priority of the WTRU synchronization source.

[0113] In another embodiment of autonomous SL-SSB transmission coordination, multicast WTRUs may form a sync cluster. As such, a WTRU configured with group cast communication may

be configured to use the multicast link to coordinate SL-SSB transmission. For example, a WTRU upon joining a multicast group may receive an indication of SL-SSB used by group members. A WTRU may receive from another WTRU member of the group, a sync cluster lead, request to start transmitting SL-SSB on specific time opportunities for a configured period. Alternatively or additionally, a WTRU may autonomously determine the time opportunities for SL-SSB transmission. For example, a WTRU may select unused transmission opportunities from WTRUs that are members of the group. Alternatively or additionally, a WTRU may determine the time opportunities for SL-SSB transmission from the WTRU ID within the group assigned to the WTRU (e.g., potentially by the leader of the group, or from the upper layers).

[0114] A WTRU may be configured to periodically select/reselect the time opportunities that the SL-SSB needs to be transmitted on. The WTRU may determine the selection/reselection time based on information bits included in an SL-MIB transmitted by a sync cluster. For example, an SL-MIB may indicate a subframe and/or DFN for SL-SSB time-resource selection/reselection. Alternatively or additionally, selection/reselection time may be fixed, for example, by the specification or configured or pre-configured.

[0115] In one embodiment concerning multicast WTRUs which may form a sync cluster, a WTRU may be configured to transmit an SL-SSB after joining a platoon. The SL-SSB time and frequency resources to be used by platoon members may be specific to the platoon. For example, the SL-SSB resource may be derived from a resource pool used by platoon members to exchange group cast messages.

[0116] As such, a platoon leader WTRU may be configured to act as sync cluster coordinator. Alternatively or additionally, a WTRU member of a platoon with high RSRP from the gNB may act as a sync cluster coordinator. The sync cluster coordinator may configure the time and frequency resources for the SL-SSB transmission for WTRUs transmitting SL-SSBs within the platoon. The sync cluster coordinator may instruct a WTRU within the platoon to stop transmitting a SL-SSB. The WTRU may be configured to stop transmitting an SL-SSB after leaving the platoon.

[0117] In an additional embodiment of autonomous SL-SSB transmission coordination, a WTRU may be involved in inter-cluster coordination. In such embodiment, the WTRU may be configured as a sync cluster coordinator. The WTRU may receive such configuration from the network or may autonomously act as sync cluster coordinator. The sync cluster coordinator may search for other SL-SSBs from a configured SL-SSB resource set. The WTRU may indicate to sync cluster members to adjust the timing and/or frequency. For example, a WTRU upon detecting an SL-

SSB from other sync clusters with timing offset which is above a configured threshold, may indicate to the sync cluster members to adjust timing and/or frequency.

[0118] Additionally, a WTRU may be configured to join another sync cluster (i.e. select/reselect the sync cluster). A WTRU may receive an indication from another WTRU to select/reselect the sync cluster or may autonomously determine to reselect another sync cluster. For example, a WTRU may be configured to select/reselect another sync cluster when the priority of a detected sync cluster is higher than current sync cluster where a WTRU is a member of. Alternatively or additionally, the WTRU may be configured to select/reselect another sync cluster when the sidelink RSRP of the SL-SSB measured from a detected sync cluster member is above a configured threshold. For example, a WTRU may be configured to select/reselect a sync cluster if the sidelink RSRP to N WTRUs belonging to the same sync cluster is above a configured threshold.

[0119] FIG. 7 is a diagram illustrating an example inter-cluster coordination between synchronization clusters shown through embodiment 700. As illustrated in FIG. 7, a WTRU may be a sync cluster coordinator and may perform inter-cluster coordination activity 760. As shown in FIG. 7, through coordination activity 760, a WTRU may be instructed by a sync cluster coordinator to either join sync cluster 1 or sync cluster 2 to share the same SL-SSB within that group. A changing of sync clusters may be based on the properties of SS blocks 710 and 720. In this case, a sync cluster coordinator may determine that another sync cluster is more suited for a WTRU to transmit in, than the current sync cluster that WTRU is assigned to. The suitability of a sync cluster may depend on conditions and parameters described throughout the application and may include for example, priority of another sync cluster, compared to the current sync cluster.

[0120] A WTRU may be configured with multiple synchronization sources, and each source may be configured with priority. The priority configuration of synchronization source can be preconfigured or semi-statically configured using SIB/SL- MIB or dynamically configured/preconfigured. The WTRU may select one synchronization source based on its priority. A WTRU may be configured with the following synchronization source: NR cell, different RAT cell, GNSS, sync cluster, NR V2X WTRU, or LTE V2X WTRU. In a case where the NR cell is selected as the synchronization source, a WTRU may select its serving cell as synchronization source. In a case where the different cell is selected as the synchronization source, a NR V2X WTRU may be configured with LTE eNB as a synchronization source.

[0121] A WTRU may be configured to select a synchronization based on the type of synchronization source. For example, a WTRU may be configured to prioritize a sync cluster

over a single WTRU transmitting synchronization. In another example, a WTRU may prioritize a sync cluster over a single WTRU when the WTRU has one or more unicast/multicast links established. Otherwise, it may use other selection criteria (e.g. RSRP). Such prioritization may further be valid as long as the sync cluster's sync RSRP is above a threshold. In another example, a WTRU may be configured to prioritize a NR WTRU transmitting synchronization over a LTE WTRU transmitting synchronization.

