

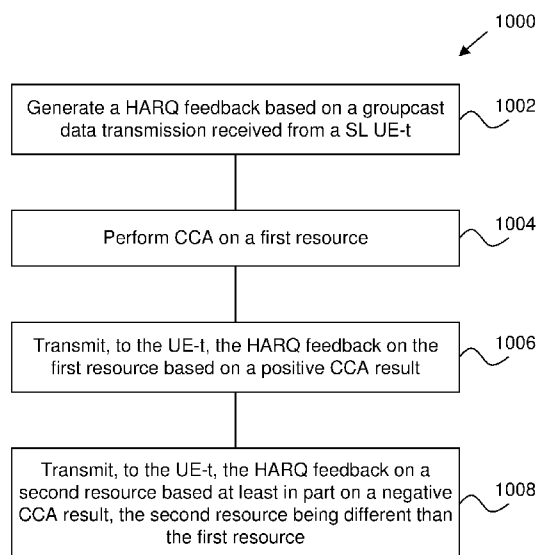


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(54) **Title:** HANDLING LBT FAILURE IN GROUPCAST SIDELINK COMMUNICATION



(57) **Abstract:** Various aspects of the present disclosure relate to generating (1005) a hybrid automatic repeat request (HARQ) feedback based on a groupcast data transmission received from a sidelink (SL) transmitter UE (UE-t) and performing (1010) a Clear Channel Assessment (CCA) of a first resource. Aspects of the present disclosure may further relate to transmitting (1015), to the SL UE-t, the HARQ feedback on the first resource based on a positive CCA result and transmitting (1020), to the SL UE-t, the HARQ feedback on a second resource based at least in part on a negative CCA result, the second resource being different than the first resource.

FIG. 10

HANDLING LBT FAILURE IN GROUPCAST SIDELINK COMMUNICATION

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to overcoming Continuous Listen-Before-Talk (C-LBT) failures in groupcast Sidelink Unlicensed (SL-U) communication.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers, or the like). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

SUMMARY

[0003] An article “a” before an element is unrestricted and understood to refer to “at least one” of those elements or “one or more” of those elements. The terms “a,” “at least one,” “one or more,” and “at least one of one or more” may be interchangeable. As used herein, including in the claims, “or” as used in a list of items (e.g., a list of items prefaced by a phrase such as “at least one of” or “one or more of” or “one or both of) indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase “based on” shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as “based on condition A” may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the

phrase “based on” shall be construed in the same manner as the phrase “based at least in part on. Further, as used herein, including in the claims, a “set” may include one or more elements.

[0004] Some implementations of the method and apparatuses described herein may further include means for generating a hybrid automatic repeat request (HARQ) feedback based on a groupcast data transmission received from a sidelink (SL) transmitter UE (UE-t). The method and apparatuses described herein may include means for performing a Clear Channel Assessment (CCA) on a first resource. The method and apparatuses described herein may include means for transmitting, to the UE-t, the HARQ feedback on the first resource based on a positive CCA result. The method and apparatuses described herein may include means for transmitting, to the UE-t, the HARQ feedback on a second resource based at least in part on a negative CCA result, the second resource being different than the first resource.

[0005] In some implementations, the method and apparatuses described herein may further include means for transmitting, to a group of SL receiver UEs (UE-r), a groupcast data transmission on a first resource. The method and apparatuses described herein may include means for receiving, from a respective SL UE-r, a message on a second resource, wherein the transmission comprises HARQ feedback for the groupcast data transmission. The method and apparatuses described herein may include means for determining whether retransmission of the groupcast data transmission is needed based on a set of received HARQ feedback. The method and apparatuses described herein may include means for performing a retransmission of a pending transport block (TB) based on determining that the retransmission of the groupcast data transmission is needed. The method and apparatuses described herein may include means for clearing the pending TB from a buffer based on determining that the retransmission of the groupcast data transmission is not needed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0007] Figure 2 illustrates an example of a Third Generation Partnership Project (3GPP) New Radio (NR) protocol stack that supports different protocol layers in the UE and the network, in accordance with aspects of the present disclosure.

[0008] Figure 3 illustrates an example of a 3GPP SL protocol stack that supports different protocol layers in the UE-t and the UE-r, in accordance with aspects of the present disclosure.

[0009] Figure 4 illustrates an example of a radio frame and an LBT procedure for unlicensed communication in accordance with aspects of the present disclosure.

[0010] Figure 5 illustrates an example of groupcast SL-U communication procedure using feedback option-1, in accordance with aspects of the present disclosure.

5 [0011] Figure 6 illustrates an example of groupcast SL-U communication procedure using feedback option-2, in accordance with aspects of the present disclosure.

[0012] Figure 7 illustrates an example of a user equipment (UE) 700 in accordance with aspects of the present disclosure.

10 [0013] Figure 8 illustrates an example of a processor 800 in accordance with aspects of the present disclosure.

[0014] Figure 9 illustrates an example of a network equipment (NE) 900 in accordance with aspects of the present disclosure.

[0015] Figure 10 illustrates a flowcharts of method performed by a UE in accordance with aspects of the present disclosure.

15 [0016] Figure 11 illustrates a flowcharts of method performed by a UE in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

20 [0017] Generally, the present disclosure describes systems, methods, and apparatuses for handling C-LBT failures in groupcast SL-U communication. In certain embodiments, the methods may be performed using computer-executable code embedded on a computer-readable medium. In certain embodiments, an apparatus or system may include a computer-readable medium containing computer-readable code which, when executed by a processor, causes the apparatus or system to perform at least a portion of the below described solutions.

25 [0018] For SL-U communication, transmitters are expected to “sense” the medium, e.g., based on a CCA protocol, and detect transmissions from other nodes prior to transmitting. The simplest CCA method is energy detection, i.e., to measure the received energy level of signals transmitted from other devices and determine whether a channel is idle or busy.

[0019] Accordingly, the UE-t must perform an LBT procedure prior to each Physical Sidelink Control Channel (PSCCH) and Physical Sidelink Shared Channel (PSSCH) transmission and transmits SL data and SL control information (SCI) to the UE-r upon LBT

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success (i.e., when the CCA yields a positive result). Similarly, the UE-r must perform an LBT procedure prior to each Physical Sidelink Feedback Channel (PSFCH) transmission and transmits HARQ feedback to the UE-t upon LBT success (i.e., when the CCA yields a positive result). However, if the CCA yields a negative result (i.e., indicating the channel is occupied/busy), then the SL channel is unavailable for transmission and the transmitting device (e.g., UE-t or UE-r) must wait for a new transmission opportunity (e.g., PSSCH, PSSCH, or PSFCH occasion) and again perform a LBT procedure.

[0020] In SL groupcast communication there are several SL UEs as members of a SL group. The Layer 2 destination (DST) identity (ID) is common across the SL group. Any member UE can make a SL groupcast (GC) transmission and may seek HARQ feedback for its transmission. There are a couple of options that can be used to seek and provide HARQ feedback in SL GC communication:

[0021] Feedback option-1: negative-only acknowledgement (also called “NACK-only”) feedback. Here only the receiver(s) that fail to decode the received PSSCH will provide HARQ NACK Feedback on common PSFCH feedback channel.

[0022] Feedback option-2: negative-positive acknowledgement (also called “ACK-NACK”) feedback. Here each UE-r provides HARQ Feedback on receiver-specific PSFCH feedback channel, i.e., both HARQ ACK and HARQ NACK feedback can be provided. The UE-t expects to receive as many HARQ feedbacks as there are group members in the SL Group. In various embodiments, the number of group members in the SL Group is informed by upper layer in the UE-t to the Access Stratum (AS).

[0023] A transmitter UE-t decides based on received NACK feedback and/ or based on ACK feedback(s) not received for a transmitted TB, if it should retransmit the TB.

[0024] Accordingly, in the feedback option-1 case, if the UE-r is unable to transmit negative HARQ feedback due to LBT failure, then the UE-t does not receive any NACK feedback and thus assumes the data was successfully received by all member UEs. So, this case leads to data loss for the UE-r because the UE-t does not retransmit the groupcast data for which no NACK feedback is received.

[0025] Further, in the feedback option-2 case, if after successfully receiving and decoding a TB from a transmitter UE-t, the UE-r unable to transmit an ACK feedback due to LBT failure, then upon not receiving any feedback from the particular UE-r, the UE-t will assume discontinuous transmission (DTX) and – according to conventional behavior – will treat this

DTX as NACK feedback and proceed to make a retransmission of the groupcast data (see, e.g., clause 5.22.1.3.2 of 3GPP Technical Specification (TS) 38.321).

[0026] While one solution would be to depend on the existing mechanism of multiple PSFCH occasions to reduce the likelihood that HARQ feedback will not be transmitted due to LBT failure (i.e., negative CCA result) due to the member UE-r having multiple opportunity to provide HARQ feedback to the transmitter UE. However, it is not always possible to have multiple PSFCH occasions due to resource constraint for groupcast communication.

Moreover, even if multiple PSFCH occasions are configured, it is still possible that the UE-r could not transmit HARQ feedback to the transmitter due to LBT failure.

[0027] To solve the problems with groupcast feedback on unlicensed spectrum discussed herein, after attempting HARQ feedback transmission and receiving an LBT failure from lower layer, the UE-r initiates a new transmission to the UE-t using different resources than those experiencing LBT failure. Upon receiving the new transmission, the UE-t will retransmit corresponding TB(s), not yet successfully received in the UE-r(s) and flush/release L2 buffer for TB(s) successfully received by all member UEs.

[0028] By using different resources, the UE-r improves the likelihood of overcoming the channel busy condition and having a positive CCA result. By making the new transmission (i.e., on different resources), the UE-r is able to provide the HARQ feedback to the UE-t, thereby avoiding extra transmission of data the UE-r has already successfully received.

[0029] Aspects of the present disclosure are described in the context of a wireless communications system.

[0030] Figure 1 illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more NE 102, one or more UE 104, and a core network (CN) 106. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as a Long-Term Evolution (LTE) network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a NR network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE

802.20. The wireless communications system 100 may support radio access technologies beyond 5G, for example, 6G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

5 **[0031]** The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a network function, a network entity, a radio access network (RAN), a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE
10 104 may communicate via a communication link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0032] An NE 102 may provide a geographic coverage area for which the NE 102 may support services for one or more UEs 104 within the geographic coverage area. For example,
15 an NE 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, an NE 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). In some implementations, different geographic coverage areas associated with the same or different radio access technologies
20 may overlap, but the different geographic coverage areas may be associated with different NE 102.

[0033] The one or more UE 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a
25 transmitter device, a receiver device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples.

30 **[0034]** A UE 104 may be able to support wireless communication directly with other UEs 104 over a communication link. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some

implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

- 5 **[0035]** An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, N2, or network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other or indirectly (e.g., via the
- 10 CN 106. In some implementations, one or more NE 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).
- 15 **[0036]** The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or
- 20 interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more NE 102 associated with the CN 106.
- 25 **[0037]** The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N2, or another network interface). The packet data network may include an application server. In some implementations, one or more UEs 104 may communicate with the application server. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or a PDN connection, or the like) with the CN 106 via an
- 30 NE 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

[0038] In the wireless communications system 100, the NEs 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the NEs 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0039] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., $\mu=0$) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu=2$) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0040] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0041] Additionally, or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For

instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., orthogonal frequency domain multiplexing (OFDM) symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0042] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the NEs 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the NEs 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the NEs 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0043] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., $\mu=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu=1$), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu=3$), which includes 120 kHz subcarrier spacing.

[0044] Wireless communication in unlicensed spectrum (also referred to as “shared spectrum”) in contrast to licensed spectrum offer some obvious cost advantages allowing communication to obviate overlaying operator’s licensed spectrum and rather use license free spectrum according to local regulation in specific geographies. From 3GPP technology perspective, the unlicensed operation can be on the Uu interface (referred to as NR-U) or also on sidelink interface (e.g., SL-U).

[0045] Figure 2 illustrates an example of a NR protocol stack 200, in accordance with aspects of the present disclosure. While Figure 2 shows the UE 206, the RAN node 208 and a 5G core network (5GC) 210 (comprising at least an AMF), these are representative of a set of UEs 104 interacting with an NE 102 (e.g., base station) and a CN 106. As depicted, the NR protocol stack 200 comprises a User Plane protocol stack 202 and a Control Plane protocol stack 204. The User Plane protocol stack 202 includes a physical (PHY) layer 212, a Medium Access Control (MAC) sublayer 214, the Radio Link Control (RLC) sublayer 216, a Packet Data Convergence Protocol (PDCP) sublayer 218, and Service Data Adaptation Protocol (SDAP) layer 220. The Control Plane protocol stack 204 includes a PHY layer 212, a MAC sublayer 214, a RLC sublayer 216, and a PDCP sublayer 218. The Control Plane protocol stack 204 also includes a Radio Resource Control (RRC) layer 222 and a Non-Access Stratum (NAS) layer 224.

[0046] The AS layer 226 (also referred to as “AS protocol stack) for the User Plane protocol stack 202 consists of at least SDAP, PDCP, RLC and MAC sublayers, and the physical layer. The AS layer 228 for the Control Plane protocol stack 204 consists of at least RRC, PDCP, RLC and MAC sublayers, and the physical layer. The Layer-2 (L2) is split into the SDAP, PDCP, RLC and MAC sublayers. The Layer-3 (L3) includes the RRC layer 222 and the NAS layer 224 for the control plane and includes, e.g., an internet protocol (IP) layer and/or PDU Layer (not depicted) for the user plane. L1 and L2 are referred to as “lower layers,” while L3 and above (e.g., transport layer, application layer) are referred to as “higher layers” or “upper layers.”

[0047] The PHY layer 212 offers transport channels to the MAC sublayer 214. The PHY layer 212 may perform a beam failure detection procedure using energy detection thresholds, as described herein. In certain embodiments, the PHY layer 212 may send an indication of beam failure to a MAC entity at the MAC sublayer 214. The MAC sublayer 214 offers logical channels to the RLC sublayer 216. The RLC sublayer 216 offers RLC channels to the PDCP sublayer 218. The PDCP sublayer 218 offers radio bearers to the SDAP sublayer 220

and/or RRC layer 222. The SDAP sublayer 220 offers QoS flows to the core network (e.g., 5GC). The RRC layer 222 provides for the addition, modification, and release of Carrier Aggregation and/or Dual Connectivity. The RRC layer 222 also manages the establishment, configuration, maintenance, and release of Signaling Radio Bearers (SRBs) and Data Radio Bearers (DRBs).

