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62/743,301 09 October 2018 (09.10.2018) US(71) Applicant: **IDAC HOLDINGS, INC.**, [US/US]; 200 Bellevue Parkway, Suite 300, Wilmington, DE 19809 (US).(72) Inventors: **XI, Fengjun**; 10838 Aderman Avenue, Apartment 144, San Diego, CA 92126 (US). **PAN, Kyle, Junglin**; 9 Country Wodds Drive, Saint James, NY 11780 (US).(74) Agent: **SCHANBACHER, Stuart, A.** et al.; Condo Roccia Koptiw Llp, 1800 Jfk Boulevard, Suite 1700, Philadelphia, PA 19103 (US).(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,

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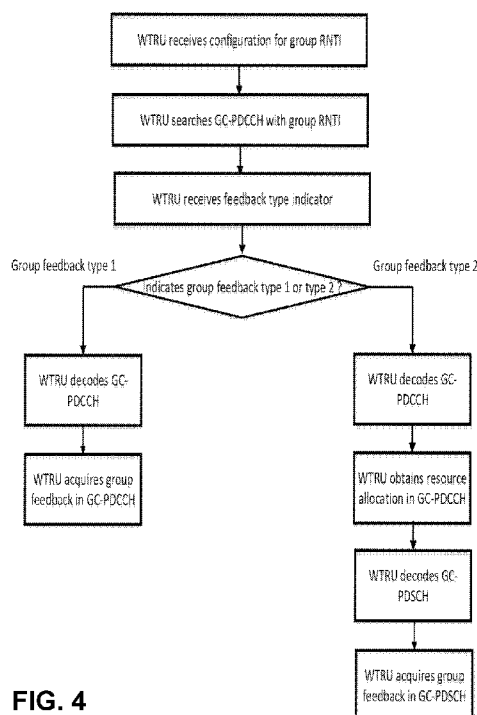


FIG. 4

(57) **Abstract:** A wireless transmit receive unit (WTRU) may receive a group feedback configuration. The group feedback configuration may comprise a group RNTI. The WTRU may receive a first group common physical downlink control channel (GC-PDCCH) transmission, which may include the GFTI. The WTRU may obtain the group feedback based on the GFTI. If the GFTI is type 1, the group feedback may be obtained from (e.g., directly from) a second GC-PDCCH transmission. If the GFTI is type 2, the second GC-PDCCH transmission may include a resource allocation, and the resource allocation may be associated with a group common physical downlink shared channel (GC-PDSCH) transmission. If the GFTI is type 2, the second GC-PDCCH transmission may include scheduling information that is associated with the GC-PDSCH transmission. The WTRU may receive the GC-PDSCH transmission (e.g., using the resource allocation and/or the scheduling information) and obtain the group feedback via the GC-PDSCH transmission.



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## EFFICIENT INDICATION AND FEEDBACK ASSOCIATED WITH NOMA

### CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims priority from: U.S. Provisional Patent Application No. 62/743,301, filed October 9, 2018, which is incorporated by reference herein in its entirety.

### BACKGROUND

**[0002]** Use cases for emerging wireless communication systems may include Enhanced Mobile Broadband (eMBB), Massive Machine Type Communications (mMTC) and/or 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/or higher reliability. A wide range of spectrum bands (e.g., ranging from 700 MHz to 80 GHz) may be considered for a variety of deployment scenarios.

**[0003]** As a carrier's frequency increases, the path loss may become a limitation, e.g., to provide a sufficient coverage area. Transmissions in millimeter wave systems may (e.g., additionally) suffer from non-line-of-sight losses, e.g., diffraction loss, penetration loss, oxygen absorption loss, foliage loss, etc. During initial access, the base station and WTRU may strive to overcome path losses and discover each other. Utilizing many antenna elements to generate a beam formed signal may be a way to compensate for the path loss, e.g., by providing significant beam forming gain. For example, beamforming techniques may include digital, analogue and hybrid beamforming.

### SUMMARY

**[0004]** A wireless transmit receive unit (WTRU) may be configured to obtain group feedback based on a group feedback type indicator (GFTI). The WTRU may receive a group feedback configuration. In examples, the group feedback configuration may comprise a group RNTI. The WTRU may receive a first group common physical downlink control channel (GC-PDCCH) transmission, which may include the GFTI, and the WTRU may obtain group feedback based on the GFTI. If the GFTI is type 1, the group feedback may be obtained from (e.g., directly from) a second GC-PDCCH transmission. In examples, the second GC-PDCCH transmission and the first GC-PDCCH transmission may be received in a single GC-PDCCH transmission (e.g., the first GC-PDCCH transmission is associated with a first control field and the second

GC-PDCCH transmission is associated with a second control field). If the GFTI is type 2, the second GC-PDCCH transmission may include a resource allocation, and the resource allocation may be associated with a group common physical downlink shared channel (GC-PDSCH) transmission. If the GFTI is type 2, the second GC-PDCCH transmission may include scheduling information that is associated with the GC-PDSCH transmission. The WTRU may receive the GC-PDSCH transmission (e.g., using the resource allocation and/or the scheduling information) and obtain the group feedback via the GC-PDSCH transmission. The WTRU may extract feedback for the WTRU from the group feedback based on an index associated with the WTRU. In examples, the feedback for the WTRU may comprise hybrid automatic repeat request (HARQ) feedback.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[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 illustrates an example block diagram of a transmitter for code-domain based non-orthogonal multiple access (NOMA);

**[0010]** FIG. 3 illustrates an example associated with group feedback;

**[0011]** FIG. 4 illustrates an example associated with group feedback;

**[0012]** FIG. 5 illustrates an example associated with hybrid automatic repeat request (HARQ) group feedback;

**[0013]** FIG. 6 illustrates an example associated with group HARQ feedback;

**[0014]** FIG. 7 illustrates an example associated with group indications;

**[0015]** FIG. 8 illustrates an example associated with group indications;

**[0016]** FIG. 9 illustrates an example associated with group indications;

**[0017]** FIG. 10 illustrates an example associated with group indications;

**[0018]** FIG. 11 illustrates an example associated with group indications;

**[0019]** FIG. 12 illustrates an example associated with group indications using demodulation reference signals (DMRS);

**[0020]** FIG. 13 illustrates an example associated with group indications using multiple access signatures (MAS);

**[0021]** FIG. 14 illustrates an example associated with HARQ type based group indications; and

**[0022]** FIG. 15 illustrates an example of MAS/DMRS associated with a transmission or retransmission index.

## DETAILED DESCRIPTION

**[0023]** A detailed description, including illustrative examples, will now be described, e.g., with reference to the various figures. Although this description may provide detailed examples of possible implementations, it should be noted that the details are intended as illustrative and in no way limit the scope of the application.

**[0024]** FIG. 1A is a diagram illustrating an example communications system 100 in which one or more disclosed embodiments may be implemented. The communications system 100 may be a multiple access system that provides content, such as voice, data, video, messaging, broadcast, etc., to multiple wireless users. The communications system 100 may enable multiple wireless users to access such content through the sharing of system resources, including wireless bandwidth. For example, the communications systems 100 may employ one or more channel access methods, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), zero-tail unique-word DFT-Spread OFDM (ZT UW DTS-s OFDM), unique word OFDM (UW-OFDM), resource block-filtered OFDM, filter bank multicarrier (FBMC), and the like.

**[0025]** As shown in FIG. 1A, the communications system 100 may include wireless transmit/receive units (WTRUs) 102a, 102b, 102c, 102d, a RAN 104/113, a CN 106/115, a public switched telephone network (PSTN) 108, the Internet 110, and other networks 112, though it will be appreciated that the disclosed embodiments contemplate any number of WTRUs, base stations, networks, and/or network elements. Each of the WTRUs 102a, 102b, 102c, 102d may be any type of device configured to operate and/or communicate in a wireless environment. By way of example, the WTRUs 102a, 102b, 102c, 102d, any of which may be referred to as a “station” and/or a “STA”, may be configured to transmit and/or receive wireless signals and may include a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a subscription-based unit, a pager, a cellular telephone, a personal digital assistant (PDA), a smartphone, a laptop, a netbook, a personal computer, a wireless sensor, a hotspot or Mi-Fi device, an Internet of Things

(IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device and applications (e.g., remote surgery), an industrial device and applications (e.g., a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. Any of the WTRUs 102a, 102b, 102c and 102d may be interchangeably referred to as a UE.

**[0026]** The communications systems 100 may also include a base station 114a and/or a base station 114b. Each of the base stations 114a, 114b may be any type of device configured to wirelessly interface with at least one of the WTRUs 102a, 102b, 102c, 102d to facilitate access to one or more communication networks, such as the CN 106/115, the Internet 110, and/or the other networks 112. By way of example, the base stations 114a, 114b may be a base transceiver station (BTS), a Node-B, an eNode B, a Home Node B, a Home eNode B, a gNB, a NR NodeB, a site controller, an access point (AP), a wireless router, and the like. While the base stations 114a, 114b are each depicted as a single element, it will be appreciated that the base stations 114a, 114b may include any number of interconnected base stations and/or network elements.

**[0027]** The base station 114a may be part of the RAN 104/113, which may also include other base stations and/or network elements (not shown), such as a base station controller (BSC), a radio network controller (RNC), relay nodes, etc. The base station 114a and/or the base station 114b may be configured to transmit and/or receive wireless signals on one or more carrier frequencies, which may be referred to as a cell (not shown). These frequencies may be in licensed spectrum, unlicensed spectrum, or a combination of licensed and unlicensed spectrum. A cell may provide coverage for a wireless service to a specific geographical area that may be relatively fixed or that may change over time. The cell may further be divided into cell sectors. For example, the cell associated with the base station 114a may be divided into three sectors. Thus, in one embodiment, the base station 114a may include three transceivers, i.e., one for each sector of the cell. In an embodiment, the base station 114a may employ multiple-input multiple output (MIMO) technology and may utilize multiple transceivers for each sector of the cell. For example, beamforming may be used to transmit and/or receive signals in desired spatial directions.

**[0028]** 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).

**[0029]** More specifically, as noted above, the communications system 100 may be a multiple access system and may employ one or more channel access schemes, such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA, and the like. For example, the base station 114a in the RAN 104/113 and the WTRUs 102a,

102b, 102c may implement a radio technology such as Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (UTRA), which may establish the air interface 115/116/117 using wideband CDMA (WCDMA). WCDMA may include communication protocols such as High-Speed Packet Access (HSPA) and/or Evolved HSPA (HSPA+). HSPA may include High-Speed Downlink (DL) Packet Access (HSDPA) and/or High-Speed UL Packet Access (HSUPA).

**[0030]** 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).

**[0031]** In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement a radio technology such as NR Radio Access, which may establish the air interface 116 using New Radio (NR).

**[0032]** In an embodiment, the base station 114a and the WTRUs 102a, 102b, 102c may implement multiple radio access technologies. For example, the base station 114a and the WTRUs 102a, 102b, 102c may implement LTE radio access and NR radio access together, for instance using dual connectivity (DC) principles. Thus, the air interface utilized by WTRUs 102a, 102b, 102c may be characterized by multiple types of radio access technologies and/or transmissions sent to/from multiple types of base stations (e.g., a eNB and a gNB).

**[0033]** 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.

**[0034]** The base station 114b in FIG. 1A may be a wireless router, Home Node B, Home eNode B, or access point, for example, and may utilize any suitable RAT for facilitating wireless connectivity in a localized area, such as a place of business, a home, a vehicle, a campus, an industrial facility, an air corridor (e.g., for use by drones), a roadway, and the like. In one embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.11 to establish a wireless local area network (WLAN). In an embodiment, the base station 114b and the WTRUs 102c, 102d may implement a radio technology such as IEEE 802.15 to establish a wireless personal area network (WPAN). In yet another embodiment, the base station 114b and the WTRUs 102c, 102d may utilize a cellular-based RAT (e.g., WCDMA, CDMA2000, GSM, LTE, LTE-A, LTE-A Pro, NR etc.) to establish a picocell or

femtocell. As shown in FIG. 1A, the base station 114b may have a direct connection to the Internet 110. Thus, the base station 114b may not be required to access the Internet 110 via the CN 106/115.

