(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 August 2020 (27.08.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/170085 A1

(51) International Patent Classification:
*H04W 74/08* (2009.01)

(21) International Application Number:
PCT/IB2020/051190

(22) International Filing Date:
13 February 2020 (13.02.2020)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/809,501 22 February 2019 (22.02.2019) US

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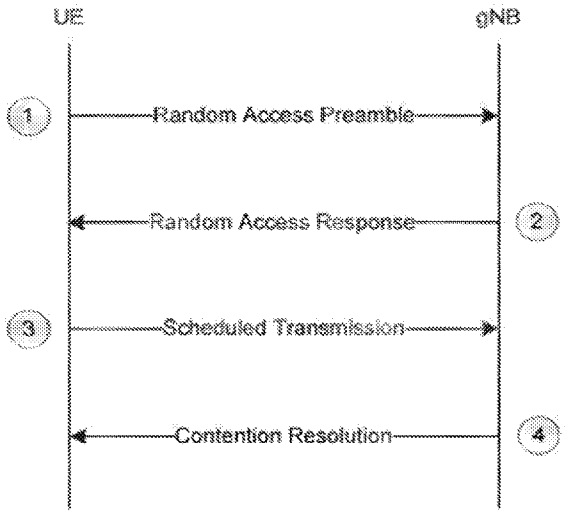
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS,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

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

**Published:**
— *with international search report (Art. 21(3))*
— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

(54) Title: DYNAMIC HYBRID AUTOMATIC REPEAT REQUEST COMBINING IN TWO-STEP RANDOM ACCESS CHANNEL MSGB RETRANSMISSION

Figure 1




(57) Abstract: According to a first embodiment, a method may include transmitting, by a network entity, at least one first message identified by at least one a radio network temporary identifier comprising at least one contention resolution identifier (CRID) to at least one user equipment (UE). The method may further include receiving, by the network entity, at least one hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback associated with at least one of the at least one contention resolution identifier. The method may further include transmitting, by the network entity, at least one second message identified at least one of the at least one radio network temporary identifier.

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# DYNAMIC HYBRID AUTOMATIC REPEAT REQUEST COMBINING IN TWO-STEP RANDOM ACCESS CHANNEL MSGB RETRANSMISSION

BACKGROUND:

**Field:**

**[0001]**Certain embodiments may relate to communication systems. For example, some embodiments may relate to random access procedures.

**Description of the Related Art:**

**[0002]**3GPP work item (WI) RP-182894 specifies a 2-step random access procedure for covering both physical layer and high layer aspects. Only contention-based random access channel procedures are specified for 2-step random access channels.

BRIEF DESCRIPTION OF THE DRAWINGS:

**[0003]**For proper understanding of this disclosure, reference should be made to the accompanying drawings, wherein:

**[0004]**FIG. 1 illustrates an example of a four-step contention-based random access procedure.

**[0005]**FIG. 2 illustrates an example of a two-step contention-based random access procedure.

**[0006]**FIG. 3 illustrates an example of dynamic switching between no-HARQ combining and HARQ combining according to certain embodiments.

**[0007]**FIG. 4 illustrates an example of dynamic switching between HARQ combining and no-HARQ combining according to certain embodiments.

**[0008]**FIG. 5 illustrates an example of a signaling diagram according to certain embodiments.

**[0009]**FIG. 6 illustrates an example of a method performed by a network entity according to certain embodiments.

**[0010]**FIG. 7 illustrates an example of a method performed by a user equipment according to certain embodiments.

**[0011]**FIG. 8 illustrates an example of a system according to certain embodiments.

DETAILED DESCRIPTION:

**[0012]**NR-U may support contention-free RACH (CFRA) and CBRA for both 2-step and 4-step RACH procedures. With respect to secondary cells, CFRA may be supported as a baseline, while both CBRA and CFRA are supported on SpCells. For 4-step RACH procedure, the messages in time order may be described as Msg1, Msg2, Msg3, Msg4, while for 2-step RACH, they are described as MsgA and MsgB.

**[0013]**For 2-step RACH procedure, the MsgA may be a signal to detect the UE and a payload, while the MsgB is for contention resolution for CBRA with a possible payload. MsgA may at least include the information equivalent to the information transmitted in Msg3 for 4-step RACH procedure.

**[0014]**NR Release-15 supports the 4-step RACH procedure, where Msg2 contains information for multiple UEs and is addressed to the RA-RNTI, which is illustrated in FIG. 1. In contrast, in the 2-step RACH procedure, MsgA combines the preamble signal (Msg1) and the data signal (Msg3), while MsgB combines the random access response (Msg2) with the contention resolution (Msg4), as shown in FIG. 2. Since there is no HARQ-ACK for Msg2, the UE transmits Msg3. The network entity then transmits Msg4 to the UE that the Msg3 was received from and is addressed to a corresponding temporary cell radio network temporary identifier (TC-RNTI). The Msg4 then acknowledges that the contention resolution is successful.

**[0015]**In response, the UE may not detect the PDCCH of Msg4, and would not transmit a HARQ-ACK. Alternatively, the UE may detect the PDCCH of Msg4, but fail to decode the PDSCH carrying Msg4; in response, the UE may not transmit a HARQ-ACK or negative ACK to the network entity. Finally, the UE may detect the PDCCH of Msg4, decode the corresponding Msg4 on PDSCH, and then transmit a HARQ-ACK to the network entity. If the network entity fails to receive a HARQ-ACK for Msg4, the network entity may transmit the second message to the user equipment.

**[0016]**When the Msg4 is addressed to a user equipment, the entire Msg4 is retransmitted to the user equipment. However, there are no solutions in two-step RACH procedure to determine whether MsgB should be sent to a single user equipment or multiple user equipment. For example, when the network entity sends MsgB to multiple user equipment, each user equipment which successfully decodes MsgB and detects its CRID transmits a HARQ-ACK to the network entity. For any user equipment which does not successfully decode the MsgB, either due to failing to decode PDCCH or failing to decode PDSCH on MsgB, and whose CRID is included in MsgB, the user equipment does not transmit a HARQ-ACK.

**[0017]**Certain embodiments described herein may have various benefits and/or advantages to overcome the disadvantages described above. Certain embodiments described below may allow user equipment which receives a retransmitted MsgB to combine the HARQ with previous transmissions. Certain embodiments may also reduce the size of MsgB. As a further result, signalling overhead may be reduced, and reliability and latency improved. Thus, certain embodiments are directed to improvements in computer-related technology.

**[0018]**As illustrated in FIG. 3, a network entity may configure a user equipment to dynamically switch between HARQ combining and no HARQ combining. HARQ combining refers to soft

combining of two or more transmissions with the same payload at the receiver. The two or more transmissions may contain the same data and parity bits, which may be referred to as chase combining, or may contain different data and parity bits, which may be referred to as incremental redundancy. For example, the first MsgB addressed to RNTI1 may include four CRIDs for four UE. These four UE may have had a MsgA which has been successfully received by the network entity, and the network entity responds with a CRID for each UE. UE 1 and UE 3 may receive MsgB, and transmit a HARQ-ACK back to the network entity. The network entity may not receive any HARQ-ACK for UE 2 and 4. The network entity may decide to retransmit MsgB only for those UE corresponding with CRIDs whose HARQ-ACK feedback is not received, for example, CRID2 and CRID4. As a result, when UE2 and UE4 receive Msg4 indicating that the payload is different from the previous transmission, UE2 and UE4 cannot HARQ combine the new transmission with the previous transmission since the payloads are not the same. UE 2 may receive MsgB, and then successfully send a HARQ-ACK back to the network entity. Meanwhile, for UE 4, there may be no HARQ-ACK received. The network entity may decide to retransmit MsgB CRIDs for UE2 and UE4, even though UE2 is successfully received so that UE4 can perform HARQ combining for MsgB. UE4 may receive MsgB with an indication that the payload is the same as that of the previous transmission, and thus, can HARQ combine the current transmission with the previous transmission.

**[0019]**In some embodiments, the same RNTI may be used for the initial transmission and retransmissions. During the entire period of initial transmission and re-transmission, the RNTI may be unique and/or may not be used to acknowledge MsgA transmissions received in a different time period or physical random access channel occasion (RO).

