

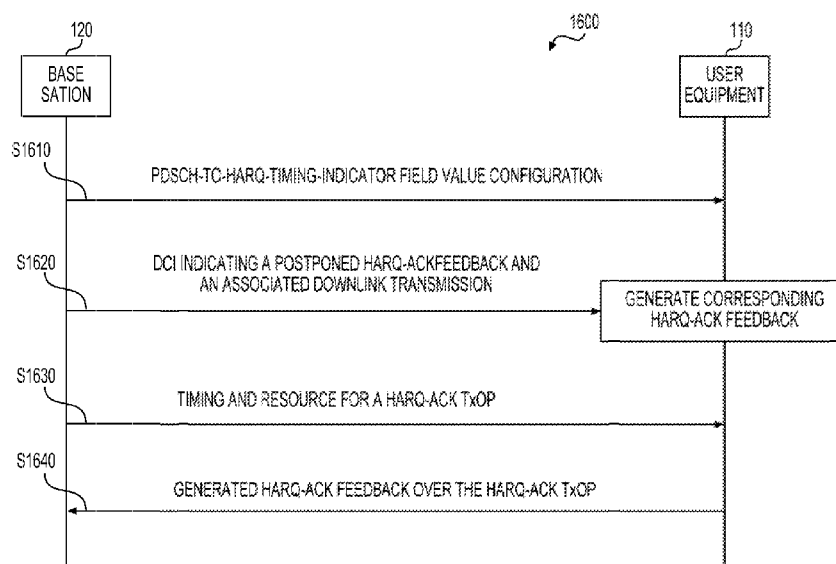
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(54) Title: MECHANISMS FOR POSTPONING HYBRID AUTOMATIC REPEAT REQUEST ACKNOWLEDGEMENT (HARQ-ACK) FEEDBACK

**FIG. 16**

(57) **Abstract:** A method for postponing a hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback is described. The method can include receiving a downlink control information (DCI) associated with a downlink transmission at a user equipment (UE) from a base station (BS) in a wireless communication system. The DCI can include a HARQ-ACK feedback timing indicator field having a field value indicating that a HARQ-ACK feedback of the downlink transmission is postponed. When a timing and resource for the HARQ-ACK feedback of the downlink transmission is received later, the HARQ-ACK feedback of the downlink transmission is transmitted from the UE to the BS over a HARQ-ACK transmission opportunity (TxOP) with the timing and resource later received.



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MECHANISMS FOR POSTPONING HYBRID AUTOMATIC REPEAT REQUEST ACKNOWLEDGEMENT (HARQ-ACK) FEEDBACK

INCORPORATION BY REFERENCE

5 [0001] This present disclosure claims the benefit of U.S. Provisional Application No. 62/737,239, "Enhanced HARQ-ACK Feedback Mechanisms" filed on September 27, 2018, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

10 [0002] The present disclosure relates to wireless communications, and specifically relates to data retransmission techniques (e.g., hybrid automatic repeat request (HARQ) related mechanisms).

BACKGROUND

15 [0003] The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent the work is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

20 [0004] Transmission over wireless channels is subject to errors due to variations in the received signal quality. Such variations can be counteracted by employing hybrid automatic repeat request (HARQ). HARQ is a combination of error correcting coding and retransmission of erroneous data units. For example, after detecting an erroneous data unit transmitted from a transmitter, a receiver can request a retransmission from the transmitter by providing a feedback to the transmitter.

SUMMARY

25 [0005] Aspects of the disclosure provide a method for postponing a hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback. The method can include receiving a downlink control information (DCI) associated with a downlink transmission at a user equipment (UE) from a base station (BS) in a wireless communication system. The DCI can include a HARQ-ACK feedback timing indicator field having a field value indicating that a HARQ-ACK feedback of the downlink transmission is postponed. When a timing and resource
30 for the HARQ-ACK feedback of the downlink transmission is received later, the HARQ-ACK feedback of the downlink transmission is transmitted from the UE to the BS over a HARQ-ACK transmission opportunity (TxOP) with the timing and resource later received.

35 [0006] In an embodiment, the timing and resource for the HARQ-ACK feedback of the downlink transmission can be provided or not provided later. In an embodiment, the method further includes receiving a configuration specifying that the field value indicates that the HARQ-ACK feedback of the downlink transmission is postponed. In an embodiment, the method further includes receiving a configuration that associates the field value with a

value indicating that the HARQ-ACK feedback of the downlink transmission is postponed. In an embodiment, the field value is predefined to indicate that the HARQ-ACK feedback of the downlink transmission is postponed.

[0007] In an embodiment, the method can further include generating HARQ-ACK information for the HARQ-ACK feedback of the downlink transmission. In an embodiment, the method can further include receiving information of the timing and resource for the HARQ-ACK feedback of the downlink transmission.

[0008] Aspects of the disclosure provide another method for postponing a HARQ-ACK feedback. The method can include transmitting a DCI associated with a downlink transmission to a UE from a BS in a wireless communication system. The DCI can include a HARQ-ACK feedback timing indicator field having a field value indicating that a HARQ-ACK feedback of the downlink transmission is postponed. The HARQ feedback of the downlink transmission is received from the UE over a HARQ-ACK TxOP with a timing and resource later provided.

[0009] Aspects of the disclosure provide a UE. The UE can include circuitry configured to receive a DCI associated with a downlink transmission from a BS in a wireless communication system. The DCI can include a HARQ-ACK feedback timing indicator field having a field value indicating that a HARQ-ACK feedback of the downlink transmission is postponed. When a timing and resource for the HARQ-ACK feedback of the downlink transmission is received later, the HARQ-ACK feedback of the downlink transmission is transmitted to the BS over a HARQ-ACK TxOP with the timing and resource later received.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Various embodiments of this disclosure that are proposed as examples will be described in detail with reference to the following figures, wherein like numerals reference like elements, and wherein:

[0011] Fig. 1 shows a group-based hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback process 100 according to some embodiments of the disclosure;

[0012] Fig. 2 shows an example of a non-group-based HARQ-ACK feedback mechanism 200;

[0013] Fig. 3 shows a first group-based HARQ-ACK feedback process 300 according to an embodiment of the disclosure;

[0014] Fig. 4 shows a second group-based HARQ-ACK feedback process 400 according to an embodiment of the disclosure;

[0015] Fig. 5 shows a third group-based HARQ-ACK feedback process 500 according to an embodiment of the disclosure;

[0016] Fig. 6 shows a fourth group-based HARQ-ACK feedback process 600 according to an embodiment of the disclosure;

[0017] Fig. 7 shows a process 700 of a group-based HARQ feedback mechanism according to an embodiment of the disclosure;

[0018] Fig. 8 shows another process 800 of the group-based HARQ feedback mechanism according to an embodiment of the disclosure;

[0019] Fig. 9 shows another group-based HARQ-ACK feedback process 900 according to an embodiment of

the disclosure;

[0020]Fig. 10 shows a process 1000 of providing a HARQ-ACK feedback for one or more HARQ-ACK feedback groups according to an embodiment of the disclosure;

[0021]Fig. 11 shows a process 1100 of receiving a HARQ-ACK feedback for one or more HARQ-ACK feedback groups according to an embodiment of the disclosure;

[0022]Fig. 12 shows an example of mapping timing indicator field values to numbers of slots by RRC signaling;

[0023]Fig. 13 shows an example of how HARQ-ACK feedback timings are determined based on timing indicator field values in downlink control informations (DCIs);

[0024]Fig. 14 shows an example of a timing indicator field value configuration 1400;

[0025]Fig. 15 shows another example of a timing indicator field value configuration 1500;

[0026]Fig. 16 shows a HARQ-ACK feedback process 1600 according to an embodiment of the disclosure; and

[0027]Fig. 17 shows an exemplary apparatus 1700 according to embodiments of the disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0028]Fig. 1 shows a group-based hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback process 100 according to some embodiments of the disclosure. The process 100 can be performed between a user equipment (UE) 110 and a base station (BS) that belong to a wireless communication system 101. In some examples, the system 101 employs the fifth-generation (5G) New Radio (NR) air interface developed by the 3rd Generation Partnership Project (3GPP). In some examples, the system 100 employs other wireless communication technologies developed by various standard development organizations.

[0029]In some examples, the BS 120 can be a base station implementing a gNB node as specified in the 5G NR air interface standards developed by 3GPP. In one example, the BS 120 can be configured to control one or more antenna arrays to form directional Tx or Rx beams for transmitting or receiving wireless signals. The UE 110 can be a mobile phone, a laptop computer, a vehicle carried mobile communication device, a utility meter fixed at a certain location, and the like. Similarly, the UE 110 can employ one or more antenna arrays to generate directional Tx or Rx beams for transmitting or receiving wireless signals in one example. Depending on the air interface between the BS 120 and the UE 110, the BS 120 and the UE 110 can communicate with each other according to respective communication protocols.

[0030]In the process 100, the BS 120 and the UE 110 employs a HARQ mechanism for data transmission in the downlink or uplink direction. For example, the HARQ mechanism can employ a HARQ entity at a MAC layer of the BS 120. The HARQ entity includes a set of stop-and-wait processes operating in parallel. Each stop-and-wait process can transmit a transport block, and stops and waits for HARQ-acknowledgement (HARQ-ACK) information from the UE 110. The HARQ-ACK information can be a signal bit indicating positive acknowledgement (ACK) or negative acknowledgement (NACK). If a NACK is received, retransmission of the transport block can be performed. At the UE 110, upon receiving the transport block, the UE 110 makes an

attempt to decode the transport block, and generate the acknowledgement indicating whether the transport block is correctly decoded or not. Similarly, a HARQ entity can be configured at the UE 110 for implementing the HARQ mechanism for the uplink data retransmission.

[0031] In the HARQ mechanism, when the HARQ-ACK feedback is not successful, for example, due to poor channel condition or occupancy of the channel by other UEs, the BS 120 may have to blindly retransmit the transport block even the transport block has been received successfully at the UE 110, or stop trying the transmission even the transport block has not been received. To counteract those undesired results, the process 100 provides a group-based HARQ-ACK feedback mechanism. In the group-based HARQ-ACK feedback mechanism, data transmissions are grouped into a HARQ-ACK feedback group (or referred to as a physical downlink shared channel (PDSCH) group) and each associated with a group index (or group indicator) (GI). When detection of a first HARQ-ACK feedback of the members of the HARQ-ACK feedback group is failed, in an example, the BS 120 can signal the GI to the UE 110 and indicate to the UE 110 that acknowledgement of all members of the HARQ-ACK feedback group should be included in a second HARQ-ACK feedback.

[0032] The process 100 can start from S130. At S130, a set of downlink transmissions 140-150 can be performed sequentially in time domain. Those downlink transmissions 140-150 can be grouped into a HARQ-ACK feedback group 159, for example, at the HARQ entity of the BS 120. In the Fig. 1 example, the downlink transmissions 140-150 can include a sequence of PDSCHs 142-152, for example, from PDSCH #0 to PDSCH #n. Each PDSCH 142-152 can be scheduled by a downlink control information (DCI) 143-153 carried in a physical downlink control channel (PDCCH), respectively. To indicate to the UE 110 the downlink transmissions 140-150 are members of the HARQ-ACK feedback group 159, a GI is employed. For example, the HARQ-ACK feedback group 159 can be assigned with a GI (e.g., GI=1), and each DCI 143-153 carries the GI of the HARQ-ACK feedback group 159. While the downlink transmissions 140-150 are shown to be sequentially in time domain in Fig. 1, in other examples, the downlink transmissions 140-150 can be performed in multiple serving cells or bandwidth parts (BWPs) configured for the UE 110. Under such a configuration, several downlink transmissions can be transmitted simultaneously but over different serving cells or BWPs.

[0033] At S132, a first HARQ-ACK feedback 160 for receptions of the PDSCHs from #0 to #n is transmitted from the UE 110 to the BS 120. For example, each DCI 143-153 may indicate a same HARQ-ACK transmission opportunity (TxOP), denoted as the first TxOP 161 in Fig. 1. HARQ-ACK bits corresponding to receptions of the PDSCHs from #0 to #n can be included in the HARQ-ACK feedback 160 and transmitted over the first TxOP 161. At the BS 120, a detection failure 162 takes place, and the HARQ-ACK feedback 160 is not received correctly.

[0034] At S134, in response to the detection failure of the HARQ-ACK feedback 160, the BS 120 transmits a request 170 for a group-based HARQ-ACK feedback. The request 170 carries the GI of the HARQ-ACK feedback group 159. The request 170 can take various forms in different embodiments. In the Fig. 1 example, the request 170 is a DCI 170 carrying the GI of the HARQ-ACK feedback group 159.

[0035] At S136, a second HARQ-ACK feedback 180 is transmitted from the UE 110 to the BS 120 over a second TxOP 181. In response to the request 170 for the group-based HARQ-ACK feedback, the UE 110 may generate the HARQ-ACK feedback 180 that includes the HARQ-ACK bits corresponding to the receptions of the

PDSCHs from #0 to #n. The second TxOP 181 can be indicated by the request 170 (e.g., the DCI 170). After receiving the HARQ-ACK feedback 180, the BS 120 may accordingly determine whether some of the downlink transmissions 140-150 need to be retransmitted, and perform the retransmission if needed. The process 100 can then terminate.

[0036] Fig. 2 shows an example of a non-group-based HARQ-ACK feedback mechanism 200. For example, the mechanism is implemented between the BS 120 and the UE 110. PDCCH monitoring occasions 201-203 and 211-213 are shown across serving cells #0-#3 that are configured for the UE 110, for example, based on a carrier aggregation (CA) scheme. Within each PDCCH monitoring occasion, there can be one or more transmissions of PDCCHs. Those PDCCHs each schedule a PDSCH within a same slot and a same serving cell, such as PDSCH from #0 to #11. For example, each PDCCH can include a DCI scheduling a downlink assignment for reception of the respective PDSCH.

[0037] In addition, controlled by the BS 120, the DCI in each PDCCH can indicate a HARQ-ACK TxOP #0 or #1 for the respective PDSCH, and thus associate each PDSCH with one of the TxOPs #0 and #1. In one example, the DCI can carry a PDSCH-to-HARQ-timing-indicator to indicate a slot offset between the PDSCH reception and the corresponding TxOP #0 or #1. Additionally, the DCI can carry a PUCCH resource indicator to indicate a PUCCH resource in the respective TxOP. Based on those indicators, the UE 110 can determine a PUCCH over the TxOP for HARQ-ACK feedback of the PDSCH scheduled by the respective DCI.