[0048] The NAS layer 224 is between the UE 206 and an AMF in the 5GC 210. NAS messages are passed transparently through the RAN. The NAS layer 224 is used to manage the establishment of communication sessions and for maintaining continuous communications with the UE 206 as it moves between different cells of the RAN. In contrast, the AS layers 226 and 228 are between the UE 206 and the RAN (i.e., RAN node 210) and carry information over the wireless portion of the network. While not depicted in Figure 2, the IP layer exists above the NAS layer 224, a transport layer exists above the IP layer, and an application layer exists above the transport layer.

[0049] The MAC sublayer 214 is the lowest sublayer in the L2 architecture of the NR protocol stack. Its connection to the PHY layer 212 below is through transport channels, and the connection to the RLC sublayer 216 above is through logical channels. The MAC sublayer 214 therefore performs multiplexing and demultiplexing between logical channels and transport channels: the MAC sublayer 214 in the transmitting side constructs MAC PDUs (also known as Transport Blocks (TBs)) from MAC Service Data Units (SDUs) received through logical channels, and the MAC sublayer 214 in the receiving side recovers MAC SDUs from MAC PDUs received through transport channels.

[0050] The MAC sublayer 214 provides a data transfer service for the RLC sublayer 216 through logical channels, which are either control logical channels which carry control data (e.g., RRC signaling) or traffic logical channels which carry user plane data. On the other hand, the data from the MAC sublayer 214 is exchanged with the PHY layer 212 through transport channels, which are classified as uplink (UL) or downlink (DL). Data is multiplexed into transport channels depending on how it is transmitted over the air.

[0051] The PHY layer 212 is responsible for the actual transmission of data and control information via the air interface, i.e., the PHY layer 212 carries all information from the MAC transport channels over the air interface on the transmission side. Some of the important functions performed by the PHY layer 212 include coding and modulation, link adaptation (e.g., Adaptive Modulation and Coding (AMC)), power control, cell search and

random access (for initial synchronization and handover purposes) and other measurements (inside the 3GPP system (i.e., NR and/or LTE system) and between systems) for the RRC layer 222. The PHY layer 212 performs transmissions based on transmission parameters, such as the modulation scheme, the coding rate (i.e., the modulation and coding scheme (MCS)), the number of Physical Resource Blocks (PRBs), etc.

[0052] Note that an LTE protocol stack comprises similar structure to the NR protocol stack 200, with the differences that the LTE protocol stack lacks the SDAP sublayer 220 in the AS layer 226 and that the NAS layer 224 is between the UE 206 and an MME in the EPC.

[0053] Figure 3 depicts an LBT procedure 300 for a radio frame 302 for communication on unlicensed spectrum, according to embodiments of the disclosure. When a communication channel is a wide bandwidth unlicensed carrier 304 (e.g., several hundred MHz), the CCA/LBT procedure relies on detecting the energy level on multiple sub-bands 306 of the communications channel as shown in Figure 3. The LBT parameters (such as type/duration, clear channel assessment parameters, etc.) may be configured in the UE 206 by the RAN node 208. In one embodiment, the LBT procedure is performed at the PHY layer 212.

[0054] Figure 3 also depicts frame structure of the radio frame 302 for communication between the UE 206 and RAN node 208 on unlicensed spectrum. The radio frame 302 may be divided into subframes (indicated by subframe boundaries 308) and may be further divided into slots (indicated by slot boundaries 310). The radio frame 302 uses a flexible arrangements where UL and DL operations are on the same frequency channel but are separated in time. However, the subframes are not configured as a DL subframe or an UL subframe and a particular subframe may be used by either the UE 206 or RAN node 208. As discussed previously, LBT is performed prior to a transmission. Where LBT does not coincide with a slot boundary 310, a reservation signal 312 may be transmitted to reserve (i.e., occupy) the channel until the slot boundary is reached and data transmission begins.

[0055] With respect to LBT failure handling, the MAC layer 214 relies on reception of a notification of LBT failure from the PHY layer 212 to detect/declare consistent UL LBT failure. The UE 206 switches to another bandwidth part (BWP) and initiates a random-access procedure (i.e., RACH procedure) upon declaration of consistent UL LBT failure on a Primary Cell (PCell) or a Primary Secondary Cell (PSCell), if there is another BWP with configured Random Access Channel (RACH) resources.

[0056] The UE 206 performs radio link failure (RLF) recovery if the consistent UL LBT failure was detected on the PCell, and UL LBT failure was detected on 'N' possible BWP. When consistent UL LBT failures are detected on the PSCell, the UE 206 informs the RAN, via the Secondary Cell Group (SCG) failure information procedure, after detecting a
5 consistent UL LBT failure on 'N' BWPs, where 'N' is the number of configured BWPs with configured Physical Random Access Channel (PRACH) resources. If 'N' is larger than one, it is up to the UE implementation which BWP the UE selects.

[0057] When consistent UL LBT failures are detected on a Secondary Cell (SCell), the UE 206 transmits a new medium access control (MAC) control element (CE) to report the
10 consistent UL LBT failure to the node to which the SCell belongs. In certain embodiments, the MAC CE can be used to report failure on the PCell.

[0058] In other words, in the case of consistent LBT failure, the UE 206 is allowed to autonomously switch the UL BWP. The motivation is that other UL BWP(s) of the NR-U cell may not be subject to large number of LBT failures, i.e., different LBT sub-bands 306 are
15 used for different UL BWP(s).

[0059] Figure 4 illustrates a SL protocol stack 400, in accordance with aspects of the present disclosure. While Figure 4 shows a UE-t 402 and a UE-r 404, these are representative of a set of UEs using SL communication over a PC5 interface; other embodiments may involve different SL UEs. In various embodiments, each of the UE-t 402
20 and a UE-r 404 may be an embodiment of the UE 104 and/or the UE 206.

[0060] As depicted, the SL protocol stack (i.e., PC5 protocol stack) includes a PHY layer 406, a MAC layer 408, a RLC layer 410, a PDCP layer 412, a SDAP layer (e.g., for the user plane), and an RRC layer (e.g., for the control plane). In Figure 4, the SDAP layer and RRC layer are depicted as combined entity "RRC / SDAP layers" 414. There may be additional
25 layers above the RRC / SDAP layers 414, such as a Proximity Services ("ProSe") and/or V2X application layer 416.

[0061] The AS layer (also referred to as "AS protocol stack") for the control plane in the PC5 interface consists of at least the RRC layer, the PDCP layer 412, the RLC layer 410, the MAC layer 408, and the PHY layer 406. The AS layer (also referred to as "AS protocol
30 stack") for the user plane in the PC5 interface consists of at least the SDAP layer, the PDCP layer 412, the RLC layer 410, the MAC layer 408, and the PHY layer 406.

[0062] Similar to the NR protocol stack, the L1 refers to the PHY layer 406. The L2 is split into the SDAP layer, the PDCP layer 412, the RLC layer 410, and the MAC layer 408. The L3 includes the RRC layer for the control plane and includes, e.g., an IP layer or PDU Layer (not depicted) for the user plane. L1 and L2 are generally referred to as “lower layers,” while L3 and above (e.g., transport layer, V2X layer, application layer) are referred to as “higher layers” or “upper layers.” The PHY layer 406, the MAC layer 408, the RLC layer 410, and the PDCP layer 412 perform similar functions as the PHY layer 212, the MAC layer 214, the RLC layer 216, and the PDCP layer 218, described above with reference to Figure 2.

[0063] In various embodiments, the SL communication relates to one or more services requiring SL connectivity, such as V2X services and ProSe services. The UE-t 402 may establish one or more SL connections with nearby UE-r's 404. For example, a V2X application running on the UE-t 402 may generate data relating to a V2X service and use a SL connection to transmit the V2X data to one or more nearby UE-r's 404.

[0064] In NR-U, channel access in both downlink and uplink relies on the LBT procedure. The gNB and/or UE must first sense the channel to find out there are no ongoing communications prior to any transmission. When a communication channel is a wide bandwidth unlicensed carrier, the LBT/CCA procedure relies on detecting the energy level on multiple sub-bands of the communications channel as shown in Figure 3. Note that no beamforming is considered for LBT in NR-U in Release 16 (Rel-16) and only omnidirectional LBT is assumed.

[0065] In LBT, transmitters are expected to “sense” the medium, based on a Clear Channel Assessment (CCA) protocol, and detect transmissions from other nodes prior to transmitting. The simplest CCA method is energy detection, i.e., to measure the received energy level of signals transmitted from other devices and determine whether a channel is idle or busy.

[0066] Regarding SL operation in unlicensed spectrum, in Rel-16, sidelink communication was developed in RAN mainly to support advanced V2X applications. In Release 17 (Rel-17), Proximity-based service including public safety and commercial related service were standardized. As part of Rel-17, power saving solutions (e.g., partial sensing, discontinuous reception (DRX)) and inter-UE coordination were developed to improve power consumption for battery limited terminals and reliability of sidelink transmissions.

[0067] Although NR sidelink was initially developed for V2X applications, there is growing interest in the industry to expand the applicability of NR sidelink to commercial use cases. For commercial sidelink applications, two key requirements have been identified: 1) increased sidelink data rate, and 2) support of new carrier frequencies for sidelink.

5 [0068] Increased sidelink data rate is motivated by applications such as sensor information (video) sharing between vehicles with high degree of driving automation. Commercial use cases could require data rates in excess of what is possible in Rel-17. Increased data rate can be achieved with the support of sidelink carrier aggregation and sidelink over unlicensed spectrum. Furthermore, by enhancing the FR2 sidelink operation,
10 increased data rate can be more efficiently supported on FR2. While the support of new carrier frequencies and larger bandwidths would also allow improvement to data rate, the main benefit would come from making sidelink more applicable for a wider range of applications. More specifically, with the support of unlicensed spectrum and the enhancement in FR2, sidelink will be in a better position to be implemented in commercial devices since
15 utilization of the ITS band is limited to ITS safety related applications.

[0069] Various systems may support sidelink communication on unlicensed spectrum for both mode 1 and mode 2 where Uu operation for mode 1 is limited to licensed spectrum only. In certain embodiments, the channel access mechanisms from NR-U (discussed above with reference to Figure 3) are reused for SL-U operation and the existing NR sidelink and NR-U
20 channel structure are also reused, as the baseline, for SL-U operation. In other words, the SL devices perform LBT/CCA prior to occupying a channel on unlicensed spectrum. In SL-U operation, the gNB does not perform Type 1 channel access to initiate and share a channel occupancy, neither Type 2 channel access to share an initiated channel occupancy, nor semi-static channel access procedures to access an unlicensed channel.

25 [0070] As discussed above, in SL GC communication there are two options that can be used to seek and provide HARQ feedback in SL GC) communication: Feedback option-1 (i.e., NACK-only feedback) and Feedback option-2 (i.e., ACK-NACK feedback).

[0071] For feedback option-1, the UE-t 402 decides based on received NACK feedback received for a transmitted TB whether or not to retransmit the TB, where PSFCH DTX is
30 treated as an ACK. For feedback option-1, the UE-t 402 makes retransmission if it receives even a single NACK feedback, and it does not matter how many UE-r's 404 transmitted the NACK feedback.

[0072] However, for feedback option-2, the UE-t 402 decides based on received ACK and NACK feedback(s) for a transmitted TB whether or not to retransmit the TB, where PSFCH DTX is treated as a NACK.

[0073] Figure 5 illustrates an example of a groupcast SL communication procedure 500 on shared spectrum (i.e., unlicensed spectrum) using SL feedback option-1, in accordance with aspects of the present disclosure. The SL communication procedure 500 involves members of a group of SL UEs including an instance of the UE-t 402 and at least two instances of the UE-r 404, here a first the UE-r 502 (denoted “UE-r_1”) and a second UE-r 504 (denoted “UE-r_2”).

[0074] The UE-t 402 transmits a data packet (denoted “TB1”) to the first UE-r 502 and the second UE-r 504. Specifically, the UE-t 402 attempts to transmit to the first UE-r 502 and the second UE-r 504 by transmitting SCI (e.g., stage 1 and stage 2) on the PSCCH (see messaging 506) and transmitting the data (i.e., TB1 transmission) on the PSSCH (see messaging 508). Note that the SCI may indicate a HARQ process identifier (HPID) of the TB1. Additionally, the SCI may indicate the type of SL feedback, i.e., feedback option-1.

[0075] The first UE-r 502 and the second UE-r 504 attempt to decode the data transmission (i.e., TB1) and each may generate HARQ feedback based on the decoding result. A positive acknowledgement (ACK) means that the Transport Block (TB) is correctly received while a negative acknowledgement (NACK) means that the TB is erroneously received. DTX means that no TB was detected by the receiver.

[0076] In the SL communication procedure 500, it is assumed that the first UE-r 502 successfully decodes the TB1 (see block 510) and would generate an ACK. However, because feedback option-1 is NACK-only, the first UE-r 502 does not attempt any PSFCH transmission towards the UE-t 402.

[0077] Further, it is assumed here that the second UE-r 504 is unsuccessful in decoding the TB1 (see block 512). Accordingly, the second UE-r 504 generates a NACK and prepares a PSFCH transmission to communicate the NACK to the UE-t 402.

[0078] In the SL communication procedure 500, it is further assumed that the second UE-r 504 is unable to perform the PSFCH transmission 514 containing the HARQ feedback due to LBT failure 516 for the PSFCH occasion. In unlicensed operation, even though the channel condition is quite good (calculated based on radio quality of discovery signals and/ or other reference signals), the second UE-r 504 may still be unable to transmit HARQ feedback

on the PSFCH channel if the CCA (clear channel assessment) fails – referred to generally as “LBT failure”. In certain embodiments, LBT failures are tracked/ counted for a Resource Block (RB) set on which the LBT/ CCA failure happens.

5 [0079] As noted above, the UE-t 402 interprets the PSFCH DTX as an ACK (see block 518). Moreover, because no NACK is received from the group of UE-r’s, the UE-t 402 does not attempt to retransmit the TB1. Rather, the UE-t 402 attempts to transmit a new data packet (denoted “TB2”) to the first UE-r 502 and the second UE-r 504 by transmitting SCI on the PSCCH (see messaging 520) and transmitting the data (i.e., TB2 transmission) on the PSSCH (see messaging 522). Note that the SCI may indicate a HPID of the TB2 and/or a
10 feedback option for the TB2.

[0080] Because the second UE-r 504 fails to successfully transmit the NACK feedback, and because there are no other group member UEs transmitting the NACK feedback – either since these other member UEs received the TB1 successfully, or if some other members not having decoded the received TB1, they also could not transmit the HARQ NACK feedback –
15 in absence of a desired retransmission, the second UE-r 504 cannot receive the corresponding TB1 and this results into data loss for this second UE-r 504 as the UE-t not receiving any Negative feedback assumes the data was successfully received by all member UEs. So, this case of data loss is a problem as shown in Figure 5 where the UE-t 402 starts transmission of TB2 not knowing that the second UE-r 504 has not received TB1 successfully.