**[0020]**FIG. 4 illustrates another example of dynamic switching between HARQ combining and no-HARQ combining. In particular, after the first transmission of MsgB, the HARQ-ACK from UE1 may be the only HARQ-ACK received by the network entity. Instead of retransmitting MsgB with only the contention resolution IDs of UE2, UE3, and UE4, which will prevent these UEs from doing HARQ combining, the network entity may decide to retransmit MsgB with all 4 CRIDs. The UEs continuing to attempt to receive their CRIDs can do HARQ combining. After the second MsgB transmission, the network entity may not receive HARQ-ACK from UE4. Instead of retransmitting all 4 CRIDs, only the CRID of UE4 is transmitted.

**[0021]**FIG. 5 illustrates a signaling diagram according to certain embodiments. Network entity 510 may be similar to network entity 810 in FIG. 8, and user equipment 520 may be similar to user equipment 820 in FIG. 8. Although only a single user equipment (UE) and network entity (NE) are illustrated, a communications network may contain one or more of each of these entities.

**[0022]**In step 501, NE 510 may transmit at least one first message addressed to at least one radio network temporary identifier comprising at least one contention resolution identifier to UE 520. In step 503, NE 510 may receive at least one hybrid automatic repeat request acknowledgement feedback associated with at least one of the at least one contention resolution identifiers from UE 520.

**[0023]**In step 505, NE 510 may transmit at least one second message addressed to at least one of the at least one radio network temporary identifier. The transmission may be at least partially according to at least one predefined configuration to UE 520. After NE 510 has received HARQ-ACK from all UEs with contention resolution IDs in the second message, there may be no further transmissions of the second message. In addition, there may be a maximum number of retransmissions for the second message after which the second message transmissions stop even if not all CRIDs have been acknowledged.

**[0024]**In some embodiments, where HARQ-ACK feedback is received from UE 520, NE 510 may transmit the at least second message including the CRIDs of all UE contained in the at least first message in step 501, including the CRIDs which have been successfully received by UE 520. This configuration allows the UE receiving the new transmission to HARQ combine it with the previous transmissions. After NE 510 has received HARQ-ACK from all UEs with contention resolution IDs in the second message, there may be no further transmissions of the second message. In addition, there may be a maximum number of retransmissions for the second message after which the second message transmissions stop even if not all CRIDs have been acknowledged.

**[0025]**In certain embodiments, where HARQ-ACK feedback is received from UE 520, NE 510 may transmit the at least second message including only the CRIDs of UEs which NE 510 did not receive a HARQ-ACK feedback in response to the at least first message. This configuration may reduce the size of the at least second message.

**[0026]**In various embodiments, where there is no HARQ-ACK feedback from UE 520, NE 510 may receive a third message. For example, UE 520 may transmit, and NE 510 may receive, at least one MsgA. In some embodiments, the at least one MsgA may at least include the information equivalent to the information transmitted in Msg3 for 4-step RACH procedure, and/or may combine at least one preamble signal (Msg1) and at least one data signal (Msg3). Upon receiving the at least one MsgA, NE 510 may retransmit the at least one first message, and cycle through the procedure described in steps 501-505 above. UE 520 may transmit the at least one third message upon failing to receive the at least one first message within a predetermined period of time, and may restart the procedure described in FIG. 5, enter a 4-step RACH procedure, or stop RACH procedures.

**[0027]**In some embodiments, there may be no HARQ-ACK feedback from UE 520, and the at least one second message may be configured to be transmitted *N* times.

**[0028]** NE 510 may semi-statically configure these above-mentioned options. For example, where no HARQ-ACK feedback is received from UE 520, the number of *N* transmissions for the at least second message may be semi-statically configured. In some embodiments, NE 510 may configure the transmission of the at least second message including the CRIDs of all UE contained in the at least first message and/or transmission of the at least second message including only the CRIDs of UEs which NE 510 did not receive a HARQ-ACK feedback in response to the at least first message, and then for each HARQ retransmission, dynamically indicate to UE 520, such as in a corresponding DCI, whether this transmission may be combined with the previous transmission or not, such as being based on whether the payload of the transmission is the same or not. In some scenarios, NE 510 may transmit the at least second message to all UEs with CRIDs included in the at least first message. Additionally or alternatively, NE 510 may transmit the at least second message to UEs with CRIDs which NE 510 did not receive a HARQ-ACK feedback in response to the at least first message.

**[0029]** In various embodiments, when the second message is transmitted, the same RNTI used for the previous transmission may be used for the retransmission. The RNTI may be unique for each message during the initial transmission and retransmissions. For example, if the initial transmission and retransmissions span *M* frames, the RNTI may be unique during *M* frames. In another example, the RNTI may be based on the slot number of the preamble transmission based on the number of slots during *M* frames. Alternatively, the RNTI may be based on the index of [time-domain] PRACH occasion within *M* frames based on the total number of [time-domain] PRACH occasions within *M* frames.

**[0030]** In certain embodiments, one bit may be added to DCI to signal whether the payload is the same as the previous transmission or not for MsgB. Alternatively, NE 510 may use the RV bits of the DCI, such as DCI1_0, to indicate whether this transmission has the same payload or a different payload from a previous transmission of step 501. For example, RV_id = 0 may indicate that the payload is different and/or there is no HARQ combining permitted by UE 520. The RV value may be incremented sequentially when HARQ combining is allowed, indicating the number of previous HARQ retransmissions that may be combined.

**[0031]**FIG. 6 illustrates an example of a method performed by a NE, for example, NE 810 in FIG. 8. In step 601, the network entity may transmit at least one first message addressed to at least one radio network temporary identifier comprising at least one contention resolution

identifier to a user equipment for example, UE 820 in FIG. 8. In step 603, the network entity may receive at least one hybrid automatic repeat request acknowledgement feedback associated with at least one of the at least one contention resolution identifiers from the user equipment.

**[0032]**In step 605, the network entity may transmit at least one second message addressed to at least one of the at least one radio network temporary identifier. The transmission of the at least one second message may be at least partially according to at least one predefined configuration to the user equipment.

**[0033]**In some embodiments, where HARQ-ACK feedback is received from the user equipment, the network entity may transmit the at least second message including the CRIDs of all UE contained in the at least first message in step 601, including the CRIDs which have been successfully received by the user equipment. This configuration may allow the user equipment receiving the new transmission to HARQ combine it with the previous transmissions.

**[0034]**In some embodiments, where HARQ-ACK feedback is received from the user equipment, the network entity may transmit the at least second message including only the CRIDs of UEs which the network entity did not receive a HARQ-ACK. This configuration may reduce the size of MsgB.

**[0035]** In some embodiments, where there is no HARQ-ACK feedback from the user equipment, the network entity may receive a third message. For example, the network entity may receive at least one MsgA. In some embodiments, the at least one MsgA may at least include the information equivalent to the information transmitted in Msg3 for 4-step RACH procedure, and/or may combine the preamble signal (Msg1) and the data signal (Msg3). Upon receiving the at least one MsgA, the network entity may retransmit the at least one first message, and cycle through the procedure described in steps 601-605 above.

**[0036]** In various embodiments, there may be no HARQ-ACK feedback from the user equipment, and the at least one second message may be configured to be transmitted *N* times.

**[0037]** The network entity may semi-statically configure these above-mentioned options. For example, where no HARQ-ACK feedback is received from the user equipment, the number of *N* transmissions for MsgB may be semi-statically configured. In some embodiments, the network entity may configure the transmission of the at least second message including the CRIDs of all UE contained in the at least first message and/or transmission of the at least second message including only the CRIDs of UEs which the network entity did not receive a HARQ-ACK feedback in response to the at least first message, and then for each HARQ retransmission, dynamically indicate to the user equipment, such as in a corresponding DCI, whether this transmission may be combined with the previous transmission or not, such as

being based on whether the payload of the transmission is the same or not.