[0038] When HARQ-ACK information of a PDSCH is to be reported to the BS 120 via a TxOP, it is said the PDSCH is associated with this TxOP. As shown in Fig. 2, the PDSCHs from #0 to #5 are associated with the TxOP #0, while the PDSCHs from #6 to #11 are associated with the TxOP #1. Thus, the PDCCH monitoring occasions 201-203 corresponding to the PDSCHs from #0 to #5 form a first PDCCH monitoring occasion union 204 corresponding to the TxOP #0, while the PDCCH monitoring occasions 211-213 corresponding to the PDSCHs from #6 to #11 form a second PDCCH monitoring occasion union 214 corresponding to TxOP #1. In some examples, the HARQ-ACK information may be one HARQ-ACK bit. In other examples, the HARQ information can be more than one HARQ-ACK bits generated for a PDSCH, e.g., when code block group (CBG) based transmission is applied in NR.

[0039] As shown, for each union 204 or 214, multiple PDSCH receptions need to be acknowledged over the TxOP #0 or #1. The UE 110 thus generates a HARQ-ACK codebook for each union 204 or 214, and reports the HARQ-ACK codebooks to the BS 120. For example, for the union 204, the codebook can have a length of 6 bits corresponding to the PDSCH #0-#5, while for the union 214, the codebook can also have a length of 6 bits corresponding to the PDSCH #6-#11. As the association between the PDSCHs and the respective TxOP is determined by the BS 120, the BS 120 and the UE 110 can have a same understanding of the size of each HARQ-ACK codebook if all DCIs scheduling the PDSCHs #0-#11 are detected correctly.

[0040] However, in case a DCI (e.g., the DCI scheduling PDSCH #3) is missed by the UE 110, for example, due to poor signal quality, the UE 110 would be unaware of the PDSCH #3. The HARQ-ACK codebook determined at the UE 110 for the union 204 would have a length of 5, resulting misaligned codebooks between the UE 110 and the BS 120. To solve this problem, a downlink assignment index (or downlink assignment indicator)

(DAI) field is introduced and included in the DCIs containing assignments for downlink transmissions (e.g., PDSCHs). The DAI field can include a counter-DAI (C-DAI) value. In case carrier aggregation is employed, the DAI field can include a pair of a C-DAI value and a total-DAI value. Both the C-DAI value and T-DAI value are accumulated over DCIs indicating the same TxOP. In one example, the C-DAI value in the DCI can indicate the accumulative number of {serving cell, PDCCH monitoring occasion}-pairs in which the DCIs indicating the same TxOP are present, up to the current serving cell and current PDCCH monitoring occasion, first in ascending order of serving cell index and then in ascending order of starting time of PDCCH monitoring occasion. The T-DAI value in the DCI can indicate the total number of {serving cell, PDCCH monitoring occasion}-pairs in which the DCIs indicating the same TxOP are present, up to the current PDCCH monitoring occasion and is updated from PDCCH monitoring occasion to PDCCH monitoring occasion.

[0041]For example, considering the PDCCH monitoring occasion 202, for the PDCCH scheduling the PDSCH #3, the number of scheduled downlink transmissions is 4 (PDSCH #1 to PDSCH #4) until the serving cell #2, while for the PDCCH scheduling the PDSCH #4, the number of scheduled downlink transmissions is 5 (PDSCH #1 to PDSCH #5) until the serving cell #3. However, at the current time of the PDCCH monitoring occasion 202, there are 5 scheduled downlink transmissions in total. Accordingly, the DCI scheduling the PDSCH #3 carries a DAI field of (4, 5), while the DCI scheduling the PDSCH #4 carries a DAI field of (5, 5).

[0042]With the DAI mechanism, the UE 110 can determine a size of the codebook at this point in time by receiving at least one component carrier and detecting the respective T-DAI value. By checking the C-DAI values, the UE 110 can determine which downlink transmission is missed, and feedback a NACK bit corresponding to the missed downlink transmission.

[0043]In the Fig. 2 example, the C-DAI values and T-DAI values are represented with decimal numbers. However, in other examples (e.g., as seen in Fig. 3 and Fig. 6), two bits are used for representing the C-DAI or T-DAI values which wrap around when values are greater than 4. Accordingly, the C-DAI or T-DAI values can be the numbers in Fig. 2 modulo four.

[0044]In this disclosure, similarly to the Fig. 2 example, PDSCHs may be shown to be scheduled by PDCCHs transmitted in the same slot and the same serving cell. However, in various examples, a PDSCH scheduled by a PDCCH may be disposed at different slots or different serving cells (e.g., cross scheduling in CA) from the scheduling PDCCH. In addition, multiple PDSCHs may be distributed on BWPs configured over one serving cell.

[0045]Further, instead of the DCIs scheduling PDSCHs as shown in Fig. 2, the non-group-based HARQ-ACK feedback scheme 200 can also be applied to a DCI indicating a semi-persistent scheduling (SPS) PDSCH release that can be acknowledged over an associated HARQ-ACK TxOP. Similarly, in the figures described in the disclosure, DCIs scheduling PDSCHs may be shown as examples to illustrate the group-based HARQ-ACK feedback techniques. Those HARQ-ACK feedback techniques described with reference to those figures can also be applied to DCIs indicating SPS PDSCH release.

[0046]Fig. 3 shows a first group-based HARQ-ACK feedback process 300 according to an embodiment of the disclosure. The BS 120 and the UE 110 are used as an example to explain the process 300.

[0047]A sequence of downlink transmissions of PDSCH from #0 to #10 over a serving cell #0 are shown in

Fig. 3. Each PDSCH is scheduled by a respective DCI. Each PDSCH is associated (in terms of HARQ-ACK feedback) with a TxOP (one of PUCCHs from #0 to #3) indicated by the respective DCI. For example, the DCI may carry a PDSCH-to-HARQ-timing-indicator and a PUCCH resource indicator for indicating the respective TxOP.

[0048] To facilitate the group-based HARQ-ACK feedback mechanism, the downlink transmissions of PDSCH from #0 to #10 are organized into different HARQ-ACK feedback groups from Group #0 to Group #2 by the BS 120. The PDSCHs #0, #1, and #2 over slots from #n to #n+2 are included in the Group #0. The PDSCHs #3, #4, #5, #8, #9, and #10 over slots from #m to #m+2 and from #s to #s+2 are included in Group #1. The PDSCHs #6 and #7 over slots from #p to #p+1 are included in the Group #2.

[0049] The grouping of the downlink transmissions can be based on a group index (GI) carried in each DCI scheduling the downlink transmission. The DCIs scheduling downlink transmissions of a same HARQ-ACK feedback group carry a same GI value. For example, the DCIs of the Group #0 each carry a same GI value of 0. The DCIs of the Group #1 each carry a same GI value of 0. The DCIs of the Group #2 each carry a GI value of 1.

[0050] The initialization of a new HARQ-ACK feedback group with a GI value can be based on a new group indicator (NGI) functioning as a toggle bit carried in each DCI scheduling the downlink transmission. For example, Group #0 and Group #1 are transmitted successively and assigned with a same GI value (GI=0). However, at slot #m, which is the starting slot of Group #1, the NGI bit toggled from 0 to 1. In this way, the UE is indicated that a new HARQ-ACK feedback group (i.e., Group #1) with GI = 0 is initiated. In this way, separate HARQ-ACK feedback groups (new group and previous group) can be identified even the HARQ-ACK feedback groups have the same GI value.

[0051] By control of the GI values and the NGI bits carried in the DCIs, the BS 120 can dynamically form a HARQ-ACK feedback group for purpose of group-based HARQ-ACK feedback. On the other side, by signaling the GI values and the NGI bits carried in the DCIs, the BS 120 can indicate to the UE 110 which downlink transmissions are within a HARQ-ACK feedback group that is to be reported to the BS for a group-based HARQ-ACK feedback.

[0052] In addition, as shown in Fig. 3, C-DAI and T-DAI values in the DCIs are accumulated within each HARQ-ACK feedback group. For example, for Group #1, the DCIs scheduling PDSCHs #3, #4, #5, #8, #9, and #10 carry C-DAI or T-DAI values of 1, 2, 3, 4, 1, and 2, respectively.

[0053] To facilitate the group-based HARQ-ACK feedback mechanism, the UE 110 can behave in the following way. In response to receiving a DCI that schedules a downlink transmission and carries a GI value of a HARQ-ACK feedback group, the UE 110 can determine to provide a group-based HARQ-ACK feedback for all downlink transmissions belonging to the HARQ-ACK feedback group with the GI value, and transmit the group-based HARQ-ACK feedback over a HARQ-ACK TxOP indicated by the DCI. In this way, each of the DCIs scheduling PDSCHs from #0 to #10 can function as a trigger DCI for a group-based HARQ-ACK feedback from the perspective of the UE 110. However, it is up to the BS 120 to dynamically control how the downlink transmissions are formed into different HARQ-ACK feedback groups.

[0054] Particularly, there can be more than one HARQ-ACK feedback groups having a same GI value. In

response to receiving the signaling of a GI value in a DCI, the UE 110 can acknowledge the most recent (or the newest) HARQ-ACK feedback group having the GI value.

[0055] The group-based HARQ-ACK feedback process 300 can be carried out in the following way. At the beginning, at BS 120, the downlink transmissions, including the PDSCHs #0-#2, are formed into Group #0 with GI=0 carried in the respective DCIs scheduling the PDSCHs #0-#2. The UE 110 receives the downlink transmissions in Group #0 successively, and transmits a HARQ-ACK codebook generated for the receptions of Group #0 over the PUCCH #0. The BS 120 receives the HARQ-ACK codebook over PUCCH #0 correctly.

[0056] Next, the BS 120 similarly transmits the downlink transmissions, PDSCHs #3-#5, with GI=0 carried in the respective DCIs scheduling the PDSCHs #3-#5. At current stage, the BS 120 knows the HARQ-ACK feedback of Group #0 has been correctly received previously (which means retransmission of the HARQ-ACK feedback of Group #0 is not needed in the further). Accordingly, the BS 120 can toggle the NGI bit from 0 to 1 at slot #m to indicate a start of Group #1 that has a same GI value as Group #0. The UE 110 receives the downlink transmissions of PDSCHs #3-#5 successively, and transmits a HARQ-ACK codebook generated for the receptions of Group #1 over the PUCCH #1.

[0057] However, the HARQ-ACK codebook over PUCCH #1 may not reach the BS 120 successfully. For example, the DCIs scheduling PDSCHs #3-#5 may be missed by the UE 110, and no feedback takes place. Or, the channel for transmitting PUCCH #1 may be occupied by a device in a listen-before-talk (LBT) protocol over an unlicensed spectrum. Or, the BS 120 cannot detect the PUCCH #1 correctly. Accordingly, the BS 120 can determine a retransmission of the ACK/NACK bits for PDSCHs #3-#5 is needed. As a result, signaling a request for the retransmission takes place later when PDSCHs #8-#10 are transmitted.

[0058] Next, the BS 120 similarly transmits the downlink transmissions, PDSCHs #6-#7, with GI=1 carried in the respective DCIs scheduling the PDSCHs #6-#7. At the slot #p, the GI value changed compared with that at slot #m+2, which indicates the PDSCHs #6-#7 belongs to a HARQ-ACK feedback group (Group #2) different from Group #1 formed by PDSCHs #3-#5. The UE 110 may receive the downlink transmissions of Group #2, and transmits a HARQ-ACK codebook for the receptions of Group #2 over the PUCCH #2.

[0059] Thereafter, the BS 120 may start to transmit the downlink transmissions PDSCHs #8-#10. At this stage, the BS 120 can determine the DCIs scheduling PDSCHs #8-#10 to carry the same GI values (GI=0) and the same NGI bits (NGI=1) as in DCIs scheduling PDSCHs #3-#5. In this way, the BS 120 can effectively indicate the UE 110 that PDSCHs #3-#5 and PDSCHs #8-#10 belong to the same HARQ-ACK feedback group (Group #1), and a retransmission of ACK/NACK bits of PDSCHs #3-#5 could be performed by generating a group-based HARQ-ACK feedback.

[0060] In response to receiving a DCI carrying the GI=0 and indicating the TxOP of PUCCH #3, such as the DCI 301 at slot #s+2 scheduling the PDSCH #10, the UE 110 can determine to provide a group-based HARQ-ACK feedback for all downlink transmissions belonging to the HARQ-ACK feedback group having GI=0, and transmit the group-based HARQ-ACK feedback over the TxOP of PUCCH #3. Particularly, there are more than one HARQ-ACK feedback groups having GI=0 (i.e., Groups #0 and #1). In response to receiving the signaling of GI=0 in the DCI 301, the UE 110 can acknowledge the most recent (or the newest) HARQ-ACK feedback group

with GI=0 (i.e., Group #1).

[0061]As can be seen, the DCI 301 scheduling the PDSCH #10 and indicating the TxOP of PUCCH #3 functions as a request for a group-based HARQ-ACK feedback. When the BS 120 determines the retransmission of the ACK/NACK bits of PDSCHs #3-#5 are needed, the BS 120 can transmit a DCI scheduling a downlink transmission belonging to the same HARQ-ACK feedback group as PDSCHs #3-#5 (by letting a GI value and an NGI bit in the DCI be the same as that of PDSCHs #3-#5), and this DCI can trigger the UE 110 to provide a group-based HARQ-ACK feedback for all members (including the members of PDSCHs #3-#5) belonging to the HARQ-ACK feedback group.

[0062]In an embodiment, if a DCI scheduling a downlink transmission functions as a trigger DCI for a group-based HARQ-ACK feedback as described above, a trigger field can be carried in the DCI to indicate to the UE 110 whether a group-based HARQ-ACK feedback is to be triggered by this DCI. For example, under the control of the BS 120, the DCIs scheduling PDSCHs #0-#10 can each carry a 1-bit trigger field. Using PDSCH #9 as an example, when the trigger field in the DCI 302 scheduling PDSCH #9 is set to 0, for example, the UE 110 can transmit HARQ-ACK information for the reception of PDSCH #9 over the PUCCH #3 indicated by the DCI without considering downlink transmission grouping. In contrast, when the trigger field in the DCI scheduling PDSCH #9 is set to 1, the UE 110 will treat the DCI as a DCI triggering a group-based HARQ-ACK feedback over the PUCCH #3 indicated by the DCI. Accordingly, the UE 110 can generate a group-based feedback based on the grouping information (the GI values and NGI bits) previously received. The group-based feedback can include ACK/NACK bits for the HARQ-ACK feedback group having GI=0 (i.e., Group #1) including PDSCHs #3, #4, #5, #8, and #9.