[0122] In one embodiment, WTRU members of a platoon may select the same synchronization source. Platoon members may exchange their synchronization source and select one synchronization source based on at least two ways. First, they may prioritize a WTRU within the platoon which is deriving its synchronization from a gNB. And second, they may prioritize a WTRU within the platoon which is deriving its synchronization from GNSS.

[0123] Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

* * *

CLAIMS

What is Claimed is:

1. A method for use in a wireless transmit/receive unit (WTRU), the method comprising:
 - selecting, a side-link synchronization signal and physical side-link broadcast channel (SL-SSB) resource-set, based on WTRU specific parameters that include information related to the geolocation of the WTRU;
 - transmitting, the WTRU specific parameters, to a base station (gNB);
 - receiving, an identification (ID) for the WTRU to be a part of a group of other WTRUs and to be distinguished from the other WTRUs in the group, where the group is created based on the WTRU specific parameters; and
 - receiving, from a gNB, network layer, or other WTRU, a SL-SSB to transmit, based on the ID.
2. The method of claim 1, wherein the WTRU is configured to monitor multiple SL-SSB resource sets for different communication types.
3. The method of claim 1, wherein the WTRU is configured to initiate and control the group of other WTRUs by notifying the group of other WTRUs to start or stop transmitting the same SL-SSB.
4. The method of claim 1, wherein the WTRU is configured to automatically determine SL-SSB transmission opportunities by selection options such as unused transmission opportunities or periodic reselection of time opportunities.
5. The method of claim 1, wherein the WTRU is configured to determine whether another WTRU should switch WTRU groups and to notify the other WTRU to switch WTRU groups.
6. The method of claim 1, wherein the WTRU is configured with multiple synchronization sources, where each synchronization source is configured with priority.
7. A wireless transmit/receive unit (WTRU) configured to perform side-link communications, the WTRU comprising:
 - a processor configured to select a side-link synchronization signal and physical side-link broadcast channel (SL-SSB) resource-set, based on WTRU specific parameters that include information related to the geolocation of the WTRU;
 - a transmitter configured to transmit the WTRU specific parameters, to a base station (gNB);

a receiver configured to receive an identification (ID) for the WTRU to be a part of a group of other WTRUs and to be distinguished from the other WTRUs in the group, where the group is created based on the WTRU specific parameters; and

the receiver further configured to receive, from a gNB, network layer, or other WTRU, a SL-SSB to transmit, based on the ID.

8. The WTRU of claim 7, wherein the WTRU is configured to monitor multiple SL-SSB resource sets for different communication types.

9. The WTRU of claim 7, wherein the processor is configured to initiate and control the group of other WTRUs by notifying the group of other WTRUs to start or stop transmitting the same SL-SSB.

10. The WTRU of claim 7, wherein the processor is configured to automatically determine SL-SSB transmission opportunities by selection options such as unused transmission opportunities or periodic reselection of time opportunities.

11. The WTRU of claim 7, wherein the processor is configured to determine whether another WTRU should switch WTRU groups and to notify the other WTRU to switch WTRU groups.

12. The WTRU of claim 7, wherein the WTRU is configured with multiple synchronization sources, where each synchronization source is configured with priority.