**[0035]** The RAN 104/113 may be in communication with the CN 106/115, which may be any type of network configured to provide voice, data, applications, and/or voice over internet protocol (VoIP) services to one or more of the WTRUs 102a, 102b, 102c, 102d. The data may have varying quality of service (QoS) requirements, such as differing throughput requirements, latency requirements, error tolerance requirements, reliability requirements, data throughput requirements, mobility requirements, and the like. The CN 106/115 may provide call control, billing services, mobile location-based services, pre-paid calling, Internet connectivity, video distribution, etc., and/or perform high-level security functions, such as user authentication. Although not shown in FIG. 1A, it will be appreciated that the RAN 104/113 and/or the CN 106/115 may be in direct or indirect communication with other RANs that employ the same RAT as the RAN 104/113 or a different RAT. For example, in addition to being connected to the RAN 104/113, which may be utilizing a NR radio technology, the CN 106/115 may also be in communication with another RAN (not shown) employing a GSM, UMTS, CDMA 2000, WiMAX, E-UTRA, or WiFi radio technology.

**[0036]** The CN 106/115 may also serve as a gateway for the WTRUs 102a, 102b, 102c, 102d to access the PSTN 108, the Internet 110, and/or the other networks 112. The PSTN 108 may include circuit-switched telephone networks that provide plain old telephone service (POTS). The Internet 110 may include a global system of interconnected computer networks and devices that use common communication protocols, such as the transmission control protocol (TCP), user datagram protocol (UDP) and/or the internet protocol (IP) in the TCP/IP internet protocol suite. The networks 112 may include wired and/or wireless communications networks owned and/or operated by other service providers. For example, the networks 112 may include another CN connected to one or more RANs, which may employ the same RAT as the RAN 104/113 or a different RAT.

**[0037]** 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.

**[0038]** 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.

**[0039]** The processor 118 may be a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), a state machine, and the like. The processor 118 may perform signal coding, data processing, power control, input/output processing, and/or any other functionality that enables the WTRU 102 to operate in a wireless environment. The processor 118 may be coupled to the transceiver 120, which may be coupled to the transmit/receive element 122. While FIG. 1B depicts the processor 118 and the transceiver 120 as separate components, it will be appreciated that the processor 118 and the transceiver 120 may be integrated together in an electronic package or chip.

**[0040]** 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.

**[0041]** 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.

**[0042]** 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.

**[0043]** 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).

**[0044]** 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.

**[0045]** 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.

**[0046]** The processor 118 may further be coupled to other peripherals 138, which may include one or more software and/or hardware modules that provide additional features, functionality and/or wired or wireless connectivity. For example, the peripherals 138 may include an accelerometer, an e-compass, a satellite transceiver, a digital camera (for photographs and/or video), a universal serial bus (USB) port, a vibration device, a television transceiver, a hands free headset, a Bluetooth® module, a frequency modulated (FM) radio unit, a digital music player, a media player, a video game player module, an Internet browser, a Virtual Reality and/or Augmented Reality (VR/AR) device, an activity tracker, and the like. The peripherals 138 may include one or more sensors, the sensors may be one or more of a gyroscope, an accelerometer, a hall effect sensor, a magnetometer, an orientation sensor, a proximity sensor, a temperature sensor, a time sensor; a geolocation sensor; an altimeter, a light sensor, a touch sensor, a magnetometer, a barometer, a gesture sensor, a biometric sensor, and/or a humidity sensor.

**[0047]** The WTRU 102 may include a full duplex radio for which transmission and reception of some or all of the signals (e.g., associated with particular subframes for both the UL (e.g., for transmission) and

downlink (e.g., for reception) may be concurrent and/or simultaneous. The full duplex radio may include an interference management unit 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 WRTU 102 may include a half-duplex radio for which transmission and reception of some or all of the signals (e.g., associated with particular subframes for either the UL (e.g., for transmission) or the downlink (e.g., for reception)).

**[0048]** 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.

**[0049]** 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.

**[0050]** 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.

**[0051]** The CN 106 shown in FIG. 1C may include a mobility management entity (MME) 162, a serving gateway (SGW) 164, and a packet data network (PDN) gateway (or PGW) 166. While each of the foregoing elements are depicted as part of the CN 106, it will be appreciated that any of these elements may be owned and/or operated by an entity other than the CN operator.

**[0052]** 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.

**[0053]** 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.

**[0054]** 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.

**[0055]** 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.

**[0056]** 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.

**[0057]** In representative embodiments, the other network 112 may be a WLAN.

**[0058]** A WLAN in Infrastructure Basic Service Set (BSS) mode may have an Access Point (AP) for the BSS and one or more stations (STAs) associated with the AP. The AP may have an access or an interface to a Distribution System (DS) or another type of wired/wireless network that carries traffic in to and/or out of the BSS. Traffic to STAs that originates from outside the BSS may arrive through the AP and may be delivered to the STAs. Traffic originating from STAs to destinations outside the BSS may be sent to the AP to be delivered to respective destinations. Traffic between STAs within the BSS may be sent through the AP, for example, where the source STA may send traffic to the AP and the AP may deliver the traffic to the destination STA. The traffic between STAs within a BSS may be considered and/or referred to as peer-to-peer traffic. The peer-to-peer traffic may be sent between (e.g., directly between) the source and destination STAs with a direct link setup (DLS). In certain representative embodiments, the DLS may use an 802.11e DLS or an 802.11z tunneled DLS (TDLS). A WLAN using an Independent BSS (IBSS) mode may not have an AP, and the STAs (e.g., all of the STAs) within or using the IBSS may communicate directly with each other. The IBSS mode of communication may sometimes be referred to herein as an "ad-hoc" mode of communication.

**[0059]** When using the 802.11ac infrastructure mode of operation or a similar mode of operations, the AP may transmit a beacon on a fixed channel, such as a primary channel. The primary channel may be a fixed

width (e.g., 20 MHz wide bandwidth) or a dynamically set width via signaling. The primary channel may be the operating channel of the BSS and may be used by the STAs to establish a connection with the AP. In certain representative embodiments, Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) may be implemented, for example in 802.11 systems. For CSMA/CA, the STAs (e.g., every STA), including the AP, may sense the primary channel. If the primary channel is sensed/detected and/or determined to be busy by a particular STA, the particular STA may back off. One STA (e.g., only one station) may transmit at any given time in a given BSS.

**[0060]** 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.

**[0061]** 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).

**[0062]** Sub 1 GHz modes of operation are supported by 802.11af and 802.11ah. The channel operating bandwidths, and carriers, are reduced in 802.11af and 802.11ah relative to those used in 802.11n, and 802.11ac. 802.11af supports 5 MHz, 10 MHz and 20 MHz bandwidths in the TV White Space (TVWS) spectrum, and 802.11ah supports 1 MHz, 2 MHz, 4 MHz, 8 MHz, and 16 MHz bandwidths using non-TVWS spectrum. According to a representative embodiment, 802.11ah may support Meter Type Control/Machine-Type Communications, such as MTC devices in a macro coverage area. MTC devices may have certain capabilities, for example, limited capabilities including support for (e.g., only support for) certain and/or limited bandwidths. The MTC devices may include a battery with a battery life above a threshold (e.g., to maintain a very long battery life).

**[0063]** WLAN systems, which may support multiple channels, and channel bandwidths, such as 802.11n, 802.11ac, 802.11af, and 802.11ah, include a channel which may be designated as the primary channel. The primary channel may have a bandwidth equal to the largest common operating bandwidth supported by all STAs in the BSS. The bandwidth of the primary channel may be set and/or limited by a STA, from

among all STAs in operating in a BSS, which supports the smallest bandwidth operating mode. In the example of 802.11ah, the primary channel may be 1 MHz wide for STAs (e.g., MTC type devices) that support (e.g., only support) a 1 MHz mode, even if the AP, and other STAs in the BSS support 2 MHz, 4 MHz, 8 MHz, 16 MHz, and/or other channel bandwidth operating modes. Carrier sensing and/or Network Allocation Vector (NAV) settings may depend on the status of the primary channel. If the primary channel is busy, for example, due to a STA (which supports only a 1 MHz operating mode), transmitting to the AP, the entire available frequency bands may be considered busy even though a majority of the frequency bands remains idle and may be available.

**[0064]** 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.

**[0065]** FIG. 1D is a system diagram illustrating the RAN 113 and the CN 115 according to an embodiment. As noted above, the RAN 113 may employ an NR radio technology to communicate with the WTRUs 102a, 102b, 102c over the air interface 116. The RAN 113 may also be in communication with the CN 115.

**[0066]** The RAN 113 may include gNBs 180a, 180b, 180c, though it will be appreciated that the RAN 113 may include any number of gNBs while remaining consistent with an embodiment. The gNBs 180a, 180b, 180c may each include one or more transceivers for communicating with the WTRUs 102a, 102b, 102c over the air interface 116. In one embodiment, the gNBs 180a, 180b, 180c may implement MIMO technology. For example, gNBs 180a, 180b may utilize beamforming to transmit signals to and/or receive signals from the gNBs 180a, 180b, 180c. Thus, the gNB 180a, for example, may use multiple antennas to transmit wireless signals to, and/or receive wireless signals from, the WTRU 102a. In an embodiment, the gNBs 180a, 180b, 180c may implement carrier aggregation technology. For example, the gNB 180a may transmit multiple component carriers to the WTRU 102a (not shown). A subset of these component carriers may be on unlicensed spectrum while the remaining component carriers may be on licensed spectrum. In an embodiment, the gNBs 180a, 180b, 180c may implement Coordinated Multi-Point (CoMP) technology. For example, WTRU 102a may receive coordinated transmissions from gNB 180a and gNB 180b (and/or gNB 180c).

**[0067]** The WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c using transmissions associated with a scalable numerology. For example, the OFDM symbol spacing and/or OFDM subcarrier spacing may vary for different transmissions, different cells, and/or different portions of the wireless transmission spectrum. The WTRUs 102a, 102b, 102c may communicate with gNBs 180a, 180b, 180c

using subframe or transmission time intervals (TTIs) of various or scalable lengths (e.g., containing varying number of OFDM symbols and/or lasting varying lengths of absolute time).

**[0068]** 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.

**[0069]** Each of the gNBs 180a, 180b, 180c may be associated with a particular cell (not shown) and may be configured to handle radio resource management decisions, handover decisions, scheduling of users in the UL and/or DL, support of network slicing, dual connectivity, interworking between NR and E-UTRA, routing of user plane data towards User Plane Function (UPF) 184a, 184b, routing of control plane information towards Access and Mobility Management Function (AMF) 182a, 182b and the like. As shown in FIG. 1D, the gNBs 180a, 180b, 180c may communicate with one another over an Xn interface.

**[0070]** The CN 115 shown in FIG. 1D may include at least one AMF 182a, 182b, at least one UPF 184a, 184b, at least one Session Management Function (SMF) 183a, 183b, and possibly a Data Network (DN) 185a, 185b. While each of the foregoing elements are depicted as part of the CN 115, it will be appreciated that any of these elements may be owned and/or operated by an entity other than the CN operator.

**[0071]** The AMF 182a, 182b may be connected to one or more of the gNBs 180a, 180b, 180c in the RAN 113 via an N2 interface and may serve as a control node. For example, the AMF 182a, 182b may be responsible for authenticating users of the WTRUs 102a, 102b, 102c, support for network slicing (e.g., handling of different PDU sessions with different requirements), selecting a particular SMF 183a, 183b, management of the registration area, termination of NAS signaling, mobility management, and the like. Network slicing may be used by the AMF 182a, 182b in order to customize CN support for WTRUs 102a, 102b, 102c based on the types of services being utilized WTRUs 102a, 102b, 102c. For example, different

network slices may be established for different use cases such as services relying on ultra-reliable low latency (URLLC) access, services relying on enhanced massive mobile broadband (eMBB) access, services for machine type communication (MTC) access, and/or the like. The AMF 162 may provide a control plane function for switching between the RAN 113 and other RANs (not shown) that employ other radio technologies, such as LTE, LTE-A, LTE-A Pro, and/or non-3GPP access technologies such as WiFi.

