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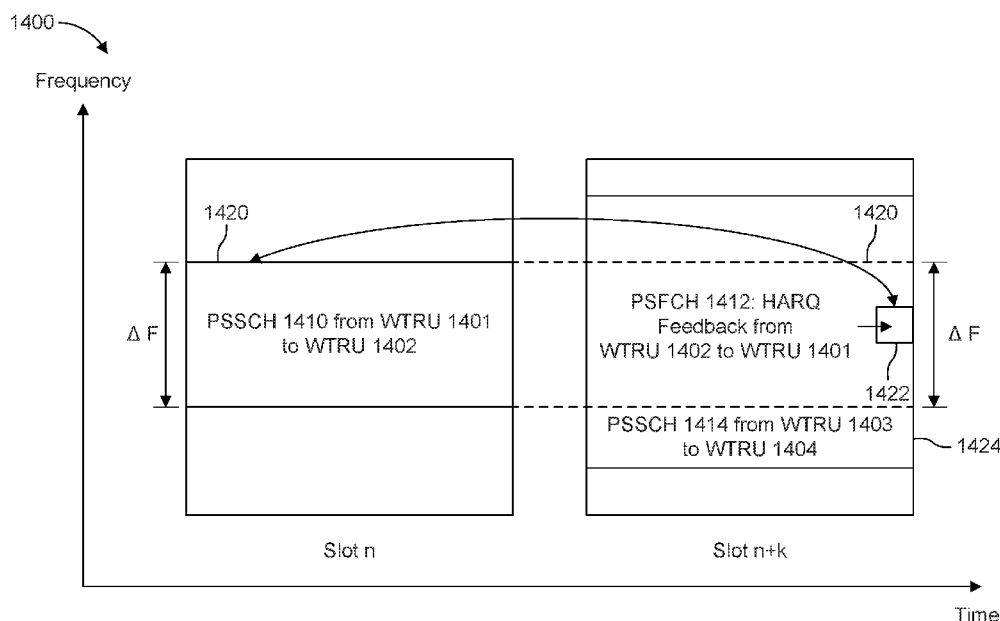


FIG. 14

(57) Abstract: Methods and apparatus for integrated access and backhaul (IAB) and vehicle-to-everything (V2X) systems are disclosed herein. A first wireless transmit/receive unit (WTRU) may monitor, in a first time slot, a first frequency resource comprising a first plurality of resource blocks (RBs) and having a first frequency range, for signals from a second WTRU. The first frequency resource may be associated with a physical sidelink shared channel (PSSCH) of the second WTRU. The WTRU may determine a feedback frequency resource based on at least one of the first frequency range, a number of RBs in the first plurality of RBs, or an identity of the first WTRU. The WTRU may transmit, in a second time slot, to the second WTRU, feedback information using the feedback frequency resource.



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METHODS AND PROCEDURES FOR IAB AND V2X

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application Nos. 62/767,291, filed November 14, 2018, and 62/790,303, filed January 9, 2019, the contents of which are incorporated herein by reference.

BACKGROUND

[0002] Recent Third Generation Partnership Project (3GPP) standards discussions define several deployment scenarios such as indoor hotspot, dense urban, rural, urban macro, and high speed. Based on general requirements set out by International Telecommunication Union Radiocommunication Sector (ITU-R), Next Generation Mobile Networks (NGMN) and 3GPP, use cases for emerging 5G systems may be broadly classified as enhanced mobile broadband (eMBB), massive machine type communications (mMTC) and ultra-reliable and low latency communications (URLLC). These use cases focus on meeting different performance requirements such as higher data rate, higher spectrum efficiency, low power and higher energy efficiency, and/or lower latency and higher reliability. Moreover, a wide range of spectrum bands ranging from 700 MHz to 80 GHz are being considered for a variety of deployment scenarios. New Radio (NR) systems are expected to have a larger available bandwidth as compared with Long Term Evolution (LTE) systems for various reasons, including mmW spectrum use and native deployment of massive MIMO or multi-beam systems.

SUMMARY

[0003] Methods and apparatus for integrated access and backhaul (IAB) and vehicle-to-everything (V2X) systems are disclosed herein. A first wireless transmit/receive unit (WTRU) may monitor, in a first time slot, a first frequency resource comprising a first plurality of resource blocks (RBs) and having a first frequency range, for signals from a second WTRU. The first frequency resource may be associated with a physical sidelink shared channel (PSSCH) of the second WTRU. The WTRU may determine a feedback frequency resource based on at least one of the first frequency range, a number of RBs in the first plurality of RBs, or an identity of the first WTRU. The WTRU may transmit, in a second time slot, to the second WTRU, feedback information using the feedback frequency resource.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Furthermore, like reference numerals in the figures indicate like elements, and wherein:

[0005] FIG. 1A is a system diagram illustrating an example communications system in which one or more disclosed embodiments may be implemented;

[0006] 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;

[0007] 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;

[0008] 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;

[0009] FIG. 2 shows an example New Radio (NR) network deployment with integrated access and backhaul (IAB) links;

[0010] FIG. 3 is a signaling diagram of an example sidelink WTRU information exchange procedure for communication between a (vehicle) WTRU and the base station for vehicle-to-everything (V2X) sidelink transmissions;

[0011] FIG. 4 shows an example physical random access channel (PRACH) configuration in an example NR IAB network deployment;

[0012] FIG. 5 illustrates synchronization signal block (SSB) subsets broadcast within a PRACH configuration;

[0013] FIG. 6 illustrates an SSB subset method for latency reduction;

[0014] FIG. 7 shows a signaling diagram of an example RACH message exchange between a WTRU and a gNB, which may be used for unlicensed operation in IAB systems;

[0015] FIG. 8A shows an example IAB network deployment;

[0016] FIG. 8B shows a signaling diagram of an example RACH message exchange according to an example transmission timing for the example IAB network deployment in FIG. 8A;

[0017] FIG. 8C shows a signaling diagram of another example RACH message exchange according to another example transmission timing for the example IAB network deployment in FIG. 8A;

[0018] FIG. 9A shows an example IAB network deployment where two WTRUs are located close to each other and at the boundary of the same cell;

[0019] FIG. 9B shows a signaling diagram of an example RACH message exchange according to an example transmission timing for the example IAB network deployment in FIG. 9A;

[0020] FIG. 10 shows a resource diagram of an example slot format where feedback resources are derived from the resources for the data transmission;

[0021] FIG. 11 shows a resource diagram of another example slot format where feedback resources are derived from the resources for the data transmission;

[0022] FIG. 12 shows a resource diagram of another example slot format 1200 where feedback resources 1222 are derived from the resources 1220 for the data transmission;

[0023] FIG. 13 shows a resource diagram of an example slot format including two scheduling assignment (SA) stages, SA Stage-1 and SA Stage-2;

[0024] FIG. 14 shows a resource diagram of an example slot format where feedback resources are derived from the resources for the data transmission;

[0025] FIG. 15 shows a resource diagram of an example slot format where feedback resources are derived from the resources for the data transmission;

[0026] FIG. 16 shows a resource diagram of another example slot format where the physical sidelink feedback channel (PSFCH) comprises multiple OFDM symbols;

[0027] FIG. 17 shows a resource diagram of another example slot format where two samples are taken of the frequency resource in which the reservation signal may be transmitted;

[0028] FIG. 18 shows a resource diagram of another example slot format including reservation signals and preemption signals; and

[0029] 19 shows a resource diagram of another example slot format including a low-latency preemption scenario.

DETAILED DESCRIPTION

[0030] 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.

[0031] 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.

[0032] 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.

[0033] 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.

[0034] 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).

[0035] 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).

[0036] 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).

[0037] 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.

[0038] 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., eNB, gNB).

[0039] 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.

[0040] 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.

[0041] 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.

[0042] 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.

[0043] 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.

[0044] 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.

[0045] 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.

[0046] 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.

[0047] 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.

[0048] 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.

[0049] 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).

[0050] 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.

[0051] 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.

[0052] 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.

[0053] 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)).

[0054] 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.

[0055] 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.

[0056] 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.

[0057] 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.

[0058] 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.

[0059] 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.

[0060] 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.

[0061] 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.

[0062] 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.

[0063] In representative embodiments, the other network 112 may be a WLAN.

[0064] 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.

[0065] 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.

[0066] 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.

[0067] 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).

[0068] 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).

[0069] 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.

[0070] 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.

[0071] 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.

[0072] 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).

[0073] 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).

[0074] 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.

[0075] 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.

[0076] 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.

[0077] 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.

[0078] 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.

[0079] 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.

[0080] 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.

[0081] 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.

[0082] 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.

[0083] 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.

[0084] Broad classification of the use cases for emerging 5G systems include Enhanced Mobile Broadband (eMBB), Massive Machine Type Communications (mMTC) and Ultra Reliable and Low latency Communications (URLLC). Different use cases may focus on different requirements such as higher data rate, higher spectrum efficiency, low power and higher energy efficiency, lower latency and higher reliability. A wide range of spectrum bands ranging from 700 MHz to 80 GHz are being considered for a variety of deployment scenarios.

[0085] As carrier frequency increases, path loss becomes a limitation that can hamper guarantees of sufficient coverage. Transmission in millimeter wave (mmW) systems may suffer from non-line-of-sight losses (e.g., diffraction loss, penetration loss, oxygen absorption loss, foliage loss). During initial access, a base station and WTRU may overcome such path losses to discover each other. Some implementations use a plurality of antenna elements (e.g., dozens or hundreds) to generate a beam formed signal (e.g., to compensate for such path loss by increasing beam forming gain). Examples of beamforming techniques may include digital, analogue and/or hybrid beamforming.

[0086] Integrated access and backhaul (IAB) may be used in NR. For example, cellular network deployment scenarios and applications may include support for wireless backhaul and relay links to

enable flexible and/or dense deployment of NR cells without the need for densifying the transport network proportionately. The expected larger bandwidth available for NR, as compared with LTE (e.g., due to mmW spectrum use) and the native deployment of massive MIMO or multi-beam systems in NR may create opportunities to deploy IAB links. This may allow easier deployment of a dense network of self-backhauled NR cells in a more integrated manner by building upon many of the control and data channels and procedures defined for providing access to WTRUs. FIG. 2 shows an example NR network deployment 200 with IAB links 204 and 210. In the example NR network deployment 200, relay nodes (e.g., relay Transmit-Receive Points, rTRPs) 206_A-206_C may multiplex access links 210 and backhaul links 204 in time, frequency, and/or space (e.g. beam-based operation) to provide network access to the WTRUs 212_A-212_C. In this example, relay node 206_A also has a fiber transport backhaul link 208.

[0087] Different links may operate on the same or different frequencies. Relay nodes operating in this way may be referred to as in-band relays and out-band relays, respectively. Efficient support of out-band relays may be important for some NR deployment scenarios. The requirements of in-band relay operation may imply tighter interworking to accommodate duplex constraints and avoid or mitigate interference because the access links may operate on the same frequency. Operating NR systems in the mmW spectrum may present challenges, such as severe short-term blocking, which may not be readily mitigated by present radio resource control (RRC) based handover mechanisms. This may be due to the larger time-scales required for completion of the RRC-based procedures as compared to the short-term blocking. Techniques for overcoming short-term blocking in mmW systems may include RAN-based (e.g., fast RAN-based) mechanisms for switching between rTRPs. Such techniques may or may not involve the core network. An integrated framework may be used that allows fast switching of access and backhaul links, in order to mitigate short-term blocking for NR operation in the mmW spectrum and/or to facilitate deployment of self-backhauled NR cells. Some implementations may use over-the-air (OTA) coordination between rTRPs to mitigate interference and support end-to-end route selection and optimization. IAB may be advantageous during network rollout and the initial network growth phase. To leverage such benefits, IAB may be made available when NR rollout occurs.

[0088] Several use cases may apply to 3GPP vehicle-to-everything (V2X), such as vehicle platooning, extended sensors, advanced driving and remote driving. Each example use case group may have different latency, reliability and data rate requirements. Table 1 illustrates example requirements for these example use case groups. Herein, user, UE, WTRU, and vehicle WTRU may equivalently and interchangeably refer to a vehicle.

Use Case Group	End-to-end latency (ms)	Reliability (%)	Data rate (Mbps)
Vehicle platooning	10	99.99	65
Advanced driving	3	99.999	53
Extended sensors	3	99.999	1000
Remote driving	5	99.999	UL: 25, DL: 1

Table 1: Example requirements for V2X use cases

[0089] A use case within each use case group may have a range of different latency, reliability and data rate requirements. For example, a lower degree of automation in a video sharing scenario of the extended sensors use case group may have a latency requirement of 50 ms, reliability requirement of 90% and data rate of 10 Mbps, whereas a higher degree of automation in sensor information sharing between WTRUs supporting a V2X application may have a latency requirement of 3 ms, reliability requirement of 99.999% and data rate of 25 Mbps.

[0090] Different transmission modes may be defined in 3GPP V2X. For example, a vehicle may be in transmission mode 3 (i.e., a mode 3 user) or may be in transmission mode 4 (i.e., a mode 4 user). A mode 3 WTRU may directly use resources allocated by a base station for sidelink (SL) communication among vehicles (or between a vehicle and a pedestrian). A mode 4 WTRU may obtain a list of candidate resources allocated by a base station, and may select a resource from among the candidate resources for the WTRU to use for SL communication. The terms user, WTRU, or UE may also refer to a vehicle herein.

[0091] FIG. 3 is a signaling diagram of an example sidelink WTRU information exchange procedure 300 for communication between a (vehicle) WTRU 302 and the base station (gNB/eNB) 304 for V2X sidelink transmissions, for example according to 5G NR V2X and/or LTE V2X. Once the WTRU 302 is camped on a cell associated with the gNB/base station (eNB) 304, the WTRU 302 may receive system information block (SIB) type 21 (SIB21) 306, which may contain V2X sidelink communication configuration. For example, SIB21 306 may include the *SL-V2X-ConfigCommon* information

element (IE), which may include, but is not limited to include, components *v2x-CommRxPool*, *v2x-CommTxPoolNormalCommon*, *v2-CommTxPoolExceptional*, and/or *v2x-InterFreqInfoList*. *v2x-InterFreqInfoList* may be a list of neighboring frequencies (e.g., up to seven neighboring frequencies) for V2X sidelink communications. The WTRU 302 may send, to gNB/base station (eNB) 304, sidelink WTRU information 308 in one or more messages. For example, as part of the sidelink WTRU information 308, the vehicle WTRU 302 may send message(s) to the gNB/base

station (eNB) 304 indicating to the gNB/base station (eNB) 304 that the WTRU 302 is (or is not) interested in receiving V2X sidelink communication and/or requesting assignment and/or release of transmission resources for V2X sidelink communication. The WTRU 302 and gNB/base station (eNB) 304 may exchange one or more RRCConnectionReconfiguration messages 310, which may include the *SL-V2X-ConfigDedicated* IE. For example, the *SL-V2X-ConfigDedicated* IE may include, but is not limited to include, *commTxResources* and/or *v2x-InterFreqInfoList*.

[0092] Study items on NR V2X consider Uu-based sidelink resource allocation/reconfiguration to identify enhancements of the LTE Uu interface and NR Uu interface to control NR sidelink from the cellular network, and to identify enhancements of the NR Uu interface to control LTE sidelink communications from the cellular network. In the context of LTE V2X synchronization, when a WTRU is connected to an eNB, the WTRU may already have the cell timing. If the WTRU is not in coverage of the eNB, the WTRU may use a global navigation satellite system (GNSS) for the timing synchronization. When the WTRU cannot find timing from either the eNB or GNSS, the WTRU may rely on sidelink WTRUs for timing information. GNSS satellites have atomic oscillators providing a stable and accurate time reference. A GNSS receiver may track signals from multiple satellites and retrieve a local time reference with absolute error less than 1 μ s for Global Positioning System (GPS) receivers. For coordinated multi-point transmission, the residual error using GPS may be around 10 ns. GNSS may be used for frequency synchronization by phase-locking the local oscillator to the incoming signal and stabilizing the carrier frequency. For modern vehicles equipped with a GNSS receiver, GNSS solutions for synchronization may be used for V2X.

[0093] For example, for synchronization in V2X, a WTRU may receive sidelink synchronization signals (SLSS) on a sidelink from other WTRUs. The SLSS may include primary sidelink synchronization signals (PSSS), secondary sidelink synchronization signals (SSSS), and/or physical sidelink broadcast channel (PSBCH) signals, which may further include synchronization information. The WTRU may use the information carried in the SLSS to obtain timing information. A threshold used for synchronization measurement (e.g., Synch-Threshold) may be received in RRC signaling (e.g. *v2x-SyncConfig* and/or *SL-V2X-Preconfiguration* IEs).

[0094] The SLSS may include, but are not limited to include, any one or more of the following example signals: PSSS, SSSS, PSBCH, and/or demodulation reference signal (DMRS) for demodulating the PSBCH. For example, PSSS and SSSS may be transmitted in adjacent time slots in the same subframe. Sidelink-ID (SID) may be split into two sets. For example, SIDs in the range of {0, 1, ..., 167} may be reserved for in-coverage WTRUs (i.e., WTRUs that can receive a signal strong enough to connect with a cell associated with the eNB) and SIDs in the range of {168, 169,

...,335} may be used for out-of-coverage WTRUs. The subframes used as radio resources to transmit SLSS and PSBCH may be configured by higher layers.

[0095] V2X may include unlicensed band operation. In unlicensed bands, a gNB or a WTRU may need to perform a listen-before-talk (LBT) procedure before accessing the unlicensed wireless channel. Specifics of the LBT procedure may differ depending on the regulatory requirements of the unlicensed channel. A LBT procedure may include a fixed and/or random duration interval during which a wireless node (e.g., gNB or WTRU) listens to (e.g., detects energy levels) of the wireless medium, and if the energy level detected from the wireless medium is greater than a threshold (e.g., specified by the regulator) the gNB or WTRU may refrain from transmitting any wireless signal; otherwise, the wireless node may transmit signal after completion of the LBT procedure. In some regulatory regimes, LBT procedures may be mandatory for unlicensed channel usage (by unlicensed user). Accordingly, various LBT categories were adopted in 3GPP licensed assisted access (LAA) (Release 13), enhanced LAA (eLAA) (Release 14) and further enhanced LAA (feLAA) (Release 15). Some implementations use the LBT Category 4 (CAT 4) scheme, as adopted in LAA/eLAA, for some or all of use cases.

