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(54) Title: METHOD, APPARATUS AND SYSTEM FOR TRANSMISSION ACKNOWLEDGEMENT CONTROL IN A WIRELESS NETWORK

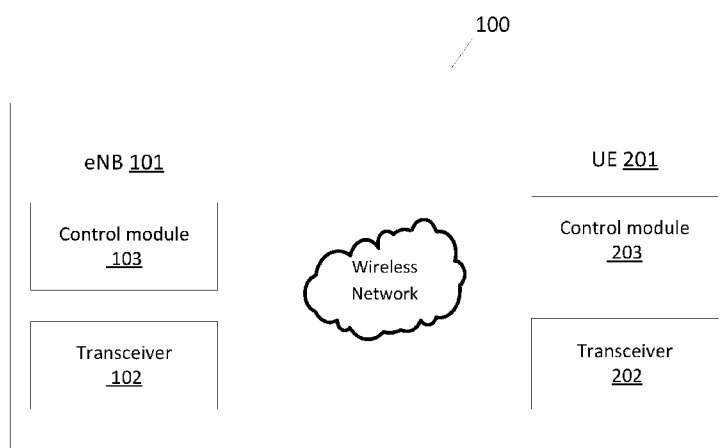


Fig.1

(57) Abstract: Described herein are base stations that may comprise a control module to segment a TB into one or more STBs, at least in part based on an ACK/NACK parameter, wherein a STB of the STBs may comprise one or more code blocks of the TB, and, to attach one or more first-level CRC bits to each of the STBs, and a transceiver to transmit the TB with the first-level CRC bits to a UE. Base stations may also comprise a transceiver to transmit a plurality of first code blocks and a first indicator to a UE, wherein the first indicator is further to indicate whether the first code blocks are new transmission blocks or not, and receive, from the UE, one or more ACK/NACK bits, and a control module to generate a second indicator to indicate whether the ACK/NACK bits have been correctly received by the base station or not.



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METHOD, APPARATUS AND SYSTEM FOR TRANSMISSION ACKNOWLEDGEMENT CONTROL IN A WIRELESS NETWORK

Field

5 Embodiments of the present application relate generally to the field of communications, and more particularly, to transmission acknowledgement control in a wireless network.

Background Information

10 In a wireless network, e.g., a 5th generation wireless network, in order to support a wider system bandwidth, a high multiple-input, multiple-output (MIMO) order and/or a high modulation order (e.g., orthogonal frequency division multiplexing (OFDM) order), a transport block may have a large size, and/or a transport block may be divided into multiple sub-transport blocks, which may bring a challenge for transmission
15 acknowledgement control.

Brief Description of the Drawings

 Embodiments of the present application are illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings in which like reference
20 numerals refer to similar elements.

Figure 1 schematically illustrates a wireless system for transmission acknowledgement control, in accordance with various embodiments.

Figure 2 schematically illustrates an example of a transport block with the transmission acknowledgement control, in accordance with various embodiments.

25 **Figure 3** schematically illustrates a method of attaching cyclical redundancy check (CRC) bits to the transport block and transmitting by a transmitter (e.g., an evolved Node B) in the wireless system, in accordance with various embodiments.

Figure 4 schematically illustrates a method of generating and transmitting acknowledgement/negative acknowledgement (ACK/NACK) bits by a receiver (a user
30 equipment) in the wireless system, in accordance with various embodiments.

Figure 5 schematically illustrates an example of transmission and retransmission combination in the wireless system, in accordance with various embodiments.

Figure 6 schematically illustrates an example of transmission and retransmission under the transmission acknowledgement control in the wireless system, in accordance with various embodiments.

5 **Figure 7** schematically illustrates a method of transmission and retransmission under the transmission acknowledgement control, to be employed by the receiver in the wireless system, in accordance with various embodiments.

Figure 8 schematically illustrates a method of transmission and retransmission under the transmission acknowledgement control, to be employed by the transmitter in the wireless system, in accordance with various embodiments.

10 **Figure 9** schematically illustrates an example system in accordance with various embodiments.

Figure 10 schematically illustrates an example of the UE device, in accordance with various embodiments.

15 **Description of the Embodiments**

Illustrative embodiments of the present disclosure include, but are not limited to, methods, systems, and apparatuses for transmission acknowledgement control in a wireless network, e.g., a 5th generation wireless network.

Various aspects of the illustrative embodiments will be described using terms
20 commonly employed by those skilled in the art to convey the substance of their work to others skilled in the art. However, it will be apparent to those skilled in the art that some alternate embodiments may be practiced using with portions of the described aspects. For purposes of explanation, specific numbers, materials, and configurations are set forth in order to provide a thorough understanding of the illustrative embodiments. However, it
25 will be apparent to one skilled in the art that alternate embodiments may be practiced without the specific details. In other instances, well-known features are omitted or simplified in order to not obscure the illustrative embodiments.

Further, various operations will be described as multiple discrete operations, in turn, in a manner that is most helpful in understanding the illustrative embodiments;
30 however, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations need not be performed in the order of presentation.

The phrase “in one embodiment” is used repeatedly. The phrase generally does not refer to the same embodiment; however, it may. The terms “comprising,” “having,” and “including” are synonymous, unless the context dictates otherwise. The phrase “A/B” means “A or B”. The phrase “A and/or B” means “(A), (B), or (A and B)”. The phrase
5 “at least one of A, B and C” means “(A), (B), (C), (A and B), (A and C), (B and C) or (A, B and C)”. The phrase “(A) B” means “(B) or (A B)”, that is, A is optional.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a wide variety of alternate and/or equivalent implementations may be substituted for the specific embodiments shown and
10 described, without departing from the scope of the embodiments of the present disclosure. This application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that the embodiments of the present disclosure be limited only by the claims and the equivalents thereof.

As used herein, the term “module” may refer to, be part of, or include an
15 Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group) and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable components that provide the described functionality.

Figure 1 schematically illustrates a wireless system for transmission
20 acknowledgement control, in accordance with various embodiments. As illustrated in Figure 1, the wireless system 100 may comprise an evolved Node B (eNB) 101, a user equipment (UE) 201 and/or others, wherein the eNB 101 and the UE 201 may communicate through a wireless system 100, e.g., a 5th generation wireless network. In some embodiments, the eNB 101 may comprise a transceiver 102 to transmit/receive
25 information to/from the UE 201 and a control module 103 to control the transmission acknowledgement at least in part with respect to the information transmissions between the eNB 101 and the UE 201. The UE 201 may comprise a transceiver 202 to receive/transmit information from/to the eNB 101, and a control module 203 to control the transmission acknowledgement at least in part with respect to the information
30 transmissions between the UE 201 and the eNB 101.

In some embodiments, the information may comprise a subframe having at least one transport block (TB), one or more cyclical redundancy check (CRC) bits and/or others. In other embodiments, the information may comprise one or more acknowledgement/negative acknowledgement (ACK/NACK) bits indicating whether the

TB has been successfully/unsuccessfully received, in which ACK may be associated with the acknowledgement of successful reception and NACK may be associated with the negative acknowledgement to the successful reception, namely, unsuccessful reception.