**[0038]** In various embodiments, when the second message is transmitted, the same RNTI used for the previous transmission may be used for the retransmission. The RNTI may be unique for each message during the initial transmission and retransmissions. For example, if the initial transmission and retransmissions span *M* frames, the RNTI may be unique during *M* frames. In another example, the RNTI may be based on the slot number of the preamble transmission based on the number of slots during *M* frames. Alternatively, the RNTI may be based on the index of [time-domain] PRACH occasion within *M* frames based on the total number of [time-domain] PRACH occasions within *M* frames.

**[0039]** In certain embodiments, one bit may be added to DCI to signal whether the payload is the same as the previous transmission or not for MsgB. Alternatively, the network entity may use the RV bits of the DCI, such as DCI1_0, to indicate whether this transmission has the same payload or a different payload from a previous transmission of step 601. For example, RV_id = 0 may indicate that the payload is different and/or there is no HARQ combining permitted by the user equipment. The RV value may be incremented sequentially when HARQ combining is allowed, indicating the number of previous HARQ retransmissions that may be combined.

**[0040]** FIG. 7 illustrates an example of a method performed by a UE, for example, UE 820 in FIG. 8. In step 701, the user equipment may receive at least one first message addressed to at least one radio network temporary identifier comprising at least one contention resolution identifier from a network entity for example, NE 810 in FIG. 8. In step 703, the user equipment may transmit at least one hybrid automatic repeat request acknowledgement feedback associated with at least one of the at least one contention resolution identifiers to the network entity.

**[0041]** In step 705, the user equipment may receive at least one second message addressed to at least one of the at least one radio network temporary identifier. The reception of the at least one second message may be at least partially according to at least one predefined configuration from the network entity.

**[0042]** In some embodiments, upon transmitting at least one HARQ-ACK feedback to the network entity, the at least one second message may be received including the CRID of at least one UE contained in the at least first message. The transmission may be performed according to a first predefined configuration, which may allow the user equipment receiving the new transmission to HARQ combine it with the previous transmissions. The at least one UE contained in the at least first message may include the UE from which the at least one HARQ-ACK feedback is received.

**[0043]**In some embodiments, where HARQ-ACK feedback is received from the user equipment, the network entity may transmit the second message including only the CRIDs of UEs which the network entity did not receive a HARQ-ACK. The transmission may be according to a second predefined configuration. This configuration may reduce the size of MsgB.

**[0044]** In some embodiments, upon failing to receive the at least one second message, the UE may transmit at least one third message, such as MsgA. In some embodiments, the at least one MsgA may at least include the information equivalent to the information transmitted in Msg3 for 4-step RACH procedure, and/or may combine the preamble signal (Msg1) and the data signal (Msg3). Upon transmitting the at least one MsgA, the user equipment may receive the at least one first message, and cycle through the procedure described in steps 701-705 above. The UE may transmit the at least one third message upon failing to receive the at least one first message within a predetermined period of time, and may restart the procedure described in FIG. 5, enter a 4-step RACH procedure, or stop RACH procedures.

**[0045]** In various embodiments, when the second message is transmitted, the same RNTI used for the previous transmission may be used for the retransmission. The RNTI may be unique for each message during the initial transmission and retransmissions. For example, if the initial transmission and retransmissions span *M* frames, the RNTI may be unique during *M* frames. In another example, the RNTI may be based on the slot number of the preamble transmission based on the number of slots during *M* frames. Alternatively, the RNTI may be based on the index of [time-domain] PRACH occasion within *M* frames based on the total number of [time-domain] PRACH occasions within *M* frames.

**[0046]** In certain embodiments, one bit may be added to DCI to signal whether the payload is the same as the previous transmission or not for MsgB. Alternatively, the network entity may use the RV bits of the DCI, such as DCI1_0, to indicate whether this transmission has the same payload or a different payload from a previous transmission. For example, RV_id = 0 may indicate that the payload is different and/or there is no HARQ combining permitted by the user equipment. The RV value may be incremented sequentially when HARQ combining is allowed, indicating the number of previous HARQ retransmissions that may be combined.

**[0047]** FIG. 8 illustrates an example of a system according to certain embodiments. In one embodiment, a system may include multiple devices, such as, for example, network entity 810 and/or user equipment 820.

**[0048]**Network entity 810 may be one or more of a base station, such as an evolved node B

(eNB) or 5G or New Radio node B (gNB), a serving gateway, a server, and/or any other access node or combination thereof.

**[0049]**User equipment 820 may include one or more of a mobile device, such as a mobile phone, smart phone, personal digital assistant (PDA), tablet, or portable media player, digital camera, pocket video camera, video game console, navigation unit, such as a global positioning system (GPS) device, desktop or laptop computer, single-location device, such as a sensor or smart meter, or any combination thereof. Furthermore, network entity 810 and/or user equipment 820 may be one or more of a citizens broadband radio service device (CBSD).

**[0050]**One or more of these devices may include at least one processor, respectively indicated as 811 and 821. Processors 811 and 821 may be embodied by any computational or data processing device, such as a central processing unit (CPU), application specific integrated circuit (ASIC), or comparable device. The processors may be implemented as a single controller, or a plurality of controllers or processors.

**[0051]**At least one memory may be provided in one or more of devices indicated at 812 and 822. The memory may be fixed or removable. The memory may include computer program instructions or computer code contained therein. Memories 812 and 822 may independently be any suitable storage device, such as a non-transitory computer-readable medium. A hard disk drive (HDD), random access memory (RAM), flash memory, or other suitable memory may be used. The memories may be combined on a single integrated circuit as the processor, or may be separate from the one or more processors. Furthermore, the computer program instructions stored in the memory and which may be processed by the processors may be any suitable form of computer program code, for example, a compiled or interpreted computer program written in any suitable programming language. Memory may be removable or non-removable.

**[0052]**Processors 811 and 821 and memories 812 and 822 or a subset thereof, may be configured to provide means corresponding to the various blocks of FIGS. 3-7. Although not shown, the devices may also include positioning hardware, such as GPS or micro electrical mechanical system (MEMS) hardware, which may be used to determine a location of the device. Other sensors are also permitted and may be included to determine location, elevation, orientation, and so forth, such as barometers, compasses, and the like.

**[0053]**As shown in FIG. 8, transceivers 813 and 823 may be provided, and one or more devices may also include at least one antenna, respectively illustrated as 814 and 824. The device may have many antennas, such as an array of antennas configured for multiple input multiple output (MIMO) communications, or multiple antennas for multiple radio access technologies. Other configurations of these devices, for example, may be provided. Transceivers 813 and 823 may

be a transmitter, a receiver, or both a transmitter and a receiver, or a unit or device that may be configured both for transmission and reception.

**[0054]**The memory and the computer program instructions may be configured, with the processor for the particular device, to cause a hardware apparatus such as user equipment to perform any of the processes described below (see, for example, FIGS. 3-7). Therefore, in certain embodiments, a non-transitory computer-readable medium may be encoded with computer instructions that, when executed in hardware, perform a process such as one of the processes described herein. Alternatively, certain embodiments may be performed entirely in hardware.

**[0055]**In certain embodiments, an apparatus may include circuitry configured to perform any of the processes or functions illustrated in FIGS. 3-7. For example, circuitry may be hardware-only circuit implementations, such as analog and/or digital circuitry. In another example, circuitry may be a combination of hardware circuits and software, such as a combination of analog and/or digital hardware circuit(s) with software or firmware, and/or any portions of hardware processor(s) with software (including digital signal processor(s)), software, and at least one memory that work together to cause an apparatus to perform various processes or functions. In yet another example, circuitry may be hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor(s), that include software, such as firmware for operation. Software in circuitry may not be present when it is not needed for the operation of the hardware.

**[0056]**The features, structures, or characteristics of certain embodiments described throughout this specification may be combined in any suitable manner in one or more embodiments. For example, the usage of the phrases "certain embodiments," "some embodiments," "other embodiments," or other similar language, throughout this specification refers to the fact that a particular feature, structure, or characteristic described in connection with the embodiment may be included in at least one embodiment of the present invention. Thus, appearance of the phrases "in certain embodiments," "in some embodiments," "in other embodiments," or other similar language, throughout this specification does not necessarily refer to the same group of embodiments, and the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

**[0057]** One having ordinary skill in the art will readily understand that certain embodiments discussed above may be practiced with steps in a different order, and/or with hardware elements in configurations which are different than those which are disclosed. Therefore, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of

the invention. In order to determine the metes and bounds of the invention, therefore, reference should be made to the appended claims.