20 [0081] Figure 6 illustrates an example of a groupcast SL communication procedure 600 performed on unlicensed spectrum (i.e., shared spectrum) using feedback option-2, in accordance with aspects of the present disclosure. The SL communication procedure 600 involves a group of SL UEs including the UE-t 402, the first UE-r 502, and the second UE-r 504.

25 [0082] The UE-t 402 transmits a data packet (denoted “TB1”) to the first UE-r 502 and the second UE-r 504. Specifically, the UE-t 402 attempts to transmit to the first UE-r 502 and the second UE-r 504 by transmitting SCI (e.g., stage 1 and stage 2) on the PSCCH (see messaging 602) and transmitting the data (i.e., TB1 transmission) on the PSSCH (see messaging 604). Note that the SCI may indicate a HPID of the TB1. Additionally, the SCI
30 may indicate the type of SL feedback, i.e., feedback option-2.

[0083] The first UE-r 502 and the second UE-r 504 attempt to decode the data transmission (i.e., TB1) and each may generate HARQ feedback based on the decoding result.

A positive acknowledgement (ACK) means that the Transport Block (TB) is correctly received while a negative acknowledgement (NACK) means that the TB is erroneously received. DTX means that no TB was detected by the receiver.

[0084] In the SL communication procedure 600, it is assumed that the first UE-r 502 successfully decodes the TB1 (see block 606) and generates an ACK. Because feedback option-2 allows for both ACK and NACK feedback, the first UE-r 502 indicates the ACK in a PSFCH transmission towards the UE-t 402 (see messaging 610).

[0085] Further, it is assumed here that the second UE-r 504 is also successful in decoding the TB1 (see block 608). Accordingly, the second UE-r 504 also generates an ACK and prepares a PSFCH transmission to communicate the ACK to the UE-t 402.

[0086] However, in the SL communication procedure 600, it is again assumed that the second UE-r 504 is unable to perform the PSFCH transmission 612 containing the HARQ feedback due to LBT failure 614 for the PSFCH occasion. In certain embodiments, LBT failures are tracked/ counted for an RB set on which the LBT/ CCA failure happens.

[0087] As noted above, the UE-t 402 interprets the PSFCH DTX as a NACK (see block 616). Because not all member UEs indicated that the TB1 was successfully received, the UE-t 402 attempts to retransmit the TB1 to the first UE-r 502 and the second UE-r 504 by transmitting SCI on the PSCCH (see messaging 618) and transmitting the data (i.e., TB1 retransmission) on the PSSCH (see messaging 620). Note that the SCI may indicate a HPID of the TB1 retransmission and/or a feedback option for the TB1 retransmission.

[0088] The UE-t 402 may end up making many such unnecessary retransmissions if the max number of allowed/ (pre)configured retransmissions are very high, such as 32 (configured using parameters sl-MaxTransNum-r16, sl-MaxTxTransNumPSSCH-r16 in 3GPP TS 38.331). This consumes battery in the UE-t 402 and wastes radio resources.

[0089] The present disclosure describes techniques to allow for an efficient and reliable way around the above described situations where HARQ feedback may not be transmitted in the SL-U groupcast operation due to LBT failure at a particular UE-r.

[0090] According to aspects of a first solution, a group member UE-r 404 will make a new transmission to the UE-t 402: A) upon failing to transmit a NACK feedback e.g., due to CCA/ LBT failure, when the UE-t 402 requests HARQ feedback option-1 based (NACK-only)

feedback; or B) upon failing to transmit an ACK feedback e.g., due to CCA/ LBT failure, when the UE-t 402 requests HARQ feedback option-2 based (ACK-NACK) feedback.

[0091] Upon receiving the new transmission, the UE-t 402 will retransmit corresponding TB(s), not yet successfully received in the group member UE-r 404 and/or flush/ release the L2 buffer for TB(s) successfully received by all member UEs.

[0092] To achieve this, the new transmission includes information informing the UE-t 402 which TBs are and/or are not yet successfully received by the particular UE-r 404. In certain embodiments, a portion of this information can be made implicitly. For example, if information is present for TBs not yet successfully received by a respective UE-r 404, then all other pending TBs are considered to have been successfully received by the UE-r 404. Similarly, if information is present for TBs successfully received by a respective UE-r 404, then all other pending TBs are considered to not have been successfully received by the UE-r 404.

[0093] Before flushing/ clearing a TB successfully received by a respective UE-r 404, the UE-t 402 needs to ensure that the same TB is received successfully by all other member UEs as well. This can be done by the UE-t 402 aggregating HARQ feedback(s) received on PSFCH from one or more member UEs and HARQ feedback included in the new transmission. As used herein, aggregation means storing and combining the PSFCH information from member UEs and the one or more new transmission received for the said TB.

[0094] Table 1 depicts an example of aggregating HARQ feedback(s) received on PSFCH from one or more member UEs and HARQ feedback (HF) included in the new transmission in accordance with embodiments of the disclosure. In this example, there are six (6) members of the group, therefore the UE-t 402 expects a total of five (5) feedbacks from the member UEs.

Receiver UE	HF in PSFCH (A)	HF from New Transmission (B)	Result (A) or (B)
Member-UE-1	ACK	Not required to be transmitted by UE-1	ACK
Member-UE-2	Not received in UE-t (DTX)	ACK	ACK

Member-UE-3	ACK	Not required to be transmitted by UE-3	ACK
Member-UE-4	ACK	Not required to be transmitted by UE-4	ACK
Member-UE-5	Not received in UE-t (DTX)	ACK	ACK

Table 1

[0095] In the example of Table 1, the UE-t receives 5 ACKs as expected and therefore the corresponding TB is not required to be retransmitted anymore and the buffer for the same can be released/ flushed.

- 5 **[0096]** For retransmission determination, the same can be based on negative PSFCH feedback as well as the said new transmission indicating need for a retransmission by a respective UE-r 404.

- 10 **[0097]** Table 2 depicts another example of aggregating HARQ feedback(s) received on PSFCH from one or more member UEs and HARQ feedback (HF) included in the new transmission in accordance with embodiments of the disclosure. In this example, there are six (6) members of the group, therefore the UE-t 402 expects a total of five (5) feedbacks from the member UEs.

Receiver UE	HF in PSFCH (A)	HF from <i>New Transmission</i> (B)	Result (A) or (B)
Member-UE-1	ACK	Not required to be transmitted by UE-1	ACK
Member-UE-2	Not received in UE-t (DTX)	ACK	ACK
Member-UE-3	ACK	Not required to be transmitted by UE-3	ACK
Member-UE-4	ACK	Not required to be transmitted by UE-4	ACK
Member-UE-5	Not received in UE-t (DTX)	NACK or DTX	NACK

Table 2

[0098] In the example of Table 2, the UE-t 402 receives 4 ACKs and 1 NACK. Therefore, the corresponding TB is required to be retransmitted and the buffer for the same cannot be released/ flushed.

5 **[0099]** The new transmission is sent to UE-t either when PSFCH transmission fails e.g., due to CCA/ LBT failure for 1 or a threshold times, or it can be sent periodically every 'n' milliseconds/ slots/ reception attempts.

[0100] Different implementations for realizing the new transmission are possible. In one implementation, the new transmission is a new MAC CE. In another implementation, the
10 new transmission is an SCI transmission.

[0101] In various embodiments, the new transmission is a new MAC CE which is identified by a MAC subheader with specific Logical Channel Identifier (LCID). The new MAC CE is transmitted on a different and available RB set, e.g., it triggers a resource selection at the UE-r 404 to avoid using the same RB set for which LBT has failed
15 consistently.

[0102] In various embodiments, the MAC CE contains a combination of one or more following elements: A) RB Set identification where PSFCH transmission failure occurred; B) HPIDs for TBs which the UE-r 404 failed to decode successfully (the included HARQ Process ID is same as the one received in SCI format 2-A/ SCI format 2-B by the UE-r 404);
20 C) No payload; and/or D) One MAC CE containing only 1 bit flag in the subheader apart from LCID and remaining reserved bit

[0103] In various embodiments, HPIDs are included along with corresponding HARQ Feedback(s) – this is like one-shot HARQ feedback for all TBs for which feedback could not be transmitted or for which the data is not yet successfully decoded by the UE-r 404. An
25 example of HPIDs and corresponding HARQ Feedbacks is shown in Table 3.

Not successfully received TBs	HPID-1
	HPID-3
Successfully received TBs	HPID-2
	HPID-4
	HPID-6

Table 3

[0104] In the case of no payload, the MAC CE may just contain a subheader and indicate that the last transmission(s) are all successfully received. Upon receiving this, a transmitter UE (i.e., UE-t 402) may flush all pending TB(s) not required to be transmitted to any other group member UE.

[0105] Alternatively, the MAC CE may just contain a subheader and indicate that the last transmission(s) are not successfully received. Upon receiving this, the transmitter UE (i.e., UE-t 402) is to retransmit/ repeat all pending TBs i.e., any TB for which a HARQ ACK has not yet been received by the UE-t 402 from the UE-r 404. In certain embodiments, the retransmission/ repeat can be done on the RB set where the said MAC CE is received. As used herein, the notation “retransmit/ repeat” or “retransmits/ repeats” indicates the performing of a retransmission and/or a transmission repetition.

[0106] As used herein, a retransmission refers to the case where the transmitter (i.e., UE-t 402) sends the same TB again making HARQ based retransmissions, e.g., using different redundancy version.

[0107] In the case of the MAC CE containing only a 1-bit flag, in one implementation, if the bit is set, then the flag indicates that the last transmission(s) are all successfully received. The UE-t 402 may flush all pending TB(s) not required to be transmitted to any other group member UE. Conversely, if the bit is not set, then the flag indicates that the last transmission(s) are not successfully received. Here, the UE-t 402 is to retransmit/ repeat all pending TBs i.e., any TB for which a HARQ ACK has not yet been received by the UE-t 402 from the UE-r 404.

[0108] In one implementation, the MAC CE has a fixed size and contains only one (or more) of the above elements – which is specified. In another implementation, the MAC CE has a variable size and contains one or more optional elements with its corresponding ‘presence’ field in the MAC CE subheader indicating if the particular element is included (or not). As one particular implementation, the new MAC CE has no payload and contains just a subheader.

[0109] In one enhancement to ensure transmission of MAC CE, the priority (e.g., Logical Channel (LCH) Priority and/ or L1 transmission priority) is considered to be the highest for the MAC CE corresponding to the new transmission described previously. This affects destination selection during the MAC Logical Channel Prioritization (LCP) procedure and

ensures that the MAC CE is always transmitted whenever a transmission grant is available at the UE-r 404. If there is more than one UE-t for which the MAC CEs need to be transmitted when a SL grant becomes available, then the UE-r 404 transmits MAC CE to a respective UE-t for which the MAC CE transmission was triggered earliest.

5 [0110] In various embodiments, the new transmission may be a new SCI in an existing SCI format, or a new SCI format containing one or more of the above elements, as described previously for the new MAC CE implementations. For example, the new SCI format may be called SCI format 2-C and contain one or more of the above fields. Alternatively, a combination of the above elements may be sent using reserved bits of the SCI format 1-A.

10 [0111] Note that SCI format 1-A, as defined by 3GPP, is used for the scheduling of PSSCH and 2nd-stage-SCI on PSSCH. The following information is transmitted by means of the SCI format 1-A: Priority; Frequency resource assignment; Time resource assignment; Resource reservation period; Demodulation Reference Signal (DMRS) pattern; 2nd-stage SCI format; Beta_offset indicator; Number of DMRS ports; Modulation and coding scheme;
15 Additional MCS table indicator; PSFCH overhead indication; and Reserved Bits. These information are defined below:

[0112] Priority is a 3 bit field, e.g., as specified in clause 5.4.3.3 of 3GPP TS 23.287 and clause 5.22.1.3.1 of 3GPP TS 38.321.

[0113] Frequency resource assignment is a variable length field, as defined in clause
20 8.1.5 of 3GPP TS 38.214. When the value of the higher layer parameter *sl-MaxNumPerReserve* is configured to 2, then this field has a length of

$$\left\lceil \log_2 \left(\frac{N_{\text{subChannel}}^{\text{SL}} (N_{\text{subChannel}}^{\text{SL}} + 1)}{2} \right) \right\rceil \text{ bits.}$$
 Otherwise, when the value of the higher layer parameter

sl-MaxNumPerReserve is configured to 3, this field has a length of

$$\left\lceil \log_2 \left(\frac{N_{\text{subChannel}}^{\text{SL}} (N_{\text{subChannel}}^{\text{SL}} + 1) (2N_{\text{subChannel}}^{\text{SL}} + 1)}{6} \right) \right\rceil \text{ bits.}$$

25 [0114] Time resource assignment is a variable length field, as defined in clause 8.1.5 of 3GPP TS 38.214. When the value of the higher layer parameter *sl-MaxNumPerReserve* is configured to 2, this field has a length of 5 bits. Otherwise, when the value of the higher layer parameter *sl-MaxNumPerReserve* is configured to 3, this field has a length of 9 bits.

[0115] Resource reservation period has a length of $\lceil \log_2 N_{\text{rsv_period}} \rceil$ bits as defined in
30 clause 16.4 of 3GPP TS 38.213, where $N_{\text{rsv_period}}$ is the number of entries in the higher layer

parameter *sl-ResourceReservePeriodList*, if higher layer parameter *sl-MultiReserveResource* is configured; 0 bit otherwise.

[0116] DMRS pattern has a length of $\lceil \log_2 N_{\text{pattern}} \rceil$ bits as defined in clause 8.4.1.1.2 of 3GPP TS 38.211, where N_{pattern} is the number of DMRS patterns configured by higher layer parameter *sl-PSSCH-DMRS-TimePatternList*.

[0117] The 2nd-stage SCI format field has a length of 2 bits, as defined in Table 8.3.1.1-1 of 3GPP TS 38.211.

[0118] Beta_offset indicator is a 2 bit field as provided by higher layer parameter *sl-BetaOffsets2ndSCI* and Table 8.3.1.1-2 of 3GPP TS 38.211.

[0119] Number of DMRS port is a 1 bit field as defined in Table 8.3.1.1-3 of 3GPP TS 38.211.

[0120] Modulation and coding scheme is a 5 bit field as defined in clause 8.1.3 of 3GPP TS 38.214.