In some embodiments, the TB may comprise a plurality of sub-transport blocks (STBs) with each of them comprising one or more code blocks (CB). The CRC bits may comprise one or more STB-level CRC bits associated with each of the STBs which may be used by a receiver ((e.g., UE 201 for downlink transmission or eNB 101 for uplink transmission) to detect if the STB is successfully received, and one or more CB-level CRC bits associated with each of the code blocks within the each STB which may be used by the receiver to detect if the code block is successfully received. The TB and the CRC attachments may be encoded and concatenated before being transmitted to the receiver.

In some embodiments, the ACK/NACK bits may comprise one or more STB-level ACK/NACK bits with each of the STB-level ACK/NACK bits associated with each of the STBs, and one or more CB-level ACK/NACK bits with each of the CB-level ACK/NACK bits associated with each of the code blocks within the each STB. More specifically, the STB-level ACK/NACK bit may indicate a successful/unsuccessful reception of the associated STB, and the CB-level ACK/NACK bit may indicate a successful/unsuccessful reception of the associated code block. The number of the code blocks that the each STB may comprise may be determined by an ACK/NACK parameter. For example, the ACK/NACK parameter may indicate the number of the STB-level ACK/NACK bits for the STB successful/unsuccessful reception feedback (e.g., parameter N_{ACK}). For another example, the ACK/NACK parameter may indicate the number of the code blocks that one STB-level ACK/NACK bit may bundle across the TB (e.g., parameter $N_{bund.CB}$).

With the STB-level ACK/NACK bits associated with the STB comprising multiple code blocks, a transmitter (e.g., eNB 101 for uplink transmission, or UE 201 for downlink transmission) may save the time for error detection of each code block within the STB having an ACK bit. In addition, the transmitter may retransmit the STB if receiving an associated NACK bit, rather than retransmit the whole TB, which may help to save the retransmission overhead. With the CB-level ACK/NACK bits associated with each code block, the transmitter may retransmit the code block if receiving an associated NACK bit at an earlier orthogonal frequency division multiplexing (OFDM) symbol, instead of retransmitting the whole STB. However, it should be understood that other technologies may implement other embodiments for retransmitting the code block(s) associated with

the NACK bit(s). For example, one-to-one mapping of frequency-time resources to the code blocks may be applied, so that the code blocks may be retransmitted with the same frequency-time resources as those for transmitting the code blocks.

However, it should be understood that other embodiments may implement other technologies for the transmission acknowledgement control. For example, no code block bundling may happen across the TB, and therefore, multiple STB-level CRC bits and/or the STB-level ACK/NACK bits may be omitted or be replaced by one STB-level CRC bit and/or one STB-level ACK/NACK bit associated with the whole TB. For another example, the CB-level CRC bits and/or the CB-level ACK/NACK bits may be omitted, in order to reduce ACK/NACK overhead.

In some embodiments, the information may comprise one or more indicator which may help the receiver (e.g., eNB 101 for uplink transmission, or UE 201 for downlink transmission) to update a receiver data buffer associated with TB. The indicator may comprise a reset indicator, an ACK/NACK correct reception indicator, and/or others. In some embodiments, the reset indicator may indicate whether the code blocks transmitted associated with the reset indicator are all new transmission blocks from the transmitter (e.g., eNB 101 for downlink transmission, or UE 201 for uplink transmission). The ACK/NACK bit correct reception indicator may indicate whether the transmitter correctly receive the ACK/NACK bits from the receiver, wherein the ACK/NACK bits may further indicate if the code blocks transmitted in a previous transmission round are successfully/unsuccessfully received by the receiver.

In some embodiments, the receiver may reset the data buffer to an initial state at least in response to a determination that the reset indicator indicates that the code blocks transmitted associated with the reset indicator are all new transmission blocks. The reset indicator may be received at least in part in response to a condition that a hybrid automatic repeat request (HARQ) process is too complex, for example, too many round trip HARQ processes. In some embodiments, the HARQ process may be used to reliably communicate data between the eNB 101 and the UE 201. The HARQ process may use a stop and wait protocol. For example, the transmitter may transmit code blocks to the receiver. The transmitter may stop and wait until it receives ACK/NACK bits from the receiver.

In some embodiments, the receiver may update the data buffer at least in part in response to the determination that the reset indicator indicates that the code blocks transmitted associated with the reset indicator may have retransmission block(s), and that

the ACK/NACK bits sent from the receiver have been correctly received. The data buffer may include a new data indicator (NDI) field to indicate whether an associated code block is a new code block or a retransmitted code block, and/or a redundancy version (RV) field to indicate a channel coding combination for the associated code block. In some

5 embodiments, the NDI and RV fields may be updated based on the ACK/NACK bits which have been correctly received. For example, in response to the ACK bit, the NDI field may be updated from 1 to 0, or from 0 to 1. In response to the NACK bit, the NDI field may remain unchanged. For another example, in response to the ACK bit, the RV field may remain unchanged. In response to the NACK bit, the RV field may be changed
10 in circle of a group comprising RV_0 , RV_2 , RV_1 , and RV_3 . This way may help to eliminate the need for the transmitter to transmit the NDI and RV parameters in uplink/downlink grant to the receiver, and therefore, lead to a much shorter downlink control information (DCI).

In some embodiments, in a condition that the code blocks transmitted from the
15 transmitter to the receiver may include new transmission block and retransmission blocks, the code blocks with a higher retransmission attempt may be transmitted at an earlier OFDM symbol. For example, a code block with a second retransmission attempt may be transmitted at an earlier OFDM symbol than a code block with a first retransmission attempt. However, it should be understood that other technologies may implement other
20 embodiments for retransmitting the code blocks. For example, one-to-one mapping of frequency-time resources to the code blocks may be applied, so that the code blocks may be retransmitted with the same frequency-time resources as those for transmitting the code blocks.

More details of the transmission acknowledgement control in the wireless system
25 100 may be explained in the below with reference to Figures 2-8.

It should be understood that other technologies may implement other embodiments of the wireless system 100 in Figure 1. In some embodiments, besides the 5th generation wireless technology, the wireless system 100 may use a variety of wireless access technologies such as Code Division Multiple Access (CDMA), Frequency Division
30 Multiple Access (FDMA), Time Division Multiple Access (TDMA), Orthogonal Frequency Division Multiple Access (OFDMA), Single Carrier Frequency Division Multiple Access (SC-FDMA), and/or others in compliance with an Institute of Electrical and Electronics Engineers (IEEE) 802 system, a 3rd Generation Project Partnership (3GPP) system, a 3GPP Long Term Evolution (LTE) system, and/or a 3GPP2 system.