**[0058]** Partial Glossary

| | | |
|---|---|---|
| **[0059]** | 3GPP | 3rd Generation Partnership Project |
| **[0060]** | BW | Bandwidth |
| **[0061]** | BWP | Bandwidth Part |
| **[0062]** | CBRA | Contention Based Random Access |
| **[0063]** | CFRA | Contention Free Random Access |
| **[0064]** | CLI | Cross Link Interference |
| **[0065]** | CQI | Channel Quality Indication |
| **[0066]** | CRID | Contention Resolution Identifier |
| **[0067]** | C-RNTI | Cell Radio Network Temporary Identifier |
| **[0068]** | CSI-RS | Channel State Information-Reference Signal |
| **[0069]** | DCI | Downlink Control Information |
| **[0070]** | DL | Downlink |
| **[0071]** | DMRS | Demodulation Reference Signal |
| **[0072]** | DRB | Data Radio Bearer |
| **[0073]** | DRX | Discontinuous Reception |
| **[0074]** | eMBB | Enhanced Mobile Broadband |
| **[0075]** | eNB | Evolved Node B |
| **[0076]** | EPC | Evolved Packet Core |
| **[0077]** | gNB | Next Generation eNB |
| **[0078]** | GPS | Global Positioning System |
| **[0079]** | HARQ-ACK | Hybrid Automatic Repeat Request Acknowledgement |
| **[0080]** | LTE | Long-Term Evolution |
| **[0081]** | MAC | Medium Access Control |
| **[0082]** | MAC-CE | Medium Access Control Control Element |
| **[0083]** | MME | Mobility Management Entity |
| **[0084]** | MSP | Measurement Profile |
| **[0085]** | MTC | Machine-Type Communications |
| **[0086]** | NE | Network Entity |
| **[0087]** | NR | New Radio |
| **[0088]** | NZP | Non-Zero-Power |
| **[0089]** | PDCCH | Physical Downlink Control Channel |
| **[0090]** | PUCCH | Physical Uplink Control Channel |

**[0091]** PDCP Packet Data Convergence Protocol

**[0092]** PDSCH Physical Downlink Shared Channel

**[0093]** PUSCH Physical Uplink Shared Channel

**[0094]** PHY Physical Layer

**[0095]** RAN Radio Access Network

**[0096]** RLC Radio Link Control

**[0097]** RNTI Radio Network Temporary Identifier

**[0098]** RO Physical Random Access Channel Occasion

**[0099]** RRC Radio Resource Control

**[0100]** RRM Radio Resource Management

**[0101]** RSRP Reference Signal Received Power

**[0102]** RSSI Received Signal Strength Indicator

**[0103]** SDAP Service Data Adaptation Protocol

**[0104]** SMTC SS Block-Based RRM Measurement Timing Configuration

**[0105]** SRS Sounding Reference Signal

**[0106]** SSB Synchronization Signal Block/Physical Broadcast Channel

**[0107]** UE User Equipment

**[0108]** UL Uplink

**[0109]** WLAN Wireless Local Area Network

**[0110]** According to a first embodiment, a method may include transmitting, by a network entity, at least one first message identified by at least one radio network temporary identifier comprising at least one contention resolution identifier (CRID) to at least one user equipment (UE). The method may further include receiving, by the network entity, at least one hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback associated with at least one of the at least one contention resolution identifier. The method may further include transmitting, by the network entity, at least one second message identified by at least one of the at least one radio network temporary identifier.

**[0111]** In a variant, identification of the at least one first message may be based on downlink control information with a cyclic redundancy check scrambled by the at least one radio network temporary identifier.

**[0112]** In a variant, the at least one first message may comprise at least one MsgB.

**[0113]** In a variant, the at least one MsgB may comprise at least a random access response and/or a contention resolution.

**[0114]** In a further variant, the at least one first message may comprise one or more of at least one random access response and/or at least one contention resolution.

**[0115]** In a variant, the at least one second message may comprise at least one MsgB.

**[0116]** In a further variant, the at least one second message may comprise one or more of at least one random access response and/or at least one contention resolution.

**[0117]** In a variant, the second message may include the at least one CRID included in the at least one first message.

**[0118]** In a further variant, the at least one second message may include all of the at least one CRID included in the at least one first message.

**[0119]** In a variant, the second message may include one or more CRIDs of the at least one CRID included in the at least one first message unacknowledged based on the HARQ-ACK feedback.

**[0120]** In a variant, the one or more of at least one random access response and/or at least one contention resolution comprised in the second message may be a retransmission of the one or more of at least one random access response and/or at least one contention resolution comprised in the at least one first message.

**[0121]** In a variant, upon receiving at least one HARQ-ACK feedback from at least one UE, the at least one second message may be transmitted including the at least one CRID in the at least one first message, wherein the at least one CRID is of the at least one UE.

**[0122]** In a further variant, the at least one HARQ-ACK feedback may be received from the UE which the at least first message may be transmitted to.

**[0123]** In a variant, upon receiving at least one HARQ-ACK feedback from the UE, the at least one second message may be transmitted including the at least one CRID of at least one UE which the network entity did not receive a HARQ-ACK feedback.

**[0124]** In a variant, upon no HARQ-ACK feedback being received from the at least one UE, the network entity may have received at least one third message prior to transmitting the at least one second message. The network entity may repeatedly receive the at least one third message and transmit the at least one first message upon receiving the at least third message. In another variant, upon no HARQ-ACK feedback received from the at least one UE, the 2-step RACH procedure may be repeated. The 2-step RACH procedure may be repeated for up to a predefined number of times.

**[0125]** In a further variant, the at least one third message may be a MsgA, and may at least include at least one of Msg1 or Msg3 for 4-step RACH procedure. In another variant, the at least one third message may be a MsgA, and may include at least the information equivalent to the information transmitted in Msg3 for 4-step RACH procedure.

**[0126]** In a further variant, the at least one third message may combine at least one preamble signal (Msg1) and/or at least one data signal (Msg3).

**[0127]** In a further variant, upon receiving the at least one third message, the network entity may retransmit the at least one first message, and monitor for receipt of HARQ-ACK feedback.

**[0128]** In a variant, upon no HARQ-ACK feedback being received from the at least one UE, the at least one second message may be transmitted and/or retransmitted a predetermined number of times.

**[0129]** In a further variant, the predetermined number of times may be configured for modification by the network entity.

**[0130]** In a variant, one or more of the at least one predefined configurations may be capable of being modified according to at least one operating condition of the network.

**[0131]** In a variant, upon transmission of the at least one second message, at least one RNTI in the at least one second message may match at least one RNTI in the at least one first message.

**[0132]** In a further variant, at least one bit in at least one DCI may be configured to signal whether the payload of the at least first message matches the payload of the at least second message or whether the size of the payload of the at least first message matches the size of the payload of the at least second message.

**[0133]** In a variant, the at least one first message may be a retransmission of at least one MsgB.

**[0134]** In a further variant, the at least one second message may be a retransmission of at least one MsgB.

**[0135]** In a further variant, the first message and the second message may comprise the same at least one RNTI.

**[0136]** According to a second embodiment, a method may include receiving or attempting to receive, by a user equipment, at least one first message identified by a radio network temporary identifier comprising at least one contention resolution identifier (CRID) from a network entity. The method may further include transmitting, by the user equipment, at least one hybrid automatic repeat request acknowledgement feedback in case the UE successfully receives the first message. The method may further include receiving, by the user equipment, at least one second message identified by at least one of the at least one radio network temporary identifier.

**[0137]** In a variant, the receiving of the at least one first message may be based on downlink control information with a cyclic redundancy check scrambled by the radio network temporary identifier.

**[0138]** In a variant, the at least one first message may comprise at least one MsgB.

**[0139]** In a further variant, the at least one MsgB may comprise at least a random access

response and/or a contention resolution.