[0121] Additional MCS table indicator is a variable length field, as defined in clause 8.1.3.1 of 3GPP TS 38.214: this field has a length of 1 bit if one MCS table is configured by higher layer parameter *sl-Additional-MCS-Table*; 2 bits if two MCS tables are configured by higher layer parameter *sl-Additional-MCS-Table*; 0 bit otherwise.

[0122] PSFCH overhead indication is a 1 bit field as defined clause 8.1.3.2 of 3GPP TS 38.214, if higher layer parameter *sl-PSFCH-Period* = 2 or 4; 0 bit otherwise.

[0123] The number of Reserved bits is determined by higher layer parameter *sl-NumReservedBits*, with value set to zero.

[0124] Referring again to the new transmission of SCI to indicate HARQ feedback and/or LBT failure information, for the 'no payload' elements as revealed previously for the new MAC CE, the SCI transmission needs to carry 1 bit to indicate this situation e.g., a Boolean flag indicating to the UE-t 402 to retransmit/ repeat all pending TBs to the UE-r 404, i.e., retransmit/ repeat any TB for which a HARQ ACK has not yet been received by the UE-t 402 from the UE-r 404.

[0125] In a further enhancement, the retransmit/ repeat can be done on the RB set where the SCI is received. To achieve this, the UE-r 404 may just indicate one bit basically asking the UE-t 402 to change the transmission RB set (in that case the UE-t 402 should ideally use

the same RB-set where it received the MAC CE), or an identification of good/ bad RB sets but no details about “which TBs”. In this case, the UE-t 402 retransmits all pending TBs i.e., TBs for which it has not yet received a HARQ ACK.

[0126] The SCI (a new SCI format or existing SCI containing new element(s)) may or may not schedule a PSSCH and may implicitly (e.g., when no valid Frequency/ Time resource assignment is included) or explicitly indicate if a PSSCH is scheduled or not.

[0127] According to aspects of a second solution, instead of using HARQ Process IDs, the UE-t 402 may include a Sequence number (SN) of fixed ‘n’ bits in the SCI. The SN can be included in an existing SCI format, or a new SCI format. The new SCI format may be called SCI format 2-C and apart from the SN, contain some parameters from SCI format 2-A and/ or SCI format 2-B, e.g., as listed in 3GPP TS 38.212 (v16.4.0). Alternatively, SN can also be included using some reserved bits of format 1-A. When the SN reaches the final value (e.g., 7 when using a 3-bit SN of 0-7), it wraps around. The SN count basically designates the TB number transmitted using the corresponding PSSCH (data) channel.

[0128] When a PSFCH transmission fails once(or a threshold number of times), or periodically every ‘n’ millisecond/ slots/ reception attempts, a UE-r 404 sends a report (i.e., the new transmission described above) to the UE-t 402. To this end, the SN is used in the member UE-r 404 to note down for which TBs it was unable to transmit a generated HARQ feedback (e.g., due to CCA/ LBT failure) and then includes the SN(s) to the transmitter in the new transmission (e.g., a MAC CE or SCI). The UE-t 402 uses this information to make retransmissions/ repetitions of the TB(s) which are indicated as not received successfully by the UE-r 404 and to clear/ flush/ release HARQ/ L2 buffer for other TBs indicated as received successfully. The UE-r 404 may include a success/ fail status for each of the last ‘n’ SNs. Accordingly, the SN length needs to be long enough to avoid having overlap among TBs in transmission. An example of SNs and corresponding HARQ Feedbacks is shown in Table 4.

Not successfully received TBs	SN-1
	SN-3
Successfully received TBs	SN-2
	SN-4
	SN-6

Table 4

[0129] According to aspects of a third solution, in addition to the maximum number of retransmissions that can be made by the UE-t 402, another threshold number of retransmission is used (denoted “new-threshold-max-ReTx”). The new-threshold-max-ReTx defines how many retransmissions can be made in the absence of any feedback from at least one UE-r 404. A counter is incremented to one for the first retransmission and incremented further for each further retransmission. Until this threshold is reached, the UE-t 402 keeps retransmitting. After that, the UE-t 402 may flush HARQ buffer or may wait for some time (using a timer threshold) to receive the new transmission, before flushing the buffer.

[0130] Figure 7 illustrates an example of a UE 700 in accordance with aspects of the present disclosure. The UE 700 may include a processor 702, a memory 704, a controller 706, and a transceiver 708. The processor 702, the memory 704, the controller 706, or the transceiver 708, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0131] The processor 702, the memory 704, the controller 706, or the transceiver 708, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0132] The processor 702 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a central processing unit (CPU), an ASIC, a field programmable gate array (FPGA), or any combination thereof). In some implementations, the processor 702 may be configured to operate the memory 704. In some other implementations, the memory 704 may be integrated into the processor 702. The processor 702 may be configured to execute computer-readable instructions stored in the memory 704 to cause the UE 700 to perform various functions of the present disclosure.

[0133] The memory 704 may include volatile or non-volatile memory. The memory 704 may store computer-readable, computer-executable code including instructions that, when executed by the processor 702, cause the UE 700 to perform various functions described

herein. The code may be stored in a non-transitory computer-readable medium such the memory 704 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage
5 medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[0134] In some implementations, the processor 702 and the memory 704 coupled with the processor 702 may be configured to cause the UE 700 to perform one or more of the UE-r functions described herein (e.g., executing, by the processor 702, instructions stored in the
10 memory 704). For example, the processor 702 may support wireless communication at the UE 700 in accordance with examples as disclosed herein. The UE 700 may be configured to support a means for generating a HARQ feedback based on a groupcast data transmission received from a SL UE-t. In certain implementations, the UE 700 may be further configured to perform a decoding procedure on the groupcast data transmission, where the HARQ
15 feedback indicates a result of the decoding procedure.

[0135] The UE 700 may be configured to support a means for performing a CCA of a first resource (e.g., a first RB set). In some implementations, to perform the CCA, the UE 700 may be configured to compare an amount of detected energy with an energy detection threshold. In such implementations, the CCA yields the positive result in response to the
20 amount of detected energy not satisfying (i.e., being less than) the energy detection threshold and yields the negative result in response to the amount of detected energy satisfying (i.e., reaching or exceeding) the energy detection threshold.

[0136] The UE 700 may be configured to support a means for performing transmitting, based on a positive CCA result, the HARQ feedback to the UE-t using the first resource. In
25 some implementations, the HARQ feedback is sent using a PSFCH transmission. In such implementations, the UE 700 may be configured to derive a set of physical resources for the PSFCH transmission based on a set of resources used to receive the groupcast data transmission.

[0137] The UE 700 may be configured to support a means for transmitting, based at least
30 in part on a negative CCA result, the HARQ feedback to the UE-t on a second resource, the second resource being different than the first resource. In some implementations, the first resource comprises a first RB set, where the UE 700 is further configured to receive the

groupcast data transmission from the SL UE-t on the first RB set. In such implementations, the second resource may be a second RB set different than the first RB set.

[0138] In certain implementations, the UE 700 may be configured to perform a resource selection procedure based on the negative CCA result. In such implementations, the second resource (e.g., second RB set) is selected using the resource selection procedure. In some implementations, the UE 700 may be configured to later transmit an update to the SL UE-t, where the update indicates that the first resource (e.g., RB set) is available for use.

[0139] In some implementations, the HARQ feedback is transmitted on the second resource using a MAC CE or a SCI transmission. In some implementations, the MAC CE includes a subheader indicating an ACK or NACK corresponding to the HARQ feedback. In certain embodiments, the subheader contains a flag used to indicate the ACK or NACK.

[0140] In some implementations, the MAC CE or SCI transmission includes at least one of the following: A) an identification of an RB set corresponding to the first resource; B) a HPID for each TB associated with a failed decoding and for which an individual feedback was not transmittable due to the negative CCA result; C) a HPID for each TB associated with a successful decoding and for which an individual feedback was not transmittable due to the negative CCA result; D) a list of SNs corresponding to each TB associated with a failed decoding and for which an individual feedback was not transmittable due to the negative CCA result; E) a list of SNs corresponding to each TB associated with a successful decoding and for which an individual feedback was not transmittable due to the negative CCA result; or F) a combination thereof.

[0141] In some embodiments, the UE 700 may be configured to receive SCI with the groupcast data transmission, wherein the SCI indicates a NACK-only feedback mode (i.e., SL feedback option-1). In such embodiments, the UE 700 may be configured to transmit, to the UE-t, the HARQ feedback on the second resource in response to the negative CCA result and further in response to the HARQ feedback comprising a NACK, and to refrain from transmitting the HARQ feedback on the second resource in response to the HARQ feedback comprising a ACK.

[0142] In some embodiments, the UE 700 may be configured to receive SCI with the groupcast data transmission, wherein the SCI indicates a combined ACK and NACK feedback mode (i.e., SL feedback option-2). In such embodiments, the UE 700 may be configured to transmit, to the UE-t, the HARQ feedback on the second resource in response

to the negative CCA result and further in response to the HARQ feedback comprising an ACK or a NACK. In certain embodiments, the UE 700 may be configured to refrain from transmitting the HARQ feedback on the second resource in response to the negative CCA result and further in response to the HARQ feedback comprising a NACK.

5 **[0143]** In some implementations, the processor 702 and the memory 704 coupled with the processor 702 may be configured to cause the UE 700 to perform one or more of the UE-t functions described herein (e.g., executing, by the processor 702, instructions stored in the memory 704). For example, the processor 702 may support wireless communication at the UE 700 in accordance with examples as disclosed herein. The UE 700 may be configured to
10 support a means for transmitting, to a group of SL UE-r's, a groupcast data transmission on a first resource (e.g., RB set). In some implementations, the UE 700 may be configured to transmit SCI with the groupcast data transmission, wherein the SCI indicates a SN corresponding to each TB associated with the groupcast data transmission.

[0144] The UE 700 may be configured to support a means for receiving, from a
15 respective SL UE-r, a message on a second resource (e.g., RB set), the message comprising HARQ feedback for the groupcast data transmission. In certain embodiments, the message may also include CCA failure information for the first resource. In some implementations, the message comprises a MAC CE or a SCI transmission. In further implementations, the UE 700 may be configured to report the contents of the message to a RAN (e.g., gNB).

20 **[0145]** In some implementations, the message includes at least one of the following: A) an identification of the RB set; B) a HPID for each TB associated with a failed decoding and for which an individual feedback was not transmittable due to the negative CCA result; C) a HPID for each TB associated with a successful decoding and for which an individual
25 feedback was not transmittable due to the negative CCA result; D) a list of SNs corresponding to each TB associated with a failed decoding and for which an individual feedback was not transmittable due to the negative CCA result; E) a list of SNs corresponding to each TB associated with a successful decoding and for which an individual feedback was not transmittable due to the negative CCA result; or F) a combination thereof.

[0146] The UE 700 may be configured to support a means for determining whether
30 retransmission of the groupcast data transmission is needed based on a set of received HARQ feedback. Here, the set of received HARQ feedback may be received from one or more members of group of SL UE-r's.

[0147] The UE 700 may be configured to support a means for performing a retransmission of the groupcast data transmission based on determining that the retransmission of the groupcast data transmission is needed. In some embodiments, to perform the retransmission, the UE 700 is configured to retransmit the pending TB on a new resource (e.g., RB set) different than the first resource (e.g., RB set).

[0148] In certain embodiments, the new resource corresponds to the second resource. In other embodiments, the UE 700 is further configured to perform a resource selection procedure in response to the message, where the new resource is selected using the resource selection procedure. In such embodiments, the resource selection procedure may consider the first resource as unusable.

[0149] The UE 700 may be configured to support a means for clearing the pending TB from a buffer based on determining that the retransmission of the groupcast data transmission is not needed. In further embodiments, the UE 700 may be configured to initiate a no-feedback counter for tracking a consecutive number of retransmission made in absence of any feedback from at least one member of the group of UE-r.

[0150] In such embodiments, the UE 700 may be configured to cease retransmissions of the pending TB towards the group of UE-r in response to satisfying the no-feedback counter and to clear the pending TB from the buffer based on satisfying the no-feedback counter. In some embodiments, the UE 700 may be configured to initiate a timer in response to satisfying the no-feedback counter and to clear the pending TB from the buffer in response to expiry of the timer.

[0151] The controller 706 may manage input and output signals for the UE 700. The controller 706 may also manage peripherals not integrated into the UE 700. In some implementations, the controller 706 may utilize an operating system (OS) such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 706 may be implemented as part of the processor 702.

[0152] In some implementations, the UE 700 may include at least one transceiver 708. In some other implementations, the UE 700 may have more than one transceiver 708. The transceiver 708 may represent a wireless transceiver. The transceiver 708 may include one or more receiver chains 710, one or more transmitter chains 712, or a combination thereof.

[0153] A receiver chain 710 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 710 may

include one or more antennas for receiving the signal over the air or wireless medium. The receiver chain 710 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 710 may include at least one demodulator configured to demodulate the received signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 710 may include at least one decoder for decoding/ processing the demodulated signal to receive the transmitted data.

[0154] A transmitter chain 712 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 712 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 712 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 712 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0155] Figure 8 illustrates an example of a processor 800 in accordance with aspects of the present disclosure. The processor 800 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 800 may include a controller 802 configured to perform various operations in accordance with examples as described herein. The processor 800 may optionally include at least one memory 804, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 800 may optionally include one or more arithmetic-logic units (ALUs) 806. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0156] The processor 800 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 800) or other memory (e.g.,

random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

5 **[0157]** The controller 802 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 800 to cause the processor 800 to support various operations in accordance with examples as described herein. For example, the controller 802 may operate as a control unit of the
10 processor 800, generating control signals that manage the operation of various components of the processor 800. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0158] The controller 802 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 804 and determine subsequent instruction(s) to be executed to
15 cause the processor 800 to support various operations in accordance with examples as described herein. The controller 802 may be configured to track memory address of instructions associated with the memory 804. The controller 802 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 802 may be configured to interpret the instruction and determine
20 control signals to be output to other components of the processor 800 to cause the processor 800 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 802 may be configured to manage flow of data within the processor 800. The controller 802 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor
25 800.

[0159] The memory 804 may include one or more caches (e.g., memory local to or included in the processor 800 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 804 may reside within or on a processor chipset (e.g., local to the processor 800). In some other implementations, the
30 memory 804 may reside external to the processor chipset (e.g., remote to the processor 800).

[0160] The memory 804 may store computer-readable, computer-executable code including instructions that, when executed by the processor 800, cause the processor 800 to

perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 802 and/or the processor 800 may be configured to execute computer-readable instructions stored in the memory 804 to cause the processor 800 to perform various

5 functions. For example, the processor 800 and/or the controller 802 may be coupled with or to the memory 804, the processor 800, the controller 802, and the memory 804 may be configured to perform various functions described herein. In some examples, the processor 800 may include multiple processors and the memory 804 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple
10 memories, which may, individually or collectively, be configured to perform various functions herein.