[0063]It is noted that while in Fig. 3 or other figures of the disclosure, downlink transmissions are shown to be transmitted over one serving cell (e.g., serving cell #0), the group-based HARQ-ACK feedback schemes described herein are applicable to scenarios where downlink transmissions (e.g., PDSCH or SPS PDSCH release) are distributed across multiple carriers or BWPs.

[0064]Fig. 4 shows a second group-based HARQ-ACK feedback process 400 according to an embodiment of the disclosure. The BS 120 and the UE 110 are used as an example to explain the process 400.

[0065]A sequence of PDSCHs from #0 to #7 is transmitted over a serving cell #0 from the BS 120 to the UE 110. Similar to the Fig. 3 example, each PDSCH is scheduled by a respective DCI. Each DCI indicates a PUCCH for feedback of HARQ-ACK information for the reception of the respective PDSCH. As shown, PDSCHs #0-#2 are associated with PUCCH #0. PDSCHs #3-#5 are associated with PUCCH #1. PDSCHs #6-#7 are associated with PUCCH #2.

[0066]Similar to the Fig. 3 example, each DCI carries a C-DAI value, a T-DAT value, a GI value, and an NGI bit, which are set by the BS 120. Based on the GI values and NGI bits, the UE 110 can determine PDSCHs #0-#2 are included in a HARQ-ACK feedback group, Group #0, while PDSCHs #3-#5 and PDSCHs #6-#7 are included in HARQ-ACK feedback groups, Group #1 and Group #2, respectively. In addition, the C-DAT and T-DAT values are accumulated over each HARQ-ACK feedback group.

[0067]In the process 400, transmissions of the PDSCHs #0-#7 and feedback of respective ACK/NACK bits

can be performed in a similar way as in the process 300 of the Fig. 3 example. Particularly, the feedback of ACK/NACK bits over PUCCH #1 for PDSCH #3-#5 can fail, and the BS 120 accordingly determines retransmission of the feedback of ACK/NACK bits for PDSCH #3-#5 is needed.

[0068] Then, at slot #s, the BS 120 can transmit a request for a group-based HARQ-ACK feedback that includes the ACK/NACK bits for PDSCH #3-#5. Different from the Fig. 3 example, a DCI 401 scheduling an uplink grant for transmission of a PUSCH #0 is used as the request. In addition, the PUSCH #0 is used as a HARQ-ACK TxOP. Specifically, controlled by the BS 120, the DCI 401 scheduling PUSCH #0 carries the GI value (GI=1) of the Group #1. In one example, the DCI 401 carrying the GI value of the Group #1 can trigger the UE 110 to perform a group-based feedback for all members of the Group #1. For example, a HARQ-ACK codebook can be generated to include the ACK/NACK bits of the receptions of PDSCH #3-#5, and transmitted to the BS 120 over the PUSCH #0. Particularly, there can be more than one HARQ-ACK feedback groups having GI=0 (i.e., Groups #0 and #1). In response to receiving the signaling of GI=0 in the DCI 401, the UE 110 can acknowledge the most recent (or the newest) HARQ-ACK feedback group with GI=0 (i.e., Group #1).

[0069] In an alternative example, an additional trigger field (or request field), denoted as RQ in Fig. 4 at slot #s, is carried by the trigger DCI 401 scheduling PUSCH #0. The trigger field, for example, can be a 1-bit field that indicates whether the DCI 401 is intended to be used as a trigger DCI for triggering a group-based HARQ-ACK feedback. For example, when RQ=0, the DCI 401 is not a trigger DCI, while when RQ=1, the DCI 401 is treated as a DCI triggering a group-based HARQ-ACK feedback.

[0070] Fig. 5 shows a third group-based HARQ-ACK feedback process 500 according to an embodiment of the disclosure. The BS 120 and the UE 110 are used as an example to explain the process 500.

[0071] As shown, downlink transmissions of PDSCHs and associated DCIs and uplink ACK/NACK feedback operations until slot #p+2 in the process 500 can be similar to the operations until slot #p+2 in the process 300 or 400. However, different from the process 300 or 400, a DCI 501 without downlink assignment or uplink grant can be used as a trigger DCI for triggering a group-based HARQ-ACK feedback. The DCI 501 can carry sufficient information for indicating a HARQ-ACK TxOP to the UE 110. The TxOP can be a PUCCH #3 as shown in Fig. 5. In one example, similar to the usage of the PDSCH-to-HARQ-timing-indicator to indicate a time slot, and a PUCCH resource indicator to indicate a PUCCH resource, a set of indicators can be employed to indicate uplink transmission resources. In other examples, other mechanisms for indicating uplink transmission resources may be used.

[0072] Similarly, the DCI 501 may carry a GI value indicating which group is to be acknowledged, or may carry a GI value and a trigger field (RQ) which in combination can trigger the group-based HARQ-ACK feedback.

[0073] Fig. 6 shows a fourth group-based HARQ-ACK feedback process 600 according to an embodiment of the disclosure. The BS 120 and the UE 110 are used as an example to explain the process 600.

[0074] In Fig. 6, a sequence of PDSCHs #0-#10 is transmitted over a serving #0. Controlled by DCIs scheduling PDSCHs #0-#10, HARQ-ACK feedbacks of PDSCHs #0-#10 are associated with HARQ-ACK TxOPs, PUCCH #0, #1, and #2, respectively. Each DCI carries a C-DAI value, a T-DAI value, a GI value, and a NGI bit. The GI values and NGI bits indicate how the PDSCHs #0-#10 are organized into HARQ-ACK feedback groups,

Group #0, #1, or #2. Specifically, PDSCHs #0-#2, PDSCHs #3-#5 and #8-#10, and PDSCHs #6-#7 are included in Group #0, #1, or #2, respectively.

[0075] Different from the previous examples of Figs. 3-5, in Fig. 6, two HARQ-ACK feedback groups, Groups #1 and #2, are associated with the same TxOP, PUCCH #2. For example, the DCI 601 scheduling PDSCH #7 carries the GI value of Group #2, and indicates the TxOP of PUCCH #2, while similarly, the DCI 602 scheduling PDSCH #10 carries the GI value of Group #1, and also indicates the TxOP of PUCCH #2. In response to receiving the trigger DCIs 601 and 602, the UE 110 can transmit a group-based HARQ-ACK feedback for both Groups #1 and #2 over the PUCCH #2.

[0076] In one example, as shown in Fig. 6, two HARQ-ACK codebooks, Codebooks #1 and #2, can be generated corresponding to Groups #1 and #2. Then, the two codebooks are combined together, for example, by concatenating one codebook with another codebook in increasing or decreasing order of corresponding GI values of Groups #1 and #2.

[0077] In other examples, signaling of associating more than one HARQ-ACK feedback group with a same TxOP can be performed using trigger DCIs similar to the trigger DCIs 401 or 501 in the Fig. 4 or Fig. 5 examples. For example, the trigger DCI 401 or 501 can be set to include two GI values corresponding to two HARQ-ACK feedback groups. For another example, more than one trigger DCIs similar to the DCI 401 or 501 can be transmitted. Those DCIs can indicate a same TxOP but carry different GI values.

[0078] Fig. 7 shows a process 700 of the group-based HARQ feedback mechanism according to an embodiment of the disclosure. The process 700 can be performed at the UE 110. The BS 120 and the UE 110 are used as an example to explain the process 700. The process 700 starts from S701 and proceeds to S710.

[0079] At S710, one or more DCIs can be received at the UE 110. Each DCI can be associated with a first downlink transmission, for example, of a PDSCH or a SPS PDSCH release. Each DCI can carry a first GI value of a first HARQ-ACK feedback group.

[0080] At S720, a request for a group-based HARQ-ACK feedback can be received by the UE 110. The request can indicate the first GI value of the first HARQ-ACK feedback group and a first HARQ-ACK TxOP.

[0081] In one example, each DCI received at S710 can further indicate a HARQ-ACK TxOP that is different from the first HARQ-ACK TxOP indicated in the request received at S720. In response to receiving the first downlink transmission(s), the UE 110 may generate and transmit a HARQ-ACK feedback over the HARQ-ACK TxOP indicated by the DCI(s). However, the BS 120 failed to detect the HARQ-ACK feedback over the HARQ-ACK TxOP indicated by the DCIs at S710. Accordingly, the BS 120 can transmit the request for a group-based HARQ-ACK feedback at S720. In another example, each DCI received at S710 can further indicate a HARQ-ACK TxOP that is the same as the first HARQ-ACK TxOP indicated in the request received at S720.

[0082] At S730, the UE 110 can generate the group-based HARQ-ACK feedback for acknowledging receptions of downlink transmissions in the first HARQ-ACK feedback group in response to receiving the request at S720. The first downlink transmissions are members of the first HARQ-ACK feedback group. Accordingly, the group-base HARQ-ACK feedback includes HARQ-ACK information bits (ACK/NACK bits) of the first transmissions.

[0083]At S740, the group-based HARQ-ACK feedback is transmitted over the first HARQ-ACK TxOP indicated by the request. The process 700 proceeds to S799 and terminates at S799.

[0084]Fig. 8 shows a process 800 of the group-based HARQ feedback mechanism according to an embodiment of the disclosure. The process 800 can be performed at the BS 120. The BS 120 and the UE 110 are used as an example to explain the process 800. The process 800 starts from S801 and proceeds to S810.

[0085]At S810, one or more DCIs can be transmitted from the BS 120. Each DCI can be associated with a first downlink transmission. Each DCI can carry a first GI value of a first HARQ-ACK feedback group.

[0086]At S820, a request for a group-based HARQ-ACK feedback can be transmitted from the BS 120. The request can indicate the first GI value of the first HARQ-ACK feedback group and a first HARQ-ACK TxOP.

[0087]At S830, the group-based HARQ-ACK feedback for acknowledging receptions of downlink transmissions in the first HARQ-ACK feedback group can be received over the first HARQ-ACK TxOP indicated by the request. The group-based HARQ-ACK feedback can include HARQ-ACK information bits of the first downlink transmissions transmitted at S810. The process 800 can proceed to S899, and terminates at S899.

[0088]In a first example, each DCI transmitted at S810 can further indicate a HARQ-ACK TxOP that is different from the first HARQ-ACK TxOP indicated in the request transmitted at S820. In response to receiving the first downlink transmission(s), the UE 110 may generate and transmit a HARQ-ACK feedback over the HARQ-ACK TxOP. Then, a detection of the HARQ-ACK feedback for the first downlink transmission(s) transmitted over the HARQ-ACK TxOP can be performed at the BS 120. However, the signal quality may be poor. Or, due to channel occupancy by a device in operation with a LBT protocol on an unlicensed spectrum, the HARQ-ACK feedback is not transmitted. Because of the above or other reasons, the BS 120 may fail to correctly detect the HARQ-ACK feedback. Accordingly, the BS 120 can determine to have a retransmission of HARQ-ACK information bits of the first downlink transmissions by transmitting the request for a group-based HARQ-ACK feedback at S820.

[0089]In a second example, each DCI transmitted at S810 can further indicate a HARQ-ACK TxOP that is the same as the first HARQ-ACK TxOP indicated in the request transmitted at S820.

[0090]For either the first or the second example, in response to receiving the request at S820, the UE 110 can generate the group-based HARQ-ACK feedback. Based on the GI values carried in DCIs transmitted at S810, the UE 110 can determine that the first downlink transmissions belong to the first HARQ-ACK feedback group. Thus, the UE 110 can generate the HARQ-ACK information bits of the first downlink transmissions for the group-based HARQ-ACK feedback.

[0091]Fig. 9 shows another group-based HARQ-ACK feedback process 900 according to an embodiment of the disclosure. In the process 900, a DCI can request a HARQ-ACK feedback for one or more HARQ-ACK feedback groups (or PDSCH groups) in a same PUCCH. Each such HARQ-ACK feedback group can include a set of downlink transmissions (e.g., transmissions of a PDSCH or an SPS PDSCH release). The BS 120 and the UE 110 are used as an example to explain the process 900.

[0092]A sequence of downlink transmissions of PDSCH from #0 to #10 over a serving cell #0 are shown in Fig. 9. Each PDSCH is scheduled by a respective DCI. Each PDSCH is associated (in terms of HARQ-ACK

feedback) with a TxOP (one of PUCCHs from #0 to #3) indicated by the respective DCI. For example, the DCI may carry a PDSCH-to-HARQ-timing-indicator and a PUCCH resource indicator for indicating the respective TxOP.

[0093] To facilitate the HARQ-ACK feedback for one or more HARQ-ACK feedback groups, the downlink transmissions of PDSCH from #0 to #10 are organized into different HARQ-ACK feedback groups from Group #0 to Group #2 by the BS 120. The PDSCHs #0, #1, and #2 over slots from #n to #n+2 are included in the Group #0. The PDSCHs #3, #4, #5, #8, #9, and #10 over slots from #m to #m+2 and from #s to #s+2 are included in Group #1. The PDSCHs #6 and #7 over slots from #p to #p+1 are included in the Group #2. The DCIs of the Group #0 each carry a same GI value of 0. The DCIs of the Group #1 each carry a same GI value of 0. The DCIs of the Group #2 each carry a GI value of 1.

[0094] Group #0 and Group #1 are transmitted successively and assigned with the same GI value (GI=0). However, at slot #m, which is the starting slot of Group #1, the NGI bit toggled from 0 to 1 to indicate a new HARQ-ACK feedback group with GI = 0 is initiated.

[0095] In response to receiving a DCI that schedules a downlink transmission and carries a GI value of a HARQ-ACK feedback group, the UE 110 can determine to provide a group-based HARQ-ACK feedback for all downlink transmissions belonging to the HARQ-ACK feedback group with the GI value, and transmit the group-based HARQ-ACK feedback (e.g., a HARQ-ACK codebook) over a HARQ-ACK TxOP indicated by the DCI. When there is more than one HARQ-ACK feedback groups having a same GI value, in response to receiving the signaling of a GI value in a DCI, the UE 110 can acknowledge the most recent (or the newest) HARQ-ACK feedback group having the GI value.

[0096] In addition to the NGIs and the GIs, each DCI can further carry a request field (denoted by RQ in Fig. 9) for indicating whether a HARQ-ACK feedback for more than one HARQ-ACK feedback groups is to be transmitted over the respective HARQ-ACK TxOP indicated by each DCI. As shown, when RQ=0 as carried in the DCIs of Group #0, only a HARQ-ACK feedback of Group #0 is transmitted over the PUCCH #0. When RQ=1 as carried in the DCIs of Group #1 at slot #s to #s+2, in addition to the HARQ-ACK feedback of Group #1, a HARQ-ACK feedback for another HARQ-ACK feedback group having a different GI value than Group #1 (the Group #2) is also transmitted over the PUCCH #3. Similarly, there can be more than one HARQ-ACK feedback groups having the same GI value (GI=1) of Group #2. In response to receiving the signaling of the RQ=1, the UE 110 can acknowledge the most recent (or the newest) HARQ-ACK feedback group having the GI value of 1.