Figure 2 schematically illustrates an example of a TB with the transmission acknowledgement control, in accordance with various embodiments. As illustrated in Figure 2, the TB may comprise a plurality of code blocks, such as the code blocks 0-9. In some embodiments, the code blocks may be divided into multiple STBs, with each of the STBs comprising one or more code blocks, such as the STBs 1-4. In some embodiments, the receiver of the wireless system 100 (e.g., UE 201 for downlink transmission, or eNB 101 for uplink transmission) may generate the STB-level ACK/NACK bits indicating whether the STBs are successfully/unsuccessfully received, wherein each of the STB-level ACK/NACK bits may be associated with each of the STBs. In some embodiments, the receiver may further generate a plurality of CB-level ACK/NACK bits indicating whether code blocks are successfully/unsuccessfully received, wherein each of the ACK/NACK bits may be associated with each of the code blocks. In other embodiments, the receiver may further generate the CB-level ACK/NACK bits associated with the code block(s) in the STB(s) which is determined as unsuccessful reception (e.g., the STB(s) associated with NACK bit(s)), rather than associated with all code blocks including the code blocks in the STB(s) which is determined as successful reception (e.g., the STB(s) associated with ACK bit(s)).

In some embodiments, taking the TB as illustrated in Figure 2 as an example, the ACK/NACK parameter indicating the number of the STB-level ACK/NACK bits for the STB successful/unsuccessful reception feedback, e.g., parameter N_{ACK} , may be determined as 4. For another example, the ACK/NACK parameter indicating the number of the code blocks that one STB-level ACK/NACK bit may bundle across the TB, e.g., parameter $N_{bund.CB}$, may be determined as 3.

Figure 3 schematically illustrates a method of attaching cyclical redundancy check (CRC) bits to the transport block and transmitting by a transmitter (e.g., an evolved Node B (eNB)) in the wireless system 100, in accordance with various embodiments. As illustrated in Figure 3, in some embodiments, a transceiver or other device of the transmitter in the wireless system 100, such as the transceiver 102 of the eNB 101 for downlink transmission or the transceiver 202 of the UE 201 for uplink transmission, may segment the TB into a plurality of STBs, with each of the STBs comprising one or more code blocks in block 301. In block 302, the transceiver or other device of the transmitter may attach one or more STB-level CRC bits to the plurality of STBs, which may help the

receiver in the wireless system 100 (e.g., the UE 201 for downlink transmission or the eNB 101 for uplink transmission) to detect if each of the STB are correctly received or not.

In some embodiments, in block 303, the transceiver or other device of the transmitter may attach one or more CB-level CRC bits to the each code block within each STB. However, it should be understood that other embodiments may implement other technologies. For example, the CB-level CRC bits may be omitted, so that the receiver may retransmit the unsuccessfully received STB(s) (e.g., the STB(s) associated with NACK bit(s)), no matter whether code block(s) within the STB(s) may be successfully received or not. In block 304, the transceiver or other device of the transmitter may encode the TB with the CRC bits including the STB-level CRC bits and the CB-level CRC bits. In some embodiments, the CB-level CRC bits may be omitted. In block 305, the transceiver or other device of the transmitter may transmit the encoded TB and CRC bits to the receiver. In some embodiments, the transceiver may implement further technologies before transmission, such as rate matching, code block concatenation, and/or others.

Figure 4 schematically illustrates a method of generating and transmitting acknowledgement/negative acknowledgement (ACK/NACK) bits by a receiver (e.g., a user equipment (UE)) in the wireless system 100, in accordance with various embodiments. As illustrated in Figure 4, in some embodiments, a transceiver or other device of the receiver in the wireless system 100, such as the transceiver 202 of the UE 201 for downlink transmission or the transceiver 102 of the eNB 101 for uplink transmission, may receive the encoded TB and CRC bits from the transmitter, in block 401. In block 402, the transceiver or other device of the receiver may decode the encoded TB and CRC bits and obtain the TB and the CRC bits, wherein the CRC bits may comprise the one or more STB-level CRC bits associated with each of the STBs, and the one or more CB-level CRC bits associated with each of the code blocks within the each STB. In some embodiments, the CB-level CRC bit may be omitted.

In block 403, the transceiver or other device of the receiver may generate one or more STB-level ACK/NACK bits at least in part based on error detection using the STB-level CRC bits associated with each of the STBs. In some embodiments, each of the STB-level ACK/NACK bits may be associated with each of the STBs and indicate if the associated STB has been successfully/unsuccessfully received. In block 404, the transceiver or other device of the receiver may determine if any STB-level NACK bits indicating an unsuccessful reception of any STBs are generated. In block 405, the transceiver or other device of the receiver may generate one or more CB-level ACK/NACK

bits in response to a determination that at least one STB-level NACK bit indicating the unsuccessful reception of at least one STB is generated. In some embodiments, the CB-level ACK/NACK bits may be generated at least in part based on error detection using the CB-level CRC bits associated with each of the code blocks within the unsuccessfully received STB, wherein each of the CB-level ACK/NACK bits may be associated with each of the code blocks and indicate if the associated code block has been successfully/unsuccessfully received. In block 406, the STB-level ACK/NACK bits and the CB-level ACK/NACK bits may be transmitted to the transmitter. In some embodiments, the ACK/NACK bits may be transmitted via a physical ACK/NACK channel or an advanced physical control channel (xPUCCH).

However, in response to a determination that no STB-level NACK bit is generated, the transceiver or other device of the receiver may not generate the CB-level ACK/NACK bits in block 405, and may transmit the STB-level ACK bits to the transmitter in block 406.

It should be understood that other embodiments may implement other technologies for the method of Figure 4. For example, more than one STB-level ACK/NACK bits may be generated for each STB, or more than one CB-level ACK/NACK bits may be generated for each code block of the unsuccessfully received STB.

Figure 5 schematically illustrates an example of transmission and retransmission combination in the wireless system 100, in accordance with various embodiments. As illustrated in Figure 5, in some embodiments, the transmitter in the wireless system 100 (e.g., the eNB 101 for downlink transmission) may transmit a first TB comprising a plurality of code blocks to the receiver (e.g., the UE 201 for the downlink transmission) in a first round of transmission (S501). For example, as illustrated in Figure 5, the code blocks may be denoted as $d0_{o,ReTx_0}$, $d0_{1,ReTx_0}$, $d0_{2,ReTx_0}$ and $d0_{3,ReTx_0}$, in which

$d0_{o,ReTx_0}$ may represent the first code block of the first TB in the first attempt of transmission, $d0_{1,ReTx_0}$ may represent the second code block of the first TB in the first attempt of transmission, $d0_{2,ReTx_0}$ may represent the third code block of the first TB in the first attempt of transmission, and $d0_{3,ReTx_0}$ may represent the fourth code block of the first TB in the first attempt of transmission.