[0096] In an example, the LBT CAT 4 procedure may start when a base station (or WTRU) seeks to transmit control or data in an unlicensed channel. The base station (or WTRU) may conduct an initial clear channel assessment (CCA) to determine whether the channel is idle for a period of time (e.g., a sum of a fixed period of time and a pseudo-random duration). The availability of the channel may be determined by comparing the level of energy detected (ED) across the bandwidth of the unlicensed channel to an energy threshold (e.g., set by the regulator). If the channel is determined to be free, the base station (or WTRU) may proceed with transmission on the channel. If the channel is determined to be in use, the base station (or WTRU) may conduct a slotted random back-off procedure. In an example slotted random back-off procedure, a random number is selected from a specified interval which may be referred to as a contention window. A back-off countdown may be obtained and it may be verified whether the channel is idle or not, and the transmission is initiated when the back-off counter goes to zero. After the base station has gained access to the channel, the base station may be only allowed to transmit for a limited duration, which may be referred to as the maximum channel occupancy time (MCOT). The CAT 4 LBT procedure with random backoff and variable contention window sizes may facilitate fair channel access and coexistence with other Radio Access Technologies (RATs), such as Wi-Fi and other LAA networks.

[0097] In IAB systems, in certain scenarios a random access channel (RACH) may be accessible to both a WTRU in an access link and an IAB node in a backhaul link. An IAB node may be a gNB, TRP, rTRP, or BS and is used interchangeably herein with gNB, TRP, rTRP and BS. the IAB node

may provide functionality of integrated access and backhaul links. The access distance for an IAB node may be farther than the access distance for the WTRU. Accordingly, RACH configurations and procedures may be designed to satisfy RACH requirements for both an IAB node and WTRU. In an example to support RACH transmission for both the IAB node and the WTRU, the physical random access channel (PRACH) configuration, PRACH preamble format, preamble configuration, and/or RACH procedures may support multiplexing of RACH transmissions from the WTRU and RACH transmissions from the IAB node.

[0098] In IAB systems, resources are allocated between backhaul links and access links. For example, resources may be allocated in IAB systems using time division multiplexing (TDM), frequency division multiplexing (FDM) and/or space division multiplexing (SDM) techniques, and resources may be allocated dynamically or semi-statically. In implementations where FDM and/or SDM is used for multiplexing backhaul links and access links, cross link interference may occur.

[0099] In IAB systems, the PRACH configuration periodicity for an IAB node may be longer than PRACH configuration periodicity for the WTRU. For example, a long PRACH configuration period may be configured for the IAB node, because IAB nodes, in some cases, may not transmit PRACH as frequently as WTRUs. However, in cases where an IAB node needs to perform random access or transmit a preamble, a long PRACH configuration period may introduce a long access delay. Accordingly, procedures may be used to mitigate the RACH delay of the IAB node corresponding to a long PRACH configuration period.

[0100] In IAB systems using unlicensed spectrum, after receiving one or more preambles, a gNB or IAB node may determine a random access response (RAR) window and transmit an RAR. The RAR window may be determined by the WTRU. The RAR window determined by the WTRU may be different from an RAR window determined by a gNB or IAB node, for example in the case that a preamble is missed by the gNB or IAB node. After receiving several preambles, a gNB or IAB node may transmit RARs. Procedures may determine how many RARs a gNB/IAB node may send and how many RACH message 3 (Msg3, e.g., (RRC Connection Request message) UL grants that gNB/IAB node may configure along with multiple RARs.

[0101] When a WTRU is operating in V2X mode, the resources used for feedback (e.g., ACK/NACK) may be known (e.g., in terms of time and frequency) to the WTRU that may transmit the data. Procedures may facilitate avoidance of collisions between transmissions of WTRUs using the ACK/NACK feedback resources, and/or address collision avoidance between resources for data transmission and feedback.

[0102] Example methods of PRACH configuration collision avoidance in an IAB system may be used. In an example, IAB systems may support network flexibility to configure backhaul RACH resources. FIG. 4 shows an example PRACH configuration 400 in an example NR IAB network deployment. The example PRACH configuration is for backhaul with different hop orders including IAB WTRUs 402₁-402₄. The network may configure offsets for PRACH occasions for mobile terminal (MT) IAB nodes 406₁-406₄ to TDM the backhaul RACH resources across adjacent hops. The offset may be defined in terms of K time durations, where the time durations may be for example radio frames, subframes, slots, mini-slots, non-slots, and/or OFDM symbols.

[0103] In the example PRACH configuration 400, WTRUs 402₁-402₄ may be configured with the same PRACH configuration for initial access, PRACH configuration 404₁. In an example, IAB nodes 406₂ and 406₄ having an even hop order are configured with the same PRACH configuration 404₂ for initial access, which may be different from the PRACH configuration 404₁ for the WTRUs 402₁-402₄. IAB nodes 406₃ having an odd hop order may be configured with the same PRACH configuration 404₃ for initial access, which may be different from the PRACH configuration 404₁ for the WTRUs 402₁-402₄ and from the PRACH configuration 404₂ for the IAB nodes 406₂ and 406₄ having an even hop order. In an example, PRACH configuration 404₁ may be the same as a R15 PRACH configuration. In an example, PRACH configurations 404₂ and/or 404₃ may have a longer periodicity period 412 than the periodicity period 410 of PRACH configuration 404₁. In an example, PRACH configurations 404₂ and/or 404₃ may have longer PRACH formats and/or may have other differences from the R15 PRACH configuration. PRACH configurations 404₁, 404₂, and 404₃ may be multiplexed with each other using TDM as shown in the example scheduling 430.

[0104] As shown in the example PRACH configuration 400, PRACH configuration periodicity for IAB nodes may be longer than PRACH configuration periodicity for WTRUs. A relatively long PRACH configuration period for an IAB node may be appropriate if the IAB node does not transmit a PRACH as frequently as the WTRUs. However, if the IAB node needs to perform random access or transmit a preamble, a relatively long PRACH configuration period may introduce a long delay. Procedures may be used to mitigate or avoid the RACH delay of an IAB node due to a long PRACH configuration period.

[0105] An example procedure to address the RACH delay of an IAB node due to a long PRACH configuration period may consider that an IAB node not be mobile and the location from one IAB node to its parent node may be relatively fixed. In this case, the received synchronization signal blocks (SSBs) from one particular IAB parent node may be a relatively fixed subset of all transmitted SSBs. To reduce the RACH access delay of an IAB node, the IAB node may associate the PRACH with a subset of SSBs rather than all SSBs (i.e., the IAB node may only report one SSB from one

SSB subset instead of reporting a SSB from all SSBs). FIG. 5 shows an example SSB configuration 500 provided by IAB node 502, and in particular shows the SSB subset information SSB1-SSB8 broadcasted as part of the PRACH configuration in each corresponding sector B1-B8.

[0106] In the example SSB configuration 500, IAB donor 502 may be transmitting eight SSBs, SSB1-SSB8. If all SSBs SSB1-SSB8 are mapped one-to-one to a RACH occasion (RO), then the delay for an SSB may be as long as eight ROs. However, if SSB subset information is used or configured, then a WTRU (not shown) may only associate to the SSB(s) that are inside the corresponding SSB subset, and the delay may be reduced. The SSB subsets may be indicated (and hence distinguished from each other) using different preamble subset(s), preamble root(s) and/or different FDM multiplexed ROs. In an example, some SSB subsets may be isolated geometrically (i.e., spatially).

[0107] FIG. 6 illustrates an SSB subset assignment procedure 600 for latency reduction. Each SSB subset may have one or more SSBs. For example, SSB subsets may include two SSBs (e.g., SSB subsets {SSB1, SSB2}, {SSB3, SSB4}, {SSB5, SSB6}, and/or {SSB7, SSB8}). If an IAB node detects SSB3, then according to the SSB subset, the IAB node may choose SSB3 and SSB4 to associate with ROs. Subset {SSB1, SSB2} and subset {SSB5, SSB6} may use the same PRACH resource/preamble resource, for example in the case that subset {SSB1, SSB2} and subset {SSB5, SSB6} are isolated naturally due to non-overlapped beams. In an example, an SSB subset approach to SSB configuration may reduce the RACH delay in unlicensed band for an access node, an IAB node and/or a gNB.

[0108] Any of the following procedures may be used for unlicensed operation for IAB. In an example, preamble power ramping may not be performed and the preamble transmission counter may not be incremented, for example in cases of LBT failure. Power ramping procedures may be used when UL LBT succeeds but no RAR is received from the gNB within the RAR window. In an example procedure, the LBT may be performed at each RO slot. An indicator (e.g., a one-bit indicator) may be used for indicating whether the channel (e.g., cell-common PDCCH, group-common PDCCH, broadcast DL channels or other PHY signaling) was free or busy in the previous RO slot. This example procedure may facilitate the WTRU in determining whether the reason the WTRU did not receive a RAR is due to hidden node interference of a gNB.

[0109] In an example, multiple PRACH transmissions may be performed before RACH Msg2 (e.g., a RAR) reception in a RAR window for initial access. The number of allowed transmissions may be pre-defined or may be indicated (e.g., in a remaining minimum system information (RMSI)). In some cases, multiple RARs may be sent to the same WTRU. In cases where a WTRU transmits

multiple preambles, multiple preambles may be used that are the same across different ROs, and/or multiple preambles may be different but may have a preconfigured or indicated order in different ROs.

[0110] In another example, the RAR may be defined in a particular way for a WTRU transmitting multiple preambles. If a WTRU transmits multiple preambles, the RAR window may be associated with the first preamble transmission. A gNB that misses the first preamble may have an incorrect RAR window. In an example, a WTRU may transmit one more preambles during any RO, as long as no (RACH) Msg2 is received before the end of the RAR window associated with the previous preamble transmission, until the preamble transmission number is achieved or an RAR is received. A gNB may send the RAR within the RAR window every time it receives one preamble from the WTRU.

[0111] In an example, if a WTRU transmits multiple preambles, a gNB may receive none of the preambles, some of the preambles or all of the preambles. In an example, the gNB may determine the RAR window and send the RAR after receiving one or more preambles. In an example, the RAR window may be derived by the WTRU, which may be different from the RAR window derived by gNB (e.g., because one or more preambles may have been missed by the gNB). In an example, the gNB may not know which preambles are from the same WTRU (or from a different WTRU). In an example, the gNB may treat the received preambles independently. For example, the gNB may use an independent RAR and RAR window for each received preamble, whether or not the preamble is from the same WTRU or a different WTRU.

[0112] After receiving several preambles, a gNB may send corresponding RARs. Procedures may be used by the gNB to determine the number of RAR that the gNB may send, and the number of Msg3 UL grants that gNB may configure along with multiple RARs.

[0113] In an example, the gNB may distinguish between preambles that are from the same WTRU or a different WTRU. In an example, the gNB may use multiple RARs with the different UL grants. In an example, multiple UL grants may be reserved. In an example, the WTRU may try to send multiple Msg3 using multiple UL resources. The use of multiple UL grant reservations may result in multiple UL/DL switching and resources.

[0114] In an example, multiple RARs may be used for multiple (e.g., one or more) UL grants, where the multiple UL grants may be the same. The configuration method of UL grant in RAR may make the UL grant in multiple RARs the same. A Msg3 UL grant in the time domain may be an offset from the end of RAR window. In an example, a gNB may reserve the same UL grants

resulting in less DL/UL switching. In this case, the same RAR window may be used at both the WTRU and the gNB.

[0115] In an example, one RAR may be used for one UL grant for a given WTRU. The gNB may respond to the first received preamble and ignore the subsequent preambles; this approach may not mitigate the RACH delay due to LBT. In an example, an RAR may be used for multiple UL grants for a given WTRU.

[0116] In an example, after receiving multiple RARs from a gNB, there may be multiple Msg3 UL grants. In an example, the WTRU responds to those Msg3 UL grants by transmitting a Msg3 in all UL grants. In this case, the chance for Msg3 transmission to fail due to an LBT failure may decrease. In another example, the WTRU may transmit only one Msg3 in response to multiple Msg3 UL grants, which may decrease interference and overhead. If multiple Msg3s are transmitted, the gNB may receive none of the transmitted Msg3s. In this case, the gNB may assign a Msg3 retransmission for each Msg3, and/or the WTRU may have multiple Msg3 UL grants.

[0117] In an example, the gNB may receive some, but not all, of the multiple Msg3s. FIG. 7 shows a signaling diagram of an example RACH message exchange 700 between WTRU 702 and gNB 704, which may be used for unlicensed operation in IAB systems. In the example RACH message exchange 700, the gNB does not successfully receive from the WTRU 702 Msg1 706 and Msg3 718, and the gNB successfully receives from the WTRU 702 Msg1 708, Msg1 710, and Msg3 716. In this case, the gNB may send Msg4 720 (after sending RARs 712 and 714) to the WTRU 702 in response to the received Msg3 716 and/or may send an assignment for Msg3 retransmission 722 to the WTRU 702 for the unreceived Msg3 718. In an example, the gNB may not assign a Msg3 retransmission because at least some of the Msg3s (Msg3 716) have been received by the WTRU 702.

[0118] In an example, a gNB may receive all of the Msg3s from a WTRU. The gNB may send to the WTRU a Msg4 for all the received Msg3s. In an example, the gNB may inform the WTRU that all the Msg3s are from the same WTRU because they have the same WTRU ID. In an example, a gNB may need to know whether a Msg3 from the same WTRU has been received. In some examples, for each Msg3, the gNB may include assistance information to indicate how and what Msg3 UL grants are present or used. For example, for each Msg3 the gNB may indicate all Msg3 UL grants that the specific WTRU is using. In an example, each Msg3 may indicate all RARs that the WTRU has received. Assistance information may include, for example, a random-access radio network temporary identifier (RA-RNTI), preamble ID, a preamble index, RACH resource index, and/or any other ID or index.

[0119] Procedures for preamble LBT blocking mitigation may be used for FDM UL transmissions. FIG. 8A shows an example IAB network deployment 800. FIG. 8B shows a signaling diagram of an example RACH message exchange 801B according to an example transmission timing for the example IAB network deployment 800. FIG. 8C shows a signaling diagram of another example RACH message exchange 801C according to another example transmission timing for the example IAB network deployment 800.

[0120] In an example, WTRU 802 may be performing RACH and WTRU 804 may be in RRC connected mode. WTRU 802 may have time delay (i.e., transmission delay between the gNB 806 and WTRU 802) of T_1 , and WTRU 804 may have time delay (i.e., transmission delay between the gNB 806 and WTRU 804) of T_2 . When WTRU 802 is transmitting a preamble 816, WTRU 804 may also be scheduled to transmit UL data 812 in a same or overlapping time slot as shown in FIG. 8B. For example, the WTRU 804 may transmit the UL data 812 with a timing advance (TA) T_3 and WTRU 802 may not know the TA T_3 (e.g., $T_3 < T_1 + T_2$). The WTRUs 802 and/or 804 may perform LBT 813/811 based on the timing of SSB reception 810 from the gNB 806. In this case, the UL data transmission 812 of WTRU 804 may jam the LBT 813 of WTRU 802 and block the preamble transmission 816 of WTRU 802.

[0121] In order to avoid blocking the preamble transmission 816, an UL transmission 820 in the same slot as the RO may use guard period 823 (gap or time duration) at the beginning of UL transmissions 820 (and after the LBT 821) scheduled in the same slot as the RO, as shown in example RACH message exchange 801C.

[0122] FIG. 9A shows an example IAB network deployment 900, where WTRUs 902 and 904 are located close to each other and at the boundary of the same cell for gNB 906. FIG. 9B shows a signaling diagram of an example RACH message exchange 901 according to an example transmission timing for the example IAB network deployment 900. The time delay from the cell boundary to the gNB 906 is denoted as T_{cell} . The WTRUs 902 and/or 904 may perform LBT 913/911 based on the timing of SSB reception 910 from the gNB 906. In order to avoid blocking the preamble transmission 916 of WTRU 902, a guard period 915 (time duration) of duration $2T_{\text{cell}}$ may be used at the beginning of the UL transmission 912 of WTRU 904. For example, the guard period 915 may be several OFDM symbols in duration.

[0123] In an example, the periodicity of SS/PBCH block may be long in IAB system (e.g., longer than 20ms). The long periodicity of SS/PBCH block may allow an IAB node (e.g., an IAB donor node) to transmit a SS/PBCH block in a longer periodicity (e.g., when IAB donor node operates in non-standalone mode (NSA)). For example, an IAB node may transmit a synchronization signal for

the physical broadcast channel (SS/PBCH) block in a periodicity 80ms or 160ms or longer. In an example, an IAB node also transmit RMSI in a long periodicity. For example, the IAB node may transmit RMSI in a longer periodicity than the SS/PBCH block. RMSI may only be needed for initial access performed by IAB. Therefore, frequent transmission of RMSI may not be used. For example, the IAB node may transmit SS/PBCH block in a periodicity 160ms or 320ms or longer. For an IAB node, RMSI may be used to acquire minimum system information for initial access. For example, a RACH configuration may be part of RMSI for IAB. Some information in RMSI may not be used.

[0124] The SS/PBCH block and RMSI may be transmitted using the same or different periodicity. If the SS/PBCH block and RMSI are transmitted at the same periodicity, additional information may not be needed in RMSI. However, if SS/PBCH block and RMSI are transmitted using different periodicities, additional information may be needed (e.g., in SS/PBCH or RMSI to indicate the presence or absence of SS/PBCH or RMSI). If the SS/PBCH block is transmitted less frequently than RMSI, additional information may be needed (e.g., in RMSI to indicate the presence or absence of SS/PBCH). In another example, if the SS/PBCH block is transmitted more frequently than RMSI, additional information may be needed (e.g., in PBCH to indicate the presence or absence of RMSI). In an example, there may be an association between SS/PBCH and RMSI. For example, if the SS/PBCH block is transmitted less frequently than RMSI, additional information may be needed (e.g., in RMSI to indicate that SS/PBCH is not present and that the association does not hold). However, if the SS/PBCH block is transmitted more frequently than RMSI, additional information may be needed (e.g., in PBCH to indicate that RMSI is not present and the association does not hold).

[0125] In an example, the SS/PBCH and RMSI may have the same periodicity. For example, SS/PBCH and RMSI may be transmitted using the same periodicity (e.g., 160ms which is longer than default 20ms). The same or a different periodicity may be indicated for SS/PBCH and RMSI transmission (e.g., by a gNB or network or transmitter). Furthermore, in cases where there are different periodicities for SS/PBCH and RMSI transmission, whether the periodicity for SS/PBCH is shorter than or longer than RMSI may also be indicated (e.g., by the gNB or network or transmitter). The presence/absence of SS/PBCH or RMSI may also be indicated to a WTRU accordingly.

[0126] Procedures for V2X feedback signals may be used with or without IAB. In an example, a physical sidelink feedback channel (PSFCH) may be used in V2X communications. The PSFCH may be used to carry any feedback information including, but not limited to, any hybrid automatic repeat request (HARQ) feedback information, ACK/NACK information, and/or channel state information (CSI).

[0127] In an example scenario, a first WTRU that has transmitted data to second WTRU may attempt to receive a type of feedback from the second WTRU (e.g., ACK and/or NACK feedback). In this example, in order to successfully receive the feedback information, the first WTRU may need to know the sidelink resources used to carry the feedback information. The sidelink resources for feedback from the second WTRU may include, but are not limited to include, time (e.g., slot index), frequency (e.g., subcarrier index), and/or code (e.g. spreading sequence index). Procedures for V2X feedback signals should ensure that feedback from multiple WTRUs (e.g., where the intended receivers of the feedback may be the same or different) do not collide, or that the probability of collision is maintained acceptably low level (e.g., below a threshold level) throughout network operation.