[0161] The one or more ALUs 806 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 806 may reside within or on a processor chipset (e.g., the processor 800). In some
15 other implementations, the one or more ALUs 806 may reside external to the processor chipset (e.g., the processor 800). One or more ALUs 806 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 806 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 806 be configured with a variety of logical
20 and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 806 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 806 to handle conditional operations, comparisons, and bitwise operations.

[0162] The processor 800 may support UE-r wireless communication in accordance with examples as disclosed herein. The processor 800 may be configured to support a means for generating a HARQ feedback based on a groupcast data transmission received from a SL UE-
t. In certain implementations, the processor 800 may be further configured to perform a decoding procedure on the groupcast data transmission, where the HARQ feedback indicates
30 a result of the decoding procedure.

[0163] The processor 800 may be configured to support a means for performing a CCA of a first resource (e.g., a first RB set). In some implementations, to perform the CCA, the processor 800 may be configured to compare an amount of detected energy with an energy

detection threshold. In such implementations, the CCA yields the positive result in response to the amount of detected energy not satisfying (i.e., being less than) the energy detection threshold and yields the negative result in response to the amount of detected energy satisfying (i.e., reaching or exceeding) the energy detection threshold.

5 **[0164]** The processor 800 may be configured to support a means for performing transmitting, based on a positive CCA result, the HARQ feedback to the UE-t using the first resource. In some implementations, the HARQ feedback is sent using a PSFCH transmission. In such implementations, the processor 800 may be configured to derive a set of physical resources for the PSFCH transmission based on a set of resources used to receive the
10 groupcast data transmission.

[0165] The processor 800 may be configured to support a means for transmitting, based at least in part on a negative CCA result, the HARQ feedback to the UE-t on a second resource, the second resource being different than the first resource. In some implementations, the first resource comprises a first RB set, where the processor 800 is further configured to
15 receive the groupcast data transmission from the SL UE-t on the first RB set. In such implementations, the second resource may be a second RB set different than the first RB set.

[0166] In certain implementations, the processor 800 may be configured to perform a resource selection procedure based on the negative CCA result. In such implementations, the second resource (e.g., second RB set) is selected using the resource selection procedure. In
20 some implementations, the processor 800 may be configured to later transmit an update to the SL UE-t, where the update indicates that the first resource (e.g., RB set) is available for use.

[0167] In some implementations, the HARQ feedback is transmitted on the second resource using a MAC CE or a SCI transmission. In some implementations, the MAC CE includes a subheader indicating an ACK or NACK corresponding to the HARQ feedback. In
25 certain embodiments, the subheader contains a flag used to indicate the ACK or NACK.

[0168] In some implementations, the MAC CE or SCI transmission includes at least one of the following: A) an identification of an RB set corresponding to the first resource; B) a HPID for each TB associated with a failed decoding and for which an individual feedback was not transmittable due to the negative CCA result; C) a HPID for each TB associated with
30 a successful decoding and for which an individual feedback was not transmittable due to the negative CCA result; D) a list of SNs corresponding to each TB associated with a failed decoding and for which an individual feedback was not transmittable due to the negative

CCA result; E) a list of SNs corresponding to each TB associated with a successful decoding and for which an individual feedback was not transmittable due to the negative CCA result; or F) a combination thereof.

5 [0169] In some embodiments, the processor 800 may be configured to receive SCI with the groupcast data transmission, wherein the SCI indicates a NACK-only feedback mode (i.e., SL feedback option-1). In such embodiments, the processor 800 may be configured to transmit, to the UE-t, the HARQ feedback on the second resource in response to the negative CCA result and further in response to the HARQ feedback comprising a NACK, and to refrain from transmitting the HARQ feedback on the second resource in response to the
10 HARQ feedback comprising a ACK.

[0170] In some embodiments, the processor 800 may be configured to receive SCI with the groupcast data transmission, wherein the SCI indicates a combined ACK and NACK feedback mode (i.e., SL feedback option-2). In such embodiments, the processor 800 may be configured to transmit, to the UE-t, the HARQ feedback on the second resource in response
15 to the negative CCA result and further in response to the HARQ feedback comprising an ACK or a NACK. In certain embodiments, the processor 800 may be configured to refrain from transmitting the HARQ feedback on the second resource in response to the negative CCA result and further in response to the HARQ feedback comprising a NACK.

[0171] The processor 800 may support UE-t wireless communication in accordance with
20 examples as disclosed herein. The processor 800 may be configured to support a means for transmitting, to a group of SL UE-r's, a groupcast data transmission on a first resource (e.g., RB set). In some implementations, the processor 800 may be configured to transmit SCI with the groupcast data transmission, wherein the SCI indicates an SN corresponding to each TB associated with the groupcast data transmission.

25 [0172] The processor 800 may be configured to support a means for receiving, from a respective SL UE-r, a message on a second resource (e.g., RB set), the message comprising HARQ feedback for the groupcast data transmission. In certain embodiments, the message may also include CCA failure information for the first resource. In some implementations, the message comprises a MAC CE or a SCI transmission. In further implementations, the
30 processor 800 may be configured to report the contents of the message to a RAN (e.g., gNB).

[0173] In some implementations, the message includes at least one of the following: A) an identification of the RB set; B) a HPID for each TB associated with a failed decoding and

for which an individual feedback was not transmittable due to the negative CCA result; C) a HPID for each TB associated with a successful decoding and for which an individual feedback was not transmittable due to the negative CCA result; D) a list of SNs corresponding to each TB associated with a failed decoding and for which an individual feedback was not transmittable due to the negative CCA result; E) a list of SNs corresponding to each TB associated with a successful decoding and for which an individual feedback was not transmittable due to the negative CCA result; or F) a combination thereof.

[0174] The processor 800 may be configured to support a means for determining whether retransmission of the groupcast data transmission is needed based on a set of received HARQ feedback. Here, the set of received HARQ feedback may be received from one or more members of group of SL UE-r's.

[0175] The processor 800 may be configured to support a means for performing a retransmission of the groupcast data transmission based on determining that the retransmission of the groupcast data transmission is needed. In some embodiments, to perform the retransmission, the processor 800 is configured to retransmit a pending TB on a new resource (e.g., RB set) different than the first resource (e.g., RB set).

[0176] In certain embodiments, the new resource corresponds to the second resource. In other embodiments, the processor 800 is further configured to perform a resource selection procedure in response to the message, where the new resource is selected using the resource selection procedure. In such embodiments, the resource selection procedure may consider the first resource as unusable.

[0177] The processor 800 may be configured to support a means for clearing the pending TB from a buffer based on determining that the retransmission of the groupcast data transmission is not needed. In further embodiments, the processor 800 may be configured to initiate a no-feedback counter for tracking a consecutive number of retransmission made in absence of any feedback from at least one member of the group of UE-r.

[0178] In such embodiments, the processor 800 may be configured to cease retransmissions of the pending TB towards the group of UE-r in response to satisfying the no-feedback counter and to clear the pending TB from the buffer based on satisfying the no-feedback counter. In some embodiments, the processor 800 may be configured to initiate a timer in response to satisfying the no-feedback counter and to clear the pending TB from the buffer in response to expiry of the timer.

[0179] Figure 9 illustrates an example of a NE 900 in accordance with aspects of the present disclosure. The NE 900 may include a processor 902, a memory 904, a controller 906, and a transceiver 908. The processor 902, the memory 904, the controller 906, or the transceiver 908, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0180] The processor 902, the memory 904, the controller 906, or the transceiver 908, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0181] The processor 902 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 902 may be configured to operate the memory 904. In some other implementations, the memory 904 may be integrated into the processor 902. The processor 902 may be configured to execute computer-readable instructions stored in the memory 904 to cause the NE 900 to perform various functions of the present disclosure.

[0182] The memory 904 may include volatile or non-volatile memory. The memory 904 may store computer-readable, computer-executable code including instructions when executed by the processor 902 cause the NE 900 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 904 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[0183] In some implementations, the processor 902 and the memory 904 coupled with the processor 902 may be configured to cause the NE 900 to perform one or more of the functions described herein (e.g., executing, by the processor 902, instructions stored in the

memory 904). For example, the processor 902 may support wireless communication at the NE 900 in accordance with examples as disclosed herein.

[0184] The controller 906 may manage input and output signals for the NE 900. The controller 906 may also manage peripherals not integrated into the NE 900. In some implementations, the controller 906 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 906 may be implemented as part of the processor 902.

[0185] In some implementations, the NE 900 may include at least one transceiver 908. In some other implementations, the NE 900 may have more than one transceiver 908. The transceiver 908 may represent a wireless transceiver. The transceiver 908 may include one or more receiver chains 910, one or more transmitter chains 912, or a combination thereof.

[0186] A receiver chain 910 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 910 may include one or more antennas for receiving the signal over the air or wireless medium. The receiver chain 910 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 910 may include at least one demodulator configured to demodulate the received signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 910 may include at least one decoder for decoding/ processing the demodulated signal to receive the transmitted data.

[0187] A transmitter chain 912 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 912 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 912 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 912 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0188] Figure 10 depicts one embodiment of a method 1000 in accordance with aspects of the present disclosure. The operations of the method 1000 may be implemented by a UE-r

as described herein. In some implementations, the UE-r may execute a set of instructions to control the function elements of the UE-r to perform the described functions.

[0189] At step 1002, the method 1000 may include generating a HARQ feedback based on a groupcast data transmission received from a SL UE-t. The operations of step 1002 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1002 may be performed by a UE-r as described with reference to Figure 7.

[0190] At step 1004, the method 1000 may include performing a CCA on a first resource. The operations of step 1004 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1004 may be performed by a UE-r as described with reference to Figure 7.

[0191] At step 1006, the method 1000 may include transmitting, to the UE-t, the HARQ feedback on the first resource based on a positive CCA result. The operations of step 1006 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1006 may be performed a UE-r as described with reference to Figure 7.

[0192] At step 1008, the method 1000 may include transmitting, to the UE-t, the HARQ feedback on a second resource based at least in part on a negative CCA result, the second resource being different than the first resource. The operations of step 1008 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1008 may be performed a UE-r as described with reference to Figure 7.

[0193] It should be noted that the method 1000 described herein describes one possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0194] Figure 11 depicts one embodiment of a method 1100 in accordance with aspects of the present disclosure. The operations of the method 1100 may be implemented by a UE-t as described herein. In some implementations, the UE-t may execute a set of instructions to control the function elements of the UE-t to perform the described functions.

[0195] At step 1102, the method 1100 may include transmitting, to a group of sidelink (SL) receiver UEs (UE-r), a groupcast data transmission on a first resource. The operations of

step 1102 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1102 may be performed by a UE-t as described with reference to Figure 7.

[0196] At step 1104, the method 1100 may include receiving, from a respective SL UE-r, a message on a second resource, wherein the transmission comprises HARQ feedback for the groupcast data transmission. The operations of step 1104 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1104 may be performed by a UE-t as described with reference to Figure 7.

[0197] At step 1106, the method 1100 may include determining whether retransmission of the groupcast data transmission is needed based on a set of received HARQ feedback. The operations of step 1106 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1106 may be performed a UE-t as described with reference to Figure 7.

[0198] At step 1108, the method 1100 may include performing a retransmission of a pending TB based on determining that the retransmission of the groupcast data transmission is needed. The operations of step 1108 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1108 may be performed by a UE-t as described with reference to Figure 7.

[0199] At step 1110, the method 1100 may include clearing the pending TB from a buffer based on determining that the retransmission of the groupcast data transmission is not needed. The operations of step 1110 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1110 may be performed a UE-t as described with reference to Figure 7.

[0200] It should be noted that the method 1100 described herein describes one possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0201] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A user equipment (UE) for wireless communication, comprising:
at least one memory; and
5 at least one processor coupled with the at least one memory and configured to cause the UE to:
generate a hybrid automatic repeat request (HARQ) feedback based on a
groupcast data transmission received from a sidelink (SL) transmitter
UE (UE-t);
10 perform a Clear Channel Assessment (CCA) on a first resource;
transmit, to the SL UE-t, the HARQ feedback on the first resource based on a
positive CCA result; and
transmit, to the SL UE-t, the HARQ feedback on a second resource based at
least in part on a negative CCA result, the second resource being
15 different than the first resource.
2. The UE of claim 1, wherein the HARQ feedback is transmitted using a Physical
Sidelink Feedback Channel (PSFCH) transmission in response to the positive CCA
result, and wherein the at least one processor is further configured to cause the UE to
derive a set of physical resources for the PSFCH transmission based on a set of
20 resources used to receive the groupcast data transmission.
3. The UE of claim 1, wherein the HARQ feedback is transmitted using a medium
access control (MAC) control element (CE) or using a sidelink control information
(SCI) transmission in response to the negative CCA result, wherein the at least one
processor is further configured to cause the UE to perform a resource selection
25 procedure based on the negative CCA result, wherein the second resource is selected
using the resource selection procedure.
4. The UE of claim 3, wherein the MAC CE or SCI transmission further comprises at
least one of the following:
an identification of a resource block (RB) set corresponding to the first
30 resource;

- a HARQ process identifier (HPID) for each transport block (TB) associated with a failed decoding and for which an individual feedback was not transmittable due to the negative CCA result;
- a HPID for each TB associated with a successful decoding and for which an individual feedback was not transmittable due to the negative CCA result;
- a list of sequence numbers (SNs) corresponding to each TB associated with a failed decoding and for which an individual feedback was not transmittable due to the negative CCA result;
- a list of SNs corresponding to each TB associated with a successful decoding and for which an individual feedback was not transmittable due to the negative CCA result;
- or a combination thereof.
5. The UE of claim 3, wherein the MAC CE comprises a subheader indicating a positive acknowledgement (ACK) or a negative acknowledgement (NACK) corresponding to the HARQ feedback.
6. The UE of claim 5, wherein the subheader comprises a flag indicating the ACK or the NACK.
7. The UE of claim 1, wherein to perform the CCA, the at least one processor is further configured to cause the UE to compare an amount of detected energy with an energy detection threshold, and wherein the CCA yields a positive result in response to the amount of detected energy failing to satisfy the energy detection threshold.
8. The UE of claim 1, wherein the at least one processor is further configured to cause the UE to:
- receive SL control information (SCI) with the groupcast data transmission, wherein the SCI indicates a negative acknowledgement (NACK) only feedback mode;
- transmit, to the SL UE-t, the HARQ feedback on the second resource in response to the negative CCA result and further in response to the HARQ feedback comprising a NACK; and

refrain from transmitting the HARQ feedback on the second resource in response to the HARQ feedback comprising a positive acknowledgement (ACK).