In some embodiments, the UE 201 may transmit a plurality of ACK/NACK bits indicating successful/unsuccessful reception of the code blocks to the eNB 101, wherein each of the ACK/NACK bits may be associated with each of the code blocks (S502). For

example, as illustrated in Figure 6, ACK ACK NCK NCK may respectively represent successful reception for code blocks $d0_{0,ReTx_0}$ and $d0_{1,ReTx_0}$, and unsuccessful reception for code blocks $d0_{2,ReTx_0}$ and $d0_{3,ReTx_0}$ in the first round of transmission. In response to the ACK/NACK bits, the eNB 101 may transmit a plurality of code blocks in a second round of transmission (S503), in which the code blocks indicated as unsuccessfully received by the NACK bits are retransmitted to the UE 201. For example, the code blocks $d0_{2,ReTx_0}$ and $d0_{3,ReTx_0}$ are retransmitted, in which $d0_{2,ReTx_1}$ may represent the third code block of the first TB in a first retransmission attempt, and $d0_{3,ReTx_1}$ may represent the fourth code block of the first TB in a first retransmission attempt, wherein the footnote $ReTx_1$ may represent the first retransmission attempt. In addition, new code blocks of a second TB, such as code blocks $d1_{0,ReTx_0}$ and $d1_{1,ReTx_0}$, may be transmitted in the second round of transmission to the UE 201, wherein $d1_{0,ReTx_0}$ may represent a first code block of the second TB in the first attempt of transmission, $d1_{1,ReTx_0}$ may represent a second code block of the second TB in the first attempt of transmission. It may be seen from S503 that retransmission code blocks (e.g., $d0_{2,ReTx_1}$ and $d0_{3,ReTx_1}$) and new transmission code blocks (e.g., $d1_{0,ReTx_0}$ and $d1_{1,ReTx_0}$) may be transmitted in the second round of transmission together, with the retransmission code block being transmitted at earlier OFDM symbols.

In some embodiments, the UE 201 may transmit ACK/NACK bits for each of the code blocks received in the second round of transmission to the eNB 101 (S504), in which each of the ACK/NACK bits may associated with each of the code blocks received in the second round of transmission and indicate successful/unsuccessful reception of the associated code blocks. For example, NCK ACK NCK ACK may represent unsuccessful reception for code blocks $d0_{2,ReTx_1}$ and $d1_{0,ReTx_0}$, and successful reception for code blocks $d0_{3,ReTx_1}$ and $d1_{1,ReTx_0}$. In response to the ACK/NACK bits, the eNB 101 may transmit a plurality of code blocks in a third round of transmission (S505), in which the code blocks indicated as unsuccessfully received by the NACK bits in S504 are retransmitted to the UE 201. For example, the code blocks $d0_{2,ReTx_2}$ and $d1_{0,ReTx_1}$ may be retransmitted, in which $d0_{2,ReTx_2}$ may represent the third code block of the first TB in a second retransmission attempt, and $d1_{0,ReTx_1}$ may represent the first code block of the second TB in a first retransmission attempt. In addition, new code blocks of a third TB, such as code

blocks $d2_{0,ReTx_0}$ and $d2_{1,ReTx_0}$, may be transmitted in the third round of transmission to the UE 201, wherein $d2_{0,ReTx_0}$ may represent a first code block of the third TB in the first attempt of transmission, $d2_{1,ReTx_0}$ may represent a second code block of the third TB in the first attempt of transmission.

5 It may be seen from S505 that retransmission code blocks (e.g., $d0_{2,ReTx_2}$ and $d1_{0,ReTx_1}$) and new transmission code blocks (e.g., $d2_{0,ReTx_0}$ and $d2_{1,ReTx_0}$) may be transmitted in the third round of transmission together, with code block having higher retransmission attempt being transmitted at earlier OFDM symbols than the code block having a lower retransmission attempt, and with retransmission code block being
10 transmitted at earlier OFDM symbols than the new transmission code blocks. For example, the code block $d0_{2,ReTx_2}$ with the second retransmission attempt is transmitted at an earlier OFDM symbol than the code block $d1_{0,ReTx_1}$ with the first retransmission attempt. For another example, retransmission code blocks $d0_{2,ReTx_2}$ and $d1_{0,ReTx_1}$ may be transmitted at earlier OFDM symbols than the new transmission code blocks $d2_{0,ReTx_0}$ and $d2_{1,ReTx_0}$.

15 In some embodiments, the UE 201 may transmit ACK/NACK bits for each of the code blocks received in the third round of transmission to the eNB 101 (S506), in which each of the ACK/NACK bits may be associated with each of the code blocks received in the third round of transmission and indicate successful/unsuccessful reception of the associated code blocks. For example, ACK ACK ACK ACK may represent successful
20 reception for code blocks $d0_{2,ReTx_2}$, $d1_{0,ReTx_1}$, $d2_{0,ReTx_0}$ and $d2_{1,ReTx_0}$.

It should be understood that other embodiments may implement other technologies of the example as illustrated in Figure 5. For example, the ACK/NACK bit may be associated with the STB comprising one or more code blocks across the TB.

Figure 6 schematically illustrates an example of transmission and retransmission
25 under the transmission acknowledgement control in the wireless system 100, in accordance with various embodiments. As illustrated in Figure 6, the transmitter of the wireless system 100 (e.g., the eNB 101 for the downlink transmission) may transmit a reset indicator and a plurality of code blocks of a first TB to the receiver in the wireless system 100 (e.g., the UE 201 for the downlink transmission) in a first round of
30 transmission (S601). The reset indicator may indicate whether the code blocks transmitted associated with the reset indicator, e.g., the code blocks $d0_{0,ReTx_0}$, $d0_{1,ReTx_0}$, $d0_{2,ReTx_0}$ and

$d0_{3,ReTx_0}$, are all new transmission blocks or not, wherein the reset indicator 1 may represent that the code blocks are all new transmission blocks, and the reset indicator 0 may represent that at least one of the code block is a retransmission block. In some embodiments, the reset indicator representing all new transmission blocks may be sent in response to an indication that the HARQ process may be too complex.

In some embodiments, the code block $d0_{o,ReTx_0}$ may represent the first code block of the first TB in the first attempt of transmission, $d0_{1,ReTx_0}$ may represent the second code block of the first TB in the first attempt of transmission, $d0_{2,ReTx_0}$ may represent the third code block of the first TB in the first attempt of transmission, and $d0_{3,ReTx_0}$ may represent the fourth code block of the first TB in the first attempt of transmission.

In some embodiments, the UE 101 may update the data buffer at least in part based on the reset indicator (S602). The data buffer may further include fields indicating HARQ state associated with the code blocks, such as a new data indicator (NDI) field and/or a redundancy version (RV) field for each code block. In response that the reset indicator indicating all code blocks are new transmission blocks, the UE 101 may reset the data buffer as an initial state (e.g., all zero). The receiver may further store the code blocks into the data buffer. In some embodiments, the UE 201 may transmit the one or more ACK/NACK bits to the eNB 101, wherein each of the ACK/NACK bits may be associated with each of the code blocks received in the first round of transmission and indicate successful/unsuccessful reception of the associated code blocks (S603). For example, ACK ACK NCK NCK may represent successful reception of blocks $d0_{o,ReTx_0}$ and $d0_{1,ReTx_0}$, and unsuccessful reception of code blocks $d0_{2,ReTx_0}$ and $d0_{3,ReTx_0}$. In some embodiments, “a round of transmission” may represent a transmission of code blocks from the eNB 101 to the UE 201 and a transmission of ACK/NACK bits indicating successful/unsuccessful reception of the code blocks from the UE 201 to the eNB 101.