[0128] According to an example procedure for V2X feedback signals, resources used for feedback (e.g., ACK/NACK) may be known in time and frequency to the WTRU that has transmitted the data (i.e., the intended recipient of the feedback), such that other WTRUs do not collide with the (e.g., ACK/NACK) feedback transmission in the V2X feedback resources. The (e.g., ACK/NACK) feedback resources may be determined by the resources used to transmit the data to which the feedback corresponds. FIG. 10 shows a resource diagram of an example slot format 1000 where feedback resources 1022 are derived from the resources 1020 for the data transmission. In slot n , WTRU 1001 transmits data to WTRU 1002 using the physical sidelink shared channel (PSSCH) 1010 that is located in frequency resource 1020 and in the frequency range $F = [F1 \text{ to } F2]$. In a later slot, slot $n + 1$, WTRU 1002 transmits feedback (e.g., ACK or NACK for the transmission in slot n) to WTRU 1001, for example using PSFCH 1014. In an example, the slot indices (e.g., n , $n+1$) of when the data is transmitted and when the feedback corresponding to the data transmission is transmitted may be pre-determined (e.g., configured). In some examples, this timing relationship may be indicated within the scheduling assignment corresponding to the data transmission. The indices of the OFDM symbols used to carry the feedback within the slot may also be pre-determined or signaled.

[0129] In an example, the frequency resources 1022 used by WTRU 1002 to transmit the feedback to WTRU 1001 may be within the same frequency resource range $F = [F1 \text{ to } F2]$ used for the transmission of the data from WTRU 1001 to WTRU 1002. By selecting resources from the range $F = [F1 \text{ to } F2]$, the feedback frequency resources 1022 may not overlap with others resources in the same time slot $n+1$, for example resources 1024 used by WTRU 1002 for transmission of data to another WTRU using PSSCH 1012.

[0130] FIG. 11 shows a resource diagram of another example slot format 1100 where feedback resources 1122 are derived from the resources 1120 for the data transmission. In slot n , WTRU

1101 transmits data to WTRU 1102 using the PSSCH 1110 that is in frequency resource 1120 and located in the frequency range $F = [F1 \text{ to } F2]$. In the same slot n , WTRU 1102 transmits feedback (e.g., ACK or NACK for the transmission in slot n) to WTRU 1101, for example using PSFCH 1112. The frequency resources 1122 used by WTRU 1102 to transmit the feedback to WTRU 1101 may be within the same frequency resource range $F = [F1 \text{ to } F2]$ used for the transmission of the data from WTRU 1101 to WTRU 1102.

[0131] When the feedback is transmitted in a different slot from the data (e.g., as shown in FIG. 10), it may be possible another WTRU has reserved resources within the frequency range $F1$ to $F2$ in the same slot (e.g., slot $n + 1$) as when the feedback is scheduled to be transmitted. In an example, the third WTRU may not transmit within the frequency range F and/or on the OFDM symbols where the feedback is scheduled to be transmitted (i.e., those resources may be excluded from transmission by other WTRUs). FIG. 12 shows a resource diagram of another example slot format 1200 where feedback resources 1222 are derived from the resources 1220 for the data transmission. In slot n , WTRU 1201 transmits data to WTRU 1202 using the PSSCH 1210 that is located in frequency resource 1220 and in the frequency range $F = [F1 \text{ to } F2]$. In a later slot, slot $n + 1$, WTRU 1202 transmits feedback (e.g., ACK or NACK for the transmission in slot n) to WTRU 1201, for example using PSFCH 1014. The frequency resources 1222 used by WTRU 1202 to transmit the feedback to WTRU 1201 may be within the same frequency resource range $F = [F1 \text{ to } F2]$. In this example, WTRU 1203 may transmit data (to another WTRU) using PSSCH 1212 that is also located in frequency resource 1220. In this case, WTRU 1203 may puncture or rate match the transport block of its data transmission so that it fits into the frequency resources 1220 with the feedback resources 1222. In this case, WTRU 1203 (and any other WTRUs trying to reserve resources) may be aware of the time/frequency resources 1222 allocated for PSFCH transmission 1214. For example, WTRUs may transmit reservation signals to reserve resources for scheduling assignment (SA)/data transmission. Due to the predetermined timing relationship between the data transmission (e.g., PSSCH 1210) and corresponding feedback (PSFCH 1213), WTRUs that receive the reservation signals may be aware of the time and/or frequency resources in which feedback will be sent. For example, in the example slot format 1200 of FIG. 12, WTRU 1201 may reserve resources 1220 in slot n and frequency range F by sending reservation signal(s) (not shown). Other WTRUs that receive the reservation signal(s), such as WTRU 1203, may also determine that certain OFDM symbols in slot $n + 1$ and frequency range F are also reserved for feedback to WTRU 1201. The slot index of the PSFCH 1214 may be indicated in the reservation signal.

[0132] Some data transmissions in IAB system may not require a feedback. For example, when a WTRU reserves a resource, the reservation signal may include information pertaining to whether the

reservation will need feedback. For example, a one-bit flag may indicate whether PSFCH should be used. In another example, another parameter within the signal may implicitly indicate if feedback is required or not. For example, the reservation signal may indicate the traffic type (e.g., unicast with feedback, groupcast with feedback, groupcast without feedback, broadcast), from which the use of feedback may be implied.

[0133] FIG. 13 shows a resource diagram of an example slot format 1300 including two SA stages, SA Stage-1 and SA Stage-2. In slot n , WTRU 1301 transmits data to WTRU 1302 using PSSCH 1310 that is located in frequency resource 1320 and in the frequency range $F = [F1 \text{ to } F2]$. In a later slot, slot $n + 1$, WTRU 1302 transmits feedback (e.g., ACK or NACK for the transmission in slot n) to WTRU 1301, for example using PSFCH 1312. The frequency resources 1322 used by WTRU 1302 to transmit the feedback to WTRU 1301 may be within the same frequency resource range $F = [F1 \text{ to } F2]$ used for the transmission of the data from WTRU 1301 to WTRU 1302. SA and physical sidelink control channel (PSCCH) may refer to the same channel. At least one of the SA stages may be decodable by all or a subset of the WTRUs in the vicinity that can receive the first stage SA. The first stage SA and the location of the corresponding PSFCH 1312 may be associated (e.g., the first stage SA may directly or indirectly indicate the location of the PSFCH 1312). Any one or more of the following may apply (Note that these methods may similarly apply to SA stage 2 as well): the location of the SA stage-1 may implicitly indicate the location of the PSFCH 1322; the control resource set (CORESET) used to carry the SA stage-1 may implicitly indicate the location of the PSFCH 1322; SA stage-1 may indicate whether the receiving WTRU is required to transmit feedback (e.g., the WTRU may be configured by the gNB, base station, or other transmitting WTRU, such as a platoon manager WTRU, to provide feedback); the location (e.g., frequency and time resource 1322) of the PSFCH 1312 and whether PSFCH 1312 feedback is needed may be indicated with a combination of SA stage-I and/or SA stage-II; and/or the location (e.g., frequency and time resource 1322) of the PSFCH 1312 and whether PSFCH 1312 feedback is needed may be indicated with a combination of SA stage-2 and a reservation signal (e.g., the reservation signal may be the same or different from the SA stage-1).

[0134] In examples where the location of the stage 1 SA implicitly indicates the time and frequency resource of the PSFCH, for example, in the case the PSFCH and the stage-1 SA are mapped to the same subcarriers (e.g., in the same slot or different slots). In some examples, the PSFCH may be mapped to a subset of the subcarriers used by the stage-1 SA. For example, the specific subset may be configured by a central controller.

[0135] In examples where the CORESET used to carry the SA-I may implicitly indicate the location of the PSFCH, the CORESET may consist of time/frequency resource units and one or

more of these time/frequency resource units may be associated with the frequency and/or time/frequency location of the PSFCH. In examples where SA-I may also indicate if the receiving WTRU is required to transmit feedback, this information may include at least one bit and may be encoded as part of the SA-I message. In examples where the demodulation reference signal (DM-RS) of SA-I or some other type of reference signal (RS) associated with SA-I may be used to indicate if feedback is required or not, the RS may include two parts and these parts may be scrambled with [1 1] or [1 -1] to indicate a one-bit information. In an example, the cyclic shift and/or the sequence index of the RS may be used to indicate this one-bit information.

[0136] In an example where the location (time/frequency resource) of the PSFCH and whether PSFCH feedback is required may be indicated using a combination of Stage-1 SA and Stage-2 SA, Stage-1 SA may indicate whether there will be a PSFCH transmission and Stage-2 SA may indicate the location (time/frequency resource) of the PSFCH, such that the PSFCH does not have to be located in the same frequency range F used for SA (or PSSCH). For example, Stage-2 SA may include encoded bits that indicate the time and/or frequency location of the PSFCH. WTRUs that are listening to the transmissions may decode Stage-1 SA and receive information regarding the reservation of the transmitting WTRU. If any other WTRUs (e.g., UE 1203 in FIG. 12) attempts to access to the same resource pool, that WTRU may also decode Stage-2 SA to determine the time/frequency resource (location) of the PSFCH. The WTRU may determine to use or not use the same resource allocated to the PSFCH (e.g., choose to use the resources, or permitted to use or prohibited from using the resources).

[0137] In an example where the time/frequency resource (location) of the PSFCH and whether PSFCH feedback is needed or not may be indicated by a combination of Stage-1 SA and the reservation signal (e.g., if the reservation signal is different than SA-I), a parameter (e.g., traffic type information), may be associated with or may indicate the existence of PSFCH and the time/frequency resource (location) of the PSFCH may be indicated by encoded bits within Stage-1 SA. In an example, Stage-1 SA may have one of multiple possible formats and at least one of these formats may include PSFCH information and at least one of these formats may not include PSFCH information. In an example, an m-bit Stage-1 SA format may include at least a one-bit field about PSFCH and an n-bit Stage-1 SA format may be known (e.g., by other WTRUs) to have no PSFCH information (e.g., implying that the upcoming transmission will not need a feedback).

[0138] In an example, another parameter within the downlink control information (DCI) may implicitly indicate whether feedback is required by the transmitter (e.g., gNB, other transmitting WTRU, etc.) or not. For example, the DCI may indicate the traffic type (e.g., unicast with feedback, groupcast with feedback, groupcast without feedback, broadcast). In an example, the stages of an

SA may be transmitted in different slots, and the DCI may be part of Stage-1 SA and/or Stage-2 SA. For example, Stage-1 SA may carry the traffic type information.

[0139] If a WTRU excludes PSFCH resources from its transmission (e.g., example WTRU 1203 in FIG. 12), the WTRU may indicate the exclusion of PSFCH resources to its intended receiver, so that the receiver may perform appropriate receive operations. In an example, the DCI in the SA transmitted by the WTRU may indicate whether any resources have been excluded in the transmission. For example, a one-bit flag may indicate whether frequency range F on m number of OFDM symbols has been excluded. With reference to FIG. 13, if the frequency range used by WTRU 1203 is larger than the frequency range 1222 of PSFCH 1214, then WTRU 1203 may exclude all of the OFDM symbols carrying the PSFCH 1214.

[0140] In an example, a subset of the frequency resources F may be allocated to PSFCH transmission. The time/frequency resource (location) of the PSFCH may be known by the WTRUs that receive and decode the PSCCH and/or the discovery channel, or some other channel. For example, a WTRU and its intended receiver may have received information regarding the time/frequency resource (location) of the PSFCH. Based on this, the WTRU may skip the PSFCH resources in its transmission (e.g., by either rate matching or puncturing) and intended receiver would not expect any information bits from the WTRU on those resources.

[0141] FIG. 14 shows a resource diagram of an example slot format 1400 where feedback resources are derived from the resources for the data transmission. In slot n , WTRU 1401 transmits data to WTRU 1402 using PSSCH 1410 in frequency resource 1420 with frequency range ΔF . WTRU 1402 monitors, in time slot n , the frequency range ΔF , which may include a corresponding plurality of resource blocks (RBs), for signals (e.g., message carrying data) from the WTRU 1401 on the PSSCH 1410. WTRU 1402 determines feedback frequency resource 1422 based on any one or more of information: the frequency range ΔF ; the number of RBs in first plurality of RBs; and/or an identity of the WTRU 1401. For example, feedback frequency resource 1422 may be determined to be a subset of the plurality of RBs in frequency resource 1420. The WTRU 1402 transmits, in time slot $n+k$, to WTRU 1401, feedback information (e.g., ACK/NAK to acknowledge/negative acknowledge the data transmitted on PSSCH 1410 by WTRU 1401 in time slot n) using the feedback frequency resources 1422. For example, WTRU 1402 may transmit, on the PSFCH 1412 using the feedback frequency resources 1422, HARQ feedback information to WTRU 1401. In slot $n+k$, another WTRU 1403 may transmit data on a PSSCH 1414 to another WTRU 1404 using different frequency resources 1424, that may not overlap with frequency resources 1422 and/or frequency resources 1420.

[0142] FIG. 15 shows a resource diagram of an example slot format 1500 where feedback resources are derived from the resources for the data transmission. In slot n , WTRU 1501 transmits control information (e.g., broadcast information on a sidelink) on a PSCCH 1508 in a frequency resource 1523 in the frequency range ΔF_c . The frequency range ΔF_c may be a subset of the frequency range ΔF , and the frequency resource 1523 may be a subset of the frequency resource 1520 (e.g., a subset of a plurality of RBs) used by WTRU 1501 to transmit data to WTRU 1502 using PSSCH 1510. WTRU 1502 monitors, in time slot n , the frequency range ΔF_c , for signals (e.g., messages carrying control information) from the WTRU 1501 on the PSCCH 1508. WTRU 1502 monitors, in time slot n , the frequency range ΔF , for signals (e.g., message carrying data) from the WTRU 1501 on the PSSCH 1510. WTRU 1502 determines feedback frequency resource 1522 based on any one or more of information: the frequency range ΔF ; the number of RBs in the plurality of RBs associated with frequency resource 1520; the frequency range ΔF_c ; the number of RBs in the plurality of RBs associated with frequency resource 1523; and/or an identity of the WTRU 1501. For example, feedback frequency resource 1522 may be determined to be a subset of the plurality of RBs in frequency resource 1523. The WTRU 1502 transmits, in time slot $n+k$, to WTRU 1501, feedback information (e.g., ACK/NAK to acknowledge/negative acknowledge the data transmitted on PSSCH 1510 by WTRU 1501 in time slot n) using the feedback frequency resources 1522. For example, WTRU 1502 may transmit, on the PSFCH 1512 using the feedback frequency resources 1522, HARQ feedback information to WTRU 1501. In slot $n+k$, another WTRU 1503 may transmit data on a PSSCH 1514 to another WTRU 1504 using different frequency resources 1524, that may not overlap with frequency resources 1522 and/or frequency resources 1520.

[0143] The example procedures described herein for V2X feedback signal apply to cases where the PSFCH covers the entire frequency range F and also cases where the PSFCH covers a subset of the frequency range F (e.g., a subset of the RBs in the frequency range F) used for the original data transmission.

[0144] In an example, ACK/NACK feedback may be transmitted with a sequence. For example, a sequence 1 transmission may indicate an ACK while a sequence 2 transmission may indicate a NACK. The sequence may include, for example, Lm coefficients where m is the number of subcarriers in an RB. In this case, the sequence may be mapped to the whole frequency range $F = [F_1 \text{ to } F_2]$, or to a subset of frequency range F . In an example, the location of the PSFCH within the frequency resource F may be fixed. For example, the feedback may always be transmitted in the first RB of the allocation F . In an example, the location of the PSFCH within the frequency resource may be based on other transmission parameters such as the UE ID (e.g., $\text{mod}(\text{UE ID}, \text{number of RB in the frequency resource})$ may indicate the index of the first RB of the PSFCH).

[0145] In an example, ACK/NACK bits may be encoded and modulated to create a feedback transport block that may be mapped to the subcarriers in the available frequency resource range F . The indices of the RBs used to transmit the feedback block may be predetermined or may be a function of other transmission parameters, such as the UE ID. In an example, the ACK/NACK feedback may be mapped to a subset of the available frequency range F and the remaining subcarriers within F may be used to transmit other control information, such as CSI. For example, if F includes N RBs, m RBs may be used by UE 2 to transmit ACK/NACK to UE 1 while the remaining $N - m$ RBs may be used by UE 2 to transmit CSI to UE 1. In such cases, ACK/NACK and CSI may be separately encoded. A CSI transmission may be requested within the DCI (e.g., aperiodic CSI) or may be configured for transmission using predetermined time and/or frequency resources. In an example, if a WTRU is not scheduled to transmit CSI but has ACK/NACK to transmit, it may use the remaining resources in frequency range F to transmit data.

[0146] In an example, if the traffic type is groupcast and feedback is required, multiple receiving WTRUs may feedback ACK/NACK within the same PSFCH. In an example, these WTRUs implement time and/or frequency and/or code division multiplexing to multiplex their ACK/NACK bits. At least one of the resources used for feedback (e.g., indices of the OFDM symbols and subcarriers, indices of cyclic shifts of a sequence, indices of a spreading sequence) may be a function of UE ID to prevent collision. In an example, the PSFCH may include multiple OFDM symbols. FIG. 16 shows a resource diagram of another example slot format 1600 where the PSFCH 1610 (transmitted from WTRU 1602 to WTRU 1601) in the frequency range $[F1, F2]$ comprises multiple OFDM symbols. In an example, at least part of one OFDM symbol may be used at the receiver for automatic gain control (AGC) purposes.

[0147] In an example, the same symbols are repeated in all OFDM symbols of the PSFCH, for example to mitigate or avoid performance loss. The symbols may be sequences and/or encoded and modulated data bits and/or DMRS symbols. In an example, the first OFDM symbol is used to transmit a known sequence, for example, a DMRS sequence, to mitigate or avoid performance loss. In an example, data bits are encoded, rate matched and modulated such that all subcarriers on all OFDM symbols are used to map the modulation symbols, for example to mitigate or avoid performance loss.