[0097] The group-based HARQ-ACK feedback process 900 can be carried out in the following way. At the beginning, at BS 120, the downlink transmissions, including the PDSCHs #0-#2, are formed into Group #0 with GI=0 and RQ=0 carried in the respective DCIs scheduling the PDSCHs #0-#2. The UE 110 receives the downlink transmissions in Group #0 successively, and transmits a HARQ-ACK codebook generated for the receptions of Group #0 over the PUCCH #0. The BS 120 receives the HARQ-ACK codebook over PUCCH #0 correctly. As the DCIs scheduling the PDSCHs #0-#2 each carry the RQ value of 0, no HARQ feedback for an additional HARQ-ACK feedback group is transmitted over the PUCCH#0.

[0098] Next, the BS 120 similarly transmits the downlink transmissions, PDSCHs #3-#5, with GI=0 and

RQ=0 carried in the respective DCIs scheduling the PDSCHs #3-#5. At current stage, the BS 120 knows the HARQ-ACK feedback of Group #0 has been correctly received previously (which means retransmission of the HARQ-ACK feedback of Group #0 is not needed in the further). Accordingly, the BS 120 can toggle the NGI bit from 0 to 1 at slot #m to indicate the start of Group #1 that has a same GI value as Group #0. The UE 110 receives the downlink transmissions of PDSCHs #3-#5 successively, and transmits a HARQ-ACK codebook generated for the receptions of Group #1 over the PUCCH #1. Similarly, as the DCIs scheduling the PDSCHs #3-#5 each carry the RQ value of 0, no HARQ feedback for an additional HARQ-ACK feedback group is transmitted over the PUCCH #1.

[0099] However, the HARQ-ACK codebook over PUCCH #1 may not reach the BS 120 successfully. Accordingly, the BS 120 can determine a retransmission of the ACK/NACK bits for PDSCHs #3-#5 is needed. As a result, signaling a request for the retransmission takes place later when PDSCHs #8-#10 are transmitted.

[00100] Next, the BS 120 similarly transmits the downlink transmissions, PDSCHs #6-#7, with GI=1 and RQ=0 carried in the respective DCIs scheduling the PDSCHs #6-#7. At the slot #p, the GI value changed compared with that at slot #m+2, which indicates the PDSCHs #6-#7 belongs to a HARQ-ACK feedback group (Group #2) different from Group #1 formed by PDSCHs #3-#5. The UE 110 may receive the downlink transmissions of Group #2, and transmits a HARQ-ACK codebook for the receptions of Group #2 over the PUCCH #2. Similarly, as the DCIs scheduling the PDSCHs #6-#7 each carry the RQ value of 0, no HARQ feedback for an additional HARQ-ACK feedback group is transmitted over the PUCCH #2.

[00101] However, the HARQ-ACK codebook over PUCCH #2 may not reach the BS 120 successfully. Accordingly, the BS 120 can determine a retransmission of the ACK/NACK bits for PDSCHs #6-#7 is needed. As a result, signaling a request for the retransmission takes place later when PDSCHs #8-#10 are transmitted. The request can be represented by an RQ having the value of 1.

[00102] Thereafter, the BS 120 may start to transmit the downlink transmissions PDSCHs #8-#10. At this stage, the BS 120 can determine the DCIs scheduling PDSCHs #8-#10 to carry the same GI values (GI=0) and the same NGI bits (NGI=1) as in DCIs scheduling PDSCHs #3-#5. In this way, the BS 120 can effectively indicate the UE 110 that PDSCHs #3-#5 and PDSCHs #8-#10 belong to the same HARQ-ACK feedback group (Group #1), and a retransmission of ACK/NACK bits of PDSCHs #3-#5 can be performed by generating a group-based HARQ-ACK feedback.

[00103] In addition, the BS 120 can determine the DCIs scheduling PDSCHs #8-#10 to carry the RQ values of 1. In this way, the BS 120 can effectively indicate the UE 110 that a retransmission of ACK/NACK bits of PDSCHs #6-#7 can be performed, and a HARQ-ACK codebook of Group #2 can be transmitted in addition to a HARQ-ACK codebook of Group #1.

[00104] In response to receiving a DCI carrying GI=0, and indicating the TxOP of PUCCH #3, such as the DCI 901 at slot #s+2 scheduling the PDSCH #10, the UE 110 can determine to provide a group-based HARQ-ACK feedback for all downlink transmissions belonging to the HARQ-ACK feedback group having GI=0, and transmit the group-based HARQ-ACK feedback over the TxOP of PUCCH #3. Particularly, there are more than one HARQ-ACK feedback groups having GI=0 (i.e., Groups #0 and #1). In response to receiving the signaling of

GI=0 in the DCI 301, the UE 110 can acknowledge the most recent (or the newest) HARQ-ACK feedback group with GI=0 (i.e., Group #1).

[00105]In addition, in response to receiving the DCI 901 carrying RQ=1, in addition to the HARQ-ACK feedback for Group #1, the UE 110 can determine to provide a group-based HARQ-ACK feedback for another HARQ-ACK feedback group with a GI value different from the GI value (GI=0) of Group #1, such as Group #2 (having the GI=1).

[00106]As can be seen, the DCI 901 scheduling the PDSCH #10 and indicating the TxOP of PUCCH #3 functions as a request for HARQ-ACK feedback for multiple HARQ-ACK feedback groups.

[00107]It is noted that a DCI used as a request for a HARQ-ACK feedback for one or more HARQ-ACK feedback groups is not limited to a DCI that triggers a retransmission of a previously failed HARQ-ACK feedback, such as the DCI 901. For example, the DCIs scheduling the PDSCH #3, #4, and #5 can also be used as a request for a HARQ-ACK feedback of one or more HARQ-ACK feedback groups. For example, assuming a HARQ-ACK feedback of a previously transmitted HARQ-ACK feedback group (Group #q) with GI=1 is failed (this HARQ-ACK feedback takes place prior to slot #m), one or all of the DCIs scheduling the PDSCH #3-#5 can be configured to carry RQ=1. The UE 110 can accordingly transmit a HARQ-ACK feedback for both Group #1 (over the slot #m-#m+2) and Group #q.

[00108]In Fig. 9, as a particular example, the GI values are indicated by a 1-bit field. Two different GI values, 0 or 1, are available for representing two HARQ-ACK feedback groups. Thus, the 1-bit request field (RQ) is sufficient to indicate whether one or two HARQ-ACK feedback groups are provided with HARQ-ACK feedbacks: if RQ=0 (or 1), only the HARQ-ACK feedback group with the indicated GI value in the DCI is provided with the feedback, while if RQ=1 (or 0), both of the two HARQ-ACK feedback groups with GI values of 1 and 0 are provided with the feedbacks.

[00109]More generally compared with the Fig. 9 example, a request for a HARQ-ACK feedback for one or more HARQ-ACK feedback groups can be conveyed by using a request field in a DCI. The request field can explicitly or implicitly indicate zero, one, or more than one HARQ-ACK feedback groups with different GI values in addition to a HARQ-ACK feedback group a GI value of which is carried in the respective DCI. The former can be referred to as second HARQ-ACK feedback groups, while the latter can be referred to as a first HARQ-ACK feedback group in the context of HARQ-ACK feedback of more than one HARQ-ACK feedback groups.

[00110]In an example, the request field for indicating second HARQ-ACK feedback groups can explicitly specify GI values of intended second HARQ-ACK feedback groups. In an example, the request field can specify a number of intended second HARQ-ACK feedback groups. A UE can accordingly transmit the same number of the most recently received second HARQ-ACK feedback groups. In an embodiment, a 1-bit request field is used: when RQ=0 (or 1), no second HARQ-ACK feedback group is acknowledged, while when RQ=1 (or 0), all of the most recently received second HARQ-ACK feedback groups with different GI values are acknowledged.

[00111]For a second HARQ-ACK feedback group indicated by the request field, there can be more than one HARQ-ACK feedback groups having a same GI value as that of the intended second HARQ feedback group. The most recent one of those HARQ-ACK feedback groups can be acknowledged as the intended second HARQ-ACK

feedback group.

[00112] In addition, compared with using a DCI scheduling a PDSCH or indicating a SPS PDSCH release as a request for a HARQ-ACK feedback for multiple HARQ-ACK feedback groups, the request can take other forms. For example, the DCIs 401 and 501 in the Fig. 4 and Fig. 5 can be used to perform the request (e.g., carry a request field to explicitly or implicitly indicate second HARQ-ACK feedback groups) in some other examples.

[00113] Further, similar to the Fig. 6 example, codebooks of a first HARQ-ACK feedback group and one or more second HARQ-ACK feedback groups can be concatenated when transmitted over a HARQ-ACK TxOP. For example, multiple HARQ-ACK codebooks can be concatenated in increasing or decreasing order of respective GI values of the first and second HARQ-ACK feedback groups.

[00114] Fig. 10 shows a process 1000 of providing a HARQ-ACK feedback for one or more HARQ-ACK feedback groups according to an embodiment of the disclosure. The process 1000 can be performed at the UE 110. The BS 120 and the UE 110 are used as an example to explain the process 1000. The process 1000 starts from S1001 and proceeds to S1010.

[00115] At S1010, a first HARQ-ACK feedback group is received. The first HARQ-ACK feedback group can include a set of downlink transmissions each associated with DCIs. The DCIs can include a first DCI requesting a HARQ-ACK feedback for one or more HARQ-ACK feedback groups. For example, the one or more HARQ-ACK feedback groups can include at least the first HARQ-ACK feedback group, and zero, one, or more than one second HARQ-ACK feedback groups. In addition, the first DCI may indicate a HARQ-ACK TxOP for transmitting the requested HARQ-ACK feedback.

[00116] At S1020, in response to receiving the first DCI, the UE 110 can generate HARQ-ACK codebooks for the first and second HARQ-ACK feedback groups, and transmit the HARQ-ACK codebooks as the requested HARQ-ACK feedback over the HARQ-ACK TxOP. For example, the HARQ-ACK codebooks can be concatenated according to a predefined order to form a combined codebook. The process 1000 proceeds to S1099 and terminates at S1099.

[00117] Fig. 11 shows a process 1100 of receiving a HARQ-ACK feedback for one or more HARQ-ACK feedback groups according to an embodiment of the disclosure. The process 1100 can be performed at the BS 120. The BS 120 and the UE 110 are used as an example to explain the process 1100. The process 1100 starts from S1101 and proceeds to S1110.

[00118] At S1110, a first HARQ-ACK feedback group is transmitted. The first HARQ-ACK feedback group can include a set of downlink transmissions each associated with DCIs. The DCIs can include a first DCI requesting a HARQ-ACK feedback for one or more HARQ-ACK feedback groups. For example, the one or more HARQ-ACK feedback groups can include at least the first HARQ-ACK feedback group, and zero, one, or more than one second HARQ-ACK feedback groups. In addition, the first DCI may indicate a HARQ-ACK TxOP for the UE 110 to transmit the requested HARQ-ACK feedback.

[00119] At S1120, the requested feedback for the first and second HARQ-ACK feedback groups can be received over the HARQ-ACK TxOP indicated by the first DCI. For example, in response to receiving the first DCI, the UE 110 can generate HARQ-ACK codebooks for the first and second HARQ-ACK feedback groups, and

transmit the HARQ-ACK codebooks as the requested HARQ-ACK feedback over the HARQ-ACK TxOP. The process 1100 proceeds to S1199 and terminates at S1199.

[00120] Details for informing a UE of a timing and resource of a HARQ-ACK TxOP are described below. As described, a DCI associated with a downlink transmission (e.g., a transmission of a PDSCH or an SPS PDSCH release) can indicate a timing and resource of a HARQ-ACK feedback TxOP corresponding to the downlink transmission. For example, a PUCCH resource can be indicated by a PUCCH resource indicator field in the DCI when a PUCCH is used for the HARQ-ACK TxOP.

[00121] In addition, a slot offset (a number of slots), denoted by k , between the downlink transmission and the HARQ-ACK TxOP can be indicated by a PDSCH-to-HARQ-timing-indicator field (also referred to as a HARQ-ACK feedback delay field) in the DCI. Accordingly, when the UE is scheduled with a PDSCH ending in slot $\#n$ by a DCI, the UE can provide a HARQ-ACK feedback for reception of the PDSCH in a HARQ-ACK TxOP starting at slot $\#n+k$. The PDSCH-to-HARQ-timing-indicator is referred to as a timing indicator below for brevity.

[00122] In an example, a first DCI format, denoted by DCI format 1_0, is used. The timing indicator field in the DCI format 1_0 can have a field size of 3 bits, and thus have 8 code points {000, 001, 010, 011, 100, 101, 110, 111}. Each code point represents a field value of the timing indicator field. Each field value (code point) can be mapped to or associated with a slot offset that is one of {1, 2, 3, 4, 5, 6, 7, 8}. This mapping relationship can be predefined (e.g., standardized, or broadcasted as system information).

[00123] To increase flexibility, in another example, a second DCI format, denoted as DCI format 1_1, is used. In DCI format 1_1, timing indicator field values (code points) are also mapped to different slot offsets. However, the mapping relationship can be dynamically configured, for example, by an RRC signaling parameter, denoted by $dl\text{-}DataToUL\text{-}ACK$.

[00124] Fig. 12 shows an example of mapping timing indicator field values to numbers of slots by RRC signaling. As shown, the timing indicator can have a field size of 1 bit, 2 bits, or 3 bits. Corresponding to different field size, the timing indicator can have different number of field values (code points). Corresponding to a timing indicator field value, a number of slots can be specified. For example, for the 3-bit field size, 8 different slot offsets can be configured.

[00125] Fig. 13 shows an example of how HARQ-ACK feedback timings are determined based on timing indicator field values in DCIs. As shown, a sequence of PDSCHs from PDSCH #1 to PDSCH #6 are transmitted over slots $\#n - \#n+2$ and $\#n+4 - \#n+6$, and two HARQ-ACK TxOPs, PUCCH #1 and PUCCH #2, are provided over slots $\#n+3$ and $\#n+7$.