In some embodiments, the eNB 101 may determine whether the ACK/NACK bits have been correctly received or not, and in response to the determination that the ACK/NACK bits have been correctly received, transmit a plurality of code blocks (e.g., $d0_{2,ReTx_1}$, $d0_{3,ReTx_1}$, $d1_{0,ReTx_0}$ and $d1_{1,ReTx_0}$) in a second round of transmission to the UE 201 as well as indicators having the reset indicator and/or a ACK/NACK correct reception indicator (S604). The code blocks may be generated at least in part based on the correctly received ACK/NACK bits. For example, the code blocks associated with NACK bits (e.g.,

$d0_{2,ReTx_1}$ and $d0_{3,ReTx_1}$) may be transmitted in earlier OFMD symbols than new transmission code blocks (e.g., $d1_{0,ReTx_0}$ and $d1_{1,ReTx_0}$), in which $d0_{2,ReTx_1}$ may represent the third code block of the first TB in the first attempt of retransmission, $d0_{3,ReTx_1}$ may represent the fourth code block of the first TB in the first attempt of the retransmission, 5 $d1_{0,ReTx_0}$ may represent the first code block of the second TB in the first attempt of the transmission, and $d1_{1,ReTx_0}$ may represent the second code block of the second TB in the first attempt of the transmission.

The ACK/NACK correct reception indicator may indicate whether the ACK/NACK bits have been correctly received or not. For example, ACK/NACK correct reception indicator “1” may represent correct reception of the ACK/NACK bits, and 10 ACK/NACK correct reception indicator “0” may represent correct reception of the ACK/NACK bits, or vice versa. If the code blocks in the second round of transmission may comprise those retransmitted in response to the NACK bits, such as the blocks $d0_{2,ReTx_1}$ and $d0_{3,ReTx_1}$, and the ACK/NACK bits have been correctly received, the eNB 101 15 may transmit reset indicator “0” and ACK/NACK correct reception indicator “1” to the UE 201 in S604.

In some embodiments, the UE 201 may update the data buffer at least in part based on the reset indicator and/or the ACK/NACK correct reception indicator, and store the code blocks received in the second round of transmission in the data buffer (S605). In 20 response to the reset indicator indicating that at least one of the code blocks is retransmission block and the ACK/NACK bits have been correctly received, the UE 201 may update the data buffer to reflect the HARQ state, e.g., NDI and/or RV fields, of the code blocks received in the second round of transmission. For example, NDI field for code block $d0_{2,ReTx_1}$, i.e., third code block of the first TB in the first attempt of retransmission, 25 may be kept unchanged, while the associated RV field may be updated from RV_0 to RV_1 . NDI field for code $d0_{3,ReTx_1}$ i.e., fourth code block of the first TB in the first attempt of retransmission, may be kept unchanged, while the associated RV field may be updated from RV_0 to RV_1 . NDI field for code block $d1_{0,ReTx_0}$, i.e., first code block of the second TB in the first round of transmission, may be kept unchanged, while the associated RV 30 field may be updated to RV_0 . NDI field for code block, i.e., $d1_{1,ReTx_0}$, second code block of

the second TB in the first round of transmission may be kept unchanged, while the associated RV field may be updated to RV_0 .

In some embodiments, the UE 201 may transmit one or more ACK/NACK bits to the eNB 101, wherein each of the ACK/NACK bits may be associated with each of the
 5 code blocks received in the second round of transmission and indicate successful/uns successful reception of the associated code blocks (S606). For example, NACK ACK ACK ACK may represent unsuccessful reception of code block $d0_{2,ReTx_1}$, and successful reception of code blocks $d0_{3,ReTx_1}$, $d1_{0,ReTx_0}$ and $d1_{1,ReTx_0}$.

In some embodiments, the UE 201 may determine whether the ACK/NACK bits
 10 have been correctly received or not, and in response to the determination that the ACK/NACK bits have been correctly received, transmit the code blocks in the third round of transmission to the UE 201, e.g., $d0_{2,ReTx_2}$, $d2_{0,ReTx_0}$, $d2_{1,ReTx_0}$ and $d2_{2,ReTx_0}$, as well as indicators having the reset indicator and/or a ACK/NACK correct reception indicator (S607). The code blocks may be generated at least in part based on the correctly received
 15 ACK/NACK bits. For example, the code blocks associated with NACK bits (e.g., $d0_{2,ReTx_2}$) may be transmitted in earlier OFMD symbol than new transmission code blocks (e.g., $d2_{0,ReTx_0}$, $d2_{1,ReTx_0}$ and $d2_{2,ReTx_0}$), in which $d0_{2,ReTx_2}$ may represent the third code block of the first TB in the second attempt of retransmission, $d2_{0,ReTx_0}$ may represent the first code block of the third TB in the first attempt of the transmission, $d2_{1,ReTx_0}$ may represent the
 20 second code block of the third TB in the first attempt of the transmission, and $d2_{2,ReTx_0}$ may represent the third code block of the third TB in the first attempt of the transmission.

Furthermore, if the code blocks in the third round of transmission may comprise those retransmitted in response to the NACK bits, such as the blocks $d0_{2,ReTx_2}$, and the
 25 ACK/NACK bits have been correctly received, the eNB 101 may transmit the reset indicator 0 and ACK/NACK correct reception indicator 1 to the UE 201 in S607.

In some embodiments, the UE 201 may update the data buffer at least in part based on the reset indicator and/or the ACK/NACK correct reception indicator, and store the code blocks received in the third round of transmission in the data buffer (S608). In
 30 response to the reset indicator indicating that at least one of the code blocks is retransmission block and the ACK/NACK bits have been correctly received, the UE 201

may update the data buffer to reflect the HARQ state (e.g., NDI and/or RV fields) of the code blocks received in the third round of transmission. For example, NDI field for code block $d0_{2,ReTx_2}$, i.e., third code block of the first TB in the second attempt of retransmission, may be kept unchanged, while the associated RV field may be updated from RV_1 to RV_2 .

- 5 NDI field for code $d2_{0,ReTx_0}$ i.e., first code block of the third TB in the first attempt of transmission, may be kept unchanged, while the associated RV field may be updated to RV_0 . NDI field for code block $d2_{1,ReTx_0}$, i.e., second code block of the third TB in the first round of transmission, may be kept unchanged, while the associated RV field may be updated to RV_0 . NDI field for code block, i.e., $d2_{2,ReTx_0}$, third code block of the third TB
 10 in the first round of transmission may be kept unchanged while the associated RV field may be updated to RV_0 .

In some embodiments, the UE 201 may transmit one or more ACK/NACK bits to the eNB 101, wherein each of the ACK/NACK bits may be associated with each of the code blocks received in the third round of transmission and indicate

- 15 successful/unsuccessful reception of the associated code blocks (S608). For example, ACK ACK ACK ACK may represent successful reception of code block $d0_{2,ReTx_2}$, $d2_{0,ReTx_0}$, $d2_{1,ReTx_0}$ and $d2_{2,ReTx_0}$.

In some embodiments, the UE 201 may determine whether the ACK/NACK bits have been correctly received or not, and in response to the determination that the

- 20 ACK/NACK bits have not been correctly received, transmit the code blocks in the fourth round of transmission to the UE 201, e.g., $d0_{2,ReTx_2}$, $d2_{0,ReTx_0}$, $d2_{1,ReTx_0}$ and $d2_{2,ReTx_0}$, in S609. The eNB 101 may further transmit indicators having the reset indicator and/or a ACK/NACK correct reception indicator to the UE 201 (S610). Because the ACK/NACK bits haven't been correctly received, the eNB 101 may retransmit the code blocks
 25 associated with the in the previous round of transmission. In other words, the code blocks in the fourth round of transmission are the same as the code blocks in the third round of transmission.