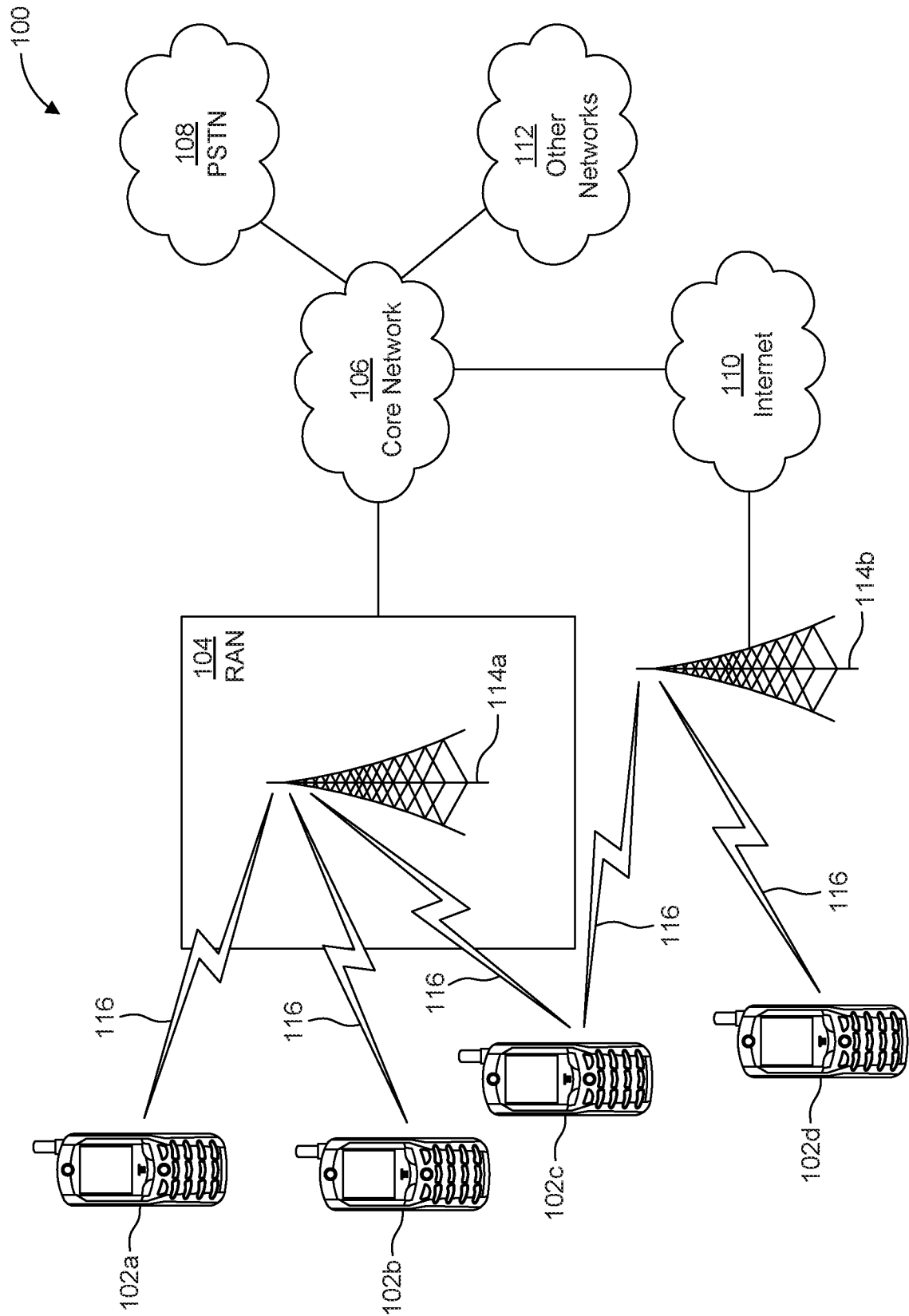


FIG. 1A

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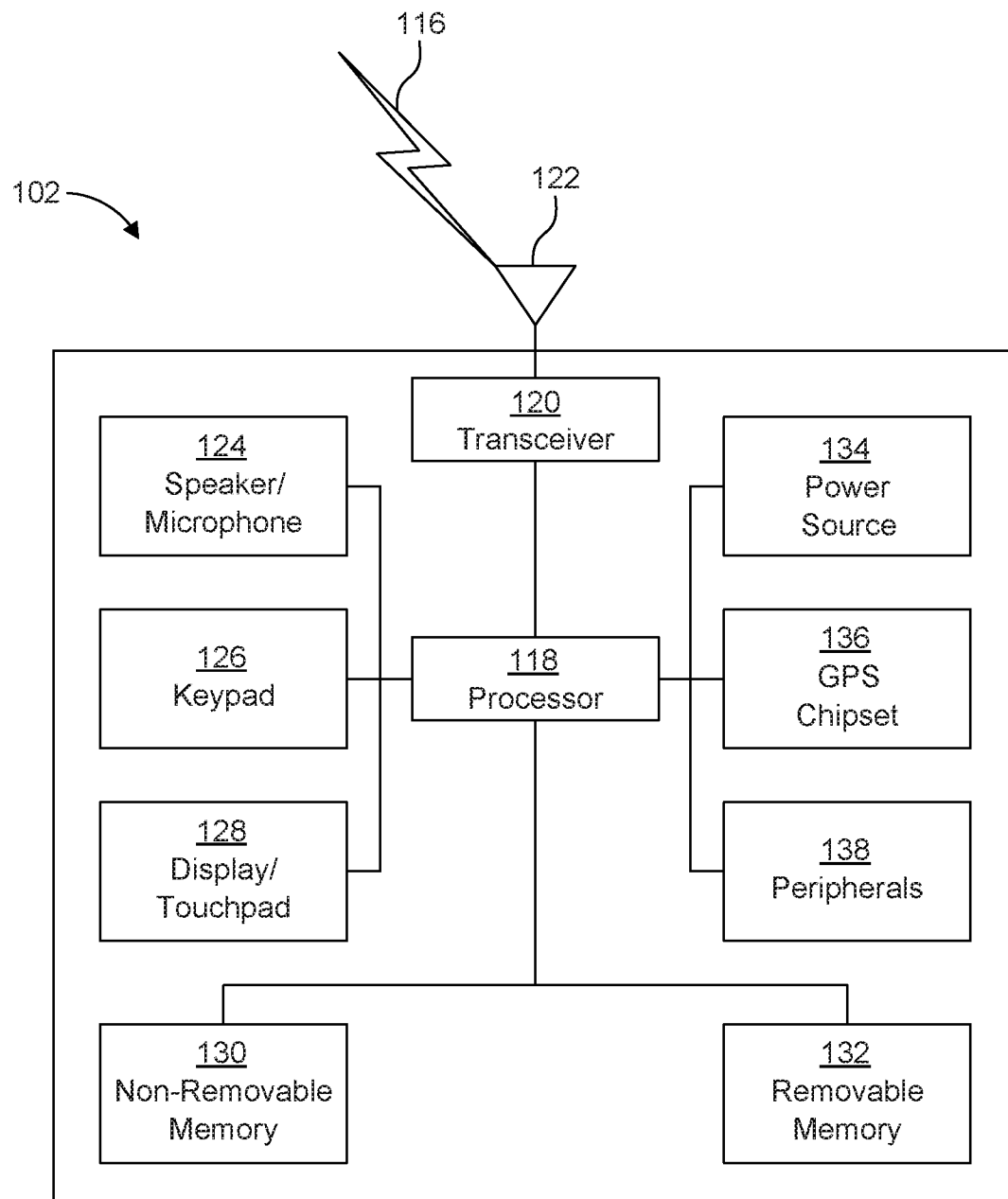