**[0072]** The SMF 183a, 183b may be connected to an AMF 182a, 182b in the CN 115 via an N11 interface. The SMF 183a, 183b may also be connected to a UPF 184a, 184b in the CN 115 via an N4 interface. The SMF 183a, 183b may select and control the UPF 184a, 184b and configure the routing of traffic through the UPF 184a, 184b. The SMF 183a, 183b may perform other functions, such as managing and allocating UE IP address, managing PDU sessions, controlling policy enforcement and QoS, providing downlink data notifications, and the like. A PDU session type may be IP-based, non-IP based, Ethernet-based, and the like.

**[0073]** The UPF 184a, 184b may be connected to one or more of the gNBs 180a, 180b, 180c in the RAN 113 via an N3 interface, which may provide the WTRUs 102a, 102b, 102c with access to packet-switched networks, such as the Internet 110, to facilitate communications between the WTRUs 102a, 102b, 102c and IP-enabled devices. The UPF 184a, 184b may perform other functions, such as routing and forwarding packets, enforcing user plane policies, supporting multi-homed PDU sessions, handling user plane QoS, buffering downlink packets, providing mobility anchoring, and the like.

**[0074]** The CN 115 may facilitate communications with other networks. For example, the CN 115 may include, or may communicate with, an IP gateway (e.g., an IP multimedia subsystem (IMS) server) that serves as an interface between the CN 115 and the PSTN 108. In addition, the CN 115 may provide the WTRUs 102a, 102b, 102c with access to the other networks 112, which may include other wired and/or wireless networks that are owned and/or operated by other service providers. In one embodiment, the WTRUs 102a, 102b, 102c may be connected to a local Data Network (DN) 185a, 185b through the UPF 184a, 184b via the N3 interface to the UPF 184a, 184b and an N6 interface between the UPF 184a, 184b and the DN 185a, 185b.

**[0075]** In view of Figures 1A-1D, and the corresponding description of Figures 1A-1D, one or more, or all, of the functions described herein with regard to one or more of: WTRU 102a-d, Base Station 114a-b, eNode-B 160a-c, MME 162, SGW 164, PGW 166, gNB 180a-c, AMF 182a-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.

**[0076]** The emulation devices may be designed to implement one or more tests of other devices in a lab environment and/or in an operator network environment. For example, the one or more emulation devices may perform the one or more, or all, functions while being fully or partially implemented and/or deployed as part of a wired and/or wireless communication network in order to test other devices within the communication network. The one or more emulation devices may perform the one or more, or all, functions while being temporarily implemented/deployed as part of a wired and/or wireless communication network. The emulation device may be directly coupled to another device for purposes of testing and/or may performing testing using over-the-air wireless communications.

**[0077]** 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.

**[0078]** A multiple access scheme, e.g., for new radio (NR), may be orthogonal for downlink and/or uplink data transmissions, e.g., time and frequency physical resources of different users may not be overlapped. Non-orthogonal multiple-access (NOMA) schemes may be used. NOMA schemes may provide differentiating factors in terms of uplink (UL) link-level sum throughput and overloading capability, system capacity enhancement in terms of supported packet arrival rate at given system outage, etc.

**[0079]** For NOMA, interference may be experienced between transmissions using overlapping resources. As system load increases, for example, the interference associated with non-orthogonality may be more pronounced (e.g., the interference experienced may increase as the system load increases). To decrease the interference between non-orthogonal transmissions, transmitter side schemes, such as spreading (e.g., linear or non-linear, with or without sparseness) and/or interleaving may be employed, e.g., to improve the performance and/or ease the burden of advanced receivers.

**[0080]** Non-orthogonal transmissions may be performed using grant-based and/or grant-free transmission. NOMA, for example, when enabling grant-free transmissions, may encompass a variety of use cases or deployment scenarios, including eMBB, URLLC, mMTC etc.

**[0081]** As new applications emerging for cellular technology, support for higher data rates, lower latency, and/or massive connectivity may increase. With a broad range of applications and usage scenarios, radio access capabilities may differ in usage across the range of applications.

**[0082]** Certain multiple access schemes used in wireless cellular communication systems may assign time/frequency/spatial resources such that each user's signal does not interfere with other users' signals. This type of access (e.g., where the users' respective signals do not interfere) may be referred to as Orthogonal Multiple Access (OMA), where multiplexing the users on orthogonal resources may be performed in the time domain (TDM), in the frequency domain (FDM), or in the spatial domain (SDM).

**[0083]** NOMA techniques may be used to address some of the challenges of wireless communications, such as high spectral efficiency and massive connectivity. A NOMA scheme may multiplex users in the code-domain. For example, different users may be assigned different spreading codes and may be multiplexed over the same time-frequency resources. FIG. 2 illustrates an example block diagram of a transmitter for code-domain based NOMA. For certain NOMA schemes, the spreading sequences may be short; for example, the spreading sequences may include four to eight samples.

**[0084]** In examples, NOMA may be used for URLLC, mMTC, and/or eMBB. Different design targets may be used for different use cases and scenarios. For example, design targets for URLLC may include low latency and high reliability. Design targets for mMTC may include large connections and coverage. Design targets for eMBB may include spectrum efficiency and throughput enhancement.

**[0085]** As described herein, NOMA may be designed or used for URLLC, mMTC, and/or eMBB. Techniques regarding scheduling and hybrid automatic repeat request (HARQ) transmissions may be provided, such as techniques for scheduling an initial HARQ transmission and HARQ retransmission. Feedback techniques for NOMA implementations may be provided. Feedback techniques may be provided for WTRUs (e.g., in the case where multiple WTRUs transmit data using a multiple access (MA) signature and/or demodulation reference signals (DMRS)), for example, to enable efficient transmissions and retransmissions of data.

**[0086]** One or more group feedback techniques (e.g., group feedback techniques for NOMA) may be provided. For example, group feedback techniques related to group feedback types and/or enhanced HARQ techniques may be provided.

**[0087]** FIG. 3 illustrates an example associated with group feedback. A WTRU may receive a configuration for resource(s) that may be used for group feedback (e.g., a group feedback configuration). The group feedback configuration may include a resource pool size. The WTRU may receive a configuration for a group RNTI (e.g., via the group feedback configuration). The configuration for the group RNTI may be received in a single configuration (e.g., via a single RRC message transmitted to multiple WTRUs) or in multiple configurations (e.g., via multiple RRC messages each of which are transmitted to multiple WTRUs). The WTRU may receive, e.g., via the group feedback configuration, a configuration for a payload size threshold (e.g., resource pool size threshold). For example, the payload size threshold may be

derived (e.g., based on the group feedback configuration) or proportional to resource pool size. The WTRU may compare the resource pool size to a resource pool size threshold e.g., to determine whether the resource pool size is greater than the resource pool size threshold. One or more of the following may apply.

**[0088]** If the resource pool size is greater than the resource pool size threshold, the WTRU may search and decode a group common control channel, such as a group common physical downlink control channel (GC-PDCCH) transmission. The WTRU may obtain scheduling information and/or a resource allocation for decoding a group common physical downlink shared channel (GC-PDSCH) (e.g., a subsequent GC-PDSCH transmission) via the GC-PDCCH. The WTRU may decode the GC-PDSCH, e.g., using the resource allocation and/or other related parameters obtained via the GC-PDCCH for decoding the GC-PDSCH. The WTRU may obtain group feedback in the GC-PDSCH. If the resource pool size does not exceed the resource pool size threshold, the WTRU may search and decode the GC-PDCCH (e.g., using the group feedback configuration). For example, the WTRU may obtain the group feedback via the GC-PDCCH.

**[0089]** Group common control may be performed using group common feedback. In examples, group feedback information may be treated as control information. The techniques describe herein may be applied to control information and/or feedback information, e.g., feedback information for uplink transmissions, downlink transmissions, or sidelink transmissions. Group common control information may be obtained via downlink group common control, downlink group common feedback, uplink group common control, uplink group common feedback, sidelink group common control, or sidelink group common feedback. The group common control or group common feedback may be applied in uplink communications, downlink communications (e.g., communications between gNB and WTRU), and/or in sidelink communications (e.g., communications between WTRUs, or communications between vehicles, such as for vehicle to everything (V2X) or device to device (D2D) communications systems).

**[0090]** FIG. 4 illustrates an example associated with group feedback. A WTRU may receive a group feedback configuration that includes a group RNTI. The WTRU may search the GC-PDCCH (e.g., using the group RNTI). The WTRU may obtain a group feedback type indicator (GFTI), for example, via the GC-PDCCH. The group RNTI and the GFTI may be received in a single GC-PDCCH transmission or separate GC-PDCCH transmissions. If the group RNTI and the GFTI are received in a single GC-PDCCH transmission, the group RNTI may be associated with a first control field and the GFTI may be associated with a second control field. The GFTI may indicate the type of group feedback to be received by the WTRU (e.g., whether the group feedback to be received by the WTRU is group feedback type 1 or group feedback type 2). The GFTI may be carried in (e.g., included in) a GC-PDCCH transmission or another signal or

channel, e.g., a short signal, initial signal or wakeup signal (WUS) and/or the like. One or more of the following may apply.

**[0091]** If GFTI type 1 is indicated (e.g., indicated via a GC-PDCCH transmission), the WTRU may obtain the group feedback via the GC-PDCCH transmission. For example, the WTRU may decode the GC-PDCCH transmission and obtain the group feedback, e.g., obtain the group feedback included in the GC-PDCCH transmission. If GFTI type 2 is indicated, the WTRU may obtain the group feedback via a GC-PDSCH transmission. For example, the WTRU may decode the GC-PDCCH, which may include resource allocation information or scheduling information associated with the GC-PDSCH transmission). The WTRU may obtain the resource allocation information or scheduling information in the GC-PDCCH. The WTRU may decode the GC-PDSCH, e.g., using the resource allocation or scheduling information. The WTRU may obtain the group feedback, e.g., obtain the group feedback included in the GC-PDSCH transmission.

**[0092]** A GFTI may be obtained using one or more of the following. The GFTI may be carried in a different transmissions, e.g., as group common control information. The GFTI may be carried in the same transmission, e.g., a group common control channel. If the GFTI is carried in a different transmission, for example, as group common control information, a group common control channel may be used for the GFTI and group common control information. In examples, a first group common control channel may be used for the GFTI a second group common control channel may be used for feedback information. If the GFTI is carried in the same transmission as group common control, a group common control channel (e.g., a single group common control channel) may be used and a common format for group common control channel may be used for GFTI 1 and GFTI 2. The common control format may carry group feedback information themselves or an indication of the resources for locating and decoding group feedback information in a group common data channel. A 1 bit indication may be used to indicate which information the group common control channel carries (e.g., the group feedback information itself or the resources/scheduling information for locating and decoding the group feedback information). In examples, if the 1 bit indication is set to "0," the group common control channel may include the group feedback information itself. If the 1 bit indication is "1," the group common control channel may include the resource/scheduling information, such as a resource allocation, e.g., to find and decode group feedback information.