[0148] In an example, reservation and preemption for V2X may be performed with or without an IAB. In an example, a WTRU may transmit a reservation signal to reserve transmission resources. A reservation signal may include coded bits and may be used to inform listening WTRUs of the resources that the transmitting WTRU is planning to reserve in a later time for its own transmission. In an example, the reservation signal may be used to reserve resources for the SA and data

transmission. For example, the reservation signal may be transmitted on a subset of the frequency resources intended for the planned SA transmission. FIG. 17 shows a resource diagram of another example slot format 1700 where two samples are taken of the frequency resource 1710, 1714 in which the reservation signal 1706, 1708 may be transmitted. A WTRU may transmit the reservation signal 1706, 1708 on a set of frequency resources 1710, 1714 in slot n . In an example, the reservation signal 1706, 1708 may be transmitted on one or more OFDM symbols within slot n . This reservation signal is used to reserve frequency resources in slots $[n+k]$ to $[n+k+L]$. It is noted that L may be non-zero or zero. The resource relationship between the reservation signal 1706, 1708 and the SA 1712, 1716 may be such that the reservation signal 1706, 1708 is transmitted in one of the PDCCH candidates of the CORESET configured for the SA 1712, 1716. In such cases, a single CORESET configuration for the SA 1712, 1716 and reservation signal 1706, 1708 may be used. In an example, a separate CORESET may be configured for the reservation signal, where the reservation signal CORESET may be a subset of the SA CORESET. It is noted that k may be zero, such that the reservation signal and the associated SA/data transmissions may take place in the same slot. In such cases, the reservation signal, the SA, and the data transmission may share the reserved frequency resources.

[0149] In an example, the CORESET of the reservation signal may be separate from the CORESET of the SA. In such cases, the control information transmitted within the reservation signal may include the frequency and/or time resources to be reserved. In an example, the time resources to be reserved may be determined from the time resources of the reservation signal. For example, the difference between first slot index of the reserved resources and the slot index of the reservation signal may be fixed; e.g., k slots. The cyclic redundancy check (CRC) of the reservation signal may be scrambled with a specific RNTI (e.g., reservation-RNTI). A WTRU that intends to initiate a transmission may detect and decode the reservation signals and create a map of reserved resources.

[0150] In an example, a preemption signal may be used to overwrite a previously transmitted reservation signal. For example, a first WTRU may transmit a reservation signal to allocate resources. A second WTRU may overwrite this allocation by sending a preemption signal. The second WTRU may have higher priority than the first WTRU. In an example, the preemption signal and the overwritten reservation signal may be associated with each other. The preemption signal may be transmitted on the same control channel frequency resources as the reservation signal. There may be a fixed timing relationship between the slot where the preemption signal is transmitted and the slot where the resources had been scheduled.

[0151] In an example, the preemption signal may be transmitted in a different PDCCH candidate within the same CORESET of the reservation signal, or in a different CORESET. The preemption signal may carry the time/frequency resources of the preempted resources. Preemption signals may be CRC scrambled with a separate RNTI, for example, a preemption-RNTI. In an example, both reservation and preemption signals may use the same format and RNTI. In an example, the DCI contents may indicate whether it is a reservation signal or a preemption signal (e.g., using a bit/flag). FIG. 18 shows a resource diagram of another example slot format 1800 including reservation signals 1806, 1808 and preemption signals 1810 and 1812. In this example, a first WTRU transmits a reservation signal 1806, 1808 in slot n to reserve resources for SA 1816, 1820 and data transmission starting from slot $n+k$. A second WTRU transmits a preemption signal 1810, 1812 in slot $n+m$ to overwrite the reservation of the first WTRU. The first WTRU, after receiving the preemption signal 1810, 1812, may exclude the previously reserved resources from availability. In an example, a subset of the available resources may include a preemptible attribute and it may be possible to preempt those resources. In an example, WTRUs that reserve those resources may need to decode all possible preemption signals.

[0152] In an example, pre-emptible resources may be preempted in the same slot when the SA and data transmission is planned to take place. FIG. 19 shows a resource diagram of another example slot format 1900 including a low-latency preemption scenario. In this example, a first WTRU receives at least the first OFDM symbol in a current slot. The first WTRU searches at least the first OFDM symbol for a preemption signal 1906. If the first WTRU detects a preemption signal 1906 that reserves the current slot for another WTRU, then the first WTRU aborts and does not use the current slot for transmission. If the first WTRU does not detect a preemption signal, it stops receiving and turns on its transmitter. The Rx/Tx turnaround time 1910 may take less than one OFDM symbol, one OFDM symbol, or more than one OFDM symbol. When the transmitter is turned on and ready, the first WTRU starts transmission of its own SA and/or data in the remaining part of the slot. From the perspective of the first WTRU, since the initial portion of the slot cannot be used for transmission, the first WTRU may puncture the already prepared transport block (TB) accordingly to compensate for the unusable resources.

[0153] In an example, the preemption may impact only part of the slot when the slot includes possible ACK/NACK transmission from the first WTRU. If the WTRU that has initiated the preemption has knowledge of the ACK/NACK transmission, the resources allocated for ACK/NACK transmission by the first WTRU may be skipped by the other WTRU. The information regarding whether a reserved resource would be used for ACK/NACK transmission may be part of the reservation signal. For example, a flag in the reservation signal may indicate that the reserved

resources may (e.g., partially) be used for ACK/NACK feedback. In an example, the reservation signal may indicate the OFDM symbols allocated for the ACK/NACK feedback. In such cases, the WTRU that preempts the reservation may permit the reserving WTRU to transmit the feedback information.

[0154] Although the features and elements of the present invention are described in the preferred embodiments in particular combinations, each feature or element can be used alone without the other features and elements of the preferred embodiments or in various combinations with or without other features and elements of the present invention.

[0155] Although the solutions described herein consider LTE, LTE-A, New Radio (NR) or 5G specific protocols, it is understood that the solutions described herein are not restricted to this scenario and are applicable to other wireless systems as well.

[0156] 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.

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CLAIMS

What is Claimed is:

1. A first wireless transmit/receive unit (WTRU) comprising:
 - a receiver configured to monitor, in a first time slot, a first frequency resource comprising a first plurality of resource blocks (RBs) and having a first frequency range, for signals from a second WTRU, wherein the first frequency resource is associated with a physical sidelink shared channel (PSSCH) of the second WTRU;
 - a processor configured to determine a feedback frequency resource based on at least one of the first frequency range, a number of RBs in the first plurality of RBs, or an identity of the first WTRU; and
 - a transmitter configured to transmit, in a second time slot, to the second WTRU, feedback information using the feedback frequency resource.
2. The first WTRU of claim 1, wherein the feedback frequency resource is a hybrid automatic repeat request (HARQ) frequency resource, and the feedback transmitted using the feedback frequency resource is HARQ feedback.
3. The first WTRU of claim 1, wherein the feedback frequency resource comprises at least a subset of the first plurality of RBs.
4. The first WTRU of claim 1, wherein the feedback frequency resource is in the first frequency range.
5. The first WTRU of claim 1, wherein a second frequency range is within the first frequency range and associated with a physical sidelink control channel (PSCCH) of the second WTRU, and the feedback frequency resource is in the second frequency range.
6. The first WTRU of claim 1, wherein the feedback frequency resource is associated with a physical sidelink feedback channel (PSFCH) of the first WTRU.
7. The first WTRU of claim 1, wherein the feedback information is one of: hybrid automatic repeat request (HARQ) feedback information; ACK/NACK information; or channel state information (CSI).
8. The first WTRU of claim 1, wherein the first frequency range includes a plurality of subcarriers in the first time slot and the plurality of subcarriers in the second time slot.
9. The first WTRU of claim 1, wherein the first frequency range includes a plurality of OFDM symbols in the first time slot and the plurality of OFDM symbols in the second time slot.
10. The first WTRU of claim 1 configured for vehicle-to-everything (V2X) communications.
11. A method performed by a first wireless transmit/receive unit (WTRU), the method comprising:

monitoring, in a first time slot, a first frequency resource comprising a first plurality of resource blocks (RBs) and having a first frequency range, for signals from a second WTRU, wherein the first frequency resource is associated with a physical sidelink shared channel (PSSCH) of the second WTRU;

determining a feedback frequency resource based on at least one of the first frequency range, a number of RBs in the first plurality of RBs, or an identity of the first WTRU; and

transmitting, in a second time slot, to the second WTRU, feedback information using the feedback frequency resource.

12. The method of claim 11, wherein the feedback frequency resource is a hybrid automatic repeat request (HARQ) frequency resource, and the feedback transmitted using the feedback frequency resource is HARQ feedback.

13. The method of claim 11, wherein the feedback frequency resource comprises at least a subset of the first plurality of RBs.

14. The method of claim 11, wherein the feedback frequency resource is in the first frequency range.

15. The method of claim 11, wherein a second frequency range is within the first frequency range and associated with a physical sidelink control channel (PSCCH) of the second WTRU, and the feedback frequency resource is in the second frequency range.

16. The method of claim 11, wherein the feedback frequency resource is associated with a physical sidelink feedback channel (PSFCH) of the first WTRU.

17. The method of claim 11, wherein the feedback information is one of: hybrid automatic repeat request (HARQ) feedback information; ACK/NACK information; or channel state information (CSI).

18. The method of claim 11, wherein the first frequency range includes a plurality of subcarriers in the first time slot and the plurality of subcarriers in the second time slot.

19. The method of claim 11, wherein the first frequency range includes a plurality of OFDM symbols in the first time slot and the plurality of OFDM symbols in the second time slot.