FIG. 1B

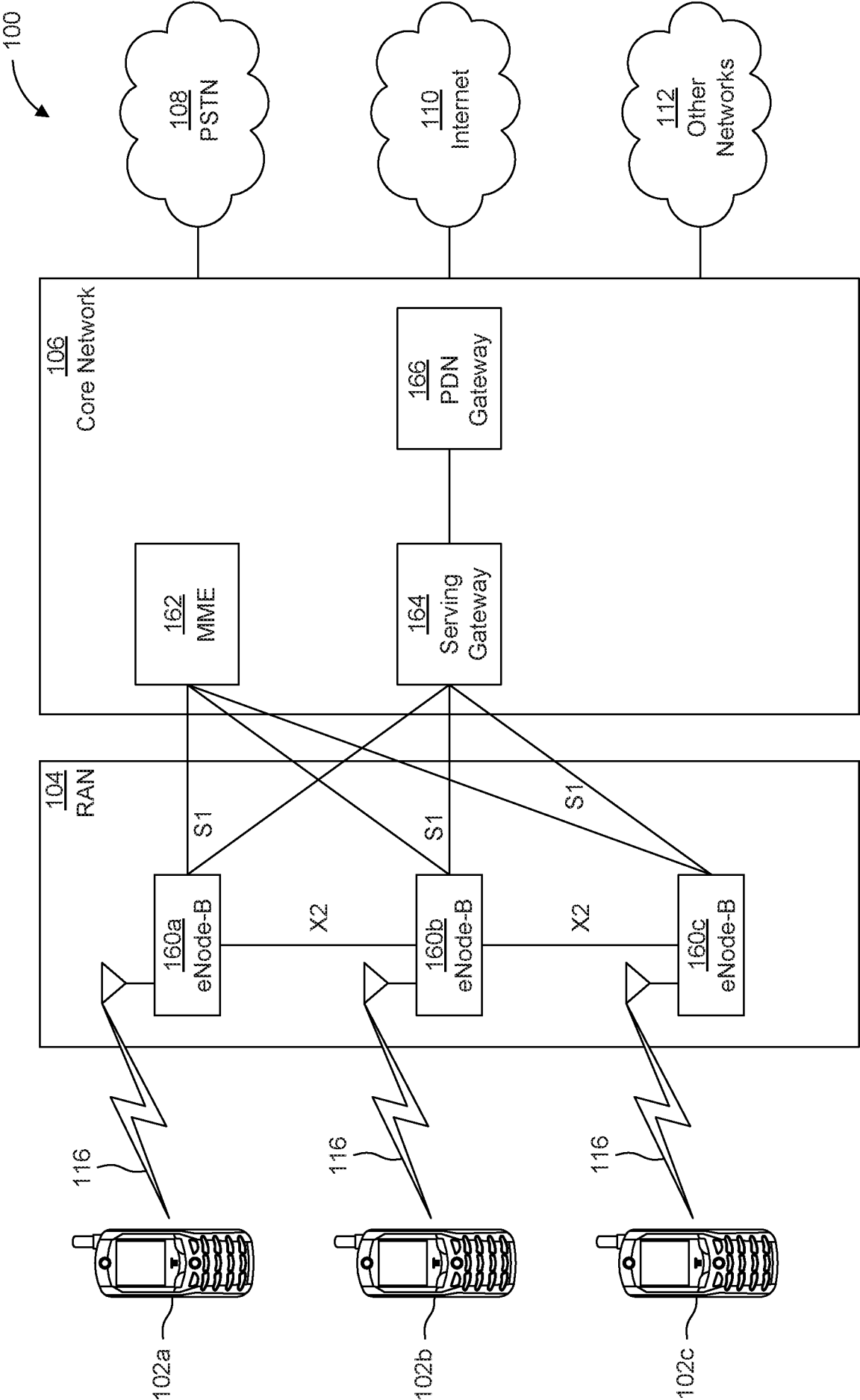


FIG. 1C

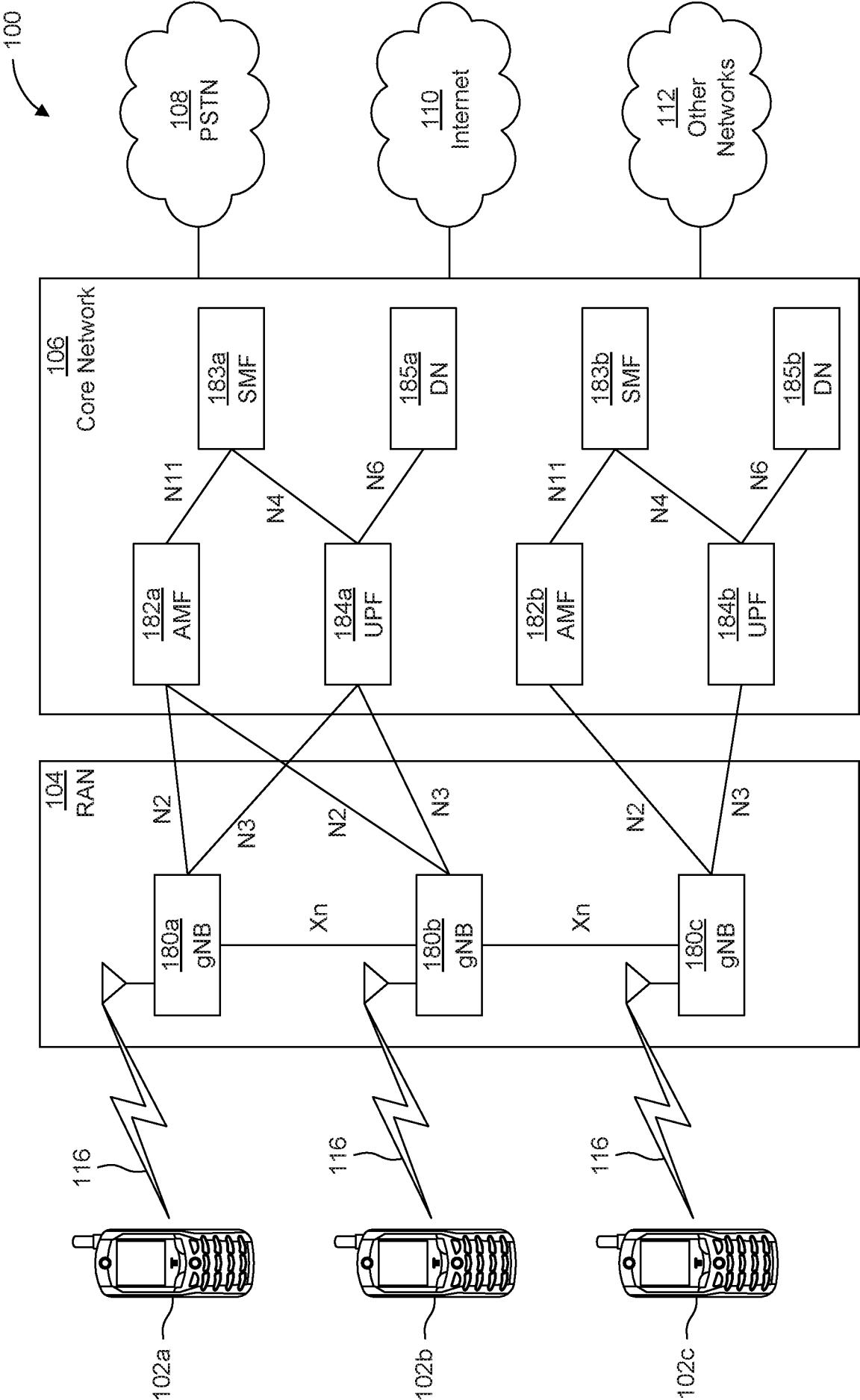


FIG. 1D