**[0093]** HARQ feedback implementation(s) may be provided. FIG. 5 illustrates an example associated with group HARQ acknowledgement/non-acknowledgement (ACK/NACK). One or more of following may apply. A WTRU may receive a group feedback configuration that includes a group RNTI. The WTRU may be configured with the group RNTI (e.g., via the group feedback configuration). The WTRU may search a GC-PDCCH using the group RNTI, e.g., if the WTRU is configured with the group RNTI. The WTRU may

decode the GC-PDCCH. The WTRU may receive a feedback indicator that indicates whether group HARQ ACK feedback is present (e.g., present in the GC-PDCCH or a GC-PDSCH). If the feedback indicator indicates that group HARQ ACK feedback is present, group HARQ ACKs may be obtained. For example, the WTRU may obtain group HARQ ACKs in the GC-PDCCH and/or a GC-PDSCH. If the feedback indicator indicates that group HARQ ACK feedback is not present, a group HARQ NACK may be indicated. For example, if the WTRU obtains a group HARQ NACK (e.g., via the GC-PDCCH or GC-PDSCH), the WTRU may retransmit data and discard the GC-PDCCH or GC-PDSCH (e.g., the remainder of the GC-PDCCH or GC-PDSCH).

**[0094]** FIG. 6 illustrates an example associated with group HARQ ACK/NACKs. One or more of the following may apply. A WTRU may receive a group feedback configuration that includes a group RNTI and/or a GC-PDCCH monitoring window. The WTRU may search a received GC-PDCCH transmission, e.g., using the group RNTI. The WTRU may attempt to detect and/or decode the GC-PDCCH, for example within the GC-PDCCH monitoring window (e.g., which may be included in the group feedback configuration). If the GC-PDCCH is detected within the GC-PDCCH monitoring window, a group HARQ ACK may be indicated. For example, if the GC-PDCCH is detected within the GC-PDCCH monitoring window the WTRU may obtain group HARQ ACKs via a GC-PDCCH and/or a GC-PDSCH transmission. If, for example, a GC-PDCCH is not detected within the GC-PDCCH monitoring window, group HARQ NACK may be indicated. In examples, a GC-PDCCH monitoring timer may be used, e.g., instead of or in conjunction with the GC-PDCCH monitoring window.

**[0095]** Group feedback indication techniques(s) may be provided. One or more WTRUs within a given group of WTRUs may transmit data and the remaining WTRUs within the given group of WTRUs may not transmit data. In examples, the one or more WTRUs that transmit data may expect HARQ feedback, for example, in response to the data transmitted by the respective WTRUs. FIG. 7 illustrates an example associated with group feedback indication techniques. In examples, the group indication techniques illustrated in FIG. 7 may be used, e.g., if a gNB is able to identify the WTRUs in a group. As illustrated in FIG. 7, the WTRUs in a group of WTRUs may be assigned (e.g., may each be assigned) an index. The index and corresponding feedback status assigned to a respective WTRU may be included in a feedback signal or channel. For example, the WTRUs may be indexed (e.g., preconfigured or assigned) as WTRU index#1, WTRU index#2, WTRU index#3, WTRU index#4 and so on. The corresponding feedback status for WTRU index#1, WTRU index#2, WTRU index#3, and WTRU index#4 may be ACK, NACK, NACK, and ACK, respectively. A WTRU may receive the feedback signal or channel and check the WTRU's index (e.g., the position of the feedback signal or channel that corresponds to a respective WTRU's index) to determine the WTRU's corresponding feedback status, e.g., ACK or NACK.

**[0096]** FIG. 8 illustrates an example associated with group indication. In examples, the group indication illustrated in FIG. 8 may be used in cases where the gNB is not be able to identify the WTRUs in the group (e.g., all the WTRUs in the group). One or more of the following may be associated with FIG. 8. The WTRUs may be indexed by WTRU index#1, WTRU index#2, WTRU index#3, WTRU index#4 and so on. The corresponding feedback status for WTRU index#1, WTRU index#2, WTRU index#3, and WTRU index#4 may be ACK, NACK, NACK, ACK, respectively. As illustrated in FIG. 8, WTRU's with an "ACK" feedback status may be fed back, while WTRU's with a "NACK" feedback status may not be fed back. Referring again to FIG. 8, WTRU index#1 and WTRU index#4 which have an "ACK" feedback status may be included in the feedback signal or channel. WTRU index#2 and WTRU index#3 which have a "NACK" feedback status may not be included in feedback signal or channel,. A WTRU may receive the feedback signal or channel and check the WTRU index and the corresponding feedback status for ACK.

**[0097]** FIG. 9 illustrates an example associated with group indication. In examples, the group indication illustrated in FIG. 9 may be used in cases where "NACK" may be fed back while feedback status "ACK" may not be fed back. One or more of the following may be associated with FIG. 9. WTRUs may be indexed by WTRU index#1, WTRU index#2, WTRU index#3, WTRU index#4 and so on. The corresponding feedback status for WTRU index#1, WTRU index#2, WTRU index#3, and WTRU index#4 may be ACK, NACK, NACK, ACK, respectively. As illustrated in FIG. 9, WTRUs with a "NACK" feedback status may be fed back, while WTRU's with an "ACK" feedback status may not be fed back. WTRU index#2 and WTRU index#3 which have a "NACK" feedback status may be included in feedback signal or channel. WTRU index#1 and WTRU index#4 which have an "ACK" feedback status may not be included in feedback signal or channel. A WTRU may receive the feedback signal or channel and check the WTRU's index and the corresponding feedback status for NACK. If, for example, a WTRU does not receive a WTRU index for itself (e.g., an index for the WTRU), the WTRU may be configured to determine that an "ACK" feedback status is indicated. If, for example, a WTRU does not receive a WTRU index for itself (e.g., an index for the WTRU), the WTRU may be configured to determine that the feedback status "NACK" is indicated.

**[0098]** FIG. 10 illustrates an example associated with group indication. In examples, the group indication illustrated in FIG. 10 may be used, e.g., in cases where "ACK" or "NACK" may be fed back while the other feedback status may not be fed back. One or more of the following may be associated with FIG. 10. WTRUs may be indexed by WTRU index#1, WTRU index#2, WTRU index#3, WTRU index#4 and so on. The corresponding feedback status for WTRU index#1, WTRU index#2, WTRU index#3, and WTRU index#4 may be ACK, NACK, NACK, ACK, respectively. An "ACK" or a "NACK" feedback status may be fed back, while the other feedback statuses may not be fed back. If, for example, an "ACK" feedback status is fed back, WTRU index#1 and WTRU index#4, which have an "ACK" feedback status, may be

included in the feedback signal or channel. A WTRU may determine that receiving a WTRU index indicates an "ACK" feedback status. If, for example, a WTRU determines that receiving a WTRU index indicates an "ACK" feedback status, the feedback status may not be included in the feedback signal or channel, e.g., as shown in FIG. 10. As illustrated in FIG. 10, WTRU index#2 and WTRU index#3 which have a "NACK" feedback status may not be included in feedback signal or channel. The indication(s) included in the feedback signal or channel may be a WTRU index (e.g., may only include WTRU index(es)). A WTRU may receive the feedback signal or channel and check for a corresponding WTRU index, which may indicate an "ACK" feedback status. If, for example, the WTRU does not receive a WTRU index for itself, the WTRU may determine that a "NACK" feedback status is indicated (e.g., the WTRU may be configured to consider failing to receive a WTRU index a NACK).

**[0099]** FIG. 11 illustrates an example associated with group indication. Referring now to FIG. 11, and similar to the examples illustrated herein, a "NACK" feedback status may be fed back and an "ACK" feedback status may not be fed back. For example, "NACK" feedback statuses may be included in a feedback signal or channel, and "ACK" feedback statuses may not be included in the feedback signal or channel. As illustrated in FIG. 11, WTRU index#2 and WTRU index#3 may be included in the feedback signal or channel, which may indicate a "NACK" feedback status. A WTRU may determine a "NACK" feedback status if the WTRU's respective index (e.g., the WTRU's index for itself) is included in the feedback channel or signal. The feedback signal or channel may not include an explicit "NACK" feedback status, for example, as illustrated in FIG. 11 (e.g., a WTRU index may be included in the feedback signal or channel but an explicit NACK may not be included in the feedback signal or channel). A WTRU may receive the feedback signal or channel and determine if the WTRU's index is included in the feedback signal or channel, which may indicate a "NACK" feedback status. If the WTRU's index is not included in the feedback signal or channel, an "ACK" the feedback status may be indicated.

**[0100]** The WTRU may be configured to determine that "NACK" feedback status is indicated if the WTRU does not receive the WTRU's index (e.g., the index for the WTRU itself) in the feedback channel or signal.

**[0101]** The feedback signal or channel may be group common control signal or channel, e.g., GC-PDCCH, or group common control and data signal or channel e.g., GC-PDCCH/GC-PDSCH. A WTRU index may include one or more of the following: a DMRS index, a MA signature index, a C-RNTI, an international mobile subscriber identity (IMSI), WTRU ID, cell specific RNTI (CS-RNTI), or another WTRU index that may identify the WTRU.

**[0102]** WTRUs may be indexed by WTRU index#1, WTRU index#2, WTRU index#3, WTRU index#4 and so on. The corresponding feedback status for WTRU index#1, WTRU index#2, WTRU index#3, WTRU index#4 may be ACK, NACK, NACK, ACK, respectively. In examples, "ACK" feedback status "ACK"

feedback status may be fed back, while a "NACK" feedback status may not be fed back. If "ACK" feedback statuses are fed back and "NACK" feedback statuses are not fed back, WTRU index #1 and WTRU index #4 which have an "ACK" feedback status may be included in feedback signal or channel. In examples, an ACK feedback status may be fed back for WTRU index #1 and WTRU index #2 if the data of WTRU index #1 and WTRU index #4 are decoded successfully. A feedback status may not be fed back for WTRU index #2 and WTRU index #3 if the data of WTRU index #2 and WTRU index #3 are not decoded successfully or decoding of the data for WTRU index #2 and WTRU index #3 fails. A WTRU determine an "ACK" feedback status if the WTRU's index corresponds is included in the feedback signal or channel. The feedback signal or channel may not include feedback status (e.g., an ACK feedback status or a NACK feedback status may be implicitly determined by the WTRU). WTRU index #2 and WTRU index #3 which has a "NACK" feedback status may not be included in the feedback signal or channel. WTRU indexes associated with "ACK" may be included in feedback signal or channel, and NACK may not be included. A WTRU may receive the feedback signal or channel and determine the WTRU indexes that are associated with an "ACK" feedback status. If, for example, the WTRU does not receive a WTRU's index in the feedback signal or channel, the WTRU may determine that a "NACK" feedback status is indicated.

**[0103]** A DMRS index may be used to determine or assign a WTRU index. FIG. 12 illustrates an example associated with group indications using demodulation reference signals (DMRS). If a DMRS index is used to determine or assign a WTRU index, the DMRS may be substituted for the WTRU index in one or more of the implementations described herein (e.g., as illustrated in FIG. 12).

**[0104]** A multiple access signature (MAS) may be used to determine or assign a WTRU index. FIG. 13 illustrates an example associated with group indications using MAS. If an MA signature index is used to determine or assign (e.g., is used as) a WTRU index, a MAS may be substituted for the WTRU index in one or more of the implementations described herein (e.g., as illustrated in FIG. 13).

**[0105]** HARQ type based group indication implementation(s) may be provided. FIG. 14 illustrates an example associated with HARQ type based group indications. One or more of the following may apply. A WTRU may receive a configuration for a group RNTI. The WTRU may search a GC-PDCCH using the group RNTI. The WTRU may receive a HARQ feedback type indicator (e.g., via the GC-PDCCH), which may indicate the HARQ feedback type. If the HARQ feedback type indicator indicates HARQ type 1, the WTRU may decode GC-PDCCH and/or GC-PDSCH. The WTRU may obtain a WTRU index(s) that are associated with an "ACK" feedback status for HARQ type 1, for example, via the GC-PDCCH/GC-PDSCH. If the HARQ feedback type indicator indicates HARQ type 2, the WTRU may decode the GC-PDCCH and/or GC-PDSCH, e.g., to obtain the WTRU index(s) associated with a "NACK" feedback status for HARQ

type 2, for example, via the GC-PDCCH/GC-PDSCH. In examples, the HARQ type indicator may be a 1-bit indicator.