20. The method of claim 11, wherein the first WTRU is configured for vehicle-to-everything (V2X) communications.

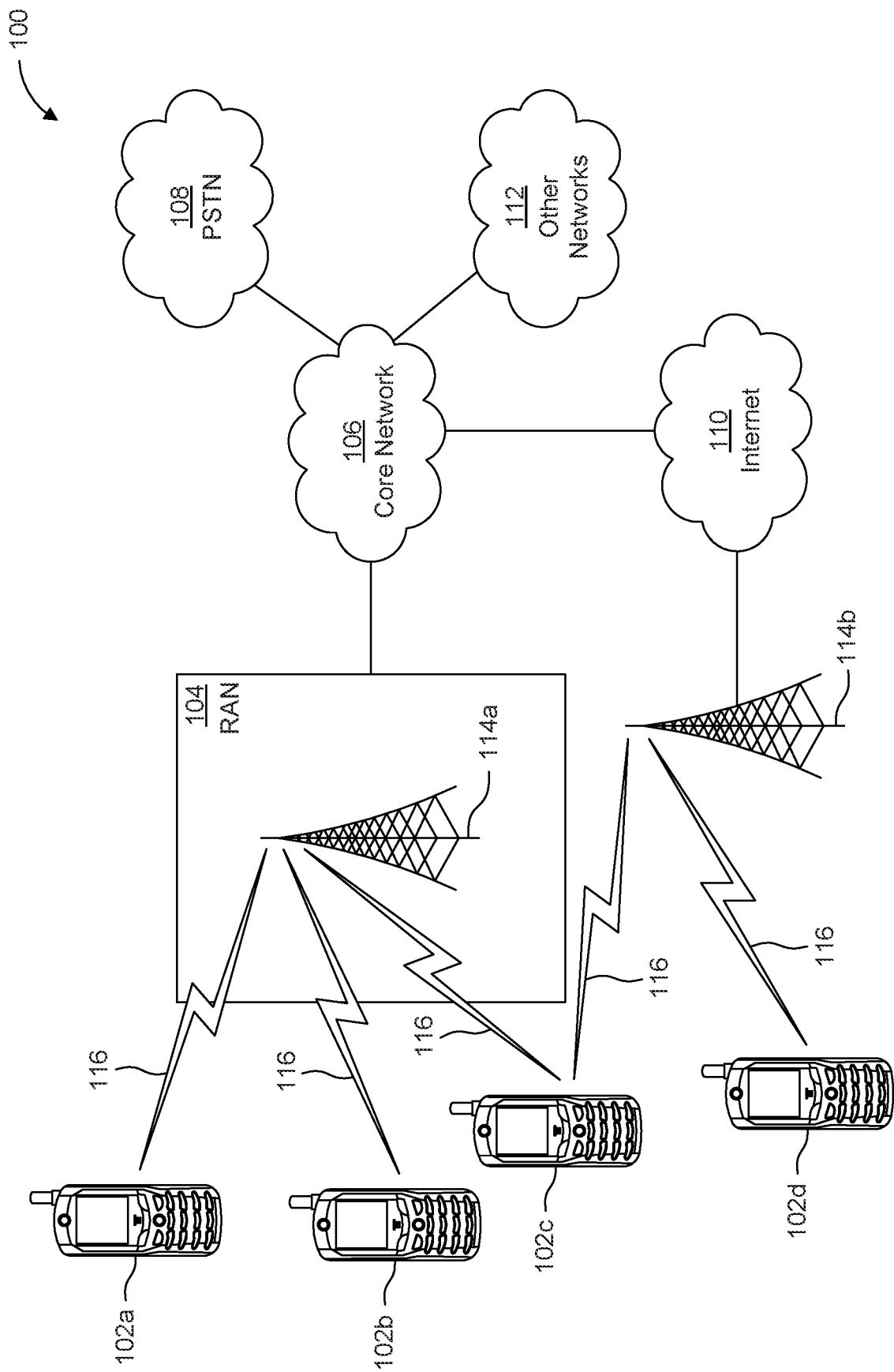


FIG. 1A

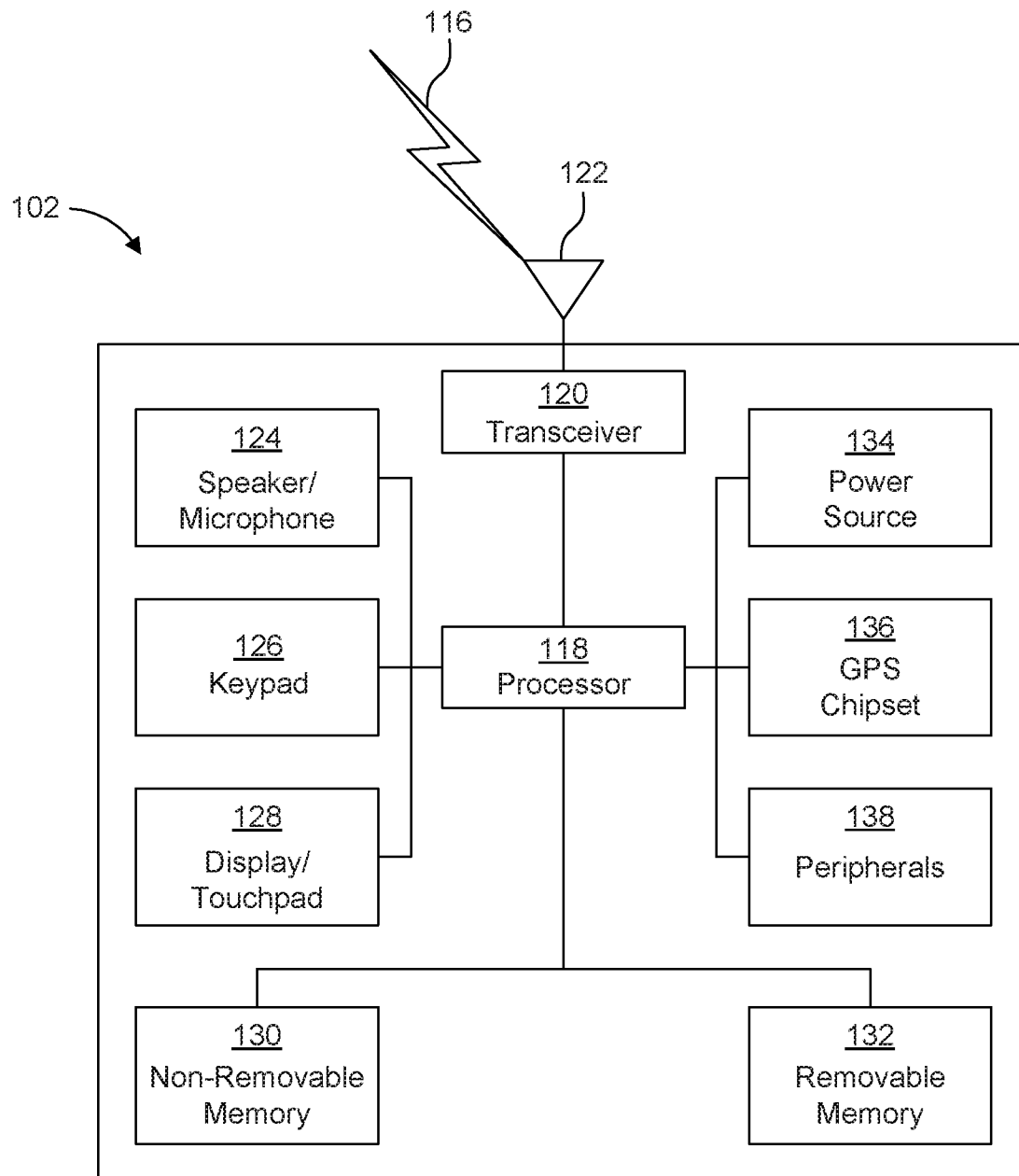


FIG. 1B

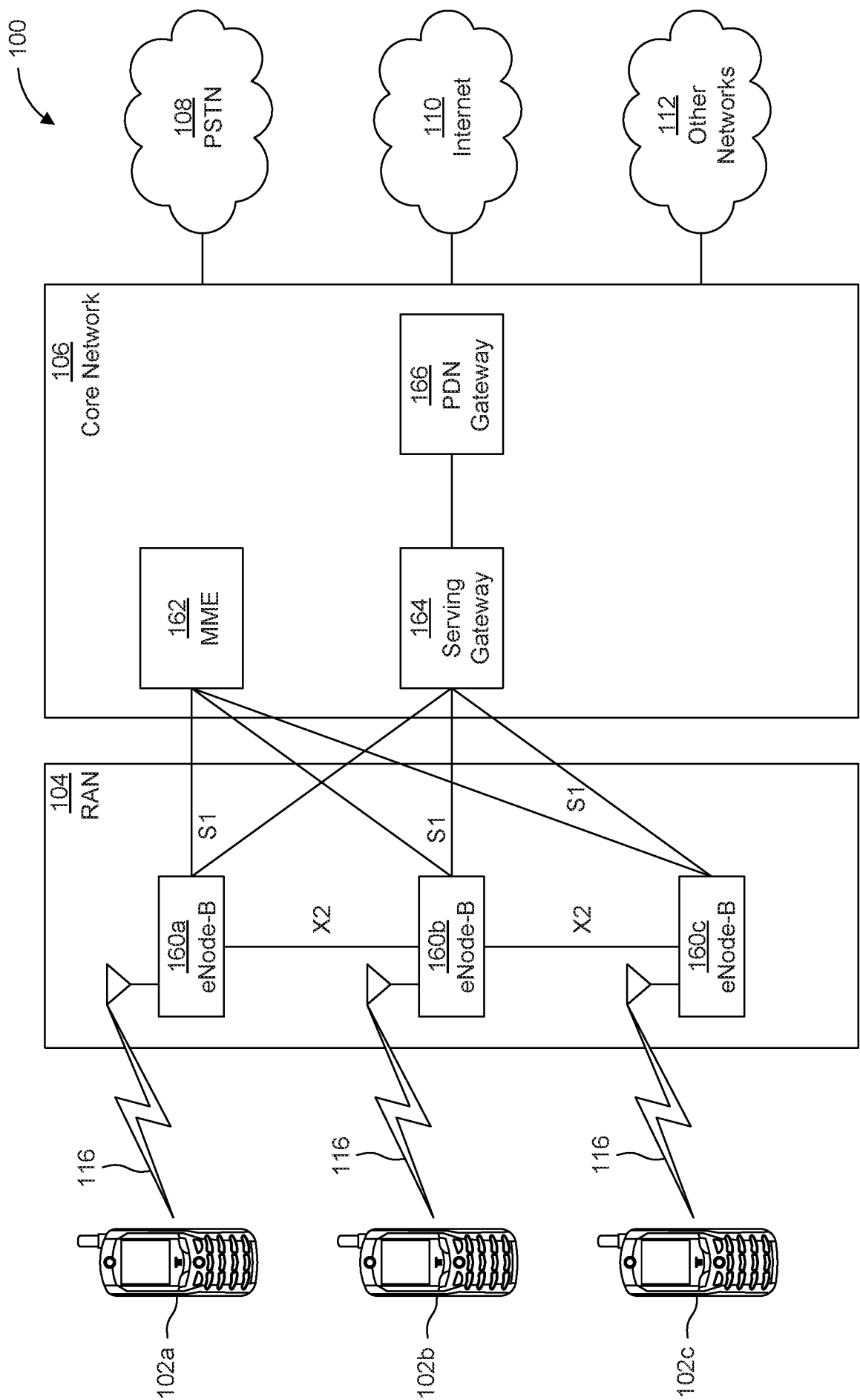


FIG. 1C

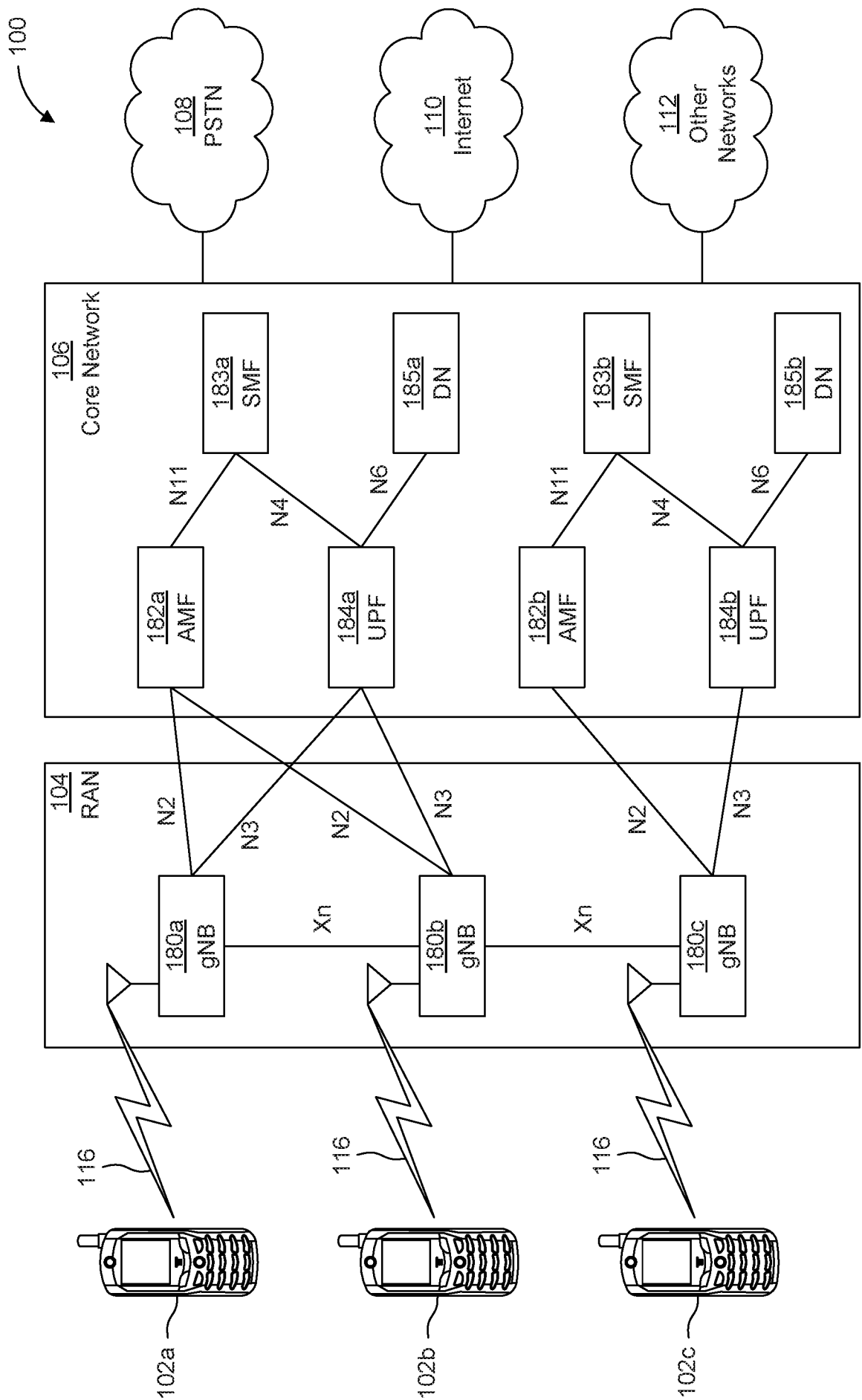


FIG. 1D

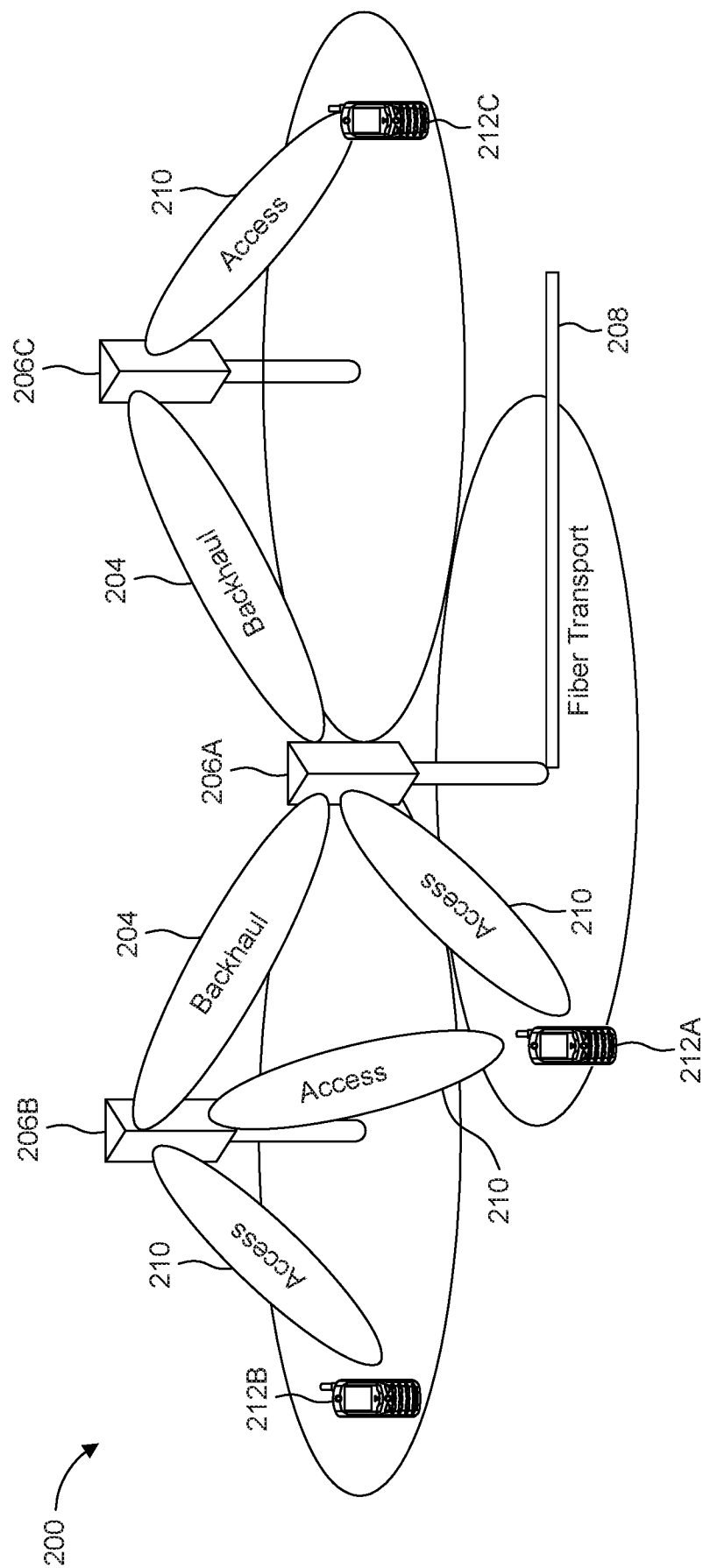


FIG. 2

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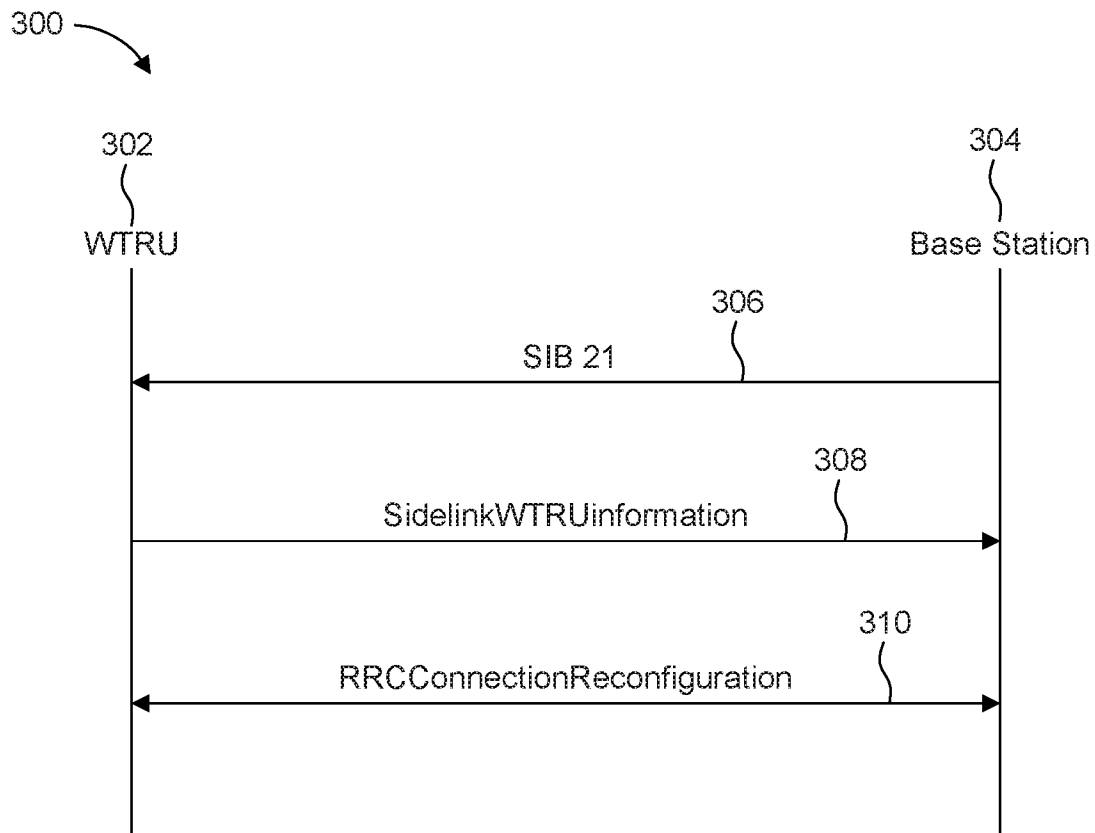


FIG. 3

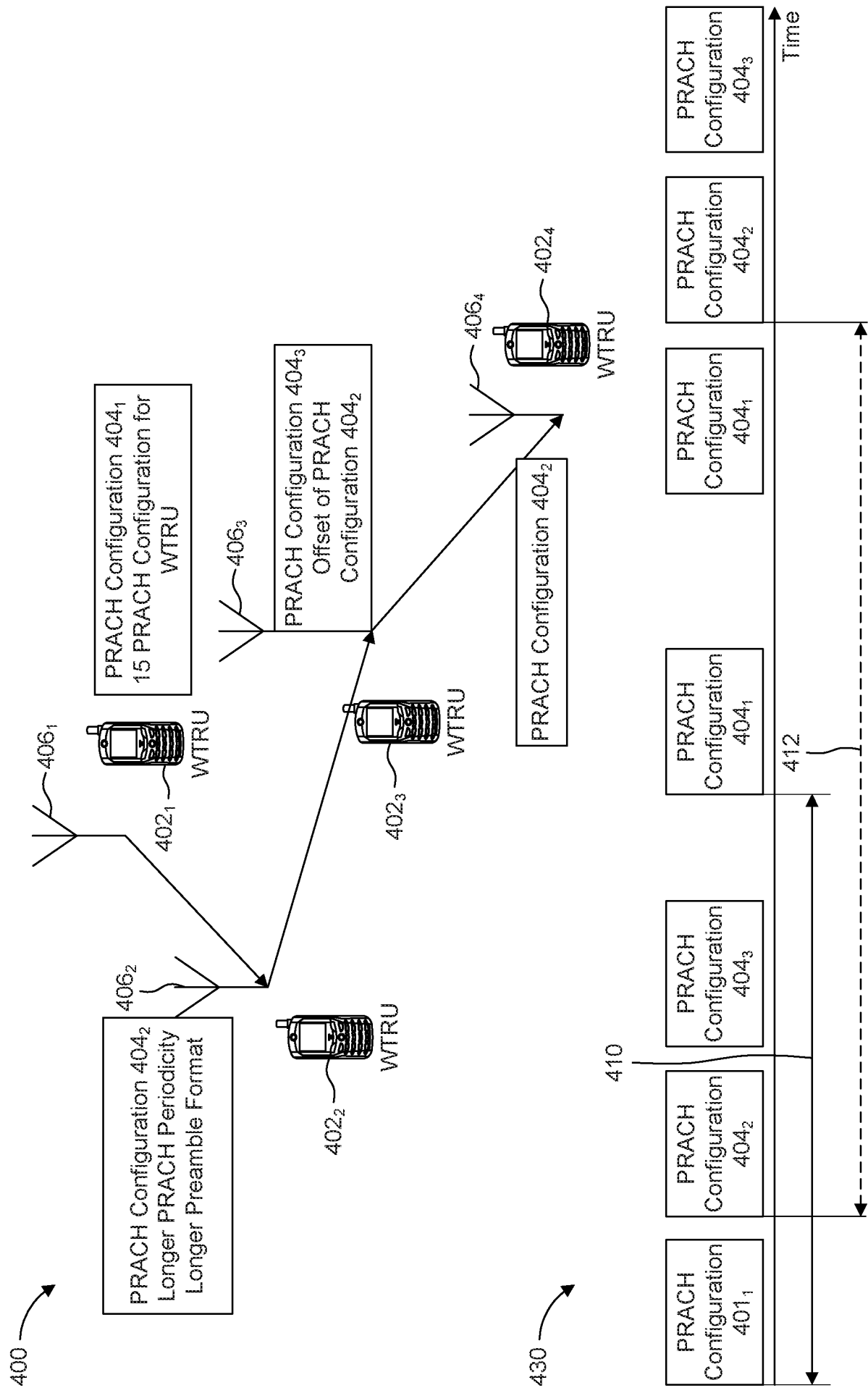
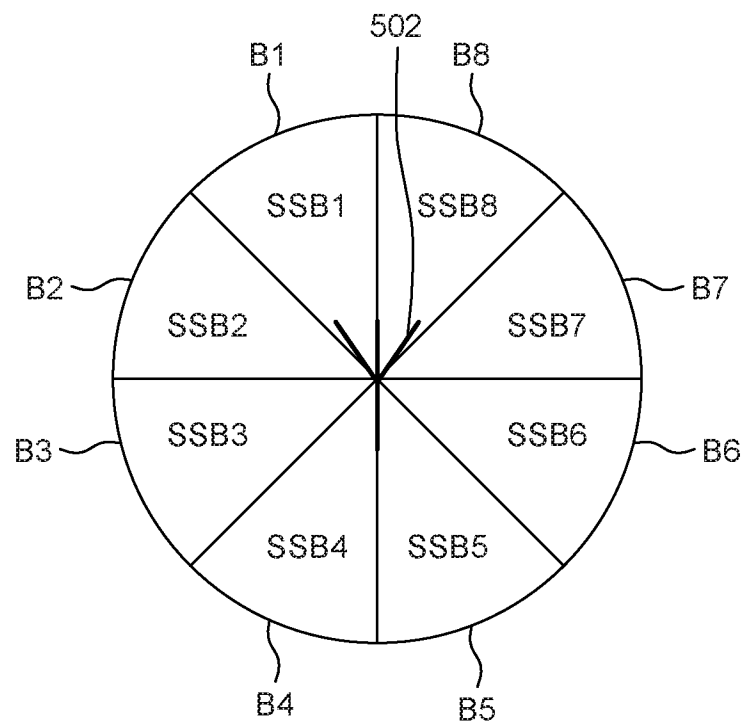