[00126] PDSCH #1 ends in slot $\#n$, and a slot offset of $k=3$ is indicated by a timing indicator field in a DCI scheduling PDSCH $\#n$. Accordingly, the UE can provide corresponding HARQ-ACK feedback information in the HARQ-ACK TxOP #1 (PUCCH #1) within slot $\#n+3$ when the DCI is detected by the UE. Similarly, PDSCH #2 at slot $\#n+1$ has a timing indicator field in a corresponding DCI indicating a slot offset of $k=2$. Accordingly, the UE can provide corresponding HARQ-ACK feedback information in the HARQ-ACK TxOP #1 (PUCCH #1) within slot $\#n+3$.

[00127] For PDSCHs #3-#6 at slots $\#n+2$, $\#n+4$, $\#n+5$, and $\#n+6$, slot offsets 5, 3, 2, and 1 are provided,

respectively, by corresponding timing indicator fields in DCIs scheduling the PDSCHs #3-#6. Accordingly, the HARQ-ACK TxOP #2 (PUCCH #2) at slot #n+7 is used by the UE to provide corresponding HARQ-ACK feedback information.

[00128]In the above example of Fig. 13, a BS determines a HARQ-ACK TxOP for a PDSCH when scheduling the PDSCH to the UE. However, in some scenarios, the BS cannot determine a HARQ-ACK TxOP for a PDSCH when scheduling the PDSCH to the UE due to, for example, uncertainty of channel access in an unlicensed band. For example, the UE may operate on an unlicensed band based on a listen-before-talk (LBT) protocol, and obtain a channel occupancy time (COT). A PDSCH scheduling may take place near the end of the COT. Considering a minimum time needed by the UE to prepare a HARQ-ACK feedback, a timing of the HARQ-ACK feedback may be after the end of the COT. The BS (e.g., gNB) may have to compete with other devices for another COT based on the listen-before-talk (LBT) protocol. Thus, whether the UE can be successful at obtaining another COT is unknown. To void such an uncertainty, the BS may determine to provide a HARQ-ACK TxOP for the PDSCH in the future after the PDSCH has been scheduled.

[00129]Under the above scenario, a mechanism can be introduced to tell the UE that the HARQ-ACK feedback for the corresponding PDSCH is postponed, the UE needs to store the corresponding HARQ-ACK information, and a timing and resource for corresponding HARQ-ACK feedback will be provided at a later time.

[00130]In an embodiment, a DCI associated with a downlink transmission to a UE can indicate the UE that the downlink transmission is associated with a pending HARQ-ACK TxOP. For example, a particular field value (a code point) of a timing indicator in the DCI can be used to convey the indication.

[00131]In a first example, a field value (a code point) of a timing indicator in a DCI can be predefined to convey the indication. For example, the DCI format 1_0 can be employed, and one of the 8 code points (e.g., 001, or 111) can be designated to represent a pending HARQ-ACK TxOP. For example, this designation can be specified in a standard, or can be provided to the UE in a form of system information.

[00132]In a second example, a field value (a code point) of a timing indicator in a DCI can be configured by a higher layer (e.g., RRC signaling) to indicate the pending HARQ-ACK TxOP. For example, the DCI format 1_1 can be employed, and one of the code points corresponding to a 1-bit, 2-bit or 3-bit field size can be configured to represent a pending HARQ-ACK TxOP.

[00133]Fig. 14 shows an example of a timing indicator field value configuration 1400. The configuration 1400 can be conveyed with an RRC signaling parameter (e.g., dl-DataToUL-ACK). As shown, a timing indicator has a 3-bit field size, and accordingly has 8 field values (code points) from 000 to 111. In the configuration 1400, the timing indicator field value 111 is configured to represent a pending HARQ-ACK TxOP (meaning a HARQ-ACK feedback for a corresponding downlink transmission is postponed). In an example, a particular value, such as 99, can be used to denote the pending HARQ-ACK TxOP, and configured to the timing indicator field value 111. The other timing indicator field values from 000 to 110 are configured to represent a slot offset of 2, 4, 5, 6, 8, 10, or 12 slots, respectively.

[00134]It is noted that, in other examples, a timing indicator may have a field size larger than 3 bits. In addition, corresponding to a particular timing indicator field size, any particular timing indicator field value can be

used to indicate a pending HARQ-ACK TxOP.

[00135] In an example, a DCI without carrying a timing indicator is used to convey to a UE that a HARQ-ACK feedback for a corresponding downlink transmission is postponed. The UE may decode such a DCI to determine an absence of the DCI, and accordingly wait for an available HARQ-ACK TxOP.

5 [00136] When a UE receives a DCI carrying a timing indicator field value associated with a pending HARQ-ACK TxOP, the UE can determine that a HARQ-ACK feedback for a downlink transmission associated with the DCI is postponed until a timing and resource for the HARQ-ACK feedback is provided later from a network side. Accordingly, the UE may generate HARQ-ACK information corresponding to the respective downlink transmission, and transmit the HARQ-ACK information to the network side when a HARQ-ACK TxOP is
10 available in a later time.

[00137] Various methods can be employed to provide a HARQ-ACK TxOP for transmission of postponed HARQ-ACK information. In an example, a UE with postponed HARQ-ACK information may automatically transmit the HARQ-ACK information once a HARQ-ACK TxOP is available. In another example, a PDSCH with postponed HARQ-ACK information can be grouped into a HARQ-ACK feedback group and associated with a GI.
15 The group-based HARQ-ACK feedback mechanism described herein can thus be used by a BS to trigger a UE to transmit the postponed HARQ-ACK information. When generating the HARQ-ACK information, the UE may generate a codebook including HARQ-ACK bits of multiple downlink transmissions of which HARQ-ACK information has been postponed. Those multiple downlink transmissions can belong to a same or different HARQ-ACK feedback groups in various examples.

20 [00138] Fig. 15 shows another example of a timing indicator field value configuration 1500. For example, the configuration 1500 can be provided from a BS to a UE by RRC signaling. As shown, there are 16 timing indicator field values from 0 to 15. The timing indicator field value 14 is configured to represent a first pending HARQ-ACK TxOP, while the timing indicator field value 15 is configured to represent a second pending HARQ-ACK TxOP. In this way, downlink transmissions with postponed HARQ-ACK information can be organized into
25 different groups by assigning different timing indicator field values in DCIs associated with the downlink transmissions. When one or more HARQ-ACK TxOPs are available in the future, the HARQ-ACK information of those different groups can be transmitted with a same HARQ-ACK TxOP or different HARQ-ACK TxOPs. In an example, the UE may determine one or more codebooks for the downlink transmissions associated with the same pending HARQ-ACK TxOP.

30 [00139] Fig. 16 shows a HARQ-ACK feedback process 1600 according to an embodiment of the disclosure. During the process 1600, a DCI associated with a downlink transmission (e.g., a transmission of a PDSCH or a SPS PDSCH release) indicates a postponed HARQ-ACK TxOP for acknowledging a reception of the downlink transmission. Therefore, a HARQ-ACK feedback for the downlink transmission is pending. The BS 120 and the UE 110 are used as an example to explain the process 1600. The process 1600 can start from S1610.

35 [00140] At S1610, a timing indicator field value configuration is transmitted from the BS 120 to the UE 110. For example, the timing indicator field value configuration can be provided by a higher layer (with respect to a physical layer), for example, in a protocol stack of a NR air interface by RRC signaling. In the timing indicator

field value configuration, a particular timing indication field value can be designated to indicate a pending HARQ-ACK TxOP (meaning a HARQ-ACK feedback for a corresponding downlink transmission is postponed). Other timing indication field value(s) can each be configured with a corresponding slot offset.

[00141]At S1620, a DCI indicating a postponed HARQ-ACK feedback for a downlink transmission associated with the DCI can be transmitted from the BS 120 to the UE 110. For example, the DCI and the associated downlink transmission may take place at a point near the end of a COT, and thus whether and when the BS 120 can obtain another COT is uncertain. Therefore, the BS 120 may determine to include the indication field value that represents a pending HARQ-ACK TxOP into the DCI. By receiving the indication field value, the UE 110 can interpret the indication field value as that the HARQ-ACK feedback for the downlink transmission is postponed until a timing and resource for the HARQ-ACK feedback is provided in a later time. In response, the UE 110 may generate HARQ-ACK feedback information, such as one or more ACK/NACK bits, for reception of the downlink transmission.

[00142]At S1630, a timing and resource for a HARQ-ACK TxOP (e.g., a PUCCH) is received. For example, a group-based HARQ-ACK feedback request may be received from the BS 120. The request may indicate the HARQ-ACK feedback for the downlink transmission at S1620 can be transmitted over the HARQ-ACK TxOP.

[00143]At S1640, the HARQ-ACK feedback generated at S1620 can be transmitted over the HARQ-ACK TxOP from the UE 110 to the BS 120 in response to receiving the timing and resource of the HARQ-ACK TxOP. While one downlink transmission at S1620 is shown in Fig. 16, there can be multiple downlink transmissions of which HARQ-ACK feedbacks are postponed. Accordingly, HARQ-ACK feedback information of the multiple downlink transmissions may be organized into one or more HARQ-ACK codebooks. All or a part of the one or more HARQ-ACK codebooks can be transmitted over the HARQ-ACK TxOP at S1640. The process 1600 can terminate thereafter.

[00144]Fig. 17 shows an exemplary apparatus 1700 according to embodiments of the disclosure. The apparatus 1700 can be configured to perform various functions in accordance with one or more embodiments or examples described herein. Thus, the apparatus 1700 can provide means for implementation of mechanisms, techniques, processes, functions, components, systems described herein. For example, the apparatus 1700 can be used to implement functions of the UE 110 or the BS 120 in various embodiments and examples described herein. The apparatus 1700 can include a general purpose processor or specially designed circuits to implement various functions, components, or processes described herein in various embodiments. The apparatus 1700 can include processing circuitry 1710, a memory 1720, and a radio frequency (RF) module 1730.

[00145]In various examples, the processing circuitry 1710 can include circuitry configured to perform the functions and processes described herein in combination with software or without software. In various examples, the processing circuitry 1710 can be a digital signal processor (DSP), an application specific integrated circuit (ASIC), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), digitally enhanced circuits, or comparable device or a combination thereof.

[00146]In some other examples, the processing circuitry 1710 can be a central processing unit (CPU) configured to execute program instructions to perform various functions and processes described herein.

Accordingly, the memory 1720 can be configured to store program instructions. The processing circuitry 1710, when executing the program instructions, can perform the functions and processes. The memory 1720 can further store other programs or data, such as operating systems, application programs, and the like. The memory 1720 can include non-transitory storage media, such as a read only memory (ROM), a random access memory (RAM), a flash memory, a solid state memory, a hard disk drive, an optical disk drive, and the like.

[00147]In an embodiment, the RF module 1730 receives a processed data signal from the processing circuitry 1710 and converts the data signal to beamforming wireless signals that are then transmitted via antenna arrays 1740, or vice versa. The RF module 1730 can include a digital to analog convertor (DAC), an analog to digital converter (ADC), a frequency up convertor, a frequency down converter, filters and amplifiers for reception and transmission operations. The RF module 1730 can include multi-antenna circuitry for beamforming operations. For example, the multi-antenna circuitry can include an uplink spatial filter circuit, and a downlink spatial filter circuit for shifting analog signal phases or scaling analog signal amplitudes. The antenna arrays 1740 can include one or more antenna arrays.

[00148]The apparatus 1700 can optionally include other components, such as input and output devices, additional or signal processing circuitry, and the like. Accordingly, the apparatus 1700 may be capable of performing other additional functions, such as executing application programs, and processing alternative communication protocols.

[00149]The processes and functions described herein can be implemented as a computer program which, when executed by one or more processors, can cause the one or more processors to perform the respective processes and functions. The computer program may be stored or distributed on a suitable medium, such as an optical storage medium or a solid-state medium supplied together with, or as part of, other hardware. The computer program may also be distributed in other forms, such as via the Internet or other wired or wireless telecommunication systems. For example, the computer program can be obtained and loaded into an apparatus, including obtaining the computer program through physical medium or distributed system, including, for example, from a server connected to the Internet.

[00150]The computer program may be accessible from a computer-readable medium providing program instructions for use by or in connection with a computer or any instruction execution system. The computer readable medium may include any apparatus that stores, communicates, propagates, or transports the computer program for use by or in connection with an instruction execution system, apparatus, or device. The computer-readable medium can be magnetic, optical, electronic, electromagnetic, infrared, or semiconductor system (or apparatus or device) or a propagation medium. The computer-readable medium may include a computer-readable non-transitory storage medium such as a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), a magnetic disk and an optical disk, and the like. The computer-readable non-transitory storage medium can include all types of computer readable medium, including magnetic storage medium, optical storage medium, flash medium, and solid state storage medium.

[00151]While aspects of the present disclosure have been described in conjunction with the specific

embodiments thereof that are proposed as examples, alternatives, modifications, and variations to the examples may be made. Accordingly, embodiments as set forth herein are intended to be illustrative and not limiting. There are changes that may be made without departing from the scope of the claims set forth below.

CLAIMS

1. A method, comprising:

receiving a downlink control information (DCI) associated with a downlink transmission at a user equipment (UE) from a base station (BS) in a wireless communication system, the DCI including a hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback timing indicator field having a field value indicating that a HARQ-ACK feedback of the downlink transmission is postponed; and

when a timing and resource for the HARQ-ACK feedback of the downlink transmission is received later, transmitting from the UE to the BS the HARQ-ACK feedback of the downlink transmission over a HARQ-ACK transmission opportunity (TxOP) with the timing and resource later received.

2. The method of claim 1, wherein that the HARQ-ACK feedback of the downlink transmission is postponed includes:

the timing and resource for the HARQ-ACK feedback of the downlink transmission is to be provided later or not provided.

3. The method of claim 1, further comprising:

receiving a configuration specifying that the field value indicates that the HARQ-ACK feedback of the downlink transmission is postponed.

4. The method of claim 1, further comprising:

receiving a configuration that associates the field value with a value indicating that the HARQ-ACK feedback of the downlink transmission is postponed.

5. The method of claim 1, wherein the field value is predefined to indicate that the HARQ-ACK feedback of the downlink transmission is postponed.

6. The method of claim 1, further comprising:

generating HARQ-ACK information for the HARQ-ACK feedback of the downlink transmission.

7. The method of claim 6, further comprising:

storing the HARQ-ACK information until the timing and resource for the HARQ-ACK feedback of the downlink transmission is received later.