**[0106]** A MAS/DMRS may be associated with a transmission/retransmission index. One or more of the following may apply. A HARQ transmission and retransmission may be assigned an index. A MAS index may be associated with the HARQ transmission and retransmission index. A DMRS signature index may be associated with the HARQ transmission and retransmission index. For example, a predefined MAS index pattern may be used and each HARQ transmission and retransmission may use or be associated with a different MAS index. Similarly, a predefined DMRS index pattern may be used and each HARQ transmission and retransmission may use or be associated with a different DMRS index.

**[0107]** A MAS index may (e.g., also) be associated with a DMRS index. If a MAS index is associated with a DMRS index, a predefined joint MAS and DMRS index pattern may be used and each transmission and retransmission may use or be associated with a different joint MAS/DMRS index.

**[0108]** For each transmission or retransmission, a WTRU may determine (e.g., predetermine) a default pattern for MAS, DMRS, or joint MAS/DMRS as default. When the WTRU receives a grant for MAS, and/or DMRS, for a particular transmission or retransmission, the WTRU may override the default MAS and/or DMRS with the scheduled MAS and/or DMRS. The predefined pattern may (e.g., also) use a hopping pattern such that the MAS, and/or DMRS hop around the transmission and/or retransmission. In examples, the MAS and/or DMRS index may follow a random pattern for HARQ transmissions or re-transmissions and hop around the HARQ transmissions or re-transmissions based on the random pattern. The MAS and/or DMRS pattern may be predetermined, predefined, preconfigured, configured, and/or indicated.

**[0109]** FIG. 15 illustrates an example of a MAS/DMRS association with a transmission or retransmission index. One or more of the following may apply. A WTRU may receive a configuration for one or more of the following: resource(s), MAS, DMRS, etc. The WTRU may determine an association between resource, MAS and/or DMRS, for example, based on the received configuration. The WTRU may use a predefined or configured pattern for the MAS and/or DMRS, e.g., for each transmission. The WTRU may check an indicator (e.g., override indicator) or a grant for an uplink transmission or retransmission. Referring to FIG. 15, if the indicator or the grant is received by the WTRU for a (re)transmission index  $k$ , the WTRU may obtain or receive an updated MAS and/or DMRS for the transmission. The WTRU may override the MAS and/or DMRS and may use the received updated MAS/DMRS for this (re)transmission. If an indicator or a grant is not received by the WTRU for (re)transmission index  $k$ , the WTRU may fall back to a default pattern. For example, the WTRU may continue using the preconfigured pattern for MAS and/or DMRS for the (re)transmission.

**[0110]** Although the features and elements of the present disclosure may be described in embodiments and/or 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.

**[0111]** Although the features and elements of the present disclosure may consider LTE, LTE-A, New Radio (NR) or 5G specific protocols, it is understood that the solutions described herein are not restricted to these technologies or scenarios and are applicable to other technologies or scenarios as well.

**[0112]** Although features and elements are described above in particular combinations, one of ordinary skill in the art will appreciate that each feature or element can be used alone or in any combination with the other features and elements. In addition, the methods described herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable medium for execution by a computer or processor. Examples of computer-readable media include electronic signals (transmitted over wired or wireless connections) and computer-readable storage media. Examples of computer-readable storage media include, but are not limited to, a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs). A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, RNC, or any host computer.

|

### CLAIMS

1. A wireless transmit receive unit (WTRU) comprising:  
a processor configured at least to:
  - receive a group feedback configuration;
  - receive a first group common physical downlink control channel (GC-PDCCH) transmission using the group feedback configuration, wherein the GC-PDCCH comprises a group feedback type indicator (GFTI);
  - receive a second GC-PDCCH transmission; and
  - obtain group feedback based on the group feedback type indicator, wherein:
    - if the GFTI is type 1, the group feedback is obtained from the second GC-PDCCH transmission, and
    - if the GFTI is type 2, a resource allocation is obtained from the second GC-PDCCH, wherein the resource allocation is associated with a group common physical downlink shared channel (GC-PDSCH) transmission that comprises the group feedback.
2. The WTRU of claim 1, wherein if the GFTI is type 2, the processor is further configured to:  
receive the GC-PDSCH transmission that comprises the group feedback; and  
extract feedback for the WTRU from the group feedback based on an index associated with the WTRU.
3. The WTRU of claim 1, wherein the group feedback configuration comprises a group RNTI, and wherein the processor is further configured to search the first GC-PDCCH transmission using the group RNTI.
4. The WTRU of claim 1, wherein the group feedback configuration comprises an index associated with the WTRU, and wherein the processor is further configured to extract feedback for the WTRU from the group feedback using the index associated with the WTRU.
5. The WTRU of claim 4, wherein the feedback for the WTRU comprises hybrid automatic repeat request (HARQ) feedback.

6. The WTRU of claim 1, wherein, if the GFTI is type 2, scheduling information is obtained from the second GC-PDCCH, wherein the scheduling information is associated with the GC-PDSCH transmission that comprises the group feedback.
7. The WTRU of claim 1, wherein the second GC-PDCCH transmission and the first GC-PDCCH transmission are received in a single GC-PDCCH transmission, wherein the first GC-PDCCH transmission is associated with a first control field, and wherein the second GC-PDCCH transmission is associated with a second control field.
8. A method comprising:
  - receiving a group feedback configuration;
  - receiving a first group common physical downlink control channel (GC-PDCCH) transmission using the group feedback configuration, wherein the GC-PDCCH comprises a group feedback type indicator (GFTI);
  - receiving a second GC-PDCCH transmission; and
  - obtaining group feedback based on the group feedback type indicator, wherein:
    - if the GFTI is type 1, the group feedback is obtained from the second GC-PDCCH transmission, and
    - if the GFTI is type 2, a resource allocation is obtained from the second GC-PDCCH, wherein the resource allocation is associated with a group common physical downlink shared channel (GC-PDSCH) transmission that comprises the group feedback.
9. The method of claim 8, wherein if the GFTI is type 2, the method further comprises:
  - receiving the GC-PDSCH transmission that comprises the group feedback; and
  - extracting feedback for the WTRU from the group feedback based on an index associated with the WTRU.
10. The method of claim 8, wherein the group feedback configuration comprises a group RNTI, and wherein the method further comprises searching the first GC-PDCCH transmission using the group RNTI.
11. The method of claim 8, wherein the group feedback configuration comprises an index associated with the WTRU, and wherein the method further comprises extracting feedback for the WTRU from the group feedback using the index associated with the WTRU.

12. The method of claim 11, wherein the feedback for the WTRU comprises hybrid automatic repeat request (HARQ) feedback.
13. The method of claim 8, wherein, if the GFTI is type 2, scheduling information is obtained from the second GC-PDCCH, wherein the scheduling information is associated with the GC-PDSCH transmission that comprises the group feedback.
14. The method of claim 8, wherein the second GC-PDCCH transmission and the first GC-PDCCH transmission are received in a single GC-PDCCH transmission, wherein the first GC-PDCCH transmission is associated with a first control field, and wherein the second GC-PDCCH transmission is associated with a second control field.

100

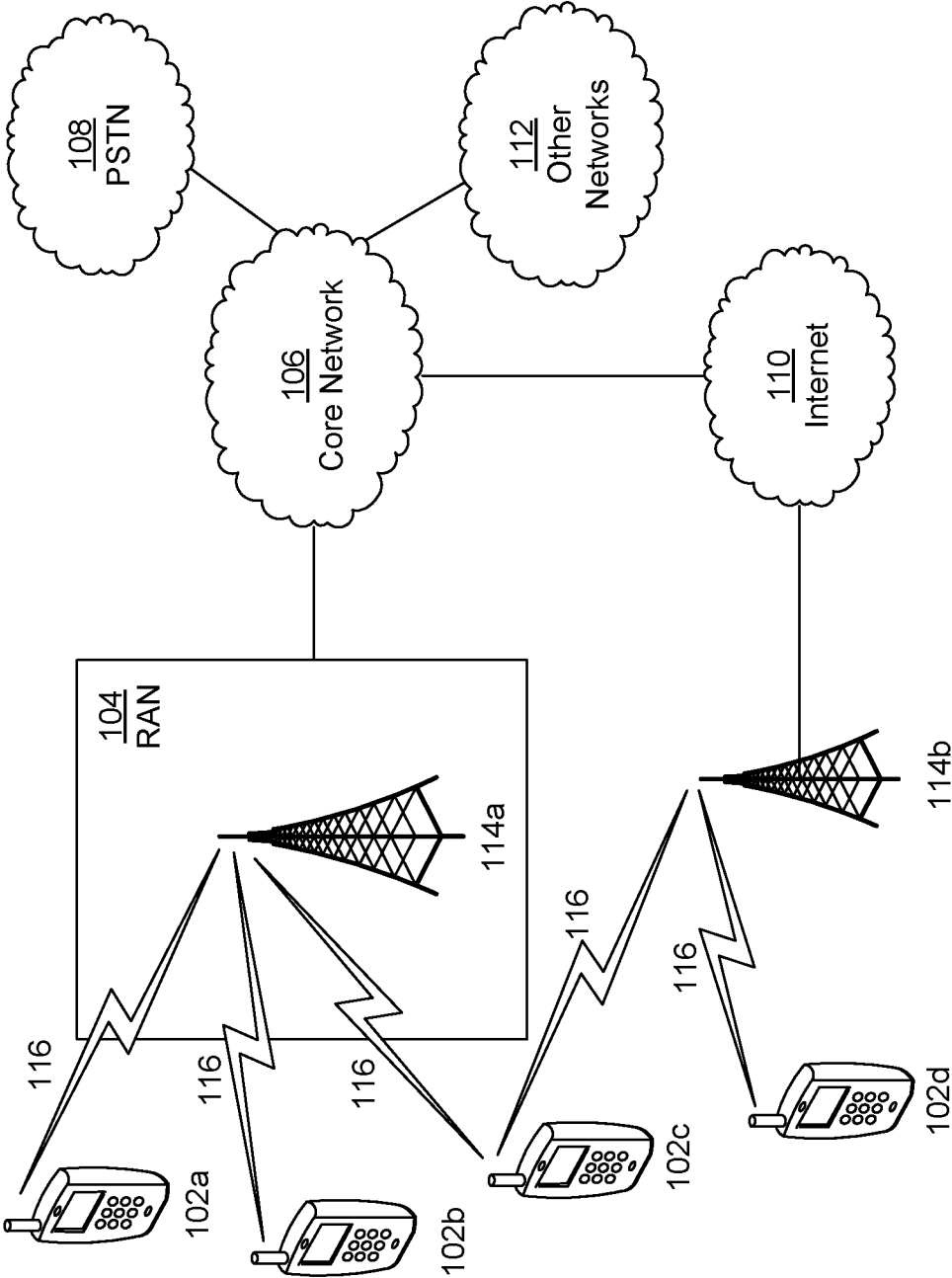
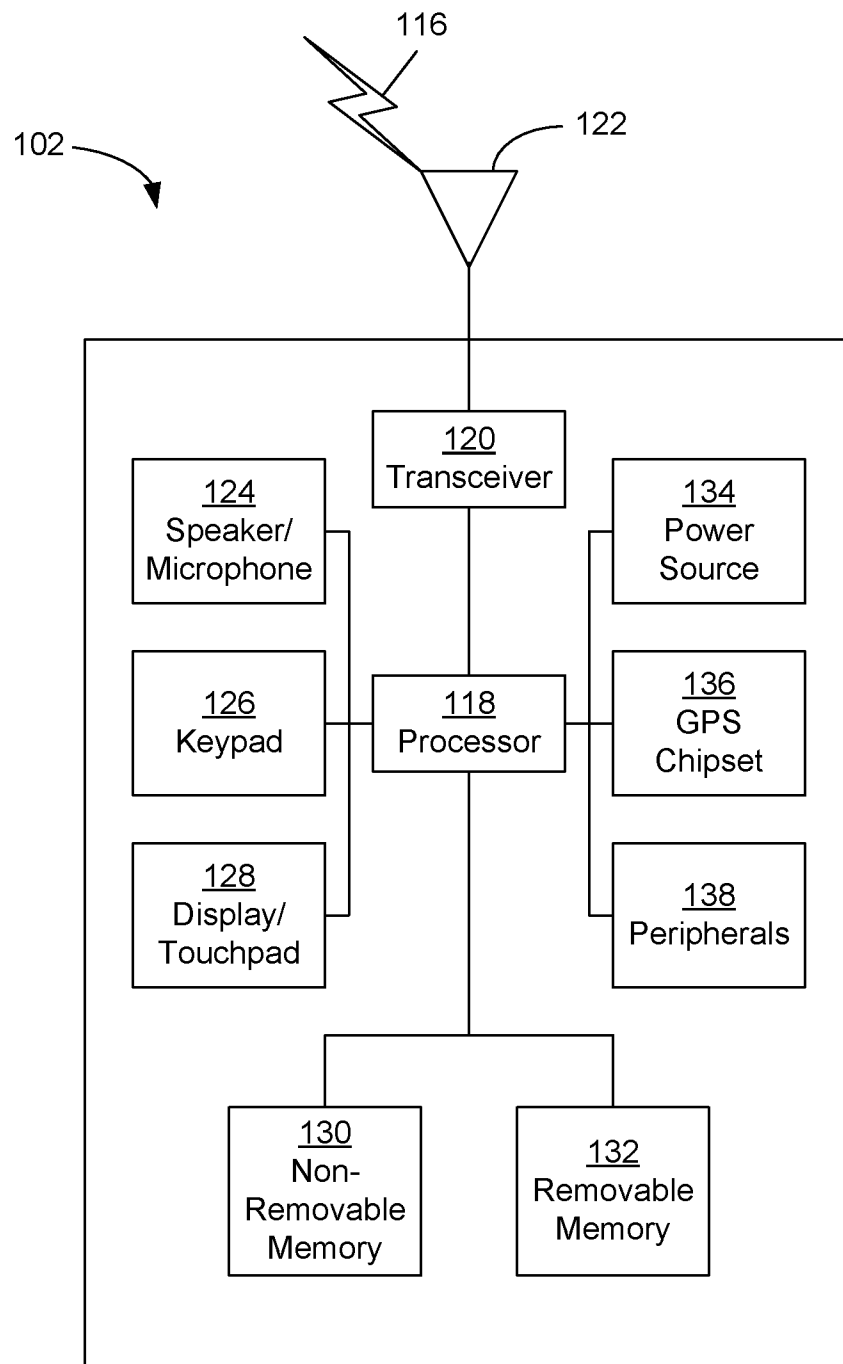