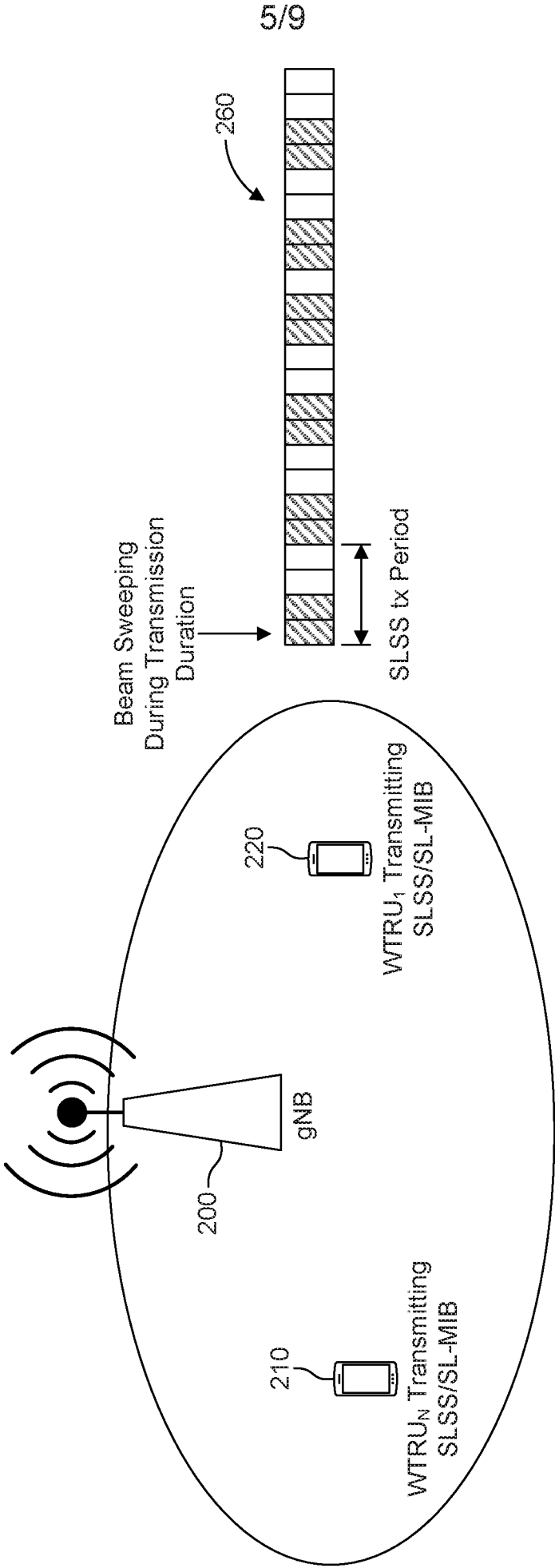


FIG. 2

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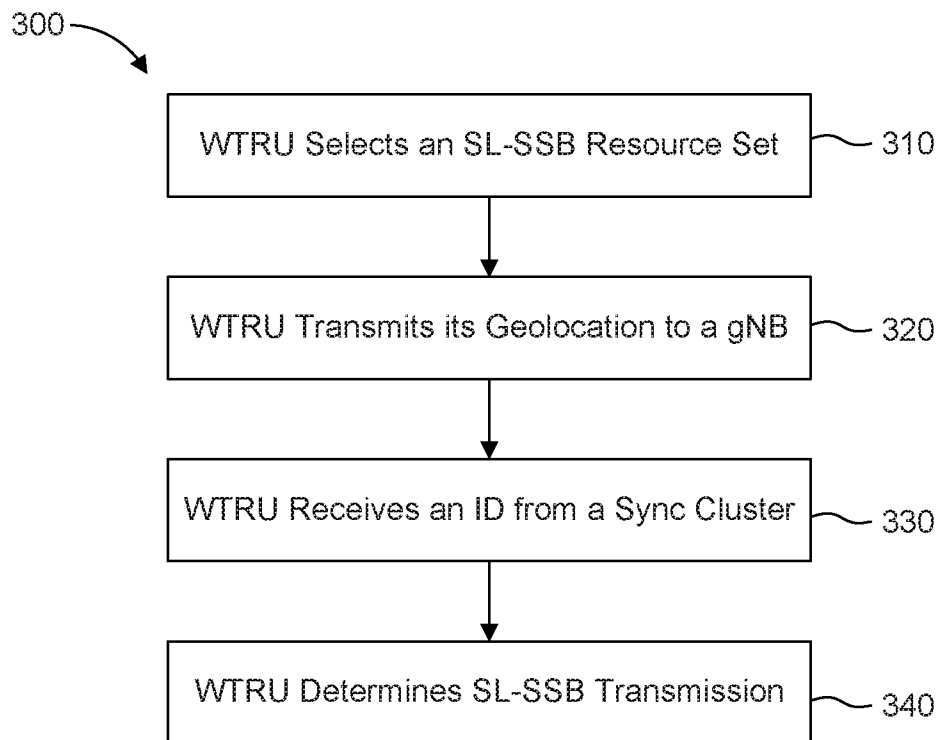