**[0140]** In a further variant, the at least one first message may comprise one or more of at least one random access response and/or at least one contention resolution.

**[0141]** In a variant, the at least one second message may comprise at least one MsgB.

**[0142]** In a further variant, the at least one second message may comprise at least one of a random access response and/or a contention resolution.

**[0143]** In a variant, the second message may include one or more of the at least one CRID included in the at least one first message.

**[0144]** In a further variant, the second message may include all of the at least one CRID included the at least one first message. This may allow the UEs receiving the second message to HARQ combine it with the first message.

**[0145]** In a variant, upon transmitting HARQ-ACK from all UEs with contention resolution ID in the first message, there will be no transmission of the second message.

**[0146]** In a variant, a maximum pre-determined number of MsgB may be transmitted, after which the second message may not be transmitted even if HARQ-ACK is not transmitted from all UEs with contention resolution ID in the first message.

**[0147]** In a variant, upon no HARQ-ACK feedback being transmitted from the at least one UE with contention resolution ID in the first message and no further transmission of second message, the UE may have transmitted at least one third message prior to receiving the at least one second message. The UE may repeatedly transmit the at least one third message and receive the at least one first message upon transmitting the at least third message. In another variant, upon no HARQ-ACK feedback transmitted from the at least one UE, the 2-step RACH procedure may be repeated. The 2-step RACH procedure may be repeated for up to a predefined number of times.

**[0148]** In a variant, the second message may include CRIDs included in the at least one first message unacknowledged based on the HARQ-ACK feedback.

**[0149]** In a variant, the at least one hybrid automatic repeat request acknowledgement feedback may be associated with at least one of the at least one contention resolution identifier.

**[0150]** In a variant, the UE may transmit at least one third message.

**[0151]** In a further variant, the at least one third message may be a MsgA, and may at least include at least one of Msg1 or Msg3 for 4-step RACH procedure. In another variant, the at least one third message may be a MsgA, and may include at least the information equivalent to the information transmitted in Msg3 for 4-step RACH procedure.

**[0152]** In a further variant, the at least one third message may combine at least one preamble signal (Msg1) and/or at least one data signal (Msg3).

**[0153]** In a further variant, the UE may transmit the at least one third message in response to failing to receive the at least one first message within a predetermined period of time, enter a 4-step RACH procedure, or stop RACH procedures.

**[0154]** In a further variant, upon receiving the at least one third message, the network entity may retransmit the at least one first message, and/or may monitor for receipt of HARQ-ACK feedback.

**[0155]** In a variant, the at least one second message may include the CRID included in the at least one first message.

**[0156]** According to a third embodiment and a fourth embodiment, an apparatus can include at least one processor and at least one memory and computer program code. The at least one memory and the computer program code can be configured to, with the at least one processor, cause the apparatus at least to perform a method according to the first embodiment, the second embodiment, and any of their variants.

**[0157]** According to a fifth embodiment and a sixth embodiment, an apparatus can include means for performing the method according to the first embodiment, the second embodiment, any of their variants.

**[0158]** According to a seventh embodiment and an eighth embodiment, a computer program product may encode instructions for performing a process including a method according to the first embodiment, the second embodiment, and any of their variants.

**[0159]** According to a ninth embodiment and a tenth embodiment, a non-transitory computer-readable medium may encode instructions that, when executed in hardware, perform a process including a method according to the first embodiment, the second embodiment, and any of their variants.

**[0160]** According to an eleventh and a twelfth embodiment, a computer program code may include instructions for performing a method according to the first embodiment, the second embodiment, and any of their variants.

**[0161]** According to a thirteenth embodiment and a fourteenth, an apparatus may include circuitry configured to perform a process including a method according to the first embodiment, the second embodiment, and any of their variants.

WE CLAIM:

1. A method comprising:

receiving or attempting to receive, by a user equipment, at least one first message identified by a radio network temporary identifier comprising at least one contention resolution identifier from a network entity;

transmitting, by the user equipment, at least one hybrid automatic repeat request acknowledgement feedback in case the user equipment successfully receives the at least one first message; and

receiving, by the user equipment, at least one second message identified by the radio network temporary identifier.

2. A method of claim 1, wherein the receiving of the at least one first message is based on downlink control information with a cyclic redundancy check scrambled by the radio network temporary identifier.

3. A method of claim 1 or claim 2, wherein the at least one first message comprises at least one MsgB.

4. A method of claim 3, wherein the at least one MsgB comprises at least one of a random access response or a contention resolution.

5. A method of claim 1 or claim 2, wherein the at least one first message comprises at least one of at least one random access response or at least one contention resolution.

6. A method of any of claims 1 to 5, wherein the at least one second message comprises at least one MsgB.

7. A method of any of claims 1 to 5, wherein the at least one second message comprises at least one of a random access response or a contention resolution.

8. A method of any of claims 1 to 7, wherein the second message comprises one or more of the at least one contention resolution identifier included in the at least one first message.

9. A method of any of claims 1 to 8, wherein the second message comprises all of the at least one contention resolution identifier included in the at least one first message, allowing user equipment receiving the at least one second message to hybrid automatic repeat request (HARQ) combine it with the at least one first message.

10. A method of any of claims 1 to 8, wherein the at least one second message includes contention resolution identifiers included in the at least one first message unacknowledged based on the hybrid automatic repeat request acknowledgement feedback.

11. A method of any of claims 1 to 8, wherein the at least one hybrid automatic repeat request acknowledgement feedback is associated with at least one of the at least one contention

resolution identifier.

12. A method of any of claims 1 to 8 comprising transmitting, by the user equipment, at least one third message.

13. A method of claim 12, wherein the at least one third message comprises a MsgA, including at least one of Msg1 or Msg3 for 4-step RACH procedure.

14. A method of claim 12, wherein the at least one third message comprises a MsgA, including information equivalent to information transmitted in Msg3 for 4-step RACH procedure.

15. A method of claim 12, wherein the at least one third message includes at least one of at least one preamble signal or at least one data signal.

16. A method of claim 12 comprising transmitting, by the user equipment, the at least one third message in response to at least one of failing to receive the at least one first message within a predetermined period of time, entering a 4-step RACH procedure, or stopping RACH procedure.

17. A method of claim 1, wherein upon transmitting hybrid automatic repeat request acknowledgement from all user equipments with contention resolution identifier in the at least one first message, there will be no transmission of the second message.

18. A method of claim 1, comprising receiving a maximum pre-determined number of MsgB, after which the at least one second message is not received even if hybrid automatic repeat request acknowledgement is not transmitted from all user equipments with contention resolution identifier in the at least one first message.

19. A method of claim 1, comprising wherein upon no hybrid automatic repeat request acknowledgement feedback being transmitted from the one user equipment with contention resolution identifier in the at least one first message and not receiving of the at least one second message, transmitting, by the user equipment, at least one third message prior to receiving the at least one second message.

20. A method of claim 19, comprising repeatedly transmitting, by the user equipment, the at least one third message, and receiving the at least one first message upon transmitting the at least one third message.

21. A method of claim 1, wherein upon no hybrid automatic repeat request acknowledgement feedback transmitted from the user equipment, a 2-step RACH procedure is repeated.

22. A method of claim 21, wherein the 2-step RACH procedure is repeated for up to a predefined number of times.

23. A method comprising:

transmitting, by a network entity, at least one first message identified by at least one radio network temporary identifier comprising at least one contention resolution identifier to at least one user equipment;

receiving, by the network entity, at least one hybrid automatic repeat request acknowledgement feedback associated with at least one of the at least one contention resolution identifier; and

transmitting, by the network entity, at least one second message identified by at least one of the at least one radio network temporary identifier.

24. A method of claim 23, wherein identification of the at least one first message is based on downlink control information with a cyclic redundancy check scrambled by the at least one radio network temporary identifier.

25. A method of claim 23 or claim 24, wherein the at least one first message comprises at least one MsgB.

26. A method of claim 25, wherein the at least one MsgB comprises at least one of a random access response or a contention resolution.

27. A method of claim 23, wherein the at least one first message comprises at least one of at least one random access response, or at least one contention resolution.