FIG. 1A

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**FIG. 1B**

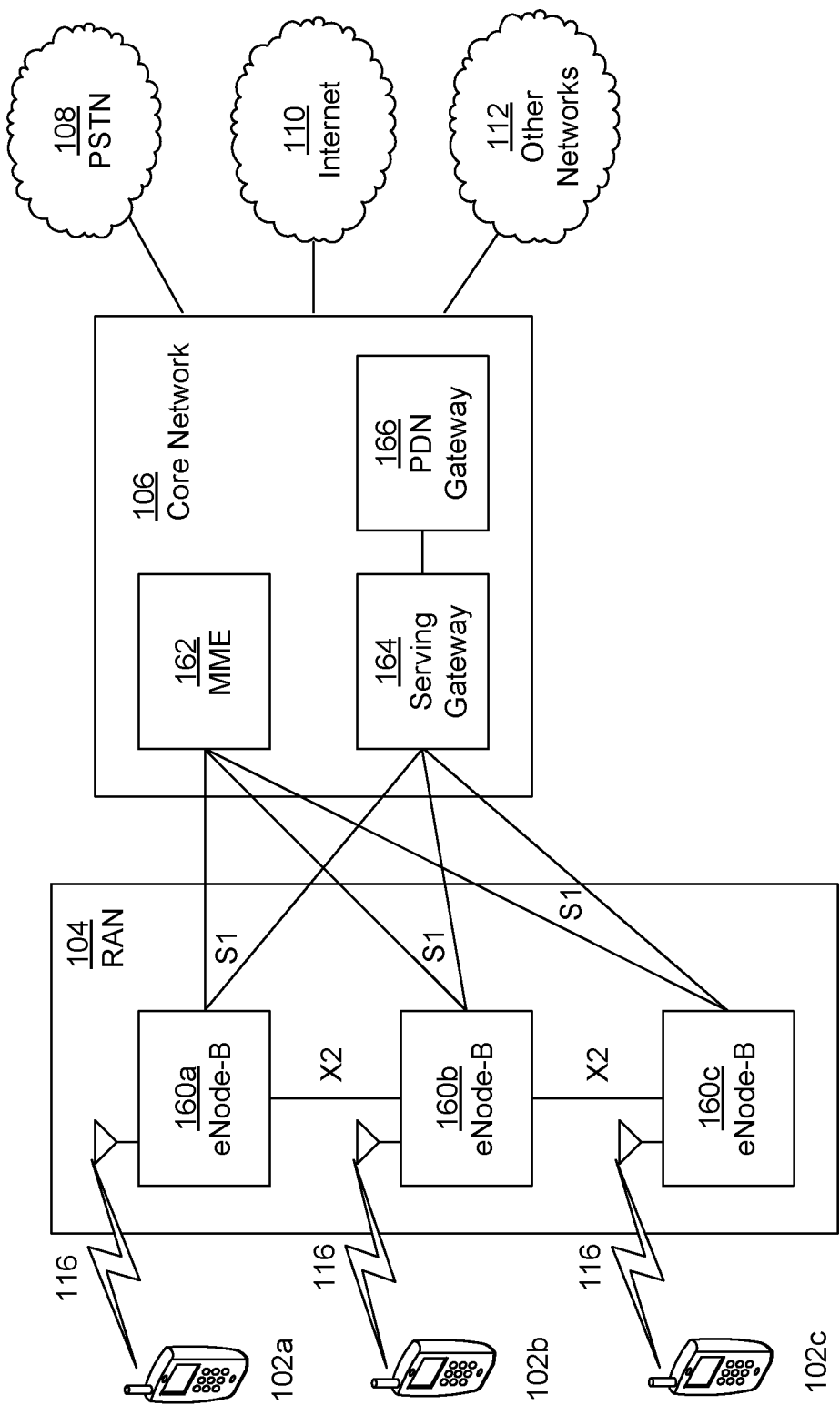


FIG. 1C

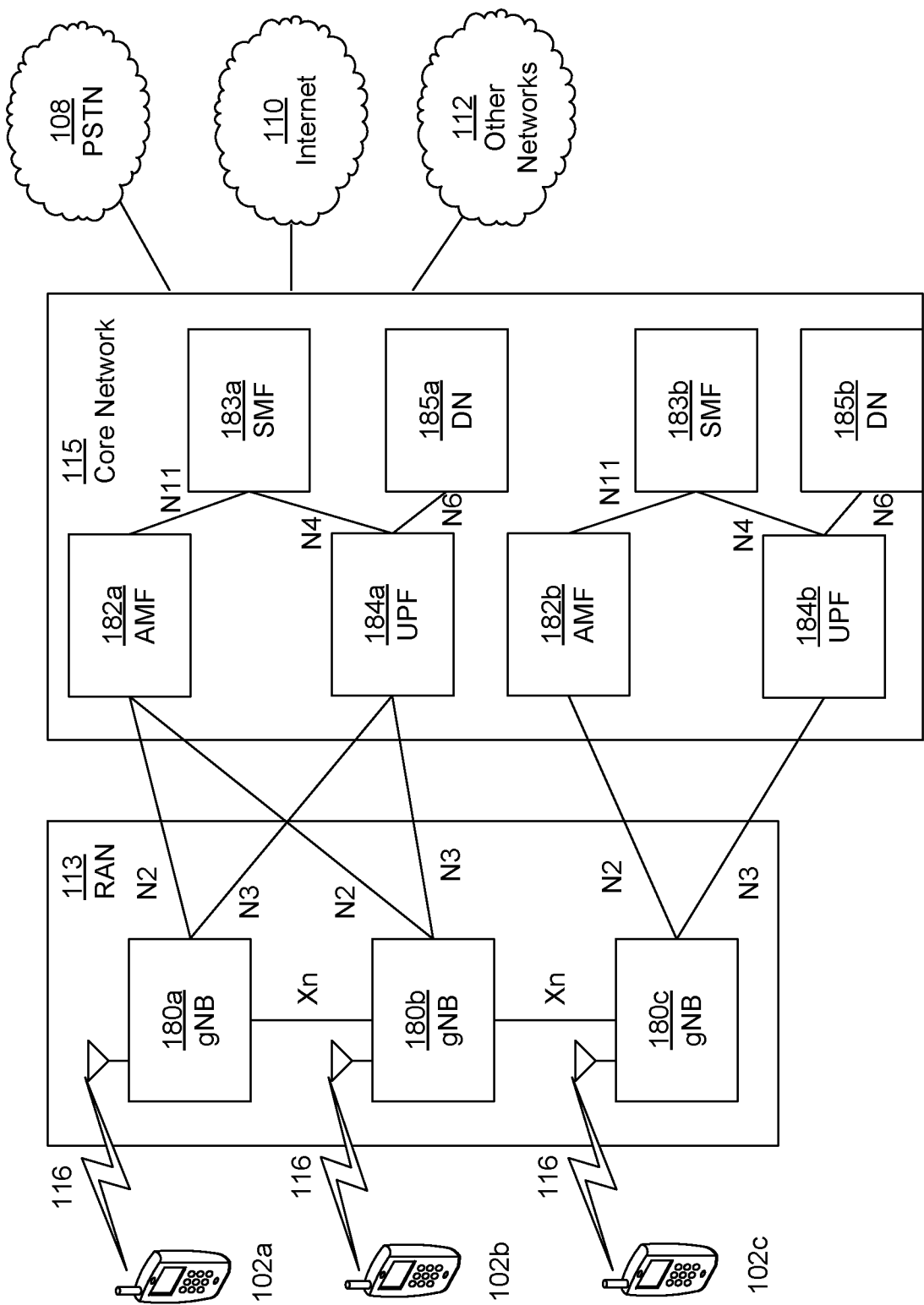