FIG. 3

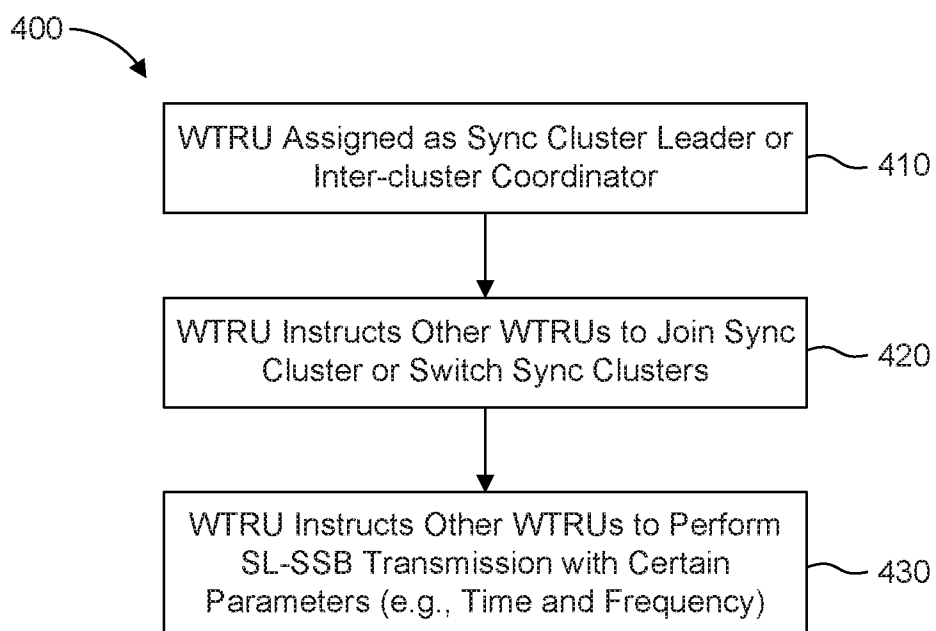


FIG. 4

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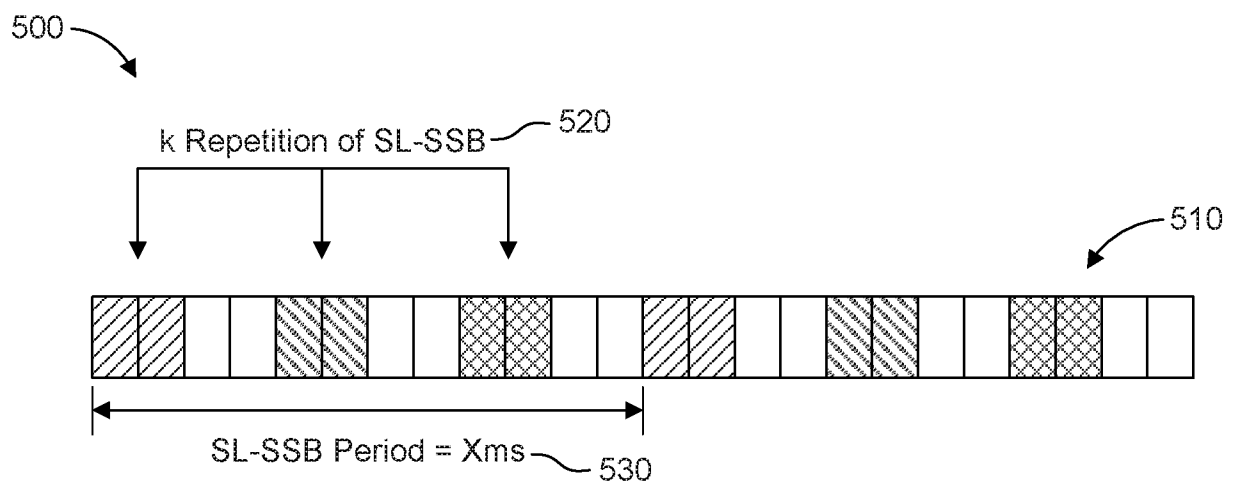