28. A method of any of claims 23 to 27, wherein the at least one second message comprises at least one MsgB.

29. A method of any of claims 23 to 27, wherein the at least one second message comprises at least one of at least one random access response or at least one contention resolution.

30. A method of claim 29, wherein the at least one of at least one random access response or at least one contention resolution comprised in the second message is a retransmission of the at least one of at least one random access response or at least one contention resolution comprised in the at least one first message.

31. A method of any of claims 23 to 30, wherein the at least one second message comprises the at least one contention resolution identifier included in the at least one first message.

32. A method of any of claims 23 to 30, wherein the at least one second message comprises all of the at least one contention resolution identifier included in the at least one first message.

33. A method of any of claims 23 to 30, wherein the second message comprises one or more contention resolution identifiers of the at least one contention resolution identifier included in the at least one first message unacknowledged based on the hybrid automatic repeat request acknowledgement feedback.

34. A method of any of claims 23 to 30 comprising: transmitting, upon receiving the at least one hybrid automatic repeat request acknowledgement feedback from the at least one user

equipment, the at least one second message including the at least one contention resolution identifier in the at least one first message, wherein the at least one contention resolution identifier is of the at least one user equipment.

35. A method of any of claims 23 to 30, wherein the at least one hybrid automatic repeat request acknowledgement feedback is received from the at least one user equipment which the at least one first message is transmitted to.

36. A method of any of claims 23 to 30 comprising: transmitting, upon receiving at least one at least one hybrid automatic repeat request acknowledgement feedback from the at least one user equipment, the at least one second message including the at least one contention resolution identifier of at least one user equipment which the network entity did not receive at least one hybrid automatic repeat request acknowledgement feedback.

37. A method of any of claims 23 to 36, wherein at least one bit in at least one downlink control information is configured to signal whether the payload of the at least one first message matches payload of the at least one second message or whether size of payload of the at least one first message matches size of payload of the at least one second message.

38. A method of any of claims 23 to 37, wherein the at least one first message is a retransmission of at least one MsgB.

39. A method of any of claims 23 to 37, wherein the at least one second message is a retransmission of at least one MsgB.

40. A method of claim 23 comprising: receiving, by the network entity, upon no hybrid automatic repeat request acknowledgement feedback being received from the at least one user equipment, at least one third message prior to transmitting the at least one second message.

41. A method of claim 40, wherein the at least one third message comprises a MsgA, including at least one of Msg1 or Msg3 for 4-step RACH procedure.

42. A method of claim 40, wherein the at least one third message comprises at least one of at least one preamble signal or at least one data signal.

43. A method of claim 40 comprising: retransmitting by the network entity, upon receiving the at least one third message, the at least one first message, and monitoring for hybrid automatic repeat request acknowledgement feedback.

44. A method of claim 1, wherein upon no hybrid automatic repeat request acknowledgement feedback received from the at least one user equipment, the 2-step RACH procedure is repeated.

45. A method of claim 1 comprising: transmitting and/or retransmitting, upon no hybrid automatic repeat request acknowledgement feedback being received from the at least one user equipment, the at least one second message a predetermined number of times.

46. An apparatus comprising:

at least one processor; and

at least one memory and computer program code;

the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to

receive or attempt to receive at least one first message identified by a radio network temporary identifier comprising at least one contention resolution identifier from a network entity;

transmit at least one hybrid automatic repeat request acknowledgement feedback in case the apparatus successfully receives the at least one first message; and

receive at least one second message identified by the radio network temporary identifier.

47. An apparatus comprising means for performing:

receiving or attempting to receive at least one first message identified by a radio network temporary identifier comprising at least one contention resolution identifier from a network entity;

transmitting at least one hybrid automatic repeat request acknowledgement feedback in case the apparatus successfully receives the at least one first message; and

receiving at least one second message identified by the radio network temporary identifier.

48. An apparatus comprising:

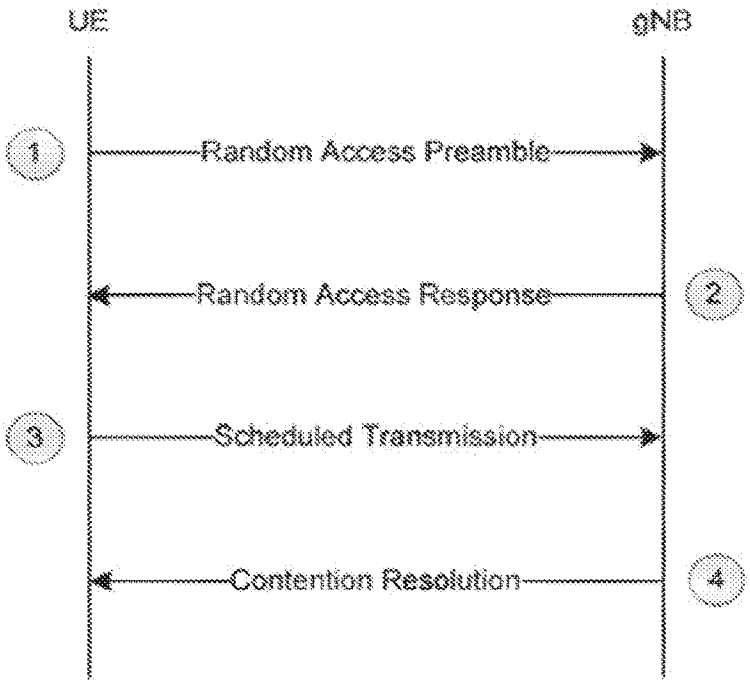
at least one processor; and

at least one memory and computer program code;

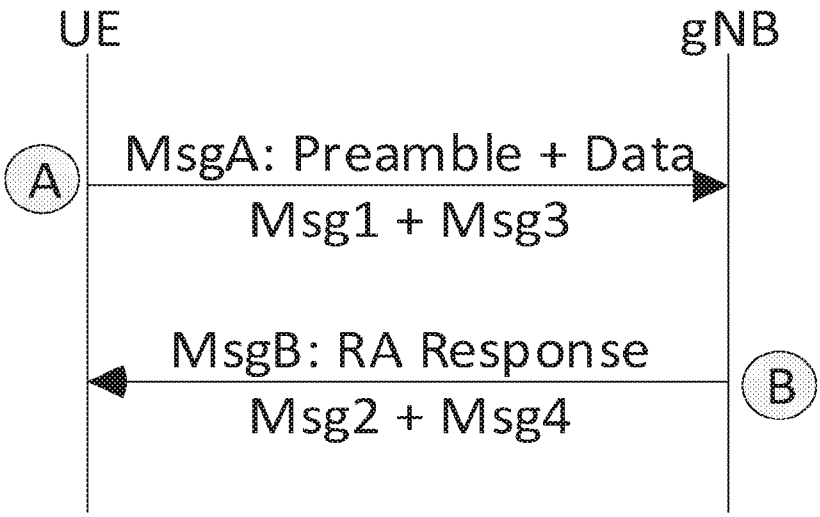
the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to perform a method according to any of claims 1 to 22, or cause the apparatus at least to perform a method according to any of claims 23 to 45.

49. An apparatus comprising means for performing a method according to any of claims 1 to 22, or comprising means for performing a method according to any of claims 23 to 45.