8. A method, comprising:

transmitting a downlink control information (DCI) associated with a downlink transmission to a user equipment (UE) from a base station (BS) in a wireless communication system, the DCI including a hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback timing indicator field having a field value indicating that a HARQ-ACK feedback of the downlink transmission is postponed; and

receiving from the UE the HARQ feedback of the downlink transmission over a HARQ-ACK transmission opportunity (TxOP) with a timing and resource later provided.

9. The method of claim 8, wherein that the HARQ-ACK feedback of the downlink transmission is postponed includes:

the timing and resource for the HARQ-ACK feedback of the downlink transmission is to be provided later or not provided.

10. The method of claim 8, further comprising:

transmitting a configuration specifying that the field value indicates that the HARQ-ACK feedback of the downlink transmission is postponed.

11. The method of claim 8, further comprising:

5 transmitting a configuration that associates the field value with a value indicating that the HARQ-ACK feedback of the downlink transmission is postponed.

12. The method of claim 8, wherein the field value is predefined to indicate that the HARQ-ACK feedback of the downlink transmission is postponed.

13. The method of claim 8, further comprising:

10 transmitting information of the timing and resource for the HARQ-ACK feedback of the downlink transmission.

14. A user equipment (UE), comprising circuitry configured to:

receive a downlink control information (DCI) associated with a downlink transmission from a base station (BS) in a wireless communication system, the DCI including a hybrid automatic repeat request acknowledgement (HARQ-ACK) feedback timing indicator field having a field value indicating that a HARQ-ACK feedback of the downlink transmission is postponed; and

when a timing and resource for the HARQ-ACK feedback of the downlink transmission is received later, transmit to the BS the HARQ-ACK feedback of the downlink transmission over a HARQ-ACK transmission opportunity (TxOP) with the timing and resource later received.

20 15. The UE of claim 14, wherein that the HARQ-ACK feedback of the downlink transmission is postponed includes:

the timing and resource for the HARQ-ACK feedback of the downlink transmission is to be provided later or not provided.

25

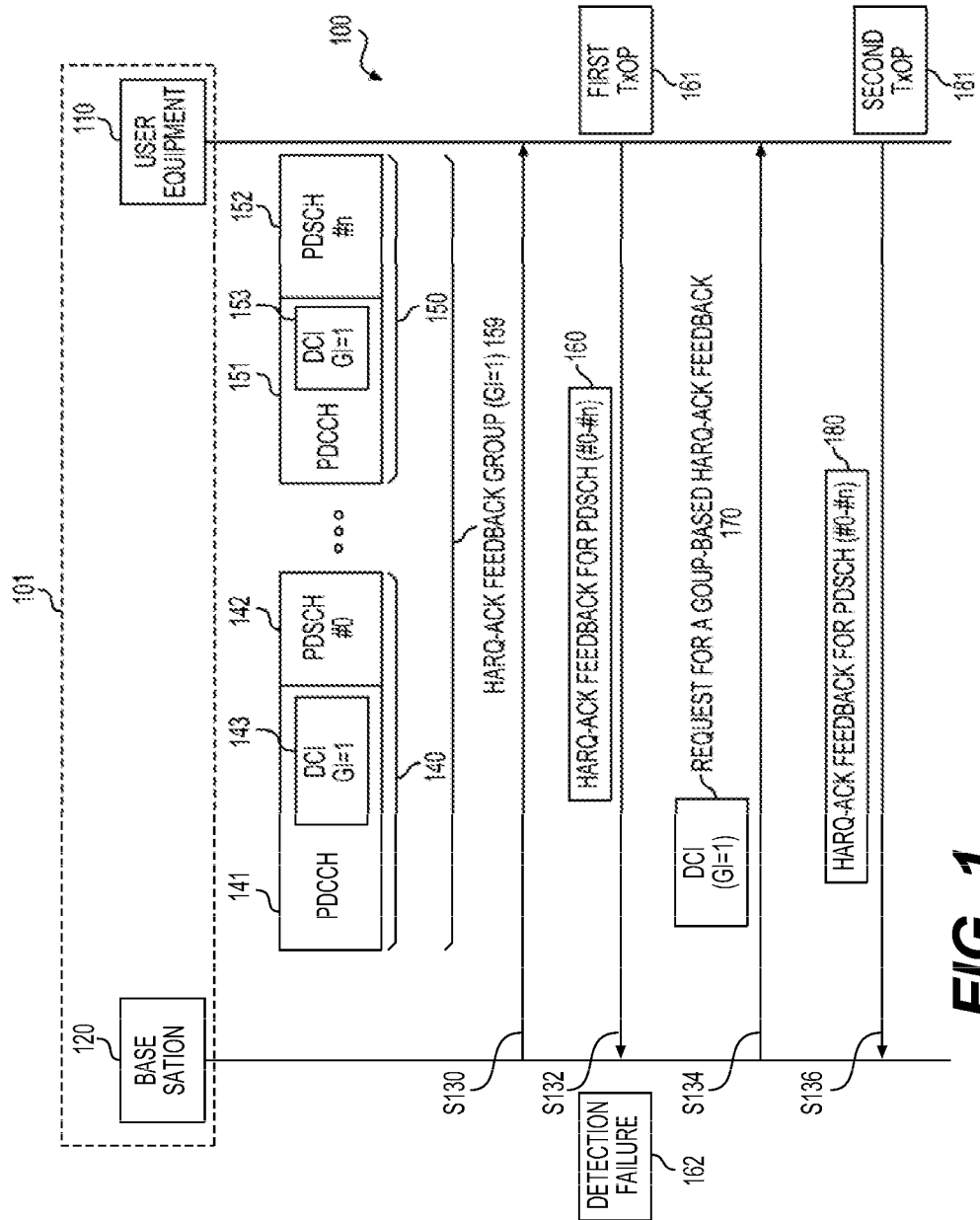


FIG. 1

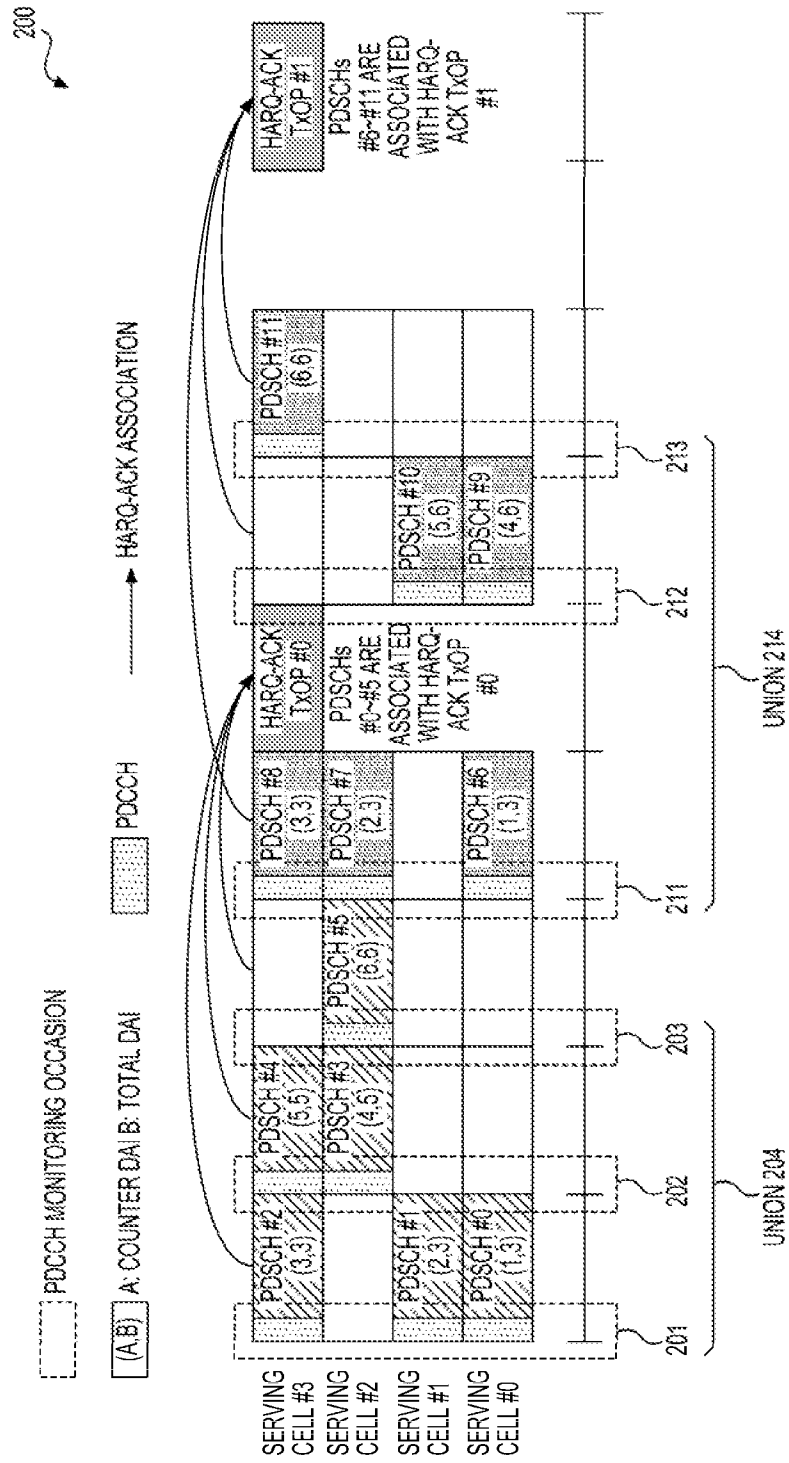
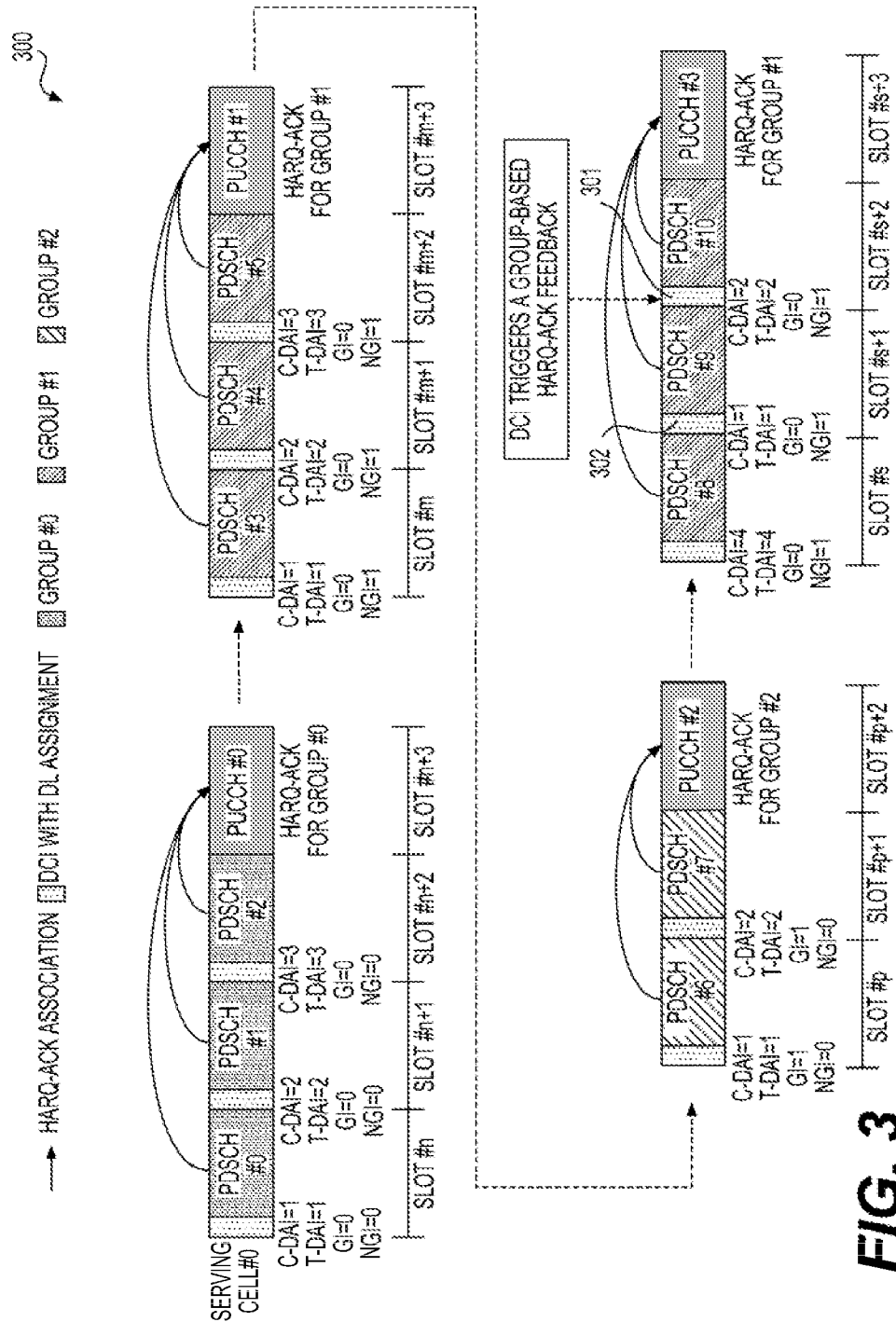