9. The UE of claim 1, wherein the at least one processor is further configured to cause the UE to:
- 5 receive SL control information (SCI) with the groupcast data transmission, wherein the SCI indicates a combined positive acknowledgement (ACK) and negative acknowledgement (NACK) feedback mode; transmit, to the SL UE-t, the HARQ feedback on the second resource in response to the negative CCA result and further in response to the HARQ feedback comprising an ACK; and
- 10 refrain from transmitting the HARQ feedback on the second resource in response to the negative CCA result and further in response to the HARQ feedback comprising a NACK.
10. The UE of claim 1, wherein the at least one processor is further configured to cause the UE to perform a decoding procedure on the groupcast data transmission, wherein the HARQ feedback indicates a result of the decoding procedure.
11. A processor for wireless communication, comprising:
- at least one controller coupled with at least one memory and configured to cause the processor to:
- 20 generate a hybrid automatic repeat request (HARQ) feedback based on a groupcast data transmission received from a sidelink (SL) transmitter UE (UE-t); perform a Clear Channel Assessment (CCA) on a first resource;
- 25 transmit, to the SL UE-t, the HARQ feedback on the first resource based on a positive CCA result; and transmit, to the SL UE-t, the HARQ feedback on a second resource based at least in part on a negative CCA result, the second resource being different than the first resource.
12. A user equipment (UE) for wireless communication, comprising:
- 30 at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the UE to:

transmit, to a group of sidelink (SL) receiver UEs (UE-r), a groupcast data transmission on a first resource;

5 receive, from a respective SL UE-r, a message on a second resource, wherein the message comprises hybrid automatic repeat request (HARQ) feedback for the groupcast data transmission;

determine whether retransmission of the groupcast data transmission is needed based on a set of received HARQ feedback;

10 perform a retransmission of a pending transport block (TB) based on determining that the retransmission of the groupcast data transmission is needed; and

clear the pending TB from a buffer based on determining that the retransmission of the groupcast data transmission is not needed.

15 13. The UE of claim 12, wherein to perform the retransmission, the at least one processor is configured to cause the UE to retransmit the pending TB on a new resource different than the first resource.

14. The UE of claim 13, wherein the new resource corresponds to the second resource.

20 15. The UE of claim 13, wherein the at least one processor is further configured to cause the UE to perform a resource selection procedure in response to the message, wherein the resource selection procedure considers the first resource as unusable, and wherein the new resource is selected using the resource selection procedure.

25 16. The UE of claim 12, wherein the message on the second resource comprises a medium access control (MAC) control element (CE) or using a SL Control Information (SCI) transmission.

17. The UE of claim 16, wherein the MAC CE or SCI transmission further comprises at least one of the following:

an identification of a resource block (RB) set corresponding to the first resource;

30 a HARQ process identifier (HPID) for each transport block (TB) associated with a failed decoding;

a HPID for each TB associated with a successful decoding and for which an individual feedback could not be transmitted due to a negative Clear Channel Assessment (CCA) result;

a list of sequence numbers (SNs) corresponding to each TB associated with a failed decoding;

a list of SNs corresponding to each TB associated with a successful decoding and for which an individual feedback could not be transmitted due to the negative CCA result;

or a combination thereof.

18. The UE of claim 12, wherein the at least one processor is further configured to cause the UE to:

initiate a no-feedback counter for tracking a consecutive number of retransmission made in absence of any feedback from at least one member of the group of UE-r;

cease retransmission of the pending TB towards the group of UE-r in response to satisfying the no-feedback counter; and

clear the pending TB from the buffer based on satisfying the no-feedback counter.

19. The UE of claim 18, wherein the at least one processor is further configured to cause the UE to:

initiate a timer in response to satisfying the no-feedback counter; and

clear the pending TB from the buffer in response to expiry of the timer.

20. A processor for wireless communication, comprising:
at least one controller coupled with at least one memory and configured to cause the processor to:

transmit, to a group of sidelink (SL) receiver UEs (UE-r), a groupcast data transmission on a first resource;

receive, from a respective SL UE-r, a message on a second resource, wherein the transmission comprises hybrid automatic repeat request (HARQ) feedback for the groupcast data transmission;

determine whether retransmission of the groupcast data transmission is needed based on a set of received HARQ feedback;

perform a retransmission of a pending transport block (TB) based on
determining that the retransmission of the groupcast data transmission
is needed; and
clear the pending TB from a buffer based on determining that the
retransmission of the groupcast data transmission is not needed.