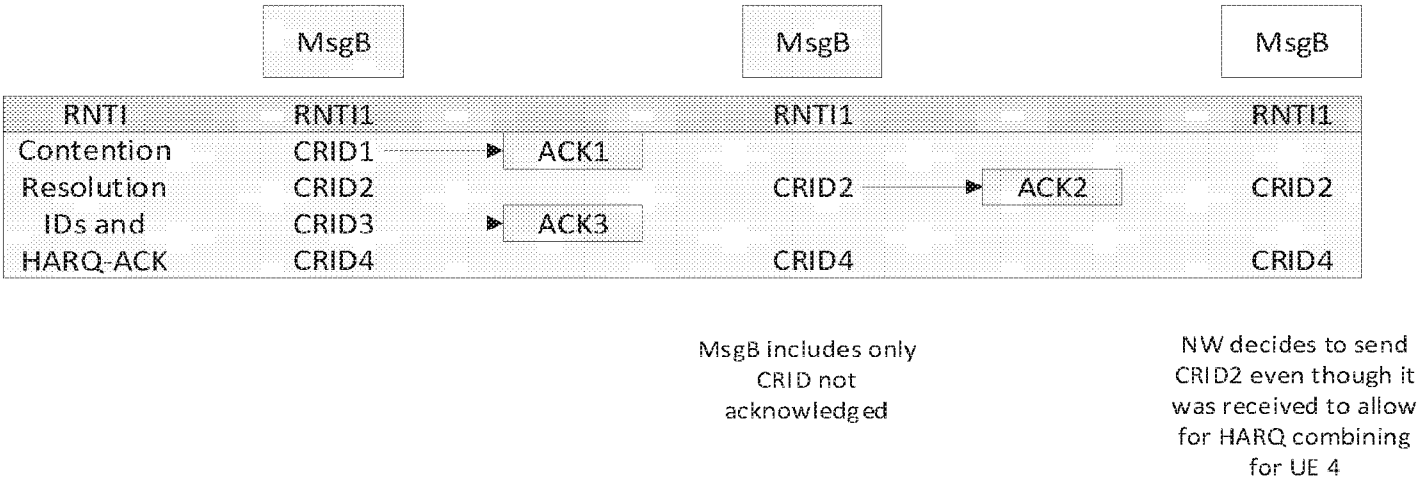
# Figure 1


UE
gNB
1
Random Access Preamble
Random Access Response
2
3
Scheduled Transmission
Contention Resolution
4

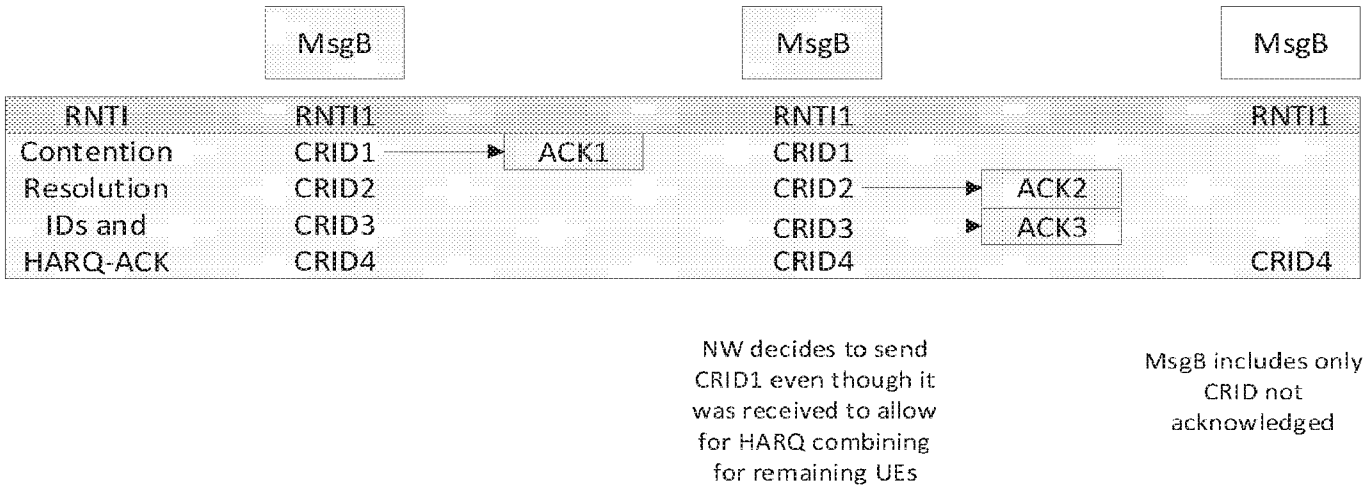
# Figure 2


UE
gNB
A
MsgA: Preamble + Data
Msg1 + Msg3
MsgB: RA Response
Msg2 + Msg4
B

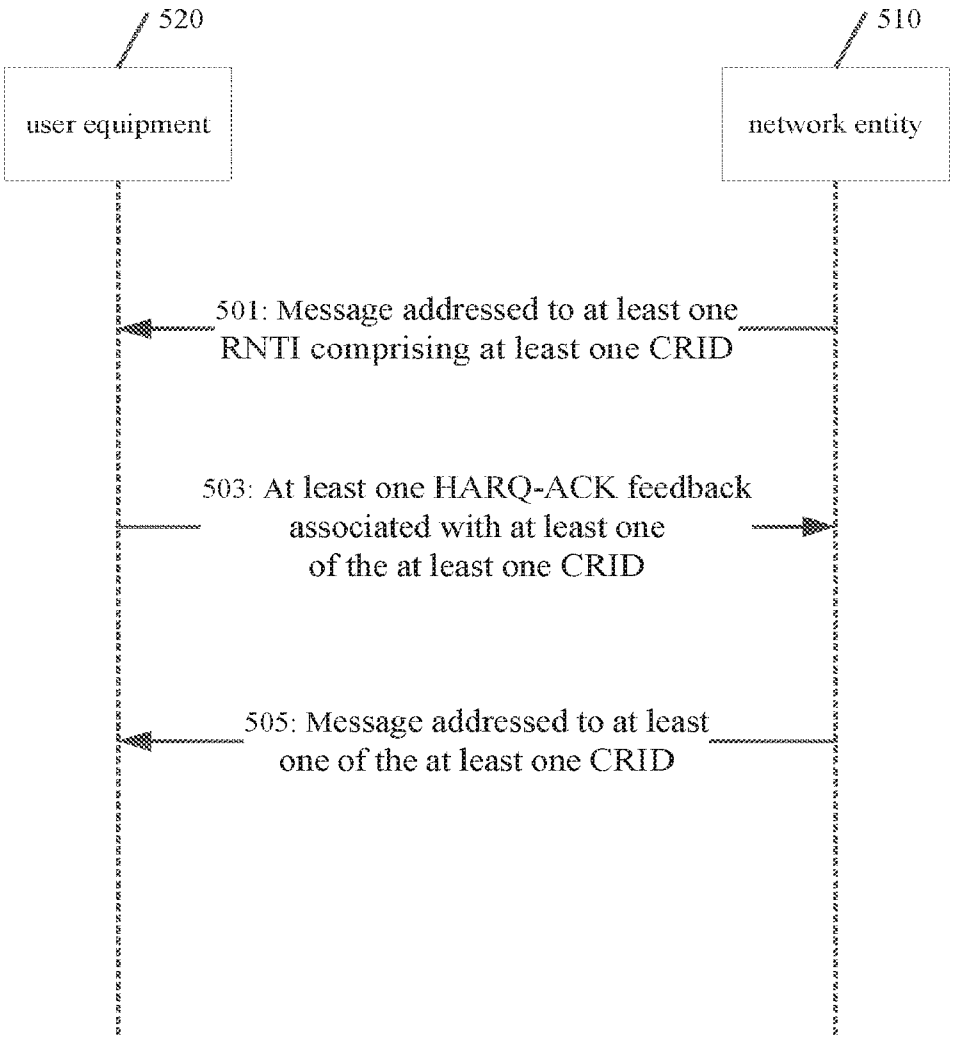
# Figure 3


MsgB
MsgB
MsgB
RNTI
RNTI1
RNTI1
RNTI1
Contention
Resolution
IDs and
HARQ-ACK
CRID1
CRID2
CRID3
CRID4
ACK1
ACK3
CRID2
ACK2
CRID2
CRID4
CRID4
MsgB includes only CRID not acknowledged
NW decides to send CRID2 even though it was received to allow for HARQ combining for UE 4