FIG. 5

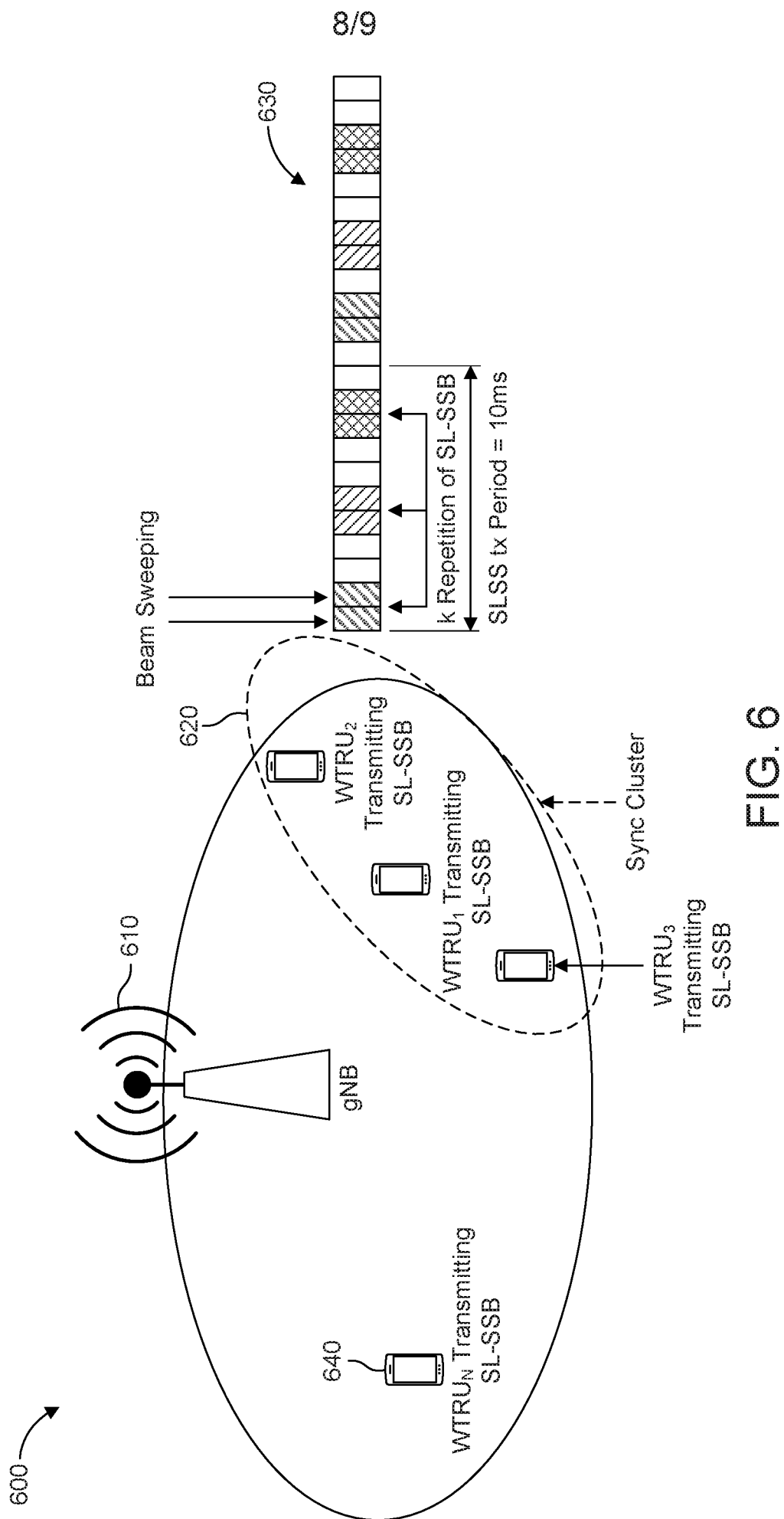


FIG. 6

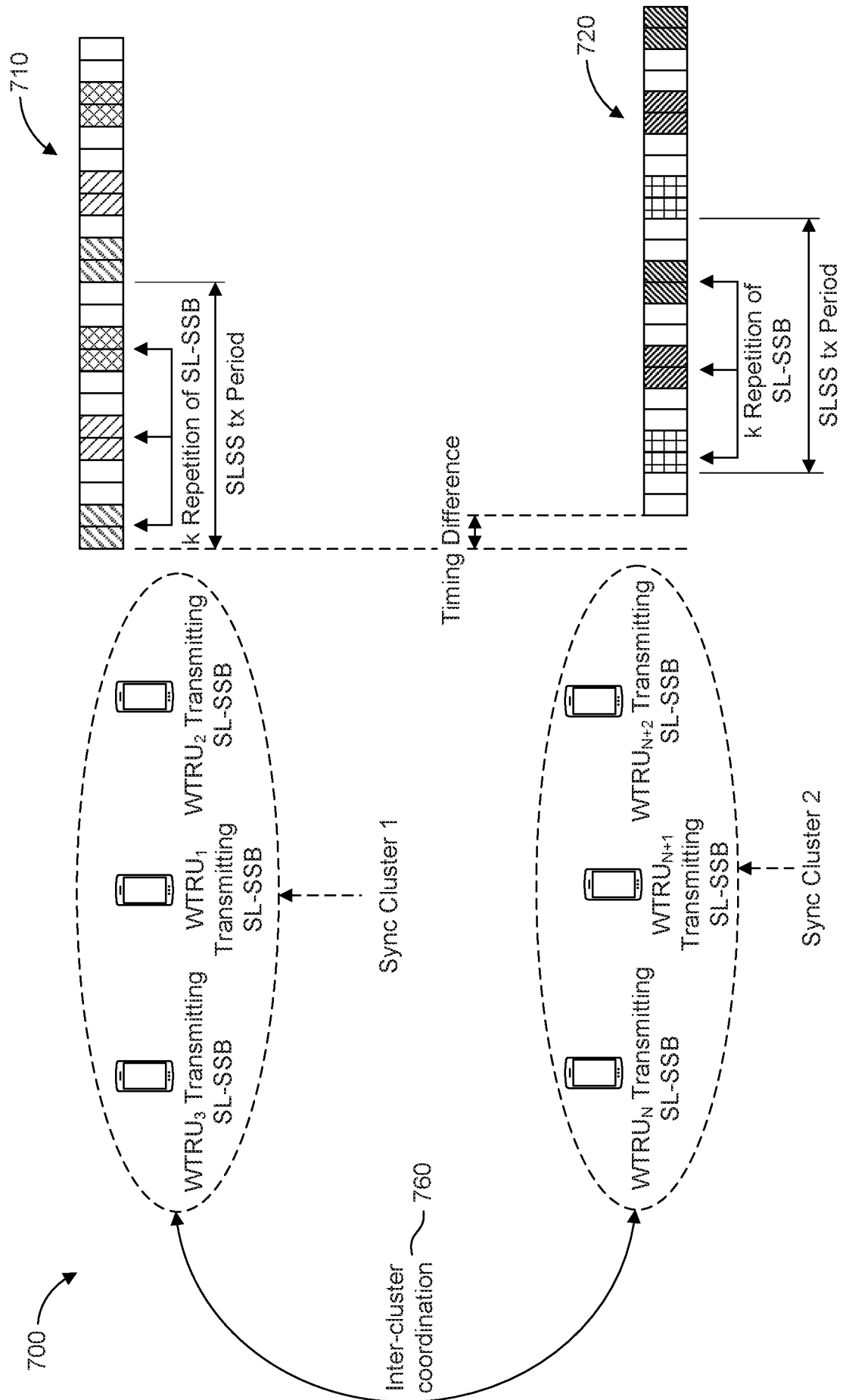


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/045529

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W56/00
ADD.

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

B. FIELDS SEARCHED

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

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

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

EP0-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 Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (Release 14)", 3GPP STANDARD ; TECHNICAL SPECIFICATION ; 3GPP TS 36.331, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. V14.2.2, 20 April 2017 (2017-04-20), pages 1-721, XP051298184, [retrieved on 2017-04-20] paragraph [5.10.2] paragraph [5.10.2.1] paragraph [5.10.7] paragraph [5.10.7.3] -----	1-12

☐

Further documents are listed in the continuation of Box C.

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See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

17 October 2019

Date of mailing of the international search report

31/10/2019

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