FIG. 2



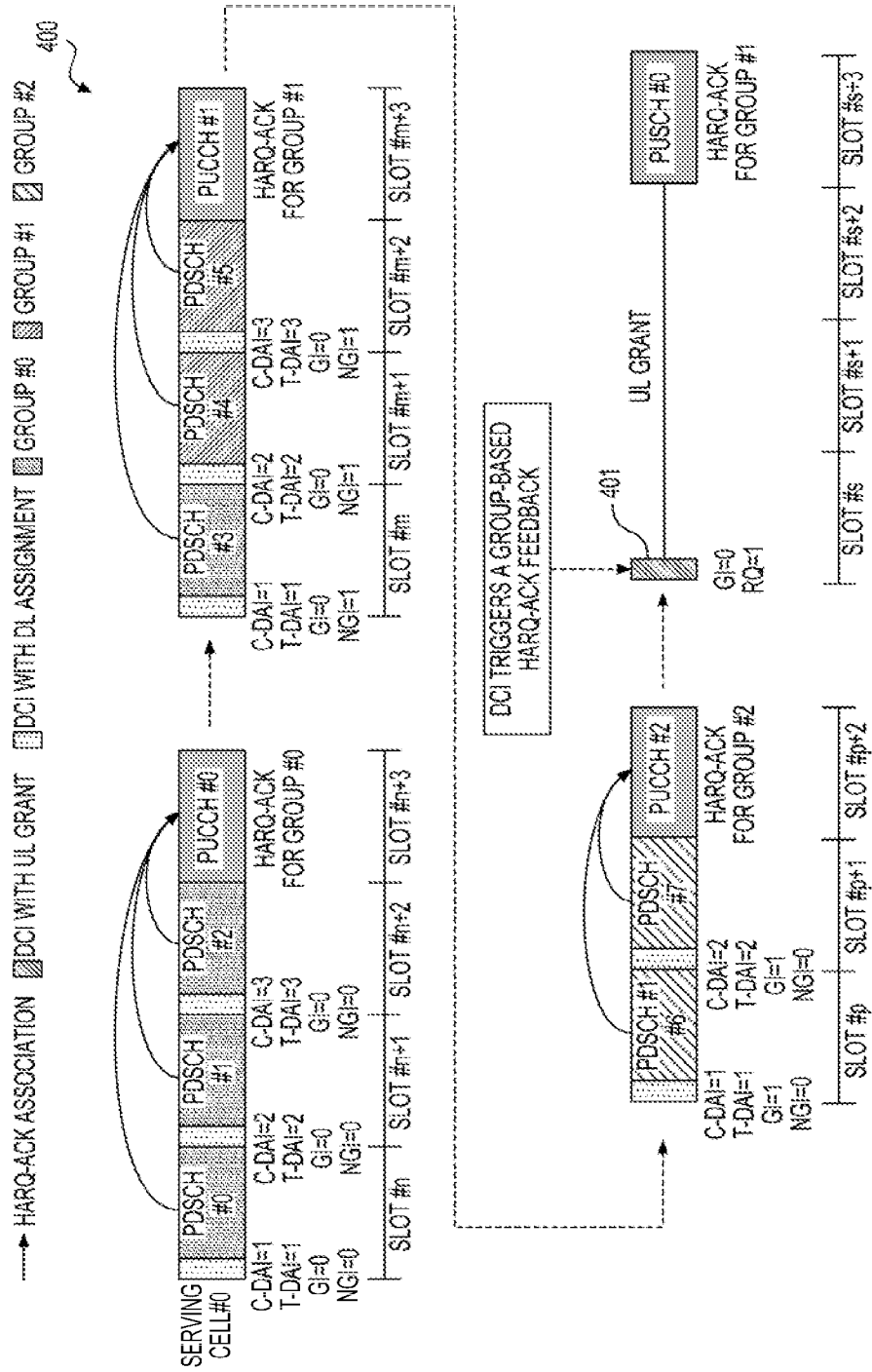


FIG. 4

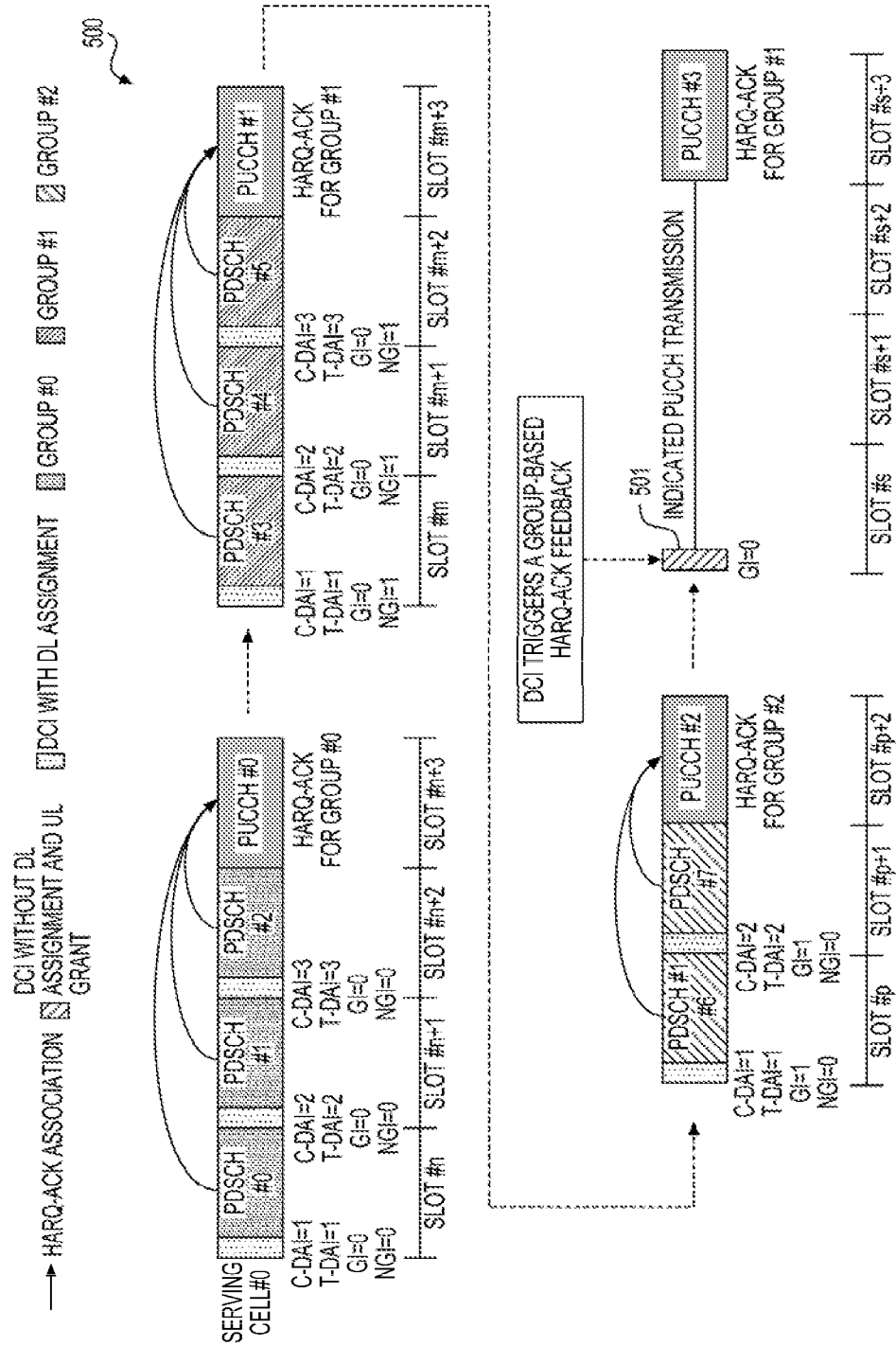


FIG. 5

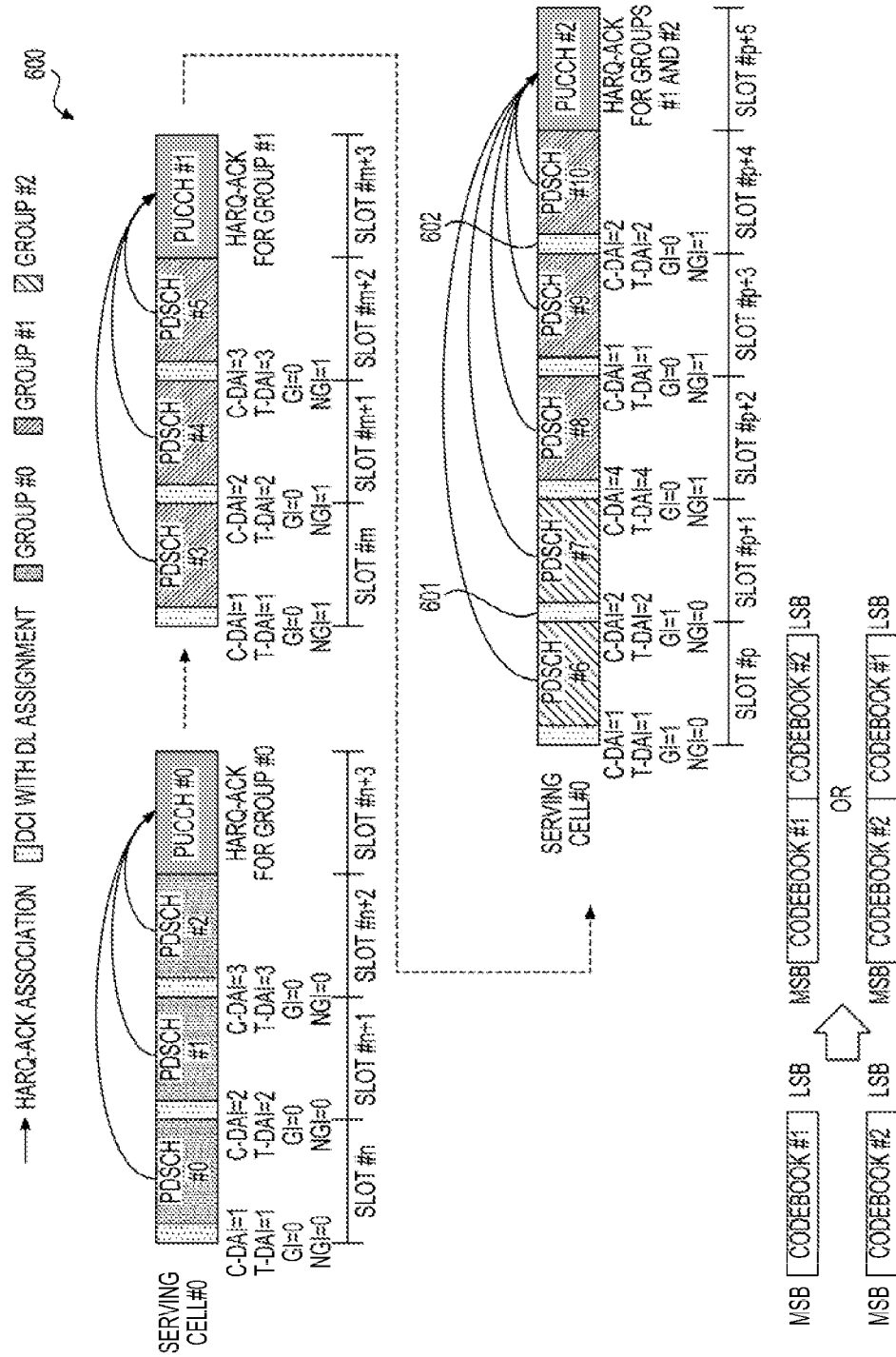
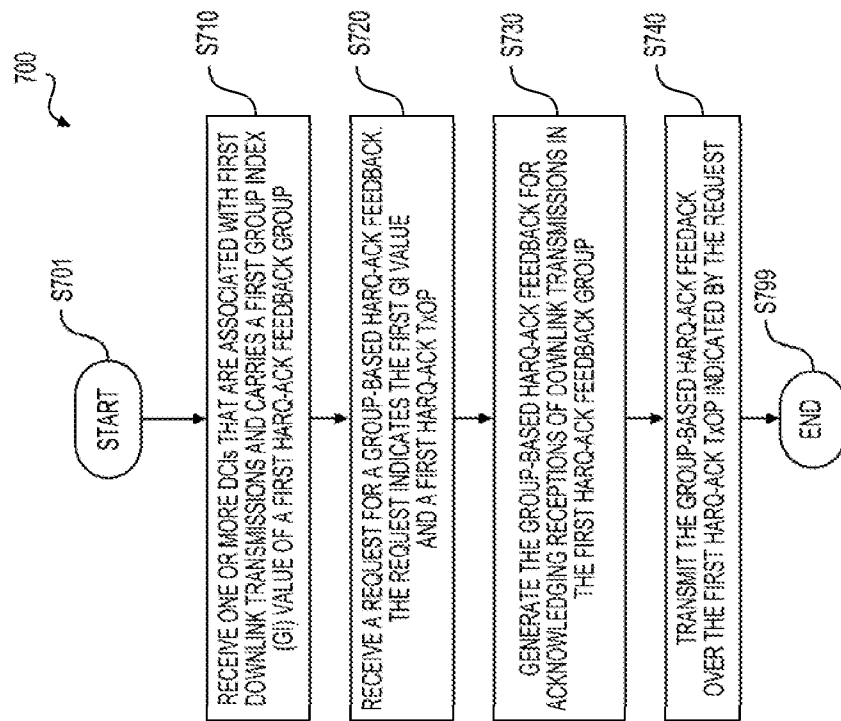
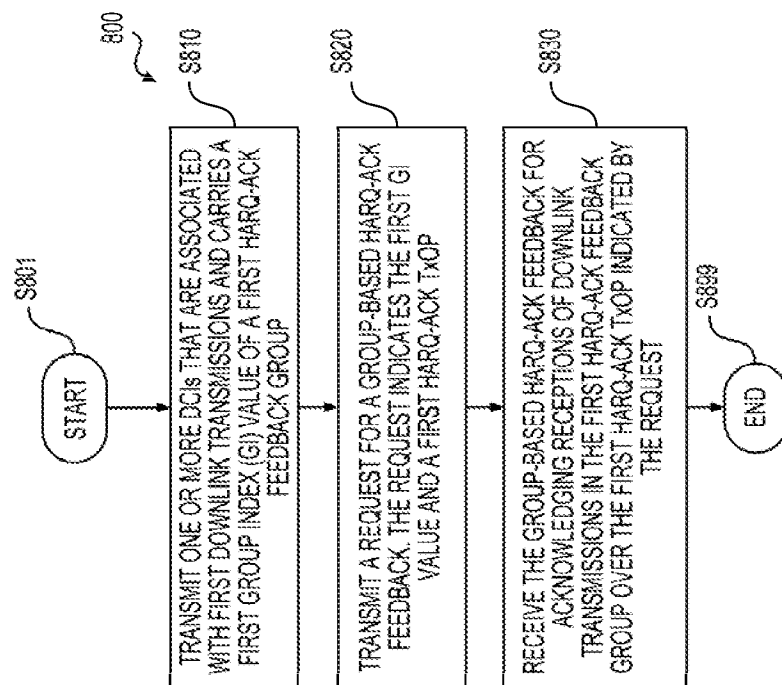