Furthermore, if the ACK/NACK bits have not been correctly received and the code blocks in the fourth round of transmission may comprise those retransmitted in response to
 30 the ACK/NACK incorrect reception, the eNB 101 may transmit the reset indicator 0 and ACK/NACK correct reception indicator 0 to the UE 201 in S611.

In some embodiments, in response to the reset indicator indicating that the code blocks comprise retransmission blocks and the ACK/NACK correct reception indicator indicating that the ACK/NACK bits have not been correctly received, the UE 201 may keep the data buffer unchanged, including the HARQ state and the data blocks (S610).

5 It should be understood that other embodiments may implement other technologies of the example as illustrated in Figure 5. For example, the ACK/NACK bit may be associated with the STB comprising one or more code blocks across the TB.

Figure 7 schematically illustrates a method of transmission and retransmission under the transmission acknowledgement control, to be employed by the receiver in the wireless system 100, in accordance with various embodiments. As illustrated in Figure 7, 10 in some embodiments, the receiver (e.g., UE 201 in the downlink transmission) may receive a plurality of code blocks with an indicator from a transmitter (e.g., eNB 101 in the downlink transmission), in block 701. The indicator may indicate a reset indicator and/or an ACK/NACK correct reception indicator. The reset indicator may indicate whether the 15 associated code blocks are all new transmission blocks or at least one of them is retransmission block. In a condition of complex HARQ state, the reset indicator may indicate that the associated code blocks, e.g., the code blocks received in block 701, are all new transmission blocks. The ACK/NACK correct reception indicator may indicate whether ACK/NACK bits sent from the UE 201 have been correctly received by the eNB 20 101 or not. In some embodiments, each of the ACK/NACK bits may be associated with at least one of the code blocks and indicate whether the associated code block is successfully/unsuccessfully received. If the reset indicator indicates that the associated code blocks are new transmission blocks, the ACK/NACK correct reception indicator may be omitted. In other words, the indicator may include the reset indicator.

25 In a case that the code blocks may comprise new transmission and/or retransmission blocks, the retransmission block may be transmitted at an earlier OFDM symbol than the new transmission block. Furthermore, the code block with a higher retransmission attempt may be transmitted at earlier OFDM symbol than the code block with a lower retransmission attempt.

30 In block 702, the UE 201 may determine if the reset indicator indicates the associated code blocks are new transmission blocks or not. In response to the determination that the reset indicator indicates that the associated code blocks are new transmission blocks, the UE 201 may reset a data buffer storing HARQ state for the code blocks to an initial state in block 703. In some embodiments, the data buffer may include

fields indicating the HARQ state, such as the new data indicator (NDI) field and/or the redundancy version (RV) field for each code block. The receiver may further store the code blocks into the data buffer.

In block 704, the UE 201 may generate ACK/NACK bits at least in part based on error checking of the code blocks. In some embodiments, each of the ACK/NACK bits may be associated with at least one of the code blocks and indicate whether the associated code block is successfully/unsuccessfully received. In block 705, the UE 201 may transmit the ACK/NACK bits to the eNB 101.

In some embodiments, in response to the determination that not all of the code blocks are new transmission blocks in block 702, the UE 201 may further determine if the ACK/NACK correct reception indicator received from the eNB 101 indicates that the ACK/NACK bits in a previous round of transmission have been correctly received (block 706). In response to the determination that the ACK/NACK bits have been correctly received, the UE 201 may update the data buffer for the HARQ state associated with the code blocks in block 707 at least in part based on the ACK/NACK bits transmitted in the previous round of transmission, such as the ACK/NACK bits generated in block 704. For example, the NDI field for the code block determined as NACK in the previous round of transmission may be kept unchanged, and the RV field for this code block may be updated from RV_0 to RV_1 in response to a first retransmission attempt, to RV_2 for a second retransmission attempt, and so on. For another example, the NDI field for the code block determined as ACK in the previous round of transmission may be changed from 1 to 0 or from 0 to 1, and the RV field of this code block may be kept unchanged or kept zero. For yet another example, the NDI field and RV field for a new transmission code block may be reset as an initial state, for example, all zero. Then, the method may go to blocks 704 again to generate the ACK/NACK bits for the code blocks received in the block 701 and transmit the ACK/NACK bits to the eNB 101 in block 705.

In some embodiments, in response to a determination that the ACK/NACK correct reception indicator indicates that the ACK/NACK bits have not been correctly received in block 706, the UE 101 may retransmit the ACK/NACK bits in the previous round of transmission to the eNB 101 in block 708.

Figure 8 schematically illustrates a method of transmission and retransmission under the transmission acknowledgement control, to be employed by the transmitter in the wireless system 100, in accordance with various embodiments. As illustrated in Figure 8, in some embodiments, the transmitter of the wireless system 100 (e.g., the eNB 101 for the

downlink transmission) may transmit a plurality of start code blocks and a start indicator to the receiver of the wireless system 100 (e.g., the UE 201 for the downlink transmission), in block 801. In some embodiments, in block 802, the eNB 101 may receive ACK/NACK bits associated with the start code blocks from the UE 201, wherein each of the

5 ACK/NACK bits may associated with each of the start code blocks, and indicate successful/unsuccessful reception for the associated code block. However, it should be understood that other embodiments may implement other technologies of the block 802 as illustrated in Figure 8. For example, the ACK/NACK bit may be associated with more than one code blocks across a transport block.

10 In some embodiments, the eNB 101 may determine if the ACK/NACK bits have been correctly received in block 803. In response to a determination that the ACK/NACK bits have been correctly received, the eNB 101 may transmit a plurality of subsequent code blocks and a subsequent indicator to the UE 201 in block 804. The subsequent indicator may comprise a subsequent reset indicator and/or a subsequent ACK/NACK

15 correct reception indicator. The subsequent code blocks are generated at least in part based on the ACK/NACK bits received in block 802, in which the code blocks associated with NACK indicating unsuccessful reception may be retransmitted. In a case that the subsequent code blocks may comprise new transmission and/or retransmission code blocks, the retransmission block may be transmitted at an earlier OFDM symbol than the

20 new transmission block. Furthermore, the code block with a higher retransmission attempt may be transmitted at earlier OFDM symbol than the code block with a lower retransmission attempt.

In some embodiments, in response to a determination that the ACK/NACK bits have not been correctly received in block 803, the eNB 101 may transmit another plurality

25 of subsequent code blocks and another subsequent indicator to the UE 201 in block 805. The another plurality of code blocks may be the same as the code blocks associated with the ACK/NACK bits, e.g., the code blocks transmitted in block 801. The another subsequent indicator may comprise another subsequent reset indicator and another subsequent ACK/NACK correct reception indicator, wherein the another subsequent reset

30 indicator may indicate that another plurality of subsequent code blocks are retransmission blocks and the ACK/NACK correct reception indicator may indicate that the ACK/NACK bits have not been correctly received.