FIG. 1D

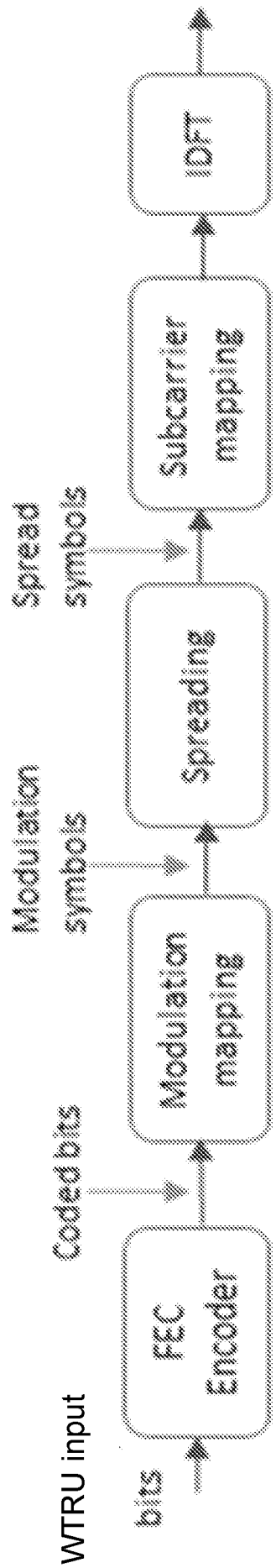
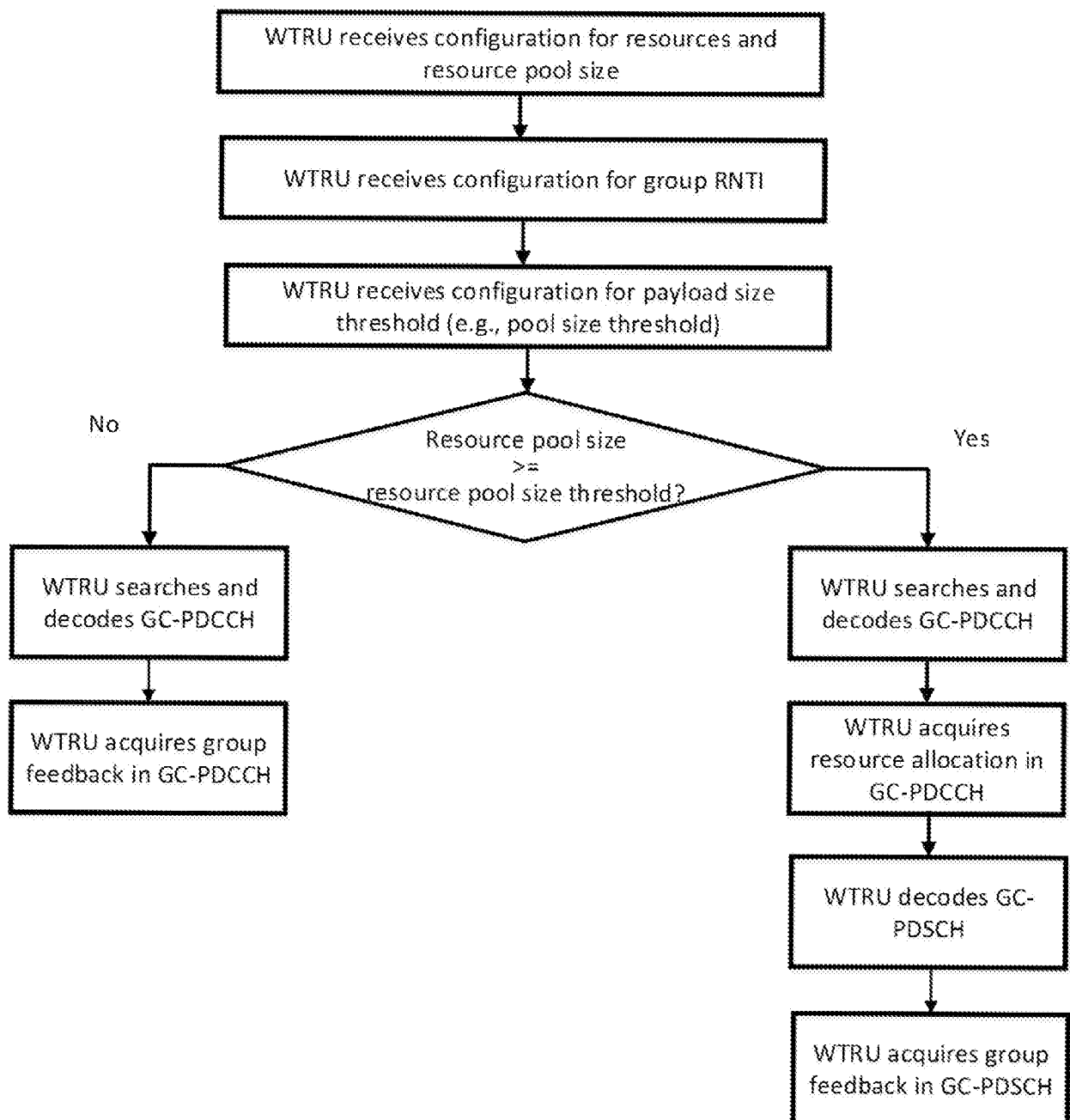
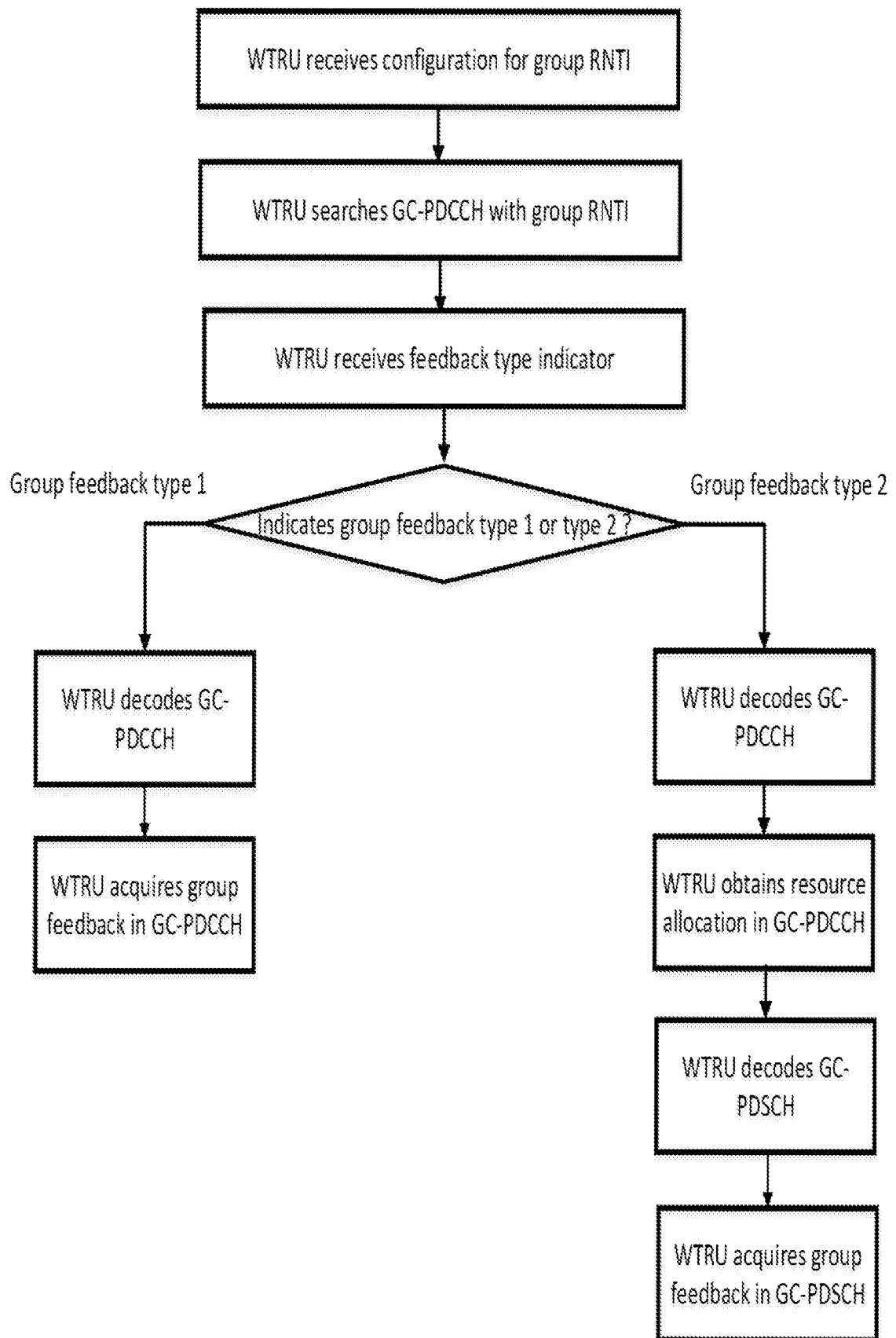