FIG. 6

**FIG. 7**

**FIG. 8**

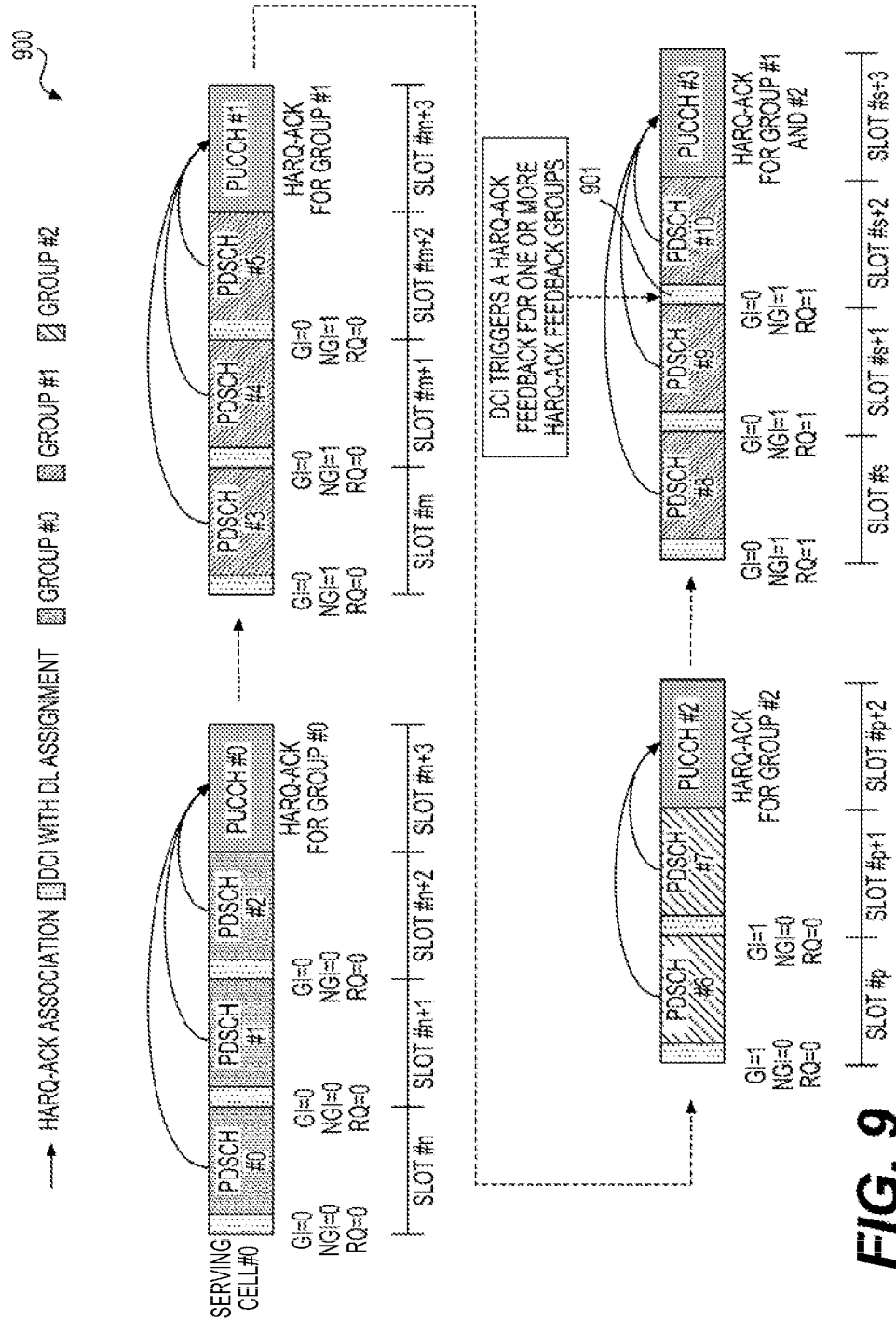
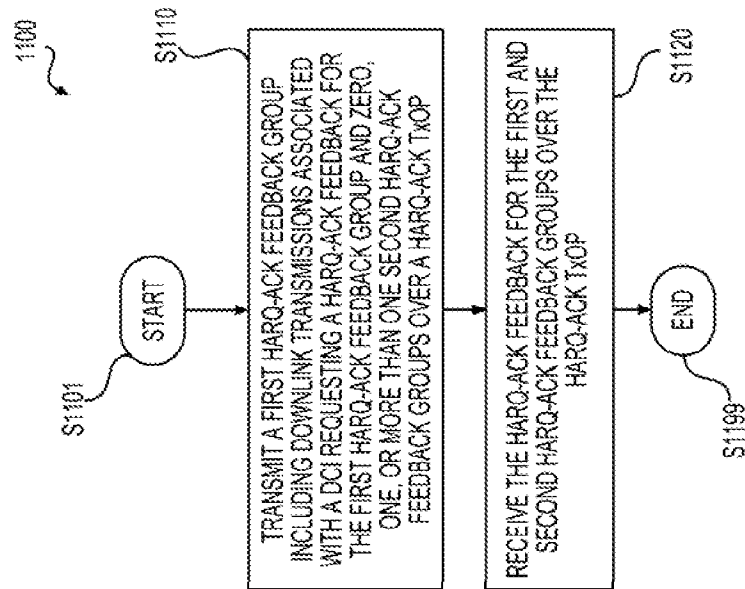
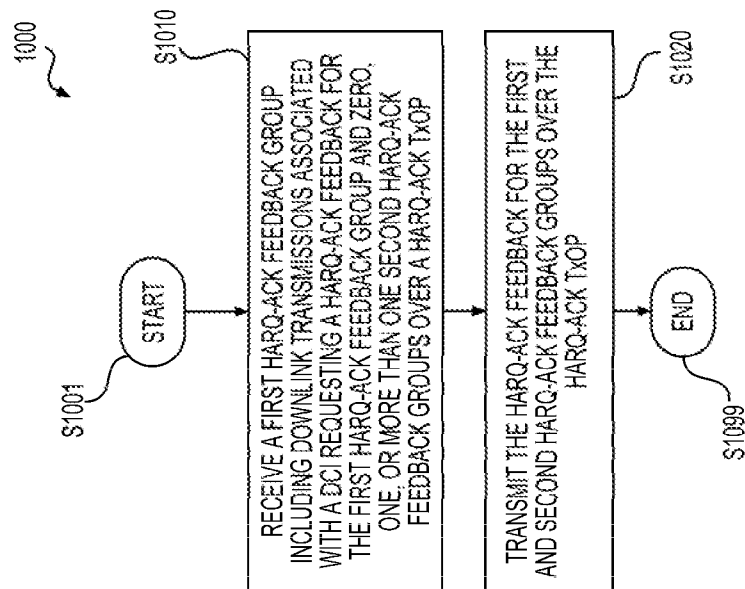


FIG. 9

**FIG. 11****FIG. 10**

PDSCH-to-HARQ-timing-indicator			Number of slots
1 bit	2 bits	3 bits	
'0'	'00'	'000'	1 st value provided by dl-DataToUL-ACK
'1'	'01'	'001'	2 nd value provided by dl-DataToUL-ACK
	'10'	'010'	3 rd value provided by dl-DataToUL-ACK
	'11'	'011'	4 th value provided by dl-DataToUL-ACK
		'100'	5 th value provided by dl-DataToUL-ACK
		'101'	6 th value provided by dl-DataToUL-ACK
		'110'	7 th value provided by dl-DataToUL-ACK
		'111'	8 th value provided by dl-DataToUL-ACK

FIG. 12

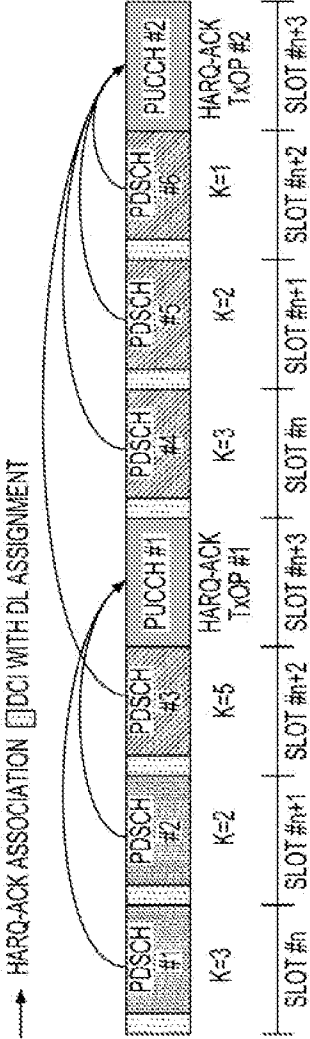


FIG. 13

1400

PDSCH-to-HARQ-timing-indicator	Number of slots
'000'	2 provided by dl-DataToUL-ACK
'001'	4 provided by dl-DataToUL-ACK
'010'	5 provided by dl-DataToUL-ACK
'011'	6 provided by dl-DataToUL-ACK
'100'	8 provided by dl-DataToUL-ACK
'101'	10 provided by dl-DataToUL-ACK
'110'	12 provided by dl-DataToUL-ACK
'111'	"Pending HARQ-ACK TxOP" provided by dl-DataToUL-ACK

FIG. 14

1500

PDSCH-to-HARQ-timing-indicator	Indication
0	Slot Offset = 1
...	...
14	Pending HARQ-ACK TxOP1
15	Pending HARQ-ACK TxOP2

FIG. 15

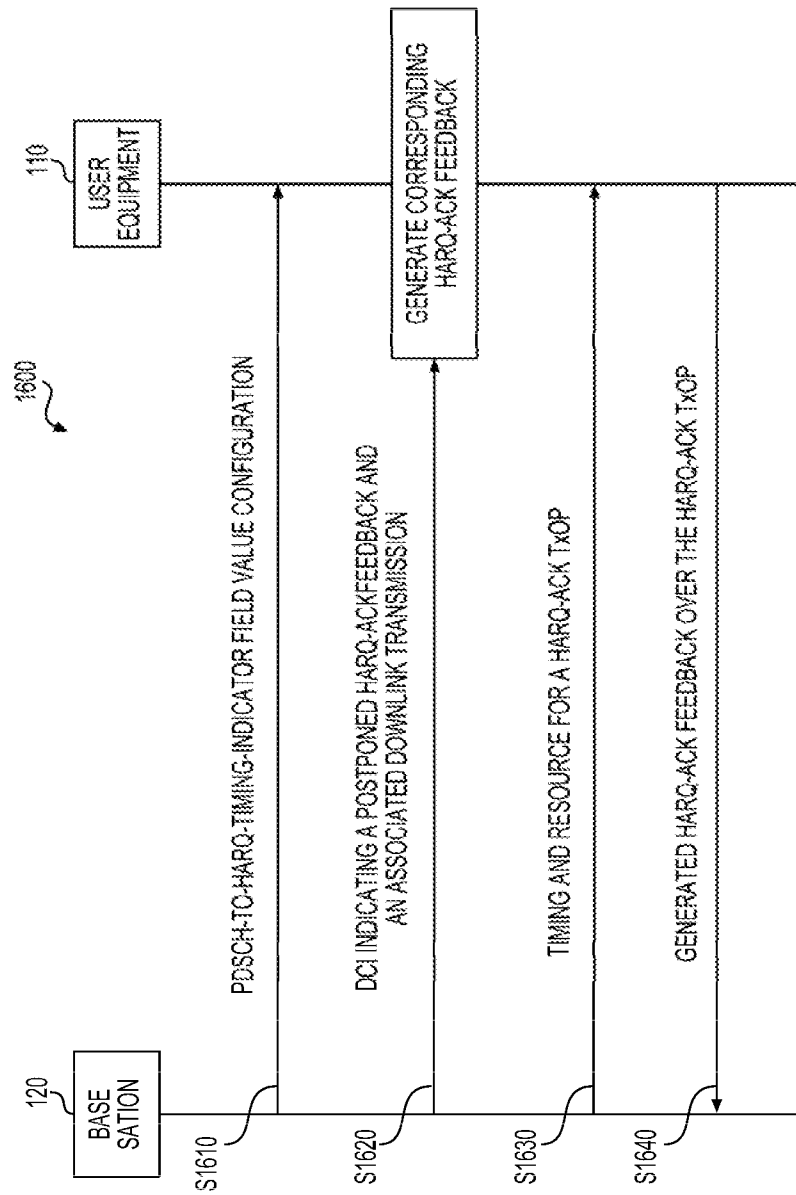


FIG. 16

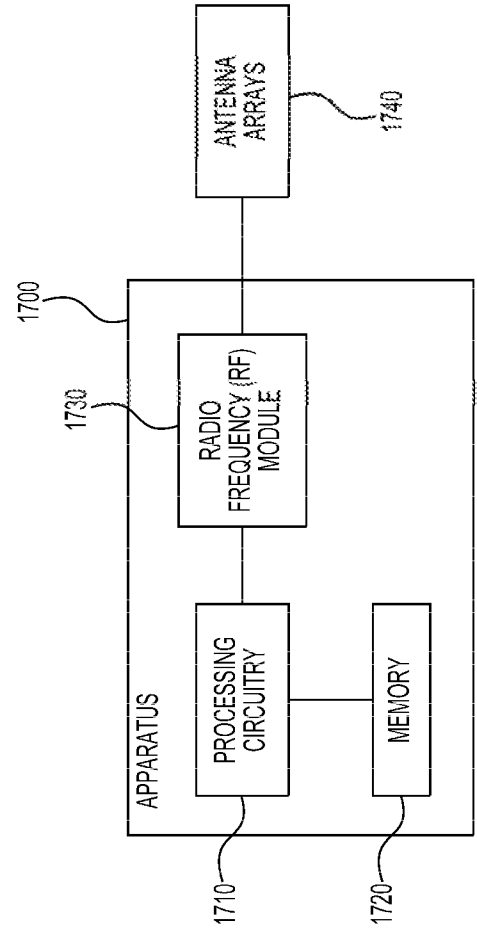


FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2019/107740

A. CLASSIFICATION OF SUBJECT MATTER

H04L 1/18(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L

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

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

CNABS,CNKI,VEN,3GPP:HARQ, DCI, feedback, postponed, delay, timing,transmission opportunity

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Ericsson. "On HARQ Feedback Timing, R1-1714439" 3GPP TSG-RAN WG1 Meeting #90, 25 August 2017 (2017-08-25), section 2	1-15
X	CN 107332646 A (ZTE CORP) 07 November 2017 (2017-11-07) paragraphs 0054-0064	1-15
A	WO 2018085790 A1 (MOTOROLA MOBILITY LLC) 11 May 2018 (2018-05-11) the whole document	1-15



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

10 December 2019

Date of mailing of the international search report

06 January 2020

Name and mailing address of the ISA/CN

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Facsimile No. (86-10)62019451

Telephone No. 86-(010)-62089572

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2019/107740

Patent document cited in search report				Publication date (day/month/year)			Patent family member(s)				Publication date (day/month/year)		
CN	107332646	A		07 November 2017	WO	2017186174	A1				02 November 2017		
					US	2019159251	A1				23 May 2019		
WO	2018085790	A1		11 May 2018	US	2018132264	A1				10 May 2018		
					CN	109906576	A				18 June 2019		
					EP	3504822	A1				03 July 2019		