FIG. 4

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500


504

FIG. 5

600 

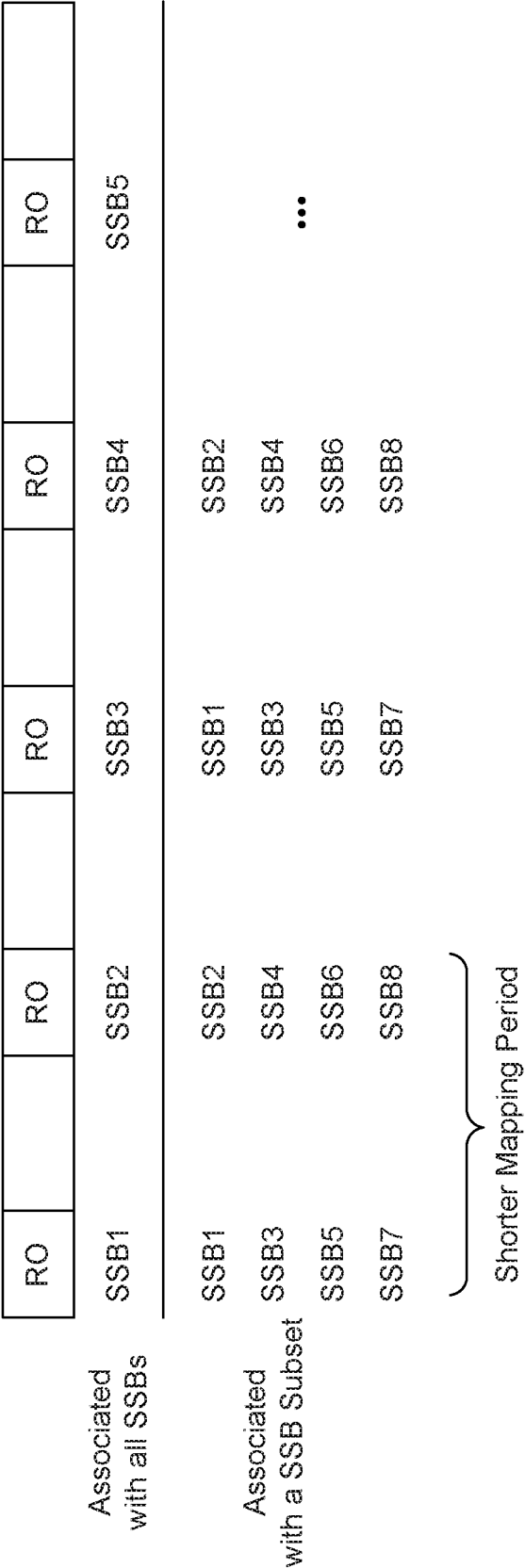


FIG. 6

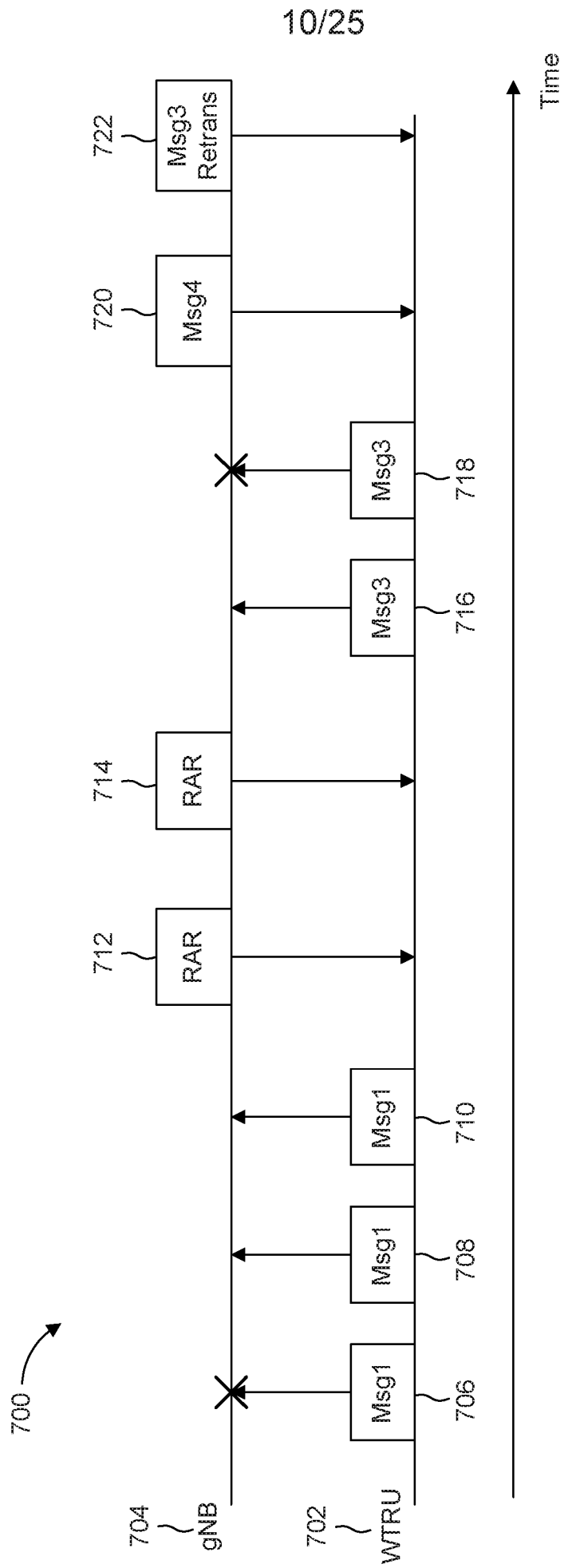


FIG. 7

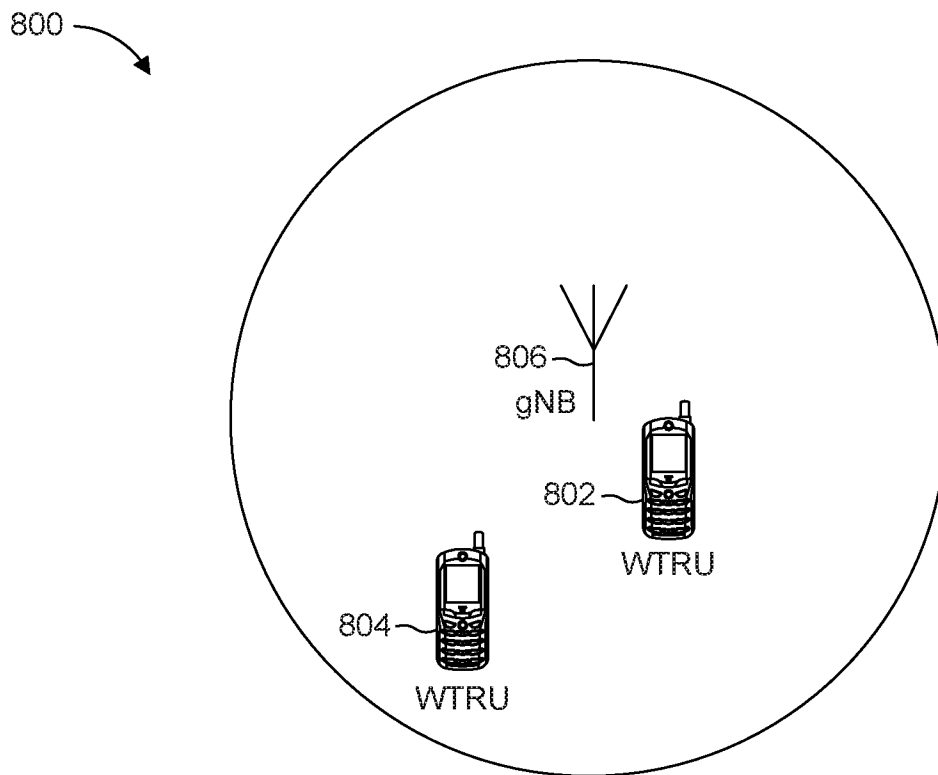


FIG. 8A

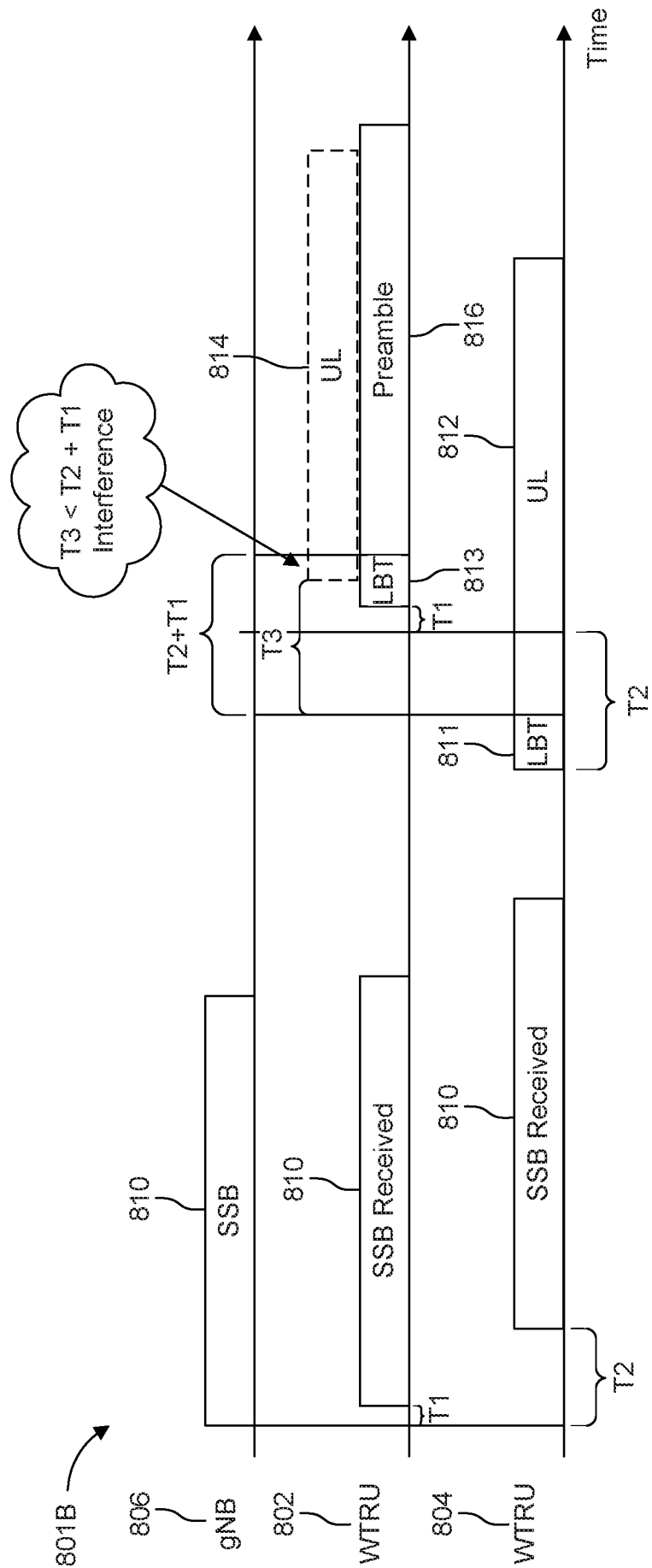


FIG. 8B

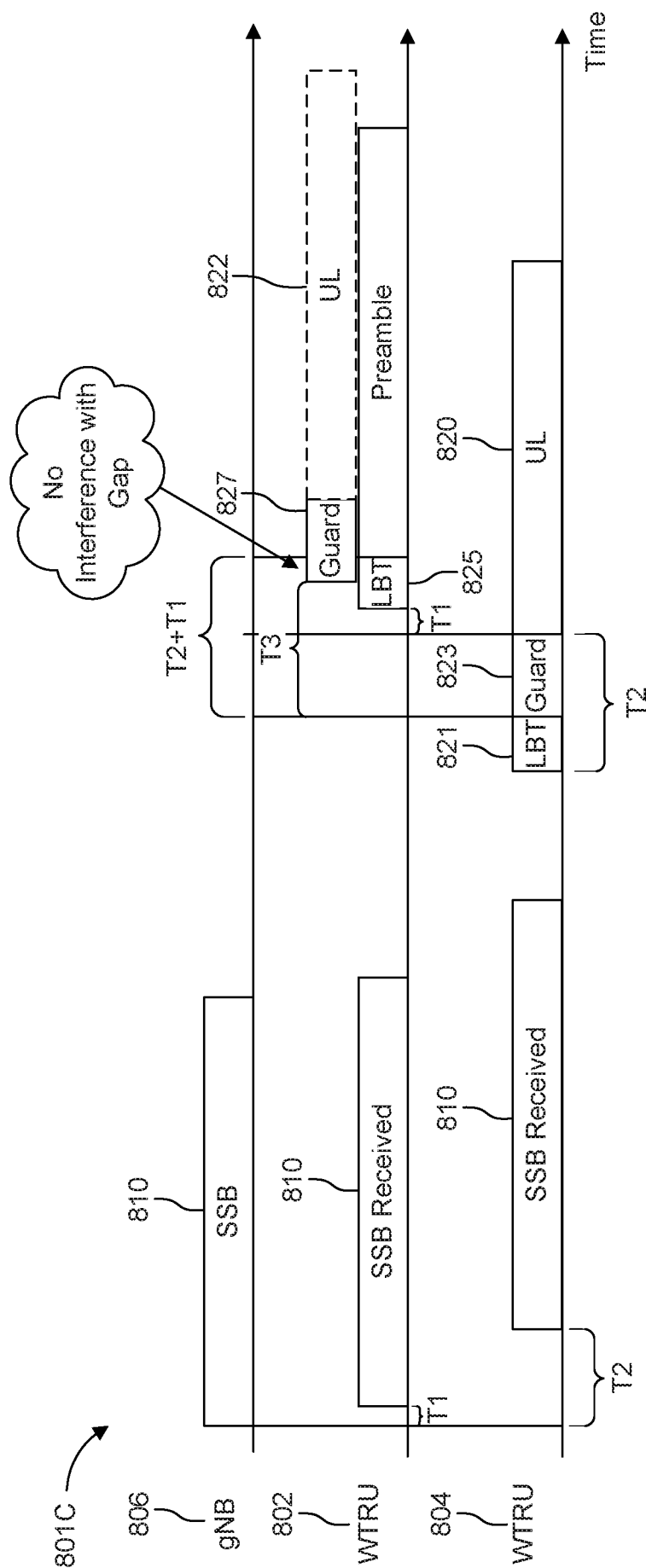


FIG. 8C

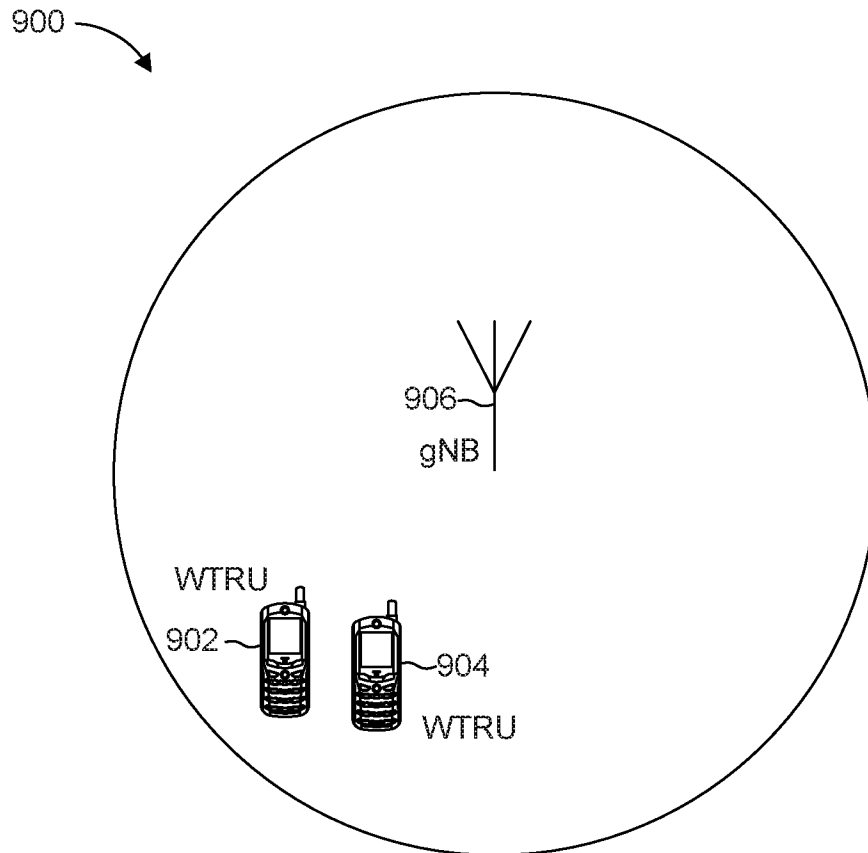


FIG. 9A

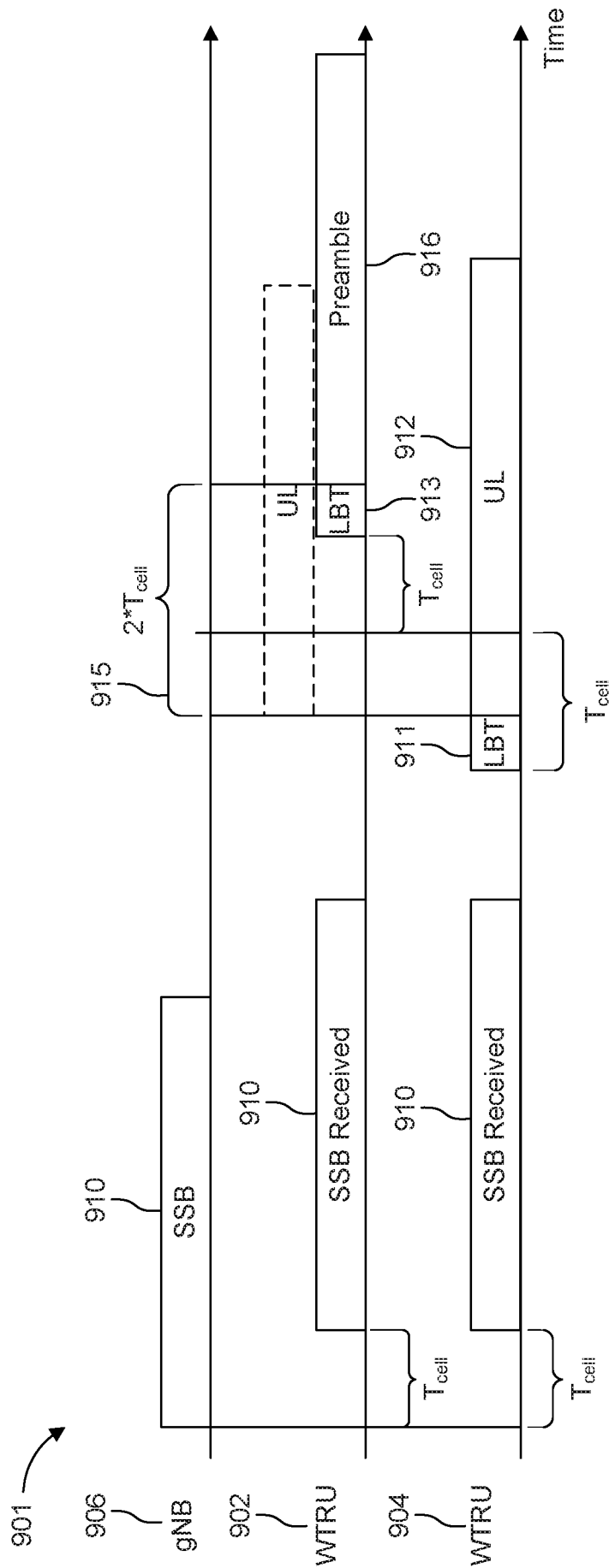