Figure 9 schematically illustrates an example system 900 in accordance with various embodiments. In an embodiment, the system 900 may comprise one or more

processor(s) 904, system control logic 908 coupled with at least one of the processor(s) 904, system memory 912 coupled with system control logic 908, non-volatile memory (NVM)/storage 916 coupled with system control logic 908, and a network interface 920 coupled with system control logic 908.

5 Processor(s) 904 may include one or more single-core or multi-core processors. Processor(s) 904 may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, baseband processors, etc.). In an embodiment in which the system 900 implements the eNB 101, processors(s) 904 may be configured to execute one or more embodiment(s) as illustrated
10 in Figures 1-3, 5-6 and 8 in accordance with various embodiments. In an embodiment in which the system 900 implements the UE 201, processors(s) 904 may be configured to execute one or more embodiment(s) as illustrated in Figures 1-2 and 4-7 in accordance with various embodiments.

 System control logic 908 for one embodiment may include any suitable interface
15 controllers to provide for any suitable interface to at least one of the processor(s) 904 and/or to any suitable device or component in communication with system control logic 908.

 System control logic 908 for one embodiment may include one or more memory controller(s) to provide an interface to system memory 912. System memory 912 may be
20 used to load and store data and/or instructions, for example, for system 900. System memory 912 for one embodiment may include any suitable volatile memory, such as suitable dynamic random access memory (DRAM), for example.

 NVM/storage 916 may include one or more tangible, non-transitory computer-readable media used to store data and/or instructions, for example. NVM/storage 916 may
25 include any suitable non-volatile memory, such as flash memory, for example, and/or may include any suitable non-volatile storage device(s), such as one or more hard disk drive(s) (HDD(s)), one or more compact disk (CD) drive(s), and/or one or more digital versatile disk (DVD) drive(s), for example.

 The NVM/storage 916 may include a storage resource physically part of a device
30 on which the system 900 is installed or it may be accessible by, but not necessarily a part of, the device. For example, the NVM/storage 916 may be accessed over a network via the network interface 920.

 System memory 912 and NVM/storage 916 may respectively include, in particular, temporal and persistent copies of instructions 924. Instructions 924 may include

instructions that when executed by at least one of the processor(s) 904 result in the system 900 implementing the method as described with reference to Figures 3-8. In various embodiments, instructions 924, or hardware, firmware, and/or software components thereof, may additionally/alternatively be located in the system control logic 908, the network interface 920, and/or the processor(s) 904.

Network interface 920 may include the transceiver 102 of the eNB 101 or the transceiver 202 of the UE 201 and/or others as illustrated in Figure 1, to provide a radio interface for system 900 to communicate over one or more network(s) and/or with any other suitable device. In various embodiments, the network interface 920 may be integrated with other components of system 900. For example, the network interface may include a processor of the processor(s) 904, memory of the system memory 912, NVM/Storage of NVM/Storage 916, and/or a firmware device (not being illustrated) having instructions that when executed by at least one of the processor(s) 904 result in the system 900 implementing the method as described with reference to Figures 3-8.

Network interface 920 may further include any suitable hardware and/or firmware to provide a multiple input, multiple output radio interface. Network interface 920 for one embodiment may be, for example, a network adapter, a wireless network adapter, a telephone modem, and/or a wireless modem.

For one embodiment, at least one of the processor(s) 904 may be packaged together with logic for one or more controller(s) of system control logic 908. For one embodiment, at least one of the processor(s) 904 may be packaged together with logic for one or more controllers of system control logic 908 to form a System in Package (SiP). For one embodiment, at least one of the processor(s) 904 may be integrated on the same die with logic for one or more controller(s) of system control logic 908. For one embodiment, at least one of the processor(s) 904 may be integrated on the same die with logic for one or more controller(s) of system control logic 908 to form a System on Chip (SoC).

The system 900 may further include input/output (I/O) devices 932. The I/O devices 932 may include user interfaces designed to enable user interaction with the system 900, peripheral component interfaces designed to enable peripheral component interaction with the system 900, and/or sensors designed to determine environmental conditions and/or location information related to the system 900.

In various embodiments, the user interfaces could include, but are not limited to, a display (e.g., a liquid crystal display, a touch screen display, etc.), a speaker, a microphone,

one or more cameras (e.g., a still camera and/or a video camera), a flashlight (e.g., a light emitting diode flash), and a keyboard.

In various embodiments, the peripheral component interfaces may include, but are not limited to, a non-volatile memory port, an audio jack, and a power supply interface.

5 In various embodiments, the sensors may include, but are not limited to, a gyro sensor, an accelerometer, a proximity sensor, an ambient light sensor, and a positioning unit. The positioning unit may also be part of, or interact with, the network interface 920 to communicate with components of a positioning network, e.g., a global positioning system (GPS) satellite.

10 In various embodiments, the system 900 may be an eNB, such as, the eNB 101. In various embodiments, system 900 may have more or less components, and/or different architectures.

FIG. 10 illustrates, for one embodiment, example components of a UE device 1000 in accordance with some embodiments. In some embodiments, the UE device 1000 may
15 include application circuitry 1002, baseband circuitry 1004, Radio Frequency (RF) circuitry 1006, front-end module (FEM) circuitry 1008, and one or more antennas 1010, coupled together at least as shown. In some embodiments, the UE device 1000 may include additional elements such as, for example, memory/storage, display, camera, sensor, and/or input/output (I/O) interface.

20 The application circuitry 1002 may include one or more application processors. For example, the application circuitry 1002 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may
25 include memory/storage and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system.

The baseband circuitry 1004 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 1004 may
30 include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 1006 and to generate baseband signals for a transmit signal path of the RF circuitry 1006. Baseband processing circuitry 1004 may interface with the application circuitry 1002 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 1006. For example,

in some embodiments, the baseband circuitry 1004 may include a second generation (2G) baseband processor 1004a, third generation (3G) baseband processor 1004b, fourth generation (4G) baseband processor 1004c, and/or other baseband processor(s) 1004d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 1004 (e.g., one or more of baseband processors 1004a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 1006. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some embodiments, modulation/demodulation circuitry of the baseband circuitry 1004 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 1004 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

In some embodiments, the baseband circuitry 1004 may include elements of a protocol stack such as, for example, elements of an EUTRAN protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), and/or RRC elements. A central processing unit (CPU) 1004e of the baseband circuitry 1004 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal processor(s) (DSP) 1004f. The audio DSP(s) 1004f may include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments. Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 1004 and the application circuitry 1002 may be implemented together such as, for example, on a system on a chip (SOC).

In some embodiments, the baseband circuitry 1004 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 1004 may support communication with an evolved

universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 1004 is configured to support radio communications of more than one wireless protocol may be referred to as

5 multi-mode baseband circuitry.

RF circuitry 1006 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 1006 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 1006 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 1008 and provide baseband signals to the baseband circuitry 1004. RF circuitry 1006 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 1004 and provide RF output signals to the FEM circuitry 1008 for transmission.