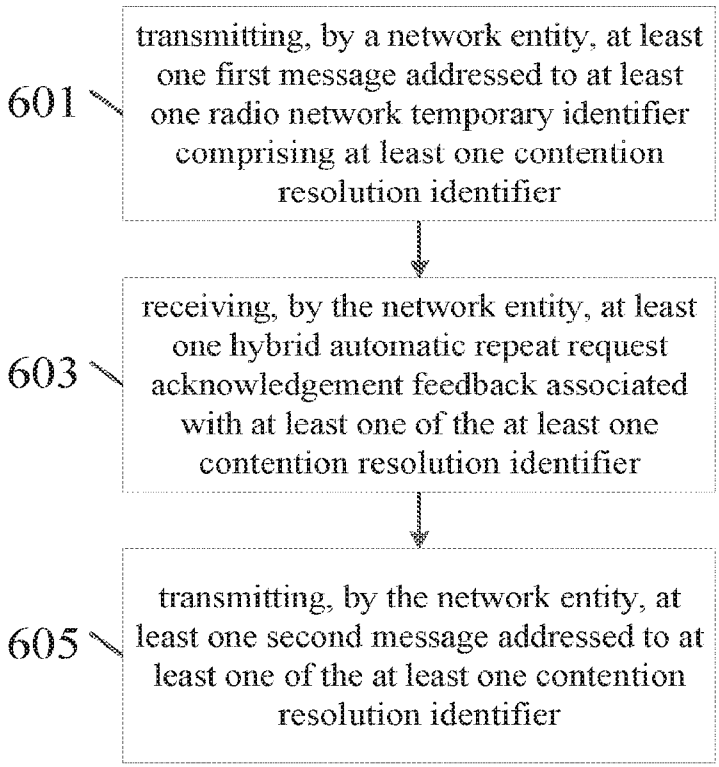
# Figure 4


MsgB
MsgB
MsgB
RNTI
RNTI1
RNTI1
RNTI1
Contention
Resolution
IDs and
HARQ-ACK
CRID1
CRID2
CRID3
CRID4
ACK1
CRID1
CRID2
CRID3
CRID4
ACK2
ACK3
CRID4
NW decides to send CRID1 even though it was received to allow for HARQ combining for remaining UEs
MsgB includes only CRID not acknowledged

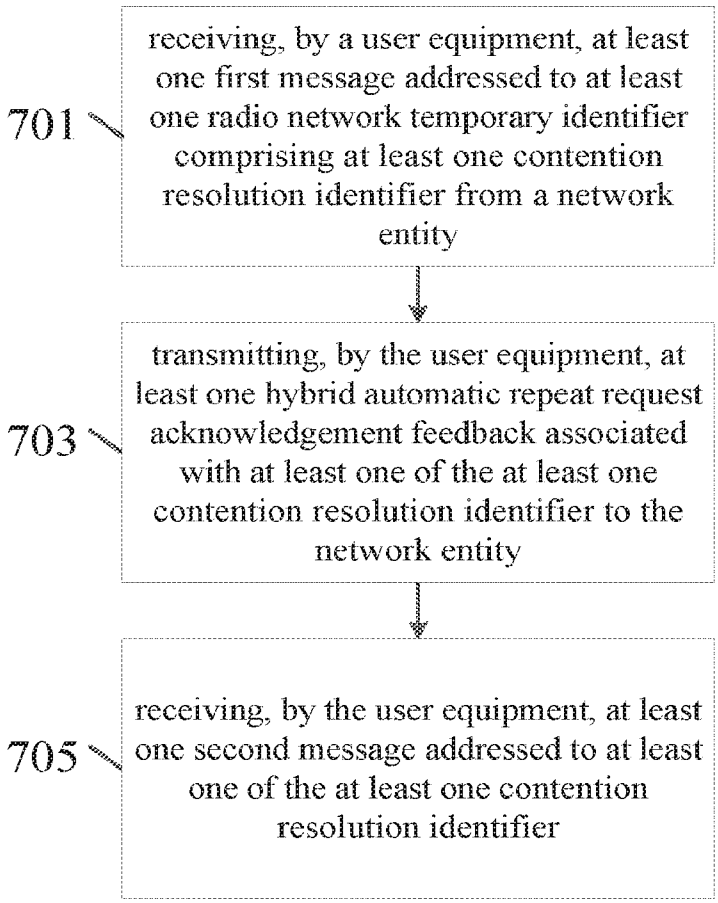
# Figure 5


520
510
user equipment
network entity
501: Message addressed to at least one RNTI comprising at least one CRID
503: At least one HARQ-ACK feedback associated with at least one of the at least one CRID
505: Message addressed to at least one of the at least one CRID

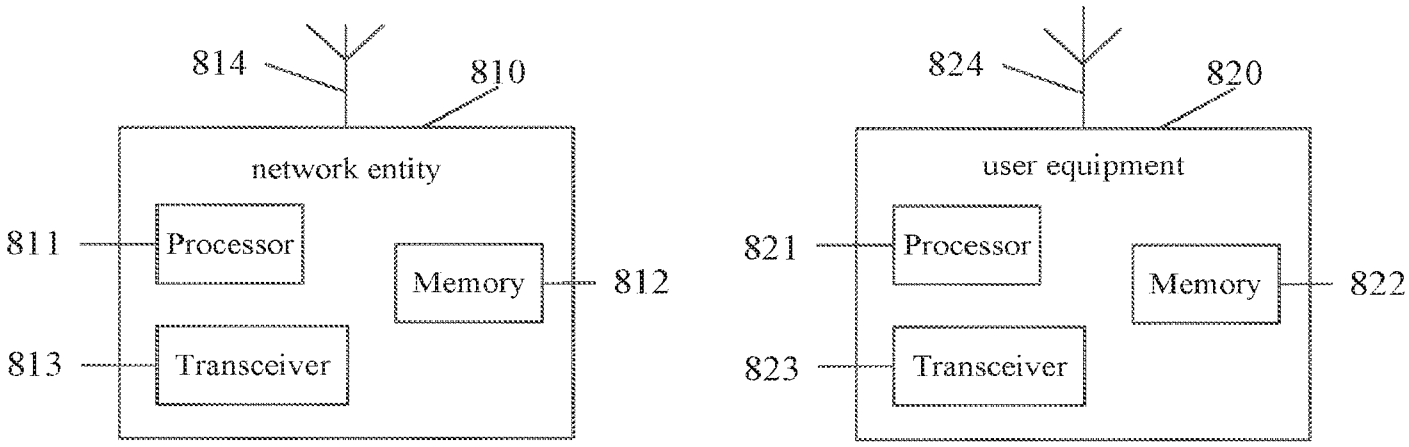
# Figure 6


601
transmitting, by a network entity, at least one first message addressed to at least one radio network temporary identifier comprising at least one contention resolution identifier
603
receiving, by the network entity, at least one hybrid automatic repeat request acknowledgement feedback associated with at least one of the at least one contention resolution identifier
605
transmitting, by the network entity, at least one second message addressed to at least one of the at least one contention resolution identifier

# Figure 7


701
receiving, by a user equipment, at least one first message addressed to at least one radio network temporary identifier comprising at least one contention resolution identifier from a network entity
703
transmitting, by the user equipment, at least one hybrid automatic repeat request acknowledgement feedback associated with at least one of the at least one contention resolution identifier to the network entity
705
receiving, by the user equipment, at least one second message addressed to at least one of the at least one contention resolution identifier

# Figure 8


814
810
network entity
811
Processor
Memory
812
813
Transceiver
824
820
user equipment
821
Processor
Memory
822
823
Transceiver

# INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2020/051190

A. CLASSIFICATION OF SUBJECT MATTER
INV. 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)
H04W H04L

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | MOTOROLA MOBILITY ET AL: "2-step RACH procedure", 3GPP DRAFT; R1-1902843 2-STEP RACH PROCEDURE V0, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Athens, Greece; 20190225 - 20190301 16 February 2019 (2019-02-16), XP051600540, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg%5Fran/WG1%5FRL1/TSGR1%5F96/Docs/R1%2D1902843%2Ezip [retrieved on 2019-02-16] section 2 ----- -/-- | 1-49 |

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"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 | Date of mailing of the international search report |
|---|---|
| 16 April 2020 | 24/04/2020 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Torrea Duran, R |

# INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2020/051190

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | KR 2017 0058238 A (ELECTRONICS & TELECOMMUNICATIONS RES INST [KR]) 26 May 2017 (2017-05-26) paragraph [0058] - paragraph [0060] | 1,23, 46-49 |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2020/051190

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| KR 20170058238 A | 26-05-2017 | NONE | |