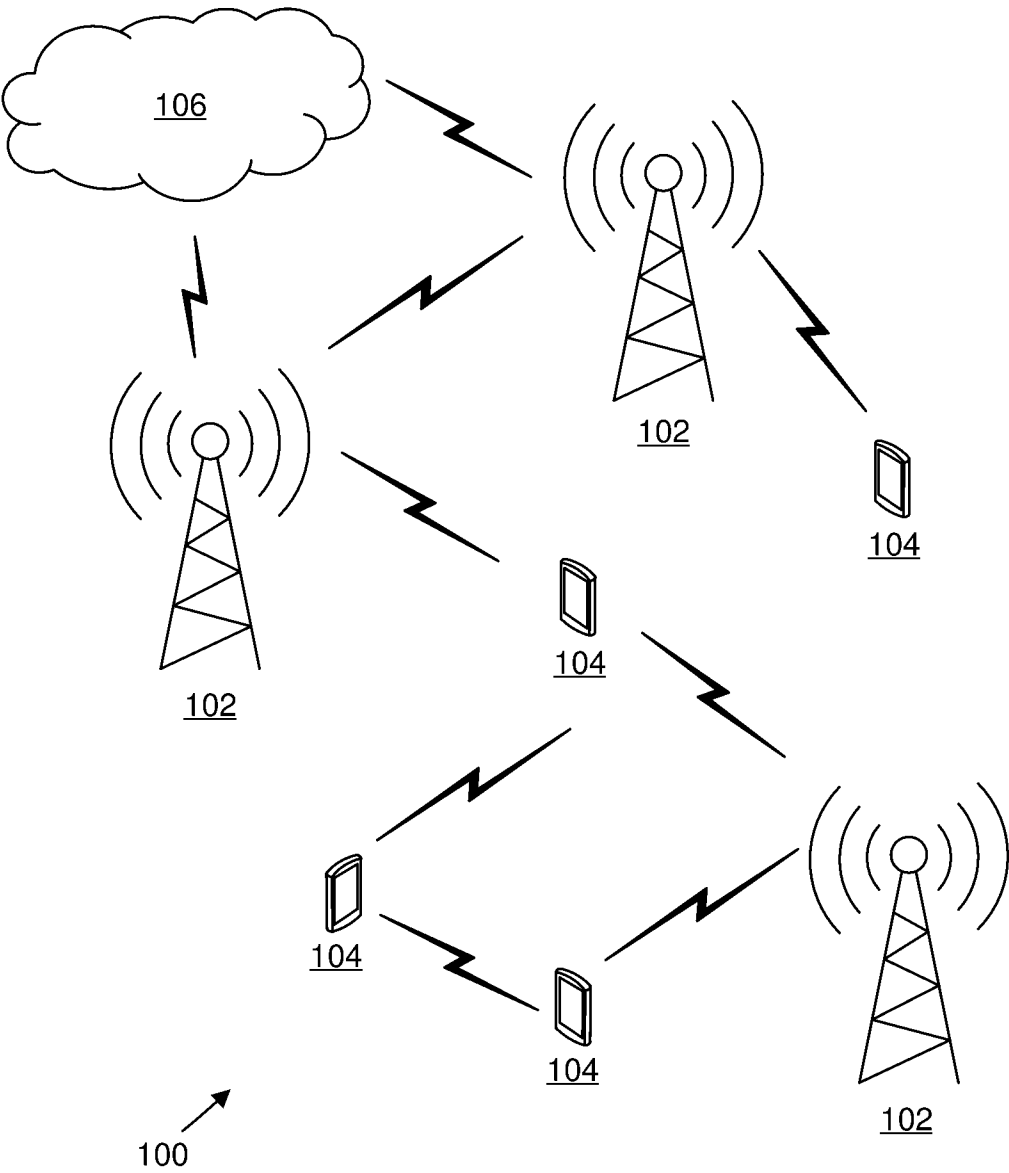


FIG. 1

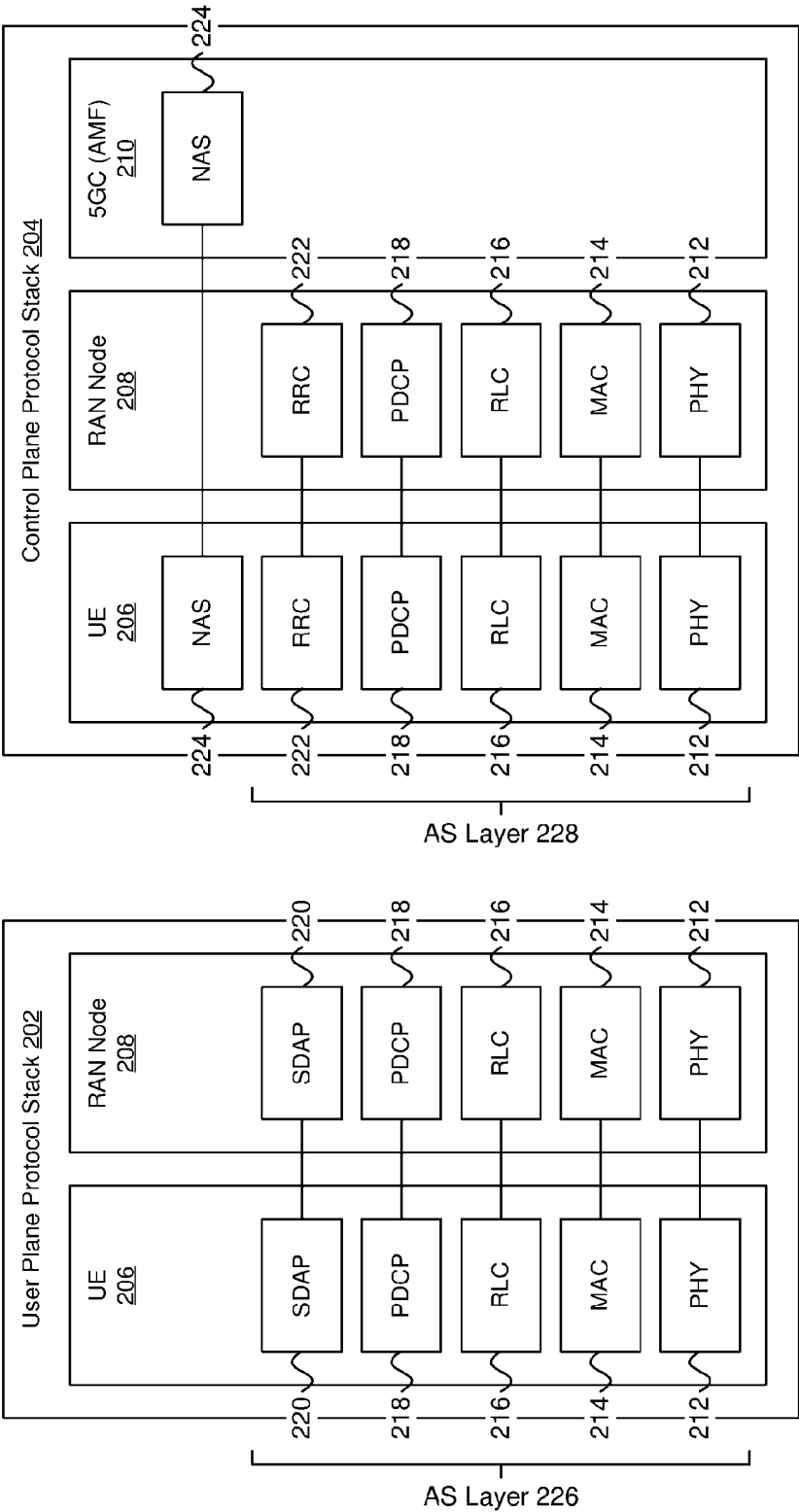


FIG. 2

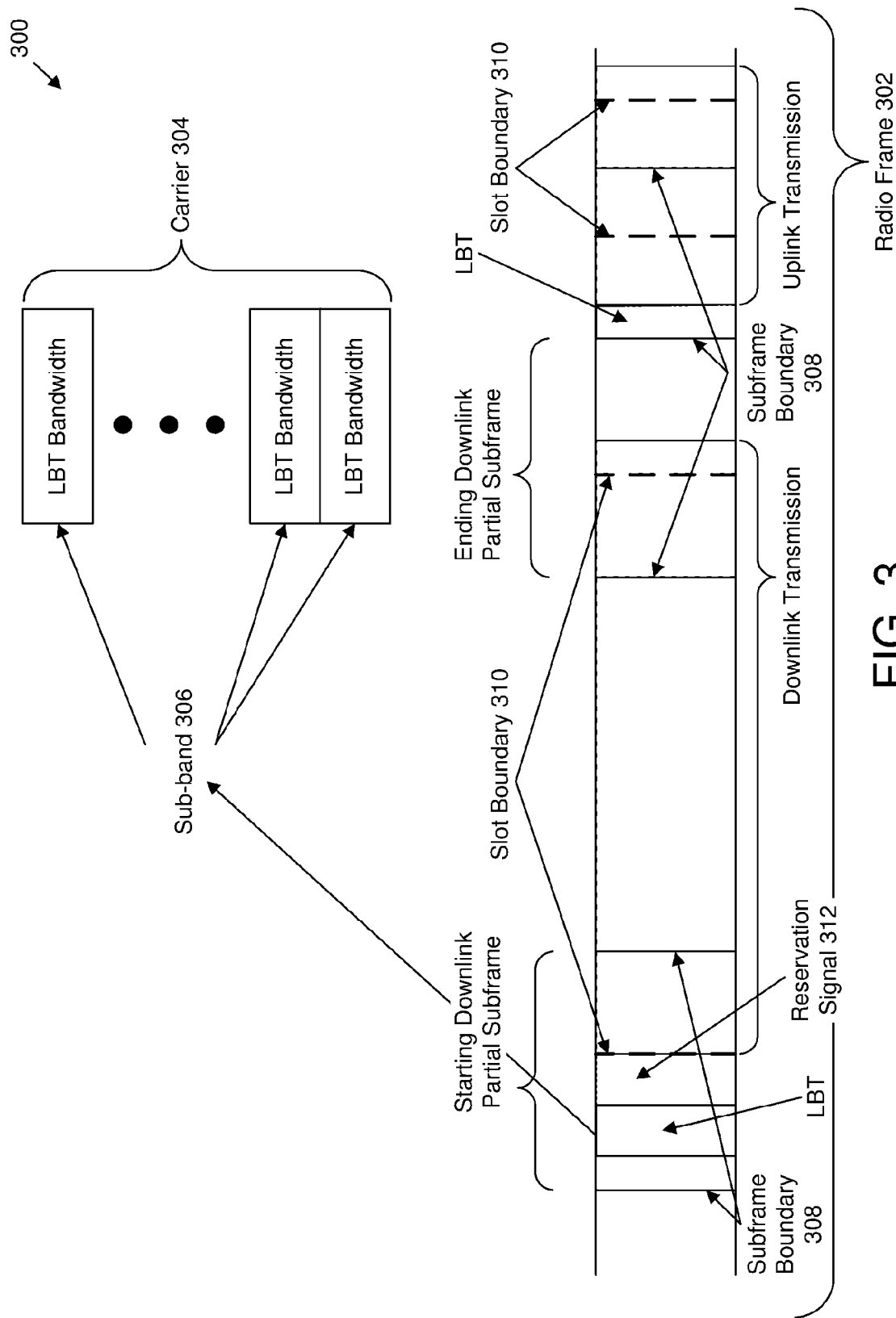


FIG. 3

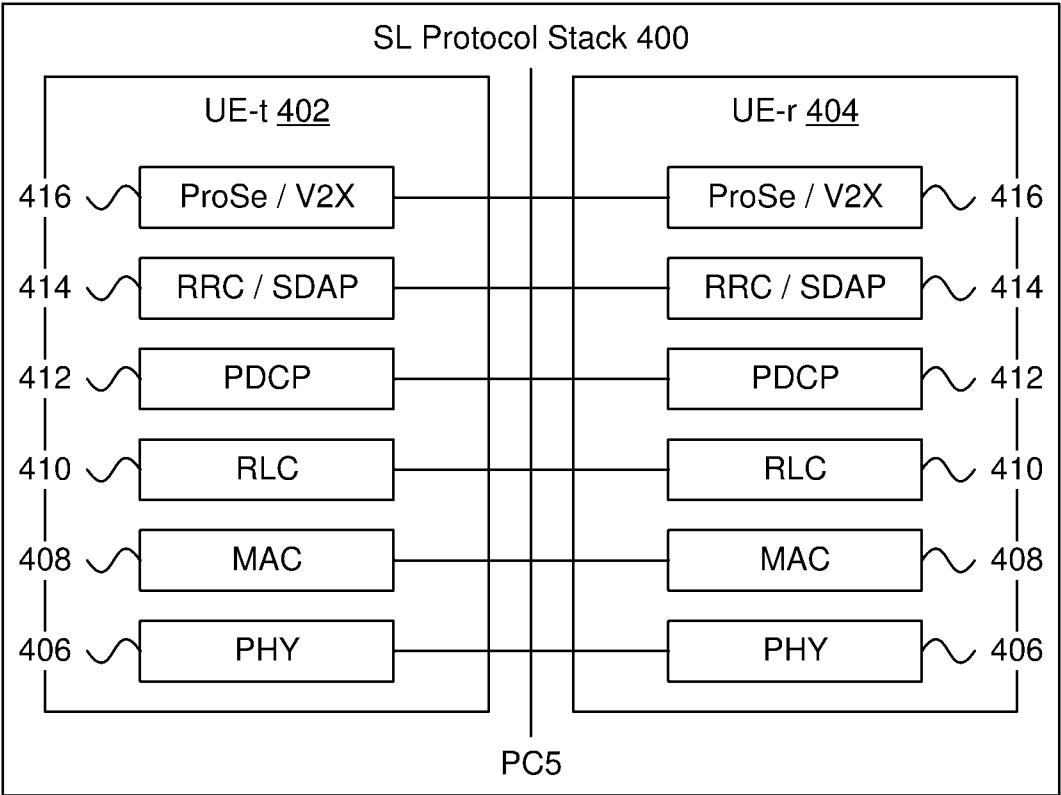


FIG. 4

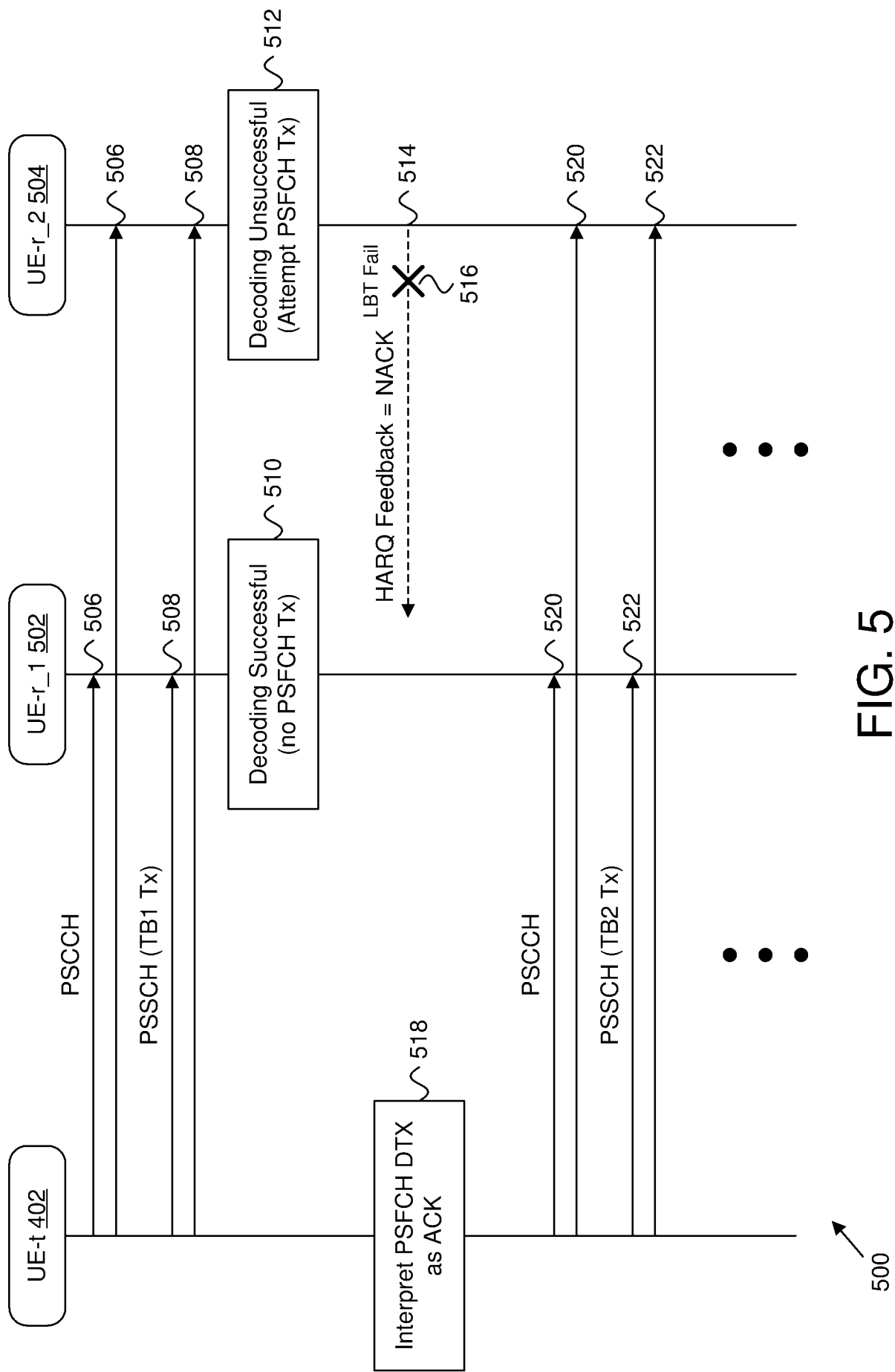


FIG. 5

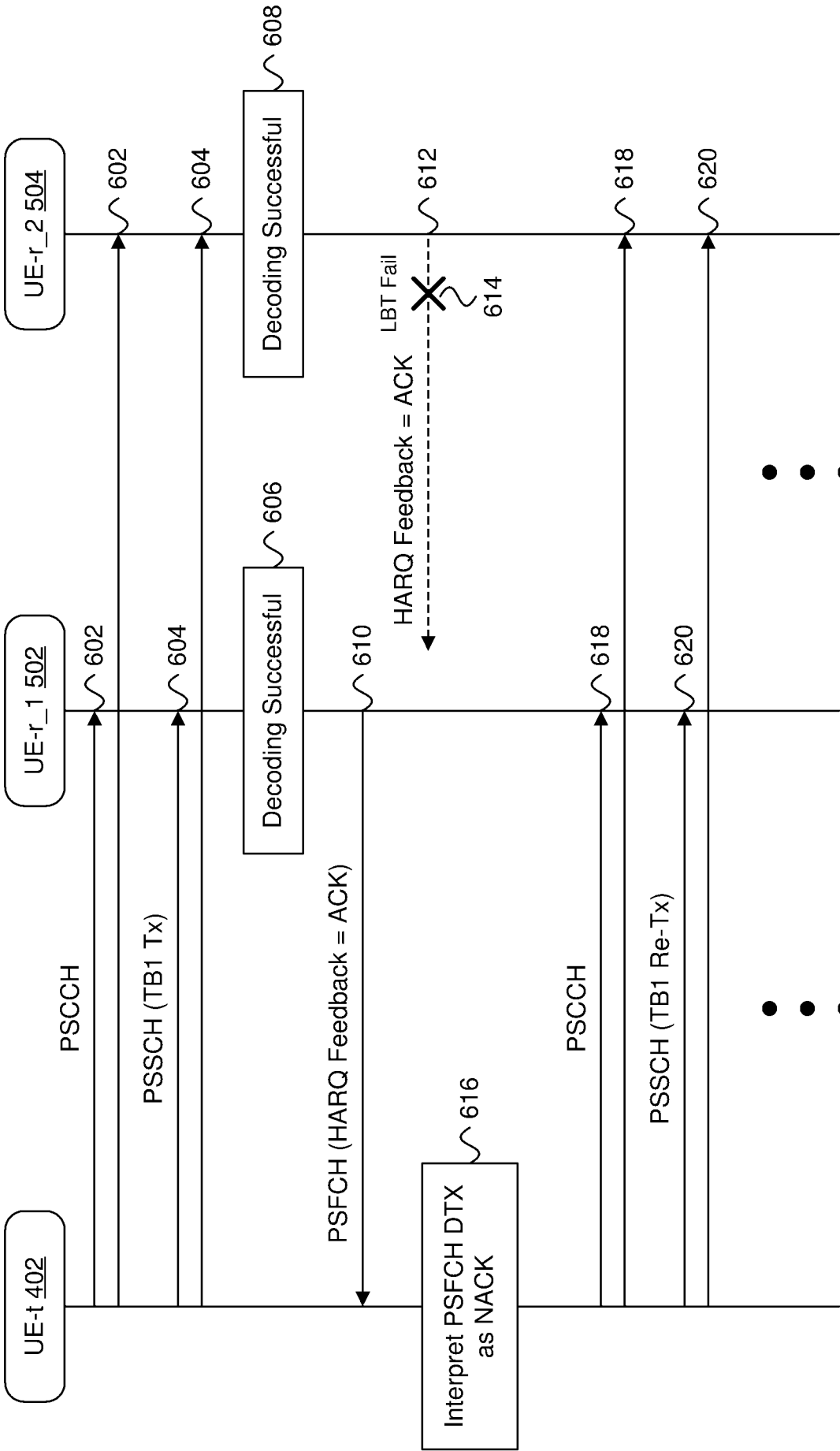


FIG. 6

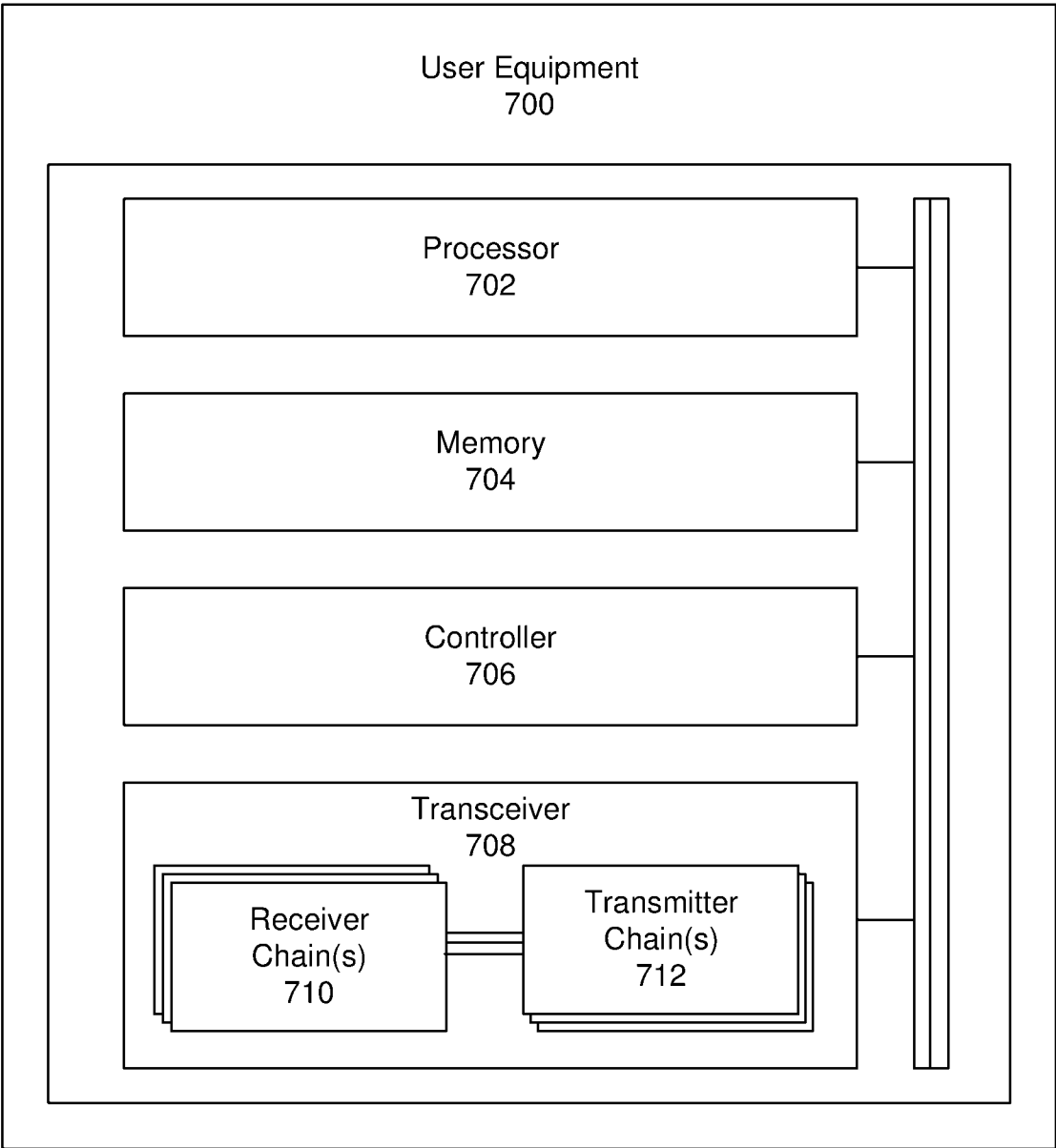


FIG. 7

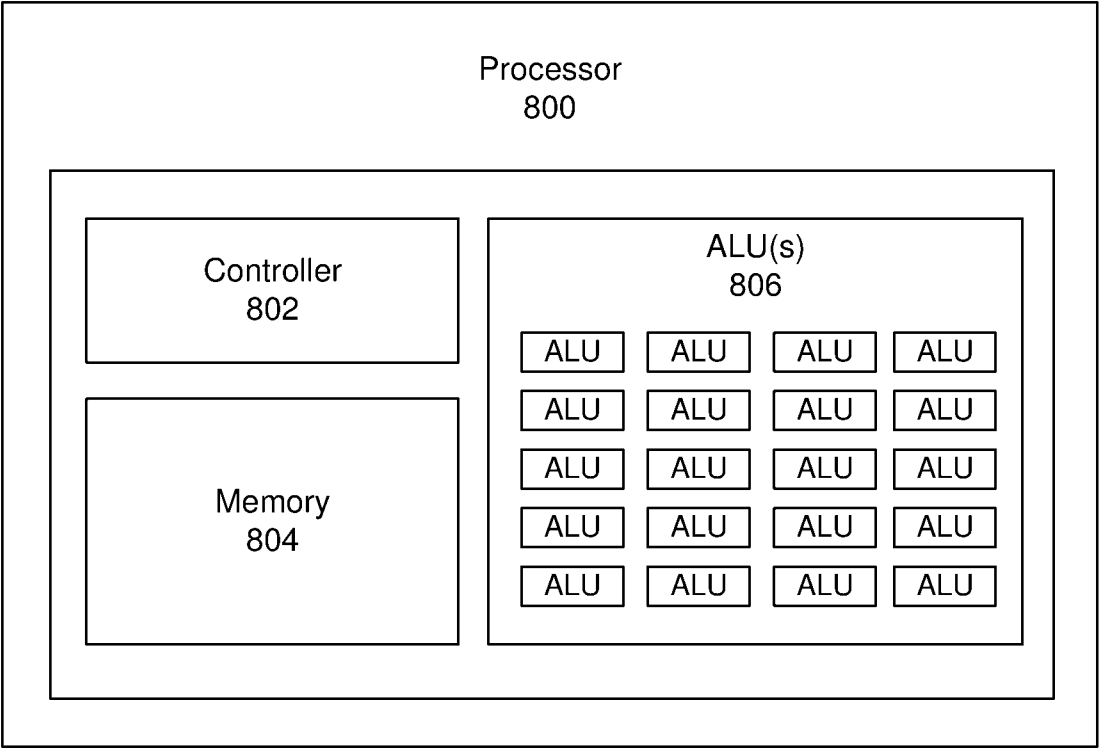


FIG. 8

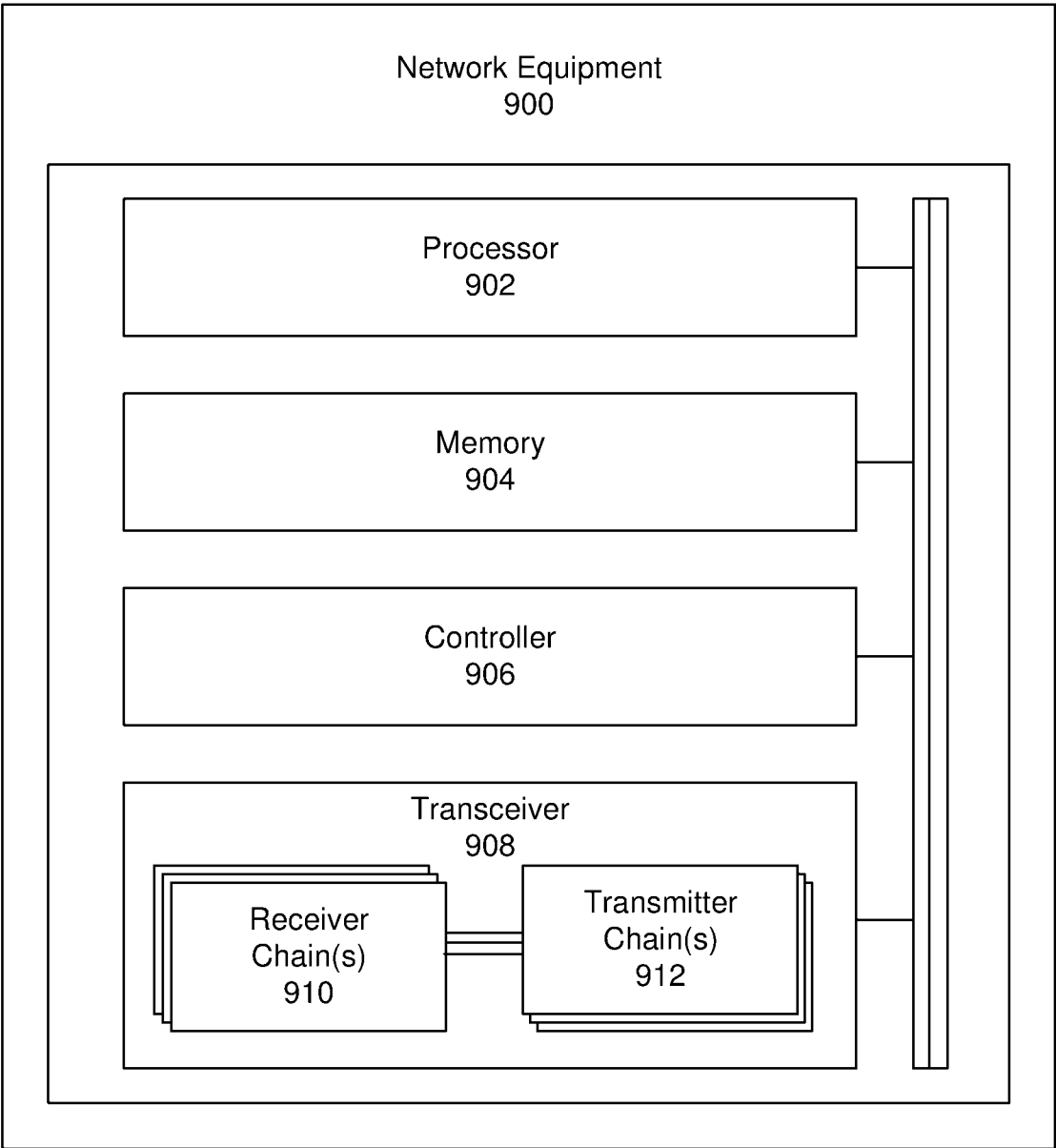


FIG. 9

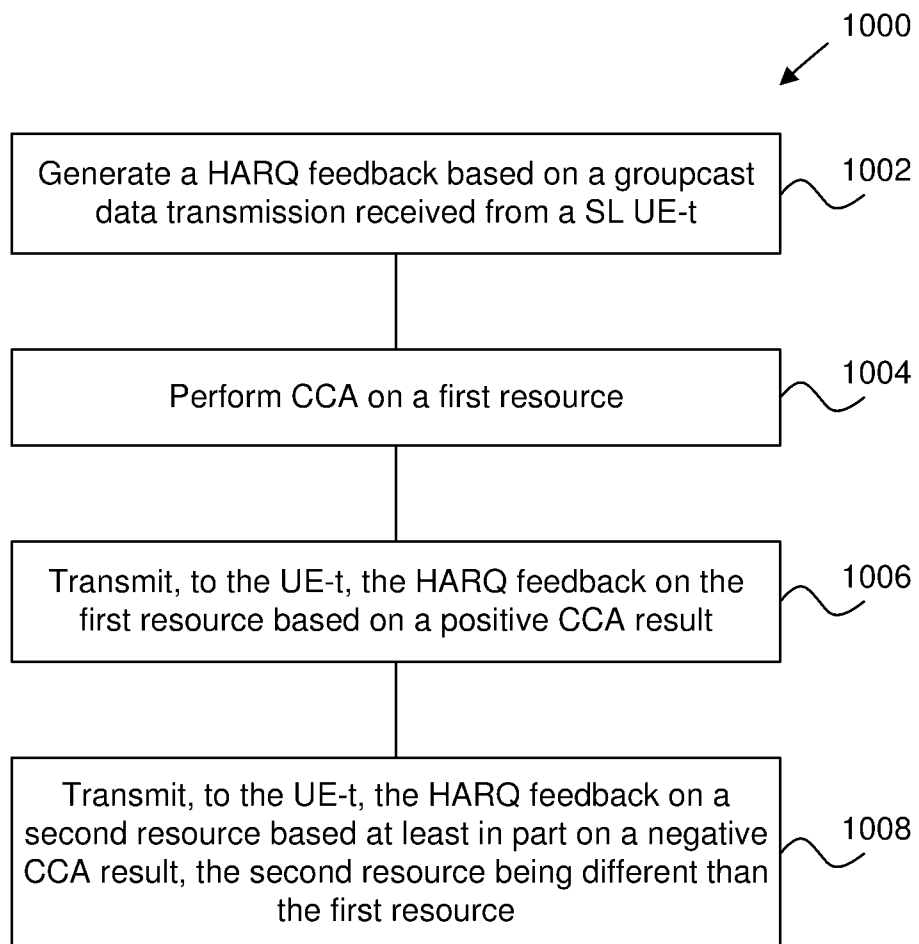


FIG. 10

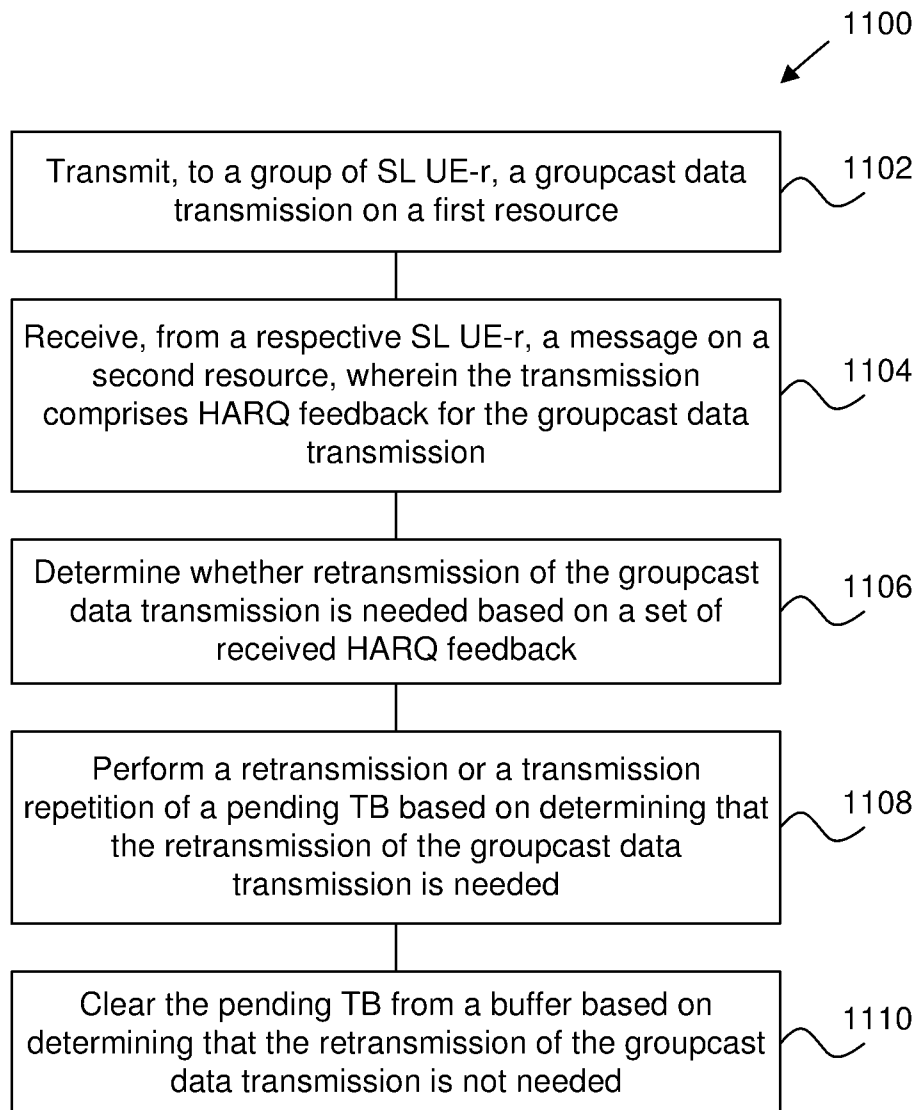


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No

PCT/CN2023/107156

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04L1/1829 H04W74/08

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 H04W

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

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

EPO-Internal, COMPENDEX, INSPEC, IBM-TDB, 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>QING LI ET AL: "Discussion on sidelink unlicensed", 3GPP DRAFT; R2-2301700; TYPE DISCUSSION, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE</p> <p>, vol. 3GPP RAN 2, no. Athens, GR; 20230227 - 20230303 17 February 2023 (2023-02-17), XP052246326, Retrieved from the Internet: URL:https://www.3gpp.org/ftp/TSG_RAN/WG2_R L2/TSGR2_121/Docs/R2-2301700.zip R2-2301700_Discussion_on_SL-U.docx [retrieved on 2023-02-17] page 4</p> <p>-----</p>	1-12, 16, 17, 20

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

28 November 2023

Date of mailing of the international search report

02/02/2024

Name and mailing address of the ISA/

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Authorized officer

Kazaniecki, Daniel

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/107156

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims;; it is covered by claims Nos.:
1-12, 16, 17, 20

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-12, 16, 17, 20

CCA-driven HARQ feedback resource change

2. claims: 12-15, 20

Data retransmission on a new resource

3. claims: 12, 18-20

Data retransmission based on a no-feedback counter