FIG. 9B

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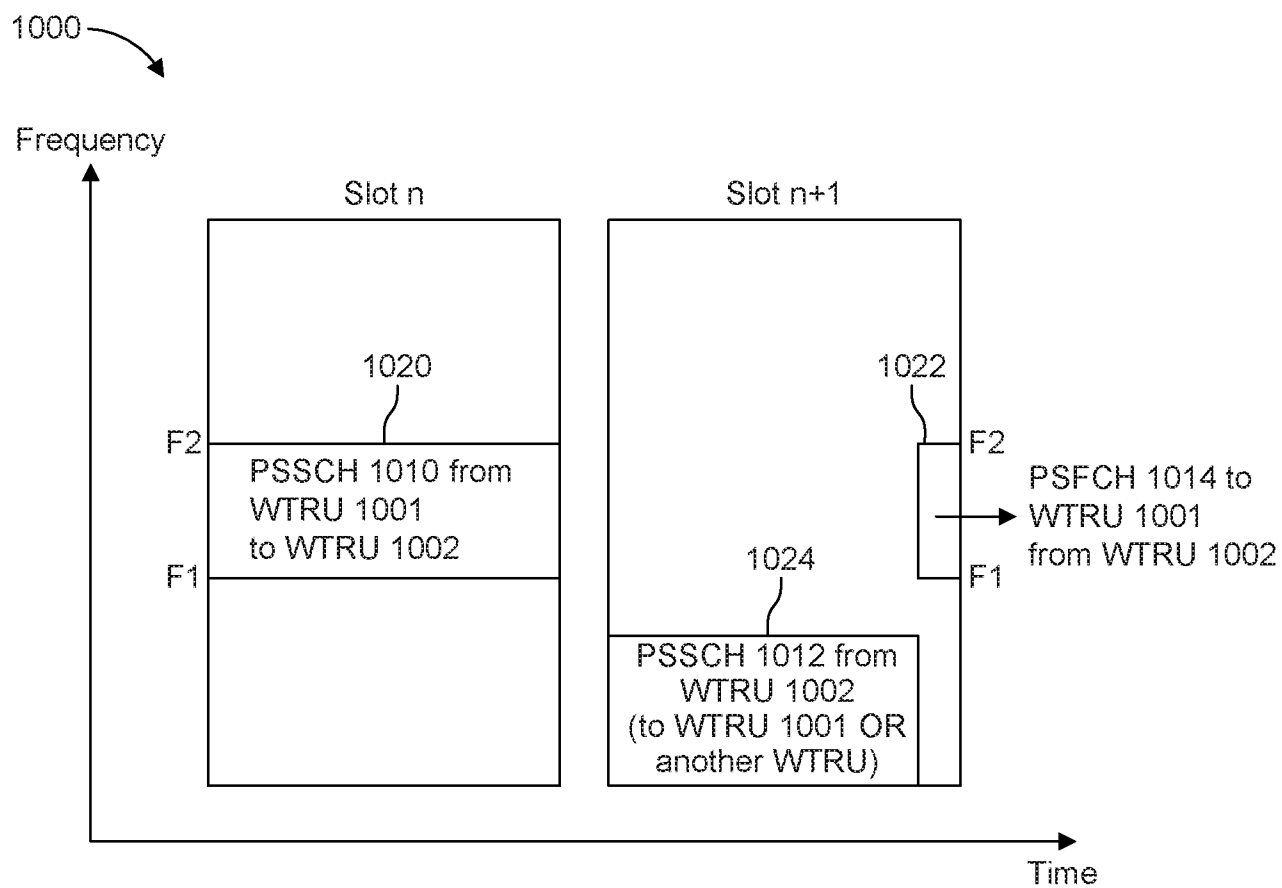


FIG. 10

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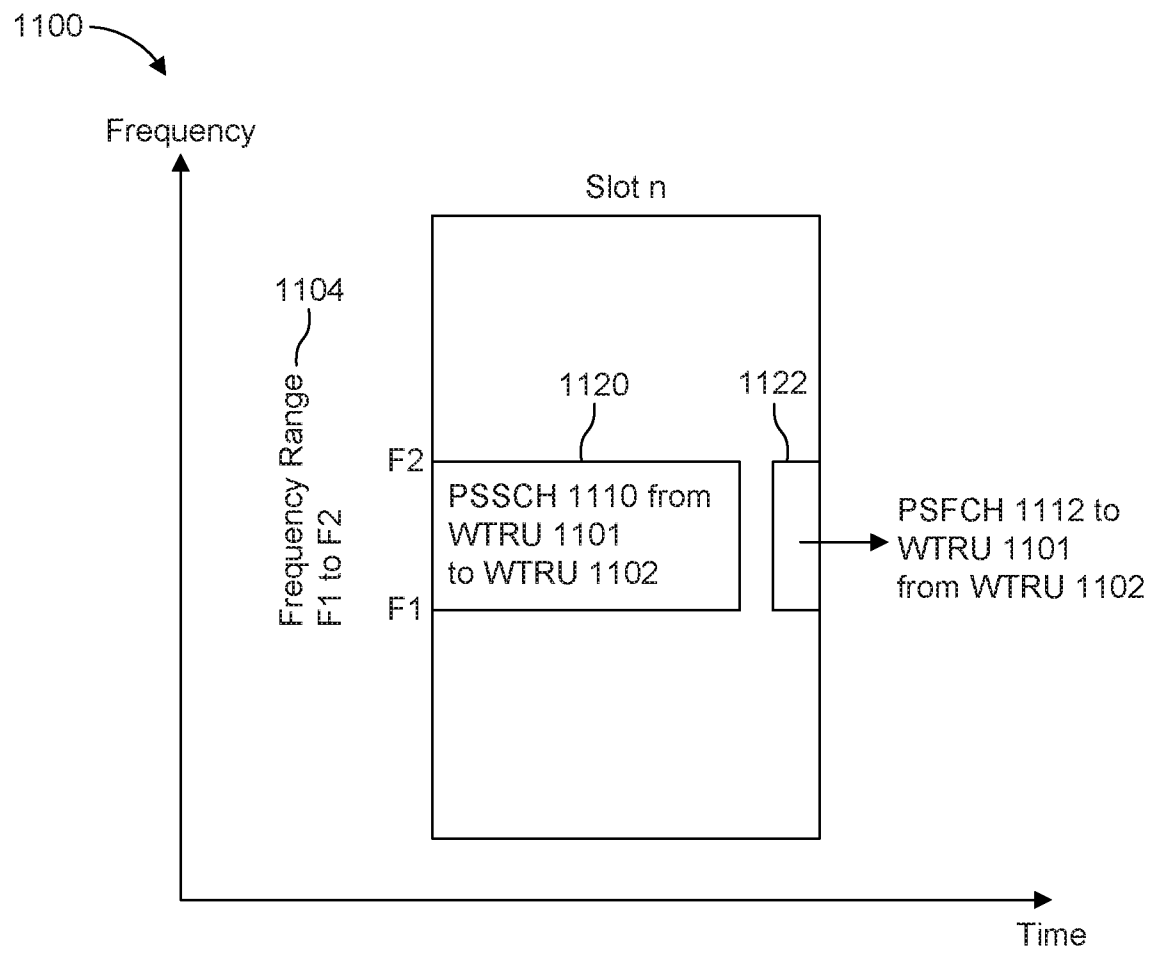


FIG. 11

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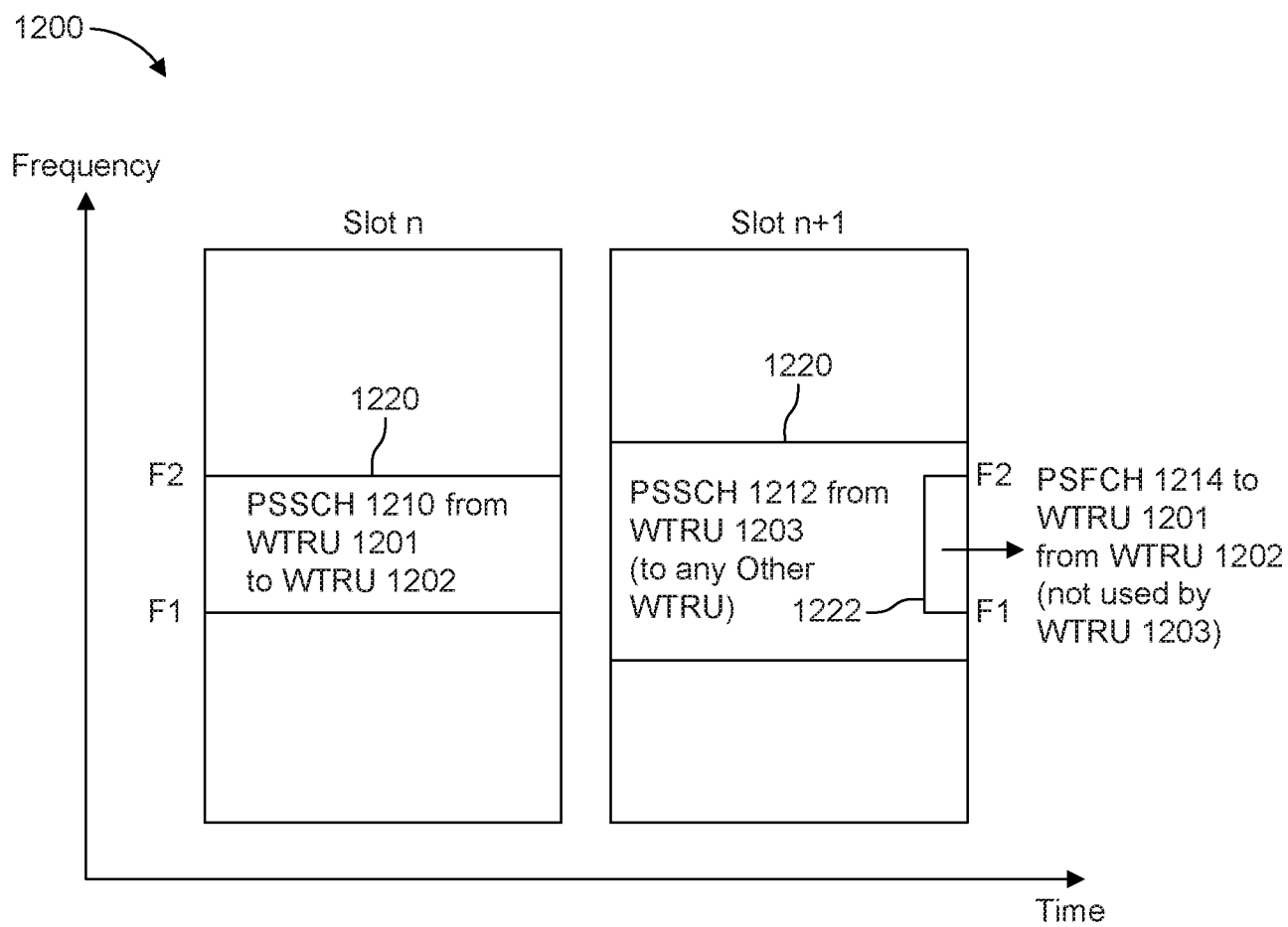


FIG. 12

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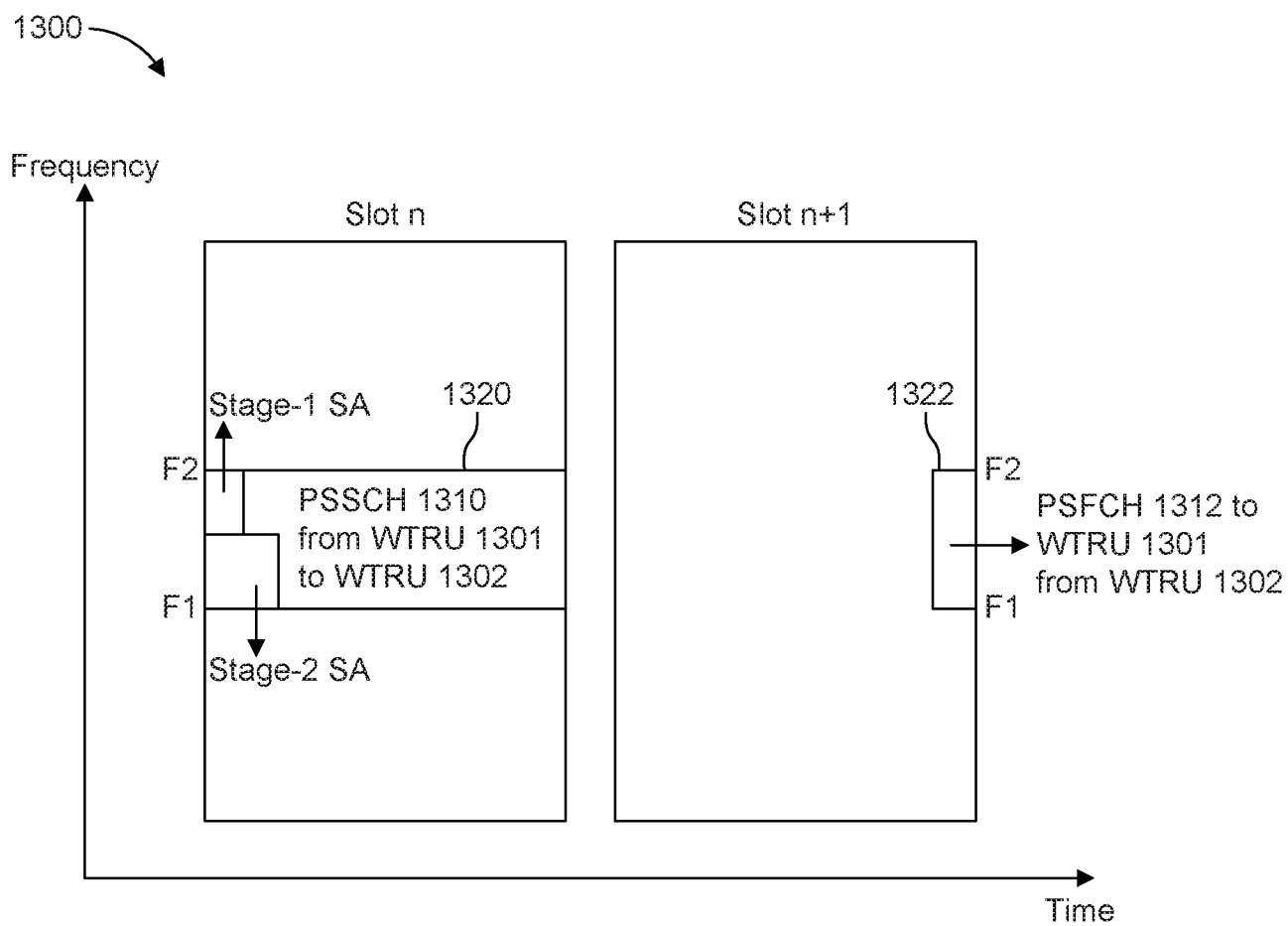