FIG. 2

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**FIG. 3**

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**FIG. 4**

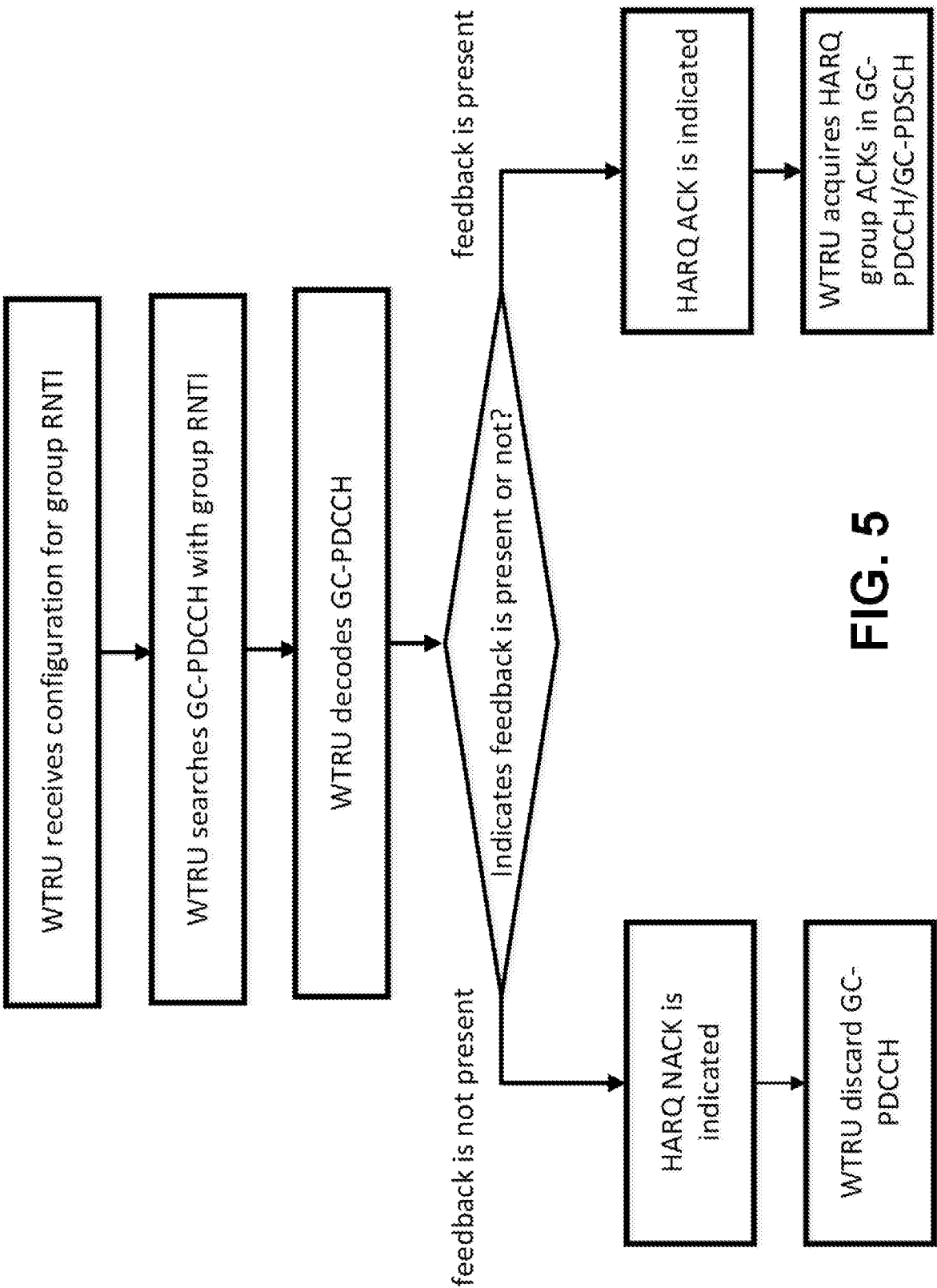


FIG. 5

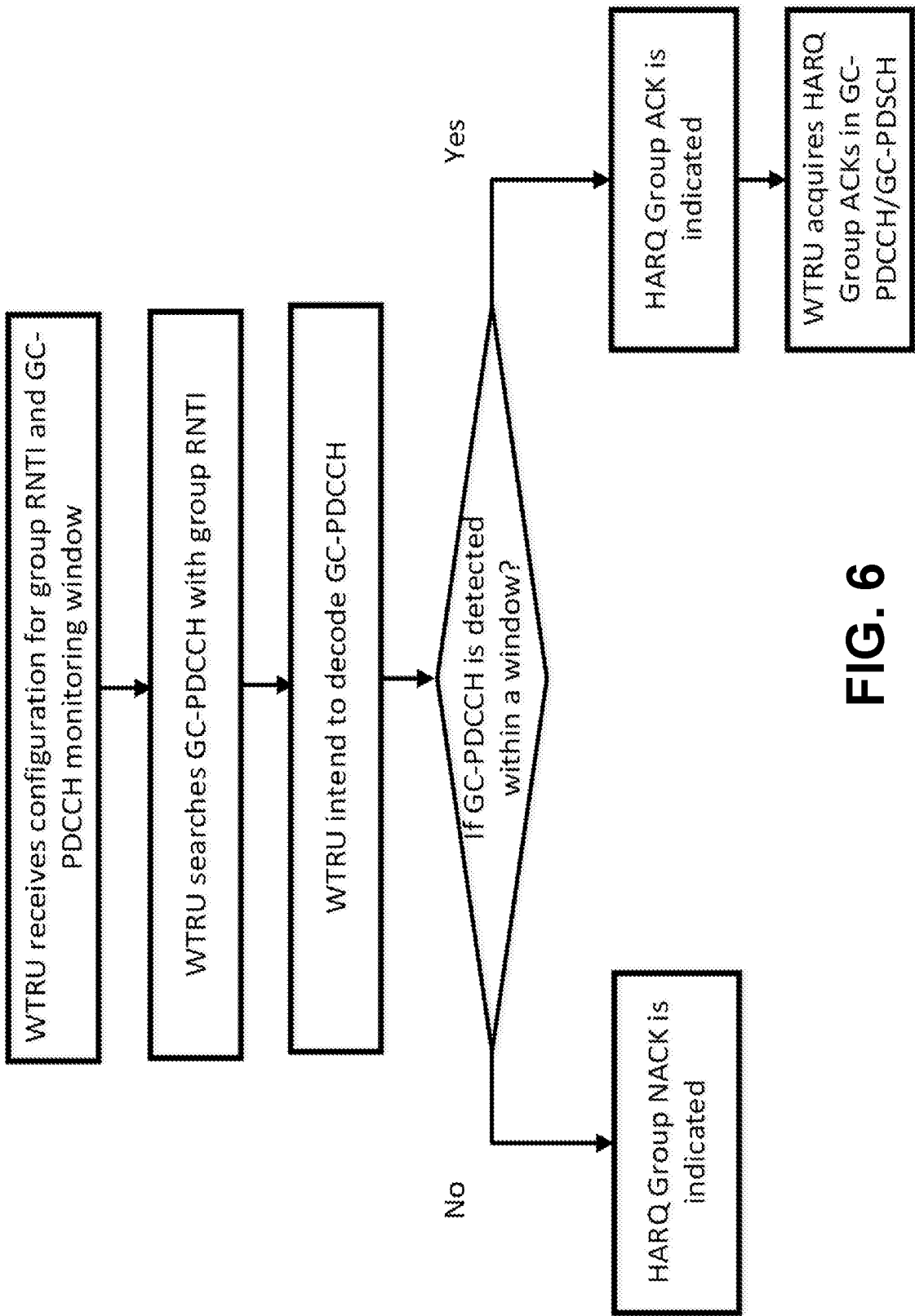


FIG. 6



FIG. 7



FIG. 8



FIG. 9



FIG. 10



FIG. 11



FIG. 12



FIG. 13

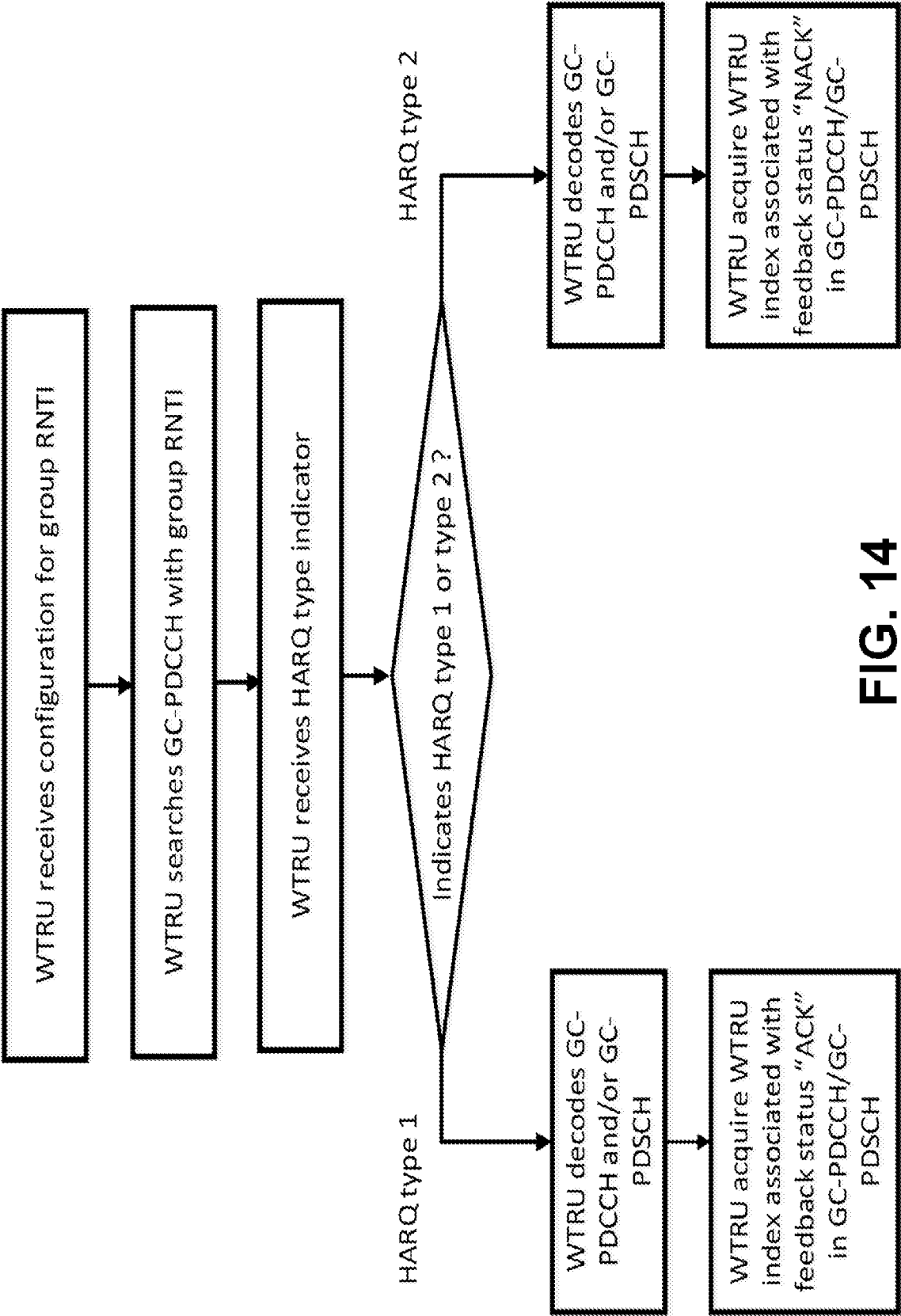
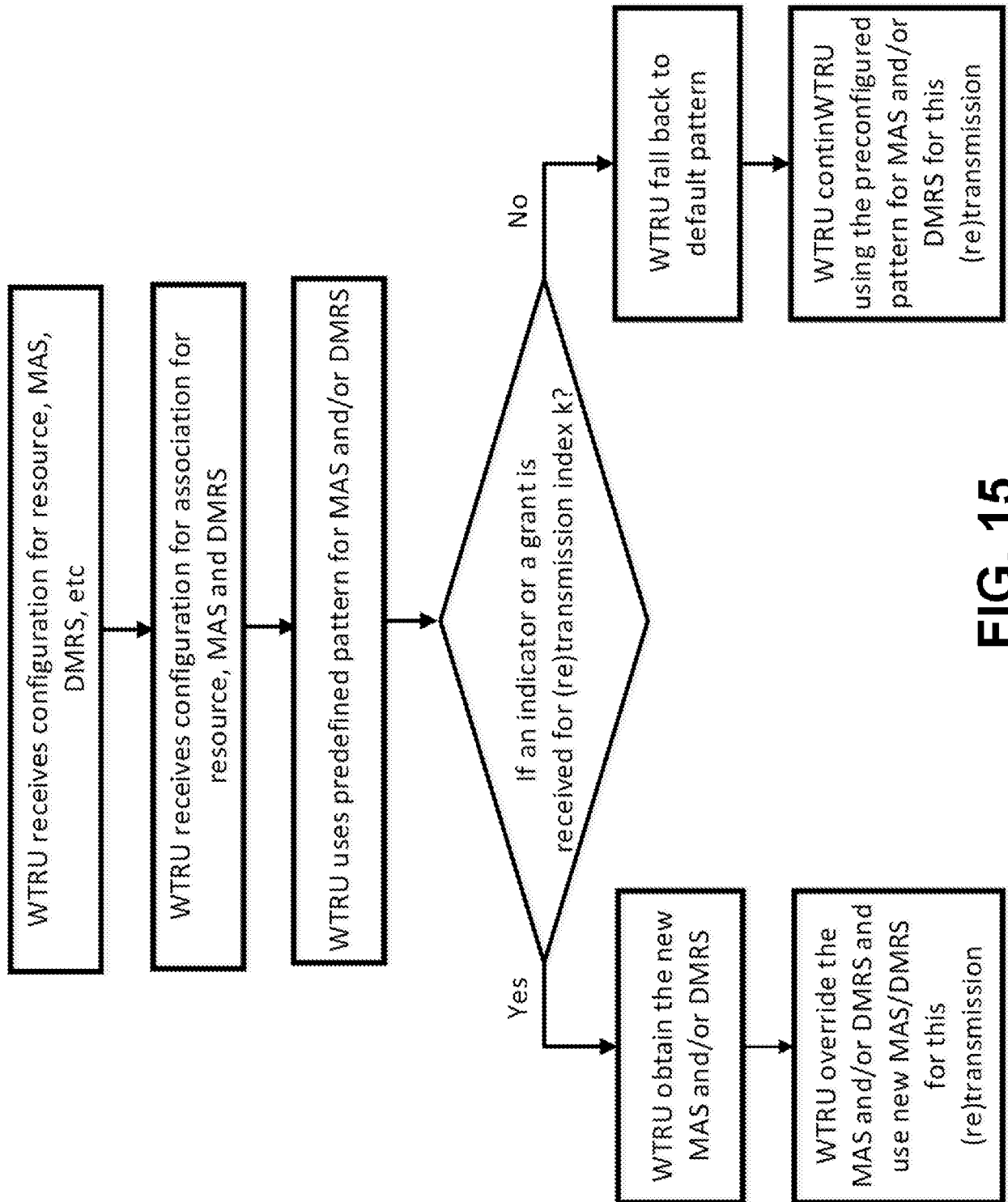


FIG. 14

**FIG. 15**

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2019/055382

A. CLASSIFICATION OF SUBJECT MATTER  
INV. H04L1/18 H04L1/16  
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, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                                                                                                                                                           | Relevant to claim No. |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | <p>US 2018/123765 A1 (CAO YU [CA] ET AL)<br/>3 May 2018 (2018-05-03)</p> <p>paragraph [0127] - paragraph [0130]<br/> paragraph [0135] - paragraph [0138]<br/> paragraph [0143] - paragraph [0144]<br/> paragraph [0156] - paragraph [0159]<br/> paragraph [0165]<br/> paragraph [0167]<br/> paragraph [0169]<br/> paragraph [0178]<br/> paragraph [0179] - paragraph [0184]<br/> paragraph [0186] - paragraph [0188]<br/> -----<br/> -/-</p> | 1-14                  |



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

17 December 2019

Date of mailing of the international search report

08/01/2020

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

García Larrodé, M

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2019/055382

| C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                                                                                                                                                                                                                                                      |                       |
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Information on patent family members

International application No

PCT/US2019/055382

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