FIG. 13

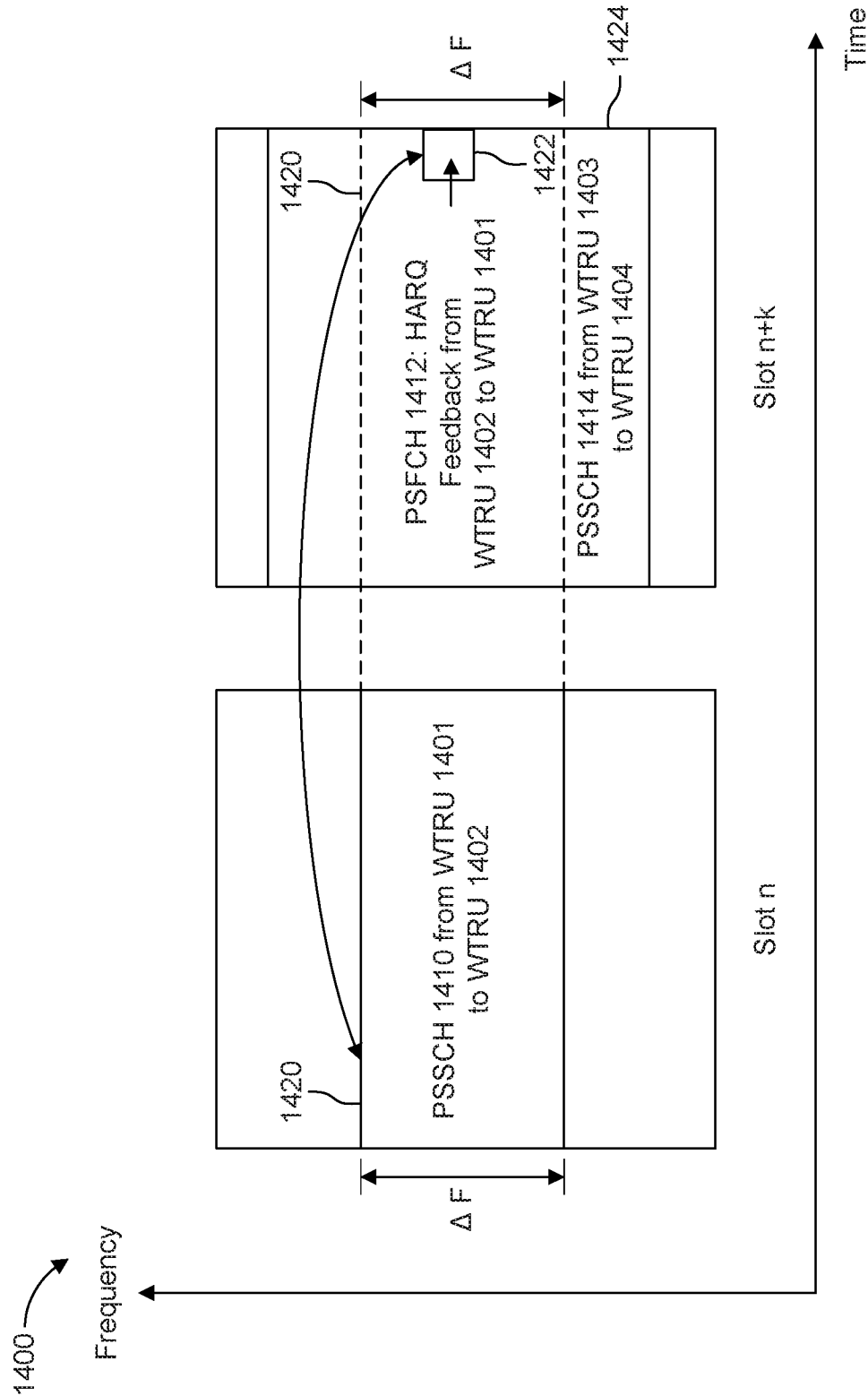


FIG. 14

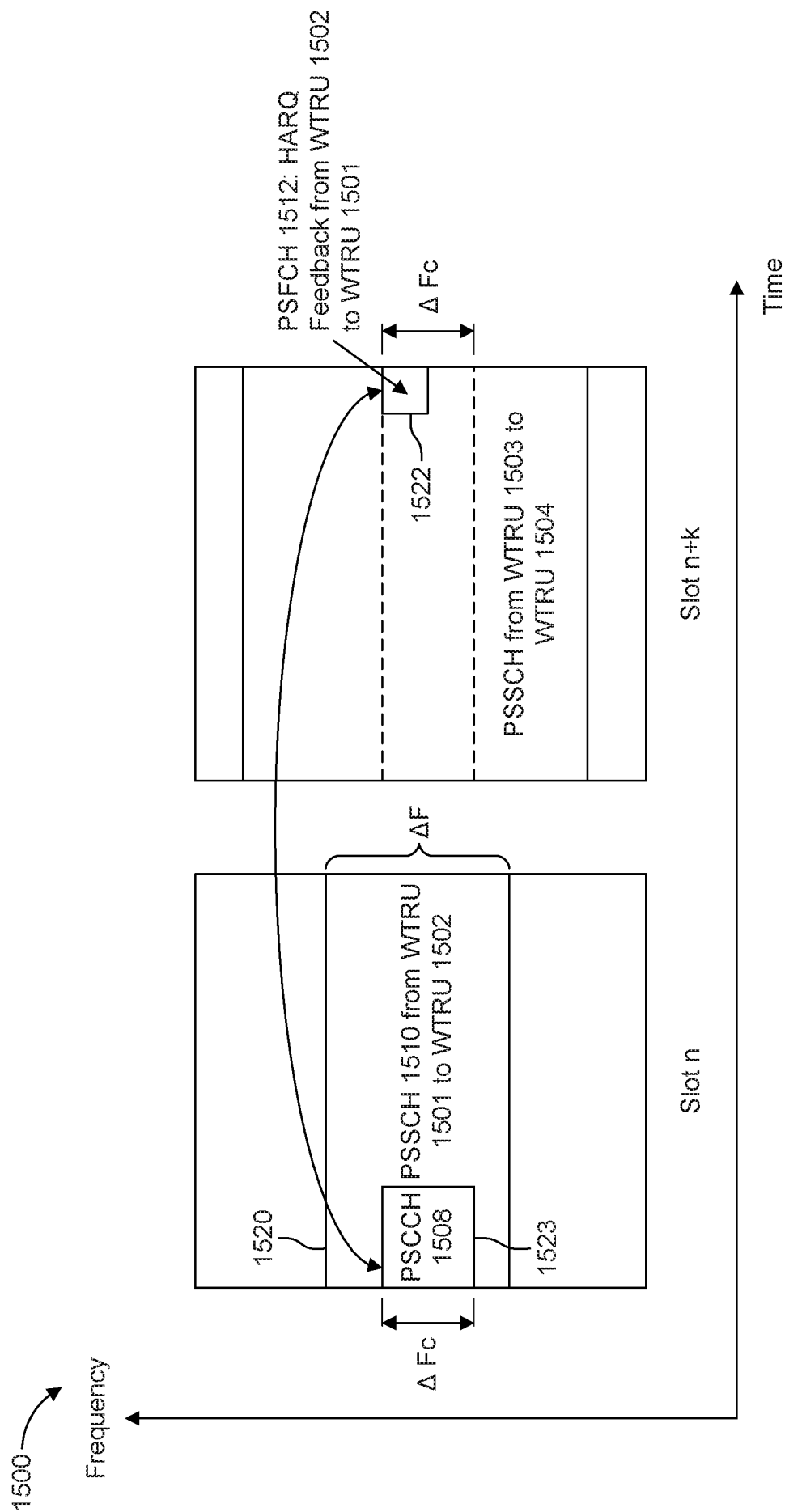


FIG. 15

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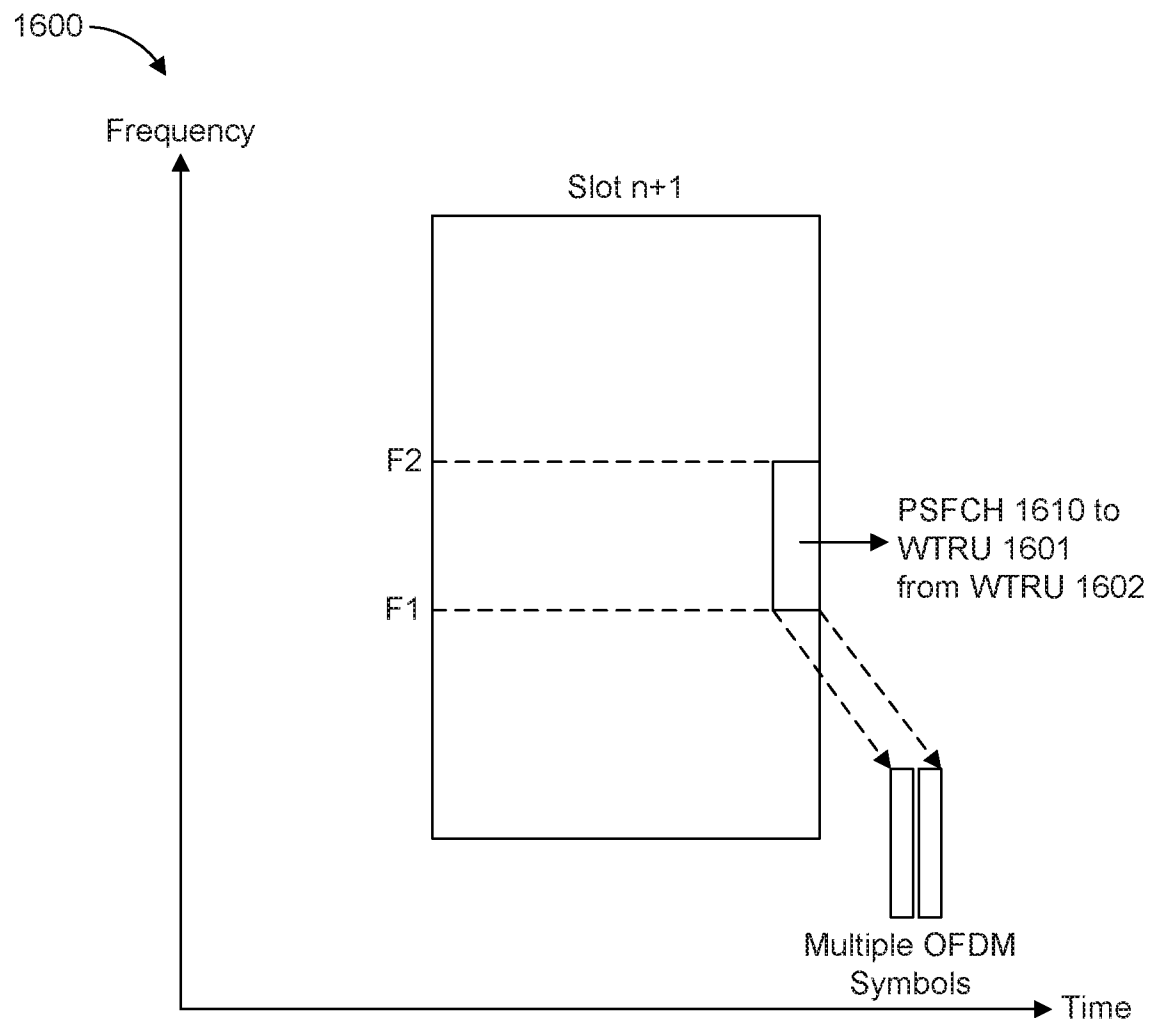


FIG. 16

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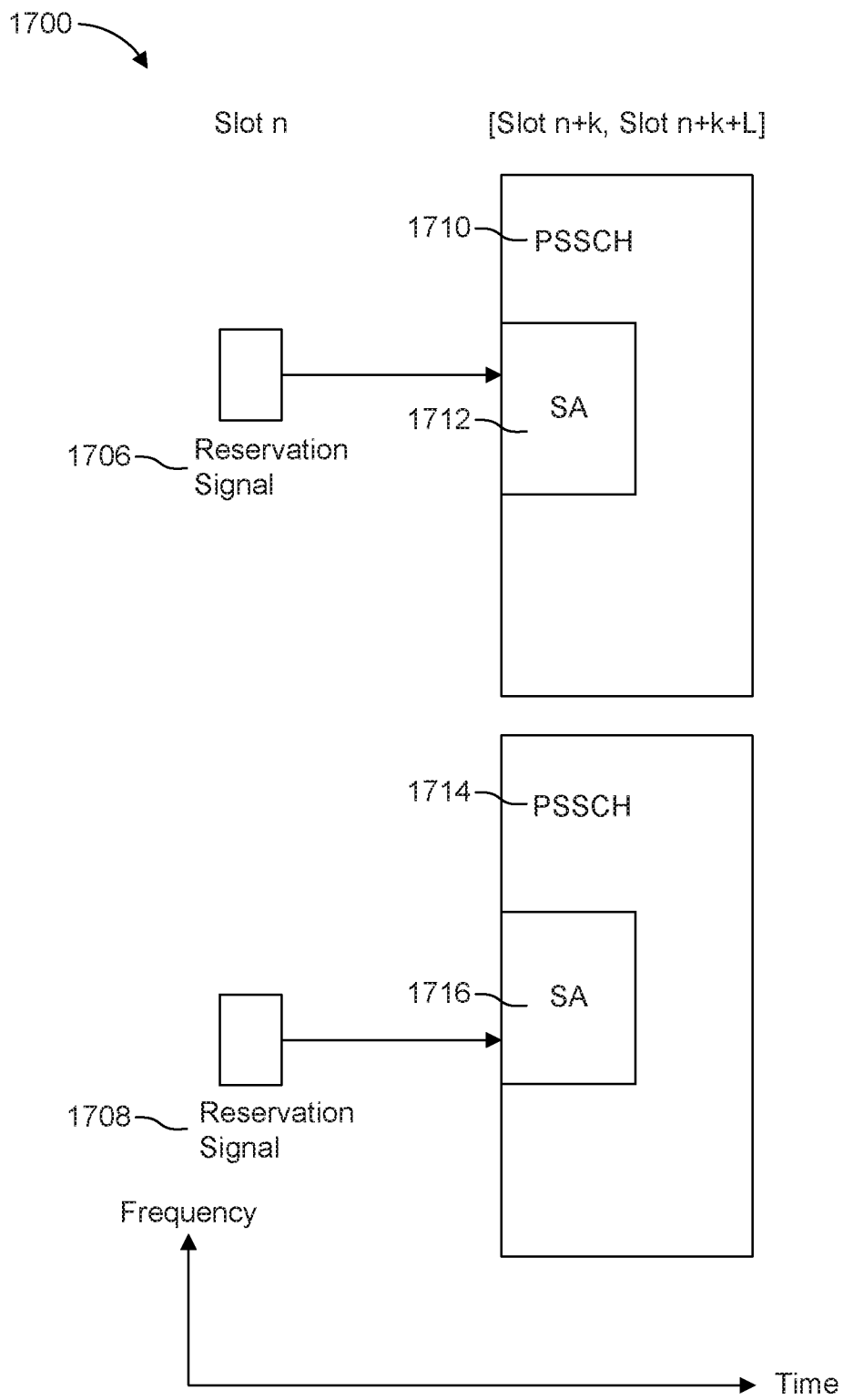


FIG. 17

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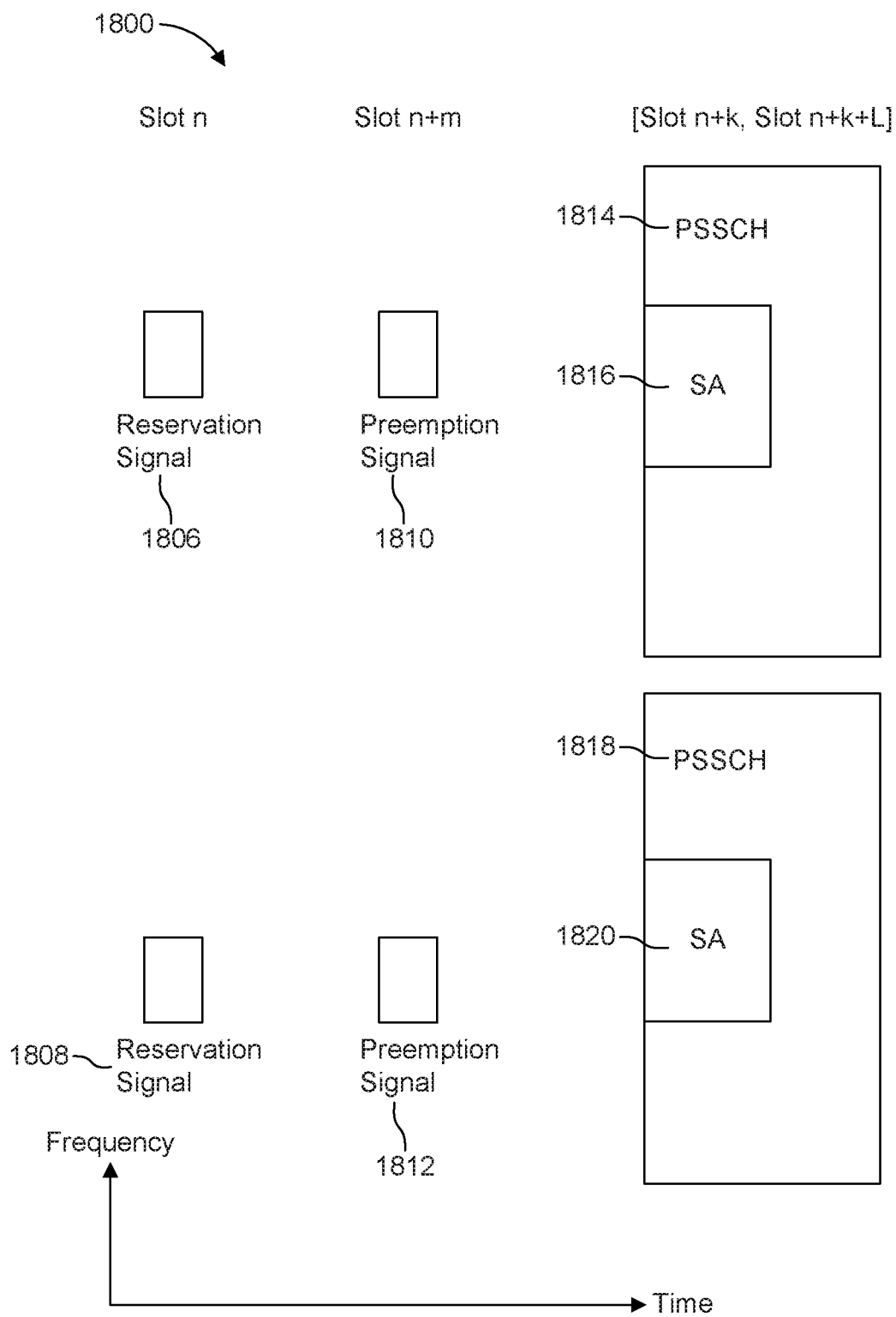


FIG. 18

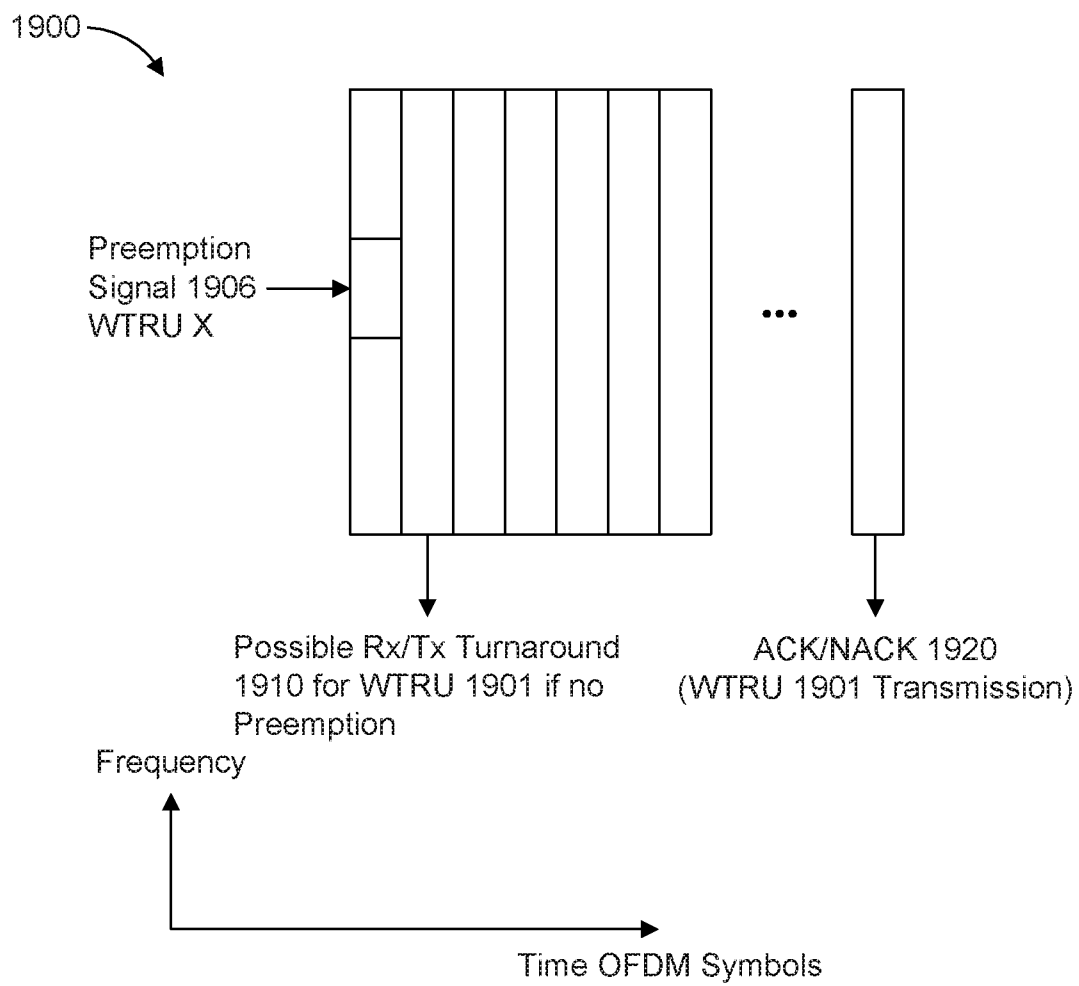


FIG. 19

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/061262

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00
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)
H04L

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HUAWEI ET AL: "Design and contents of PSCCH and PSFCH", 3GPP DRAFT; R1-1813554, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Spokane, USA; 20181112 - 20181116 11 November 2018 (2018-11-11), XP051555609, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings%5F3GP P%5FSYNC/RAN1/Docs/R1%2D1813554%2Ezip [retrieved on 2018-11-11] sections 1-3 ----- -/--	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

27 February 2020

Date of mailing of the international search report

12/03/2020

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

Reilly, Declan

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/061262

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	QUALCOMM INCORPORATED: "Considerations on Physical Layer aspects of NR V2X", 3GPP DRAFT; R1-1813421 CONSIDERATIONS ON PHYSICAL LAYER ASPECTS OF NR V2X, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX, France vol. RAN WG1, no. Spokane, USA; 20181112 - 20181116 11 November 2018 (2018-11-11), XP051555460, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings%5F3GPP%5FSYNC/RAN1/Docs/R1%2D1813421%2Ezip [retrieved on 2018-11-11] Sections 2, 4, 5 -----	1-20