15 In some embodiments, the RF circuitry 1006 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 1006 may include mixer circuitry 1006a, amplifier circuitry 1006b and filter circuitry 1006c. The transmit signal path of the RF circuitry 1006 may include filter circuitry 1006c and mixer circuitry 1006a. RF circuitry 1006 may also include synthesizer circuitry 1006d for synthesizing a frequency for use by the mixer circuitry 1006a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 1006a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 1008 based on the synthesized frequency provided by synthesizer circuitry 1006d. The amplifier circuitry 1006b may be configured to amplify the down-converted signals and the filter circuitry 1006c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to the baseband circuitry 1004 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some 20 embodiments, mixer circuitry 1006a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 1006a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 1006d to generate RF output signals for the FEM

circuitry 1008. The baseband signals may be provided by the baseband circuitry 1004 and may be filtered by filter circuitry 1006c. The filter circuitry 1006c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 1006a of the receive signal path and the mixer circuitry 1006a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 1006a of the receive signal path and the mixer circuitry 1006a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 1006a of the receive signal path and the mixer circuitry 1006a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 1006a of the receive signal path and the mixer circuitry 1006a of the transmit signal path may be configured for super-heterodyne operation.

In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 1006 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 1004 may include a digital baseband interface to communicate with the RF circuitry 1006.

In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

In some embodiments, the synthesizer circuitry 1006d may be a fractional-N synthesizer or a fractional N/N+1 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 1006d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

The synthesizer circuitry 1006d may be configured to synthesize an output frequency for use by the mixer circuitry 1006a of the RF circuitry 1006 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 1006d may be a fractional N/N+1 synthesizer.

In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be

provided by either the baseband circuitry 1004 or the applications processor 1002 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 1002.

5 Synthesizer circuitry 1006d of the RF circuitry 1006 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+1 (e.g., based on a carry out) to provide a
10 fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into Nd equal packets of phase, where Nd is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay
15 through the delay line is one VCO cycle.

 In some embodiments, synthesizer circuitry 1006d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and
20 divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 1006 may include an IQ/polar converter.

 FEM circuitry 1008 may include a receive signal path which may include circuitry
25 configured to operate on RF signals received from one or more antennas 1010, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 1006 for further processing. FEM circuitry 1008 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 1006 for transmission by one or more of the one or more
30 antennas 1010.

 In some embodiments, the FEM circuitry 1008 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals

and provide the amplified received RF signals as an output (e.g., to the RF circuitry 1006). The transmit signal path of the FEM circuitry 1008 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 1006), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more
5 antennas 1010.

In some embodiments, the UE 1000 comprises a plurality of power saving mechanisms. If the UE 1000 is in an RRC_Connected state, where it is still connected to the eNB as it expects to receive traffic shortly, then it may enter a state known as Discontinuous Reception Mode (DRX) after a period of inactivity. During this state, the
10 device may power down for brief intervals of time and thus save power.

If there is no data traffic activity for an extended period of time, then the UE 1000 may transition off to an RRC_Idle state, where it disconnects from the network and does not perform operations such as channel quality feedback, handover, etc. The UE 1000 goes into a very low power state and it performs paging where again it periodically wakes
15 up to listen to the network and then powers down again. The device cannot receive data in this state, in order to receive data, it must transition back to RRC_Connected state.

An additional power saving mode may allow a device to be unavailable to the network for periods longer than a paging interval (ranging from seconds to a few hours). During this time, the device is totally unreachable to the network and may power down
20 completely. Any data sent during this time incurs a large delay and it is assumed the delay is acceptable.

The disclosure may include various example embodiments disclosed below.

Example 1 may include a base station may comprise a control module to segment a transport block (TB) into one or more sub-transport blocks (STBs), at least in part based
25 on an acknowledgement/negative acknowledgement (ACK/NACK) parameter, wherein a STB of the STBs may comprise one or more code blocks of the TB; and, to attach one or more first-level cyclical redundancy check (CRC) bits to each of the STBs; and a transceiver to transmit the TB with the first-level CRC bits to a user equipment (UE).

Example 2 may include the subject matter of Example 1, and optionally, wherein
30 the control module may further attach one or more second-level CRC bits to each of the code blocks; and the transceiver is further to transmit the second-level CRC bits to the UE.

Example 3 may include the subject matter of any one of Examples 1-2, and optionally, wherein the ACK/NACK parameter may indicate a number of ACK/NACK bits for STB successful/unsuccessful reception feedback from the UE.

Example 4 may include the subject matter of any one of Examples 1-3, and optionally, wherein the ACK/NACK parameter may indicate a number of the code blocks associated with an ACK/NACK bit for STB successful/unsuccessful reception feedback from the UE.

5 Example 5 may include the subject matter of any one of Examples 1-4, and optionally, wherein the base station may be an evolved Node B (eNB).

Example 6 may include a user equipment (UE) comprising a transceiver to receive, from a base station, a transport block (TB) and one or more first-level cyclical redundancy check (CRC) bits, wherein the TB comprises one or more sub-transport blocks (STBs) and
10 a STB of the STBs comprises one or more code blocks of the TB; and a control module to generate one or more first-level ACK/NACK bits at least in part based on the first-level CRC bits associated with the STBs, wherein the transceiver is further to transmit the first-level ACK/NACK bits to the base station.

Example 7 may include the subject matter of Example 6, and optionally, wherein
15 the transceiver may receive one or more second-level CRC bits from the base station, wherein the second-level CRC bits are associated with the code blocks.

Example 8 may include the subject matter of any one of Examples 6-7, and optionally, wherein the control module may determine that at least one first-level NACK bit is generated to indicate unsuccessful reception of at least one STB of the STBs;
20 generate one or more second-level ACK/NACK bits at least in part based on the second-level CRC bits associated with the code blocks within the at least one STB; and wherein the transceiver is further to transmit the second-level ACK/NACK bits to the base station.

Example 9 may include the subject matter of any one of Examples 6-8, and optionally, wherein a number of the STBs may be determined at least in part based on an
25 acknowledgement/negative acknowledgement (ACK/NACK) parameter.

Example 10 may include the subject matter of any one of Examples 6-9, and optionally, wherein the ACK/NACK parameter may indicate a number of the first-level ACK/NACK bits for STB successful/unsuccessful reception feedback from the receiver.

Example 11 may include the subject matter of any one of Examples 6-10, and
30 optionally, wherein, the ACK/NACK parameter may indicate a number of the code blocks associated with a first-level ACK/NACK bit of the first-level ACK/NACK bits.

Example 12 may include the subject matter of any one of Examples 6-11, and optionally, wherein the base station may be an evolved Node B.

Example 13 may include a user equipment (UE) comprising a transmitter to receive a plurality of code blocks and an indicator from a base station; and a control module to reset a data buffer associated with the code blocks to an initial state, at least in part in response to a determination that the indicator indicates that the code blocks are new transmission blocks; and, to update the data buffer at least in part in response to a determination that the indicator indicates that at least one of the code blocks is a retransmission block and one or more previous acknowledgement/negative acknowledgement (ACK/NACK) bits associated with a plurality of previous code blocks have been correctly received by the base station.

Example 14 may include the subject matter of Example 13, and optionally, wherein the control module may generate one or more ACK/NACK bits indicating whether the code blocks are successfully/unsuccessfully received; and, a transceiver is further to transmit the ACK/NACK bits to the base station.

Example 15 may include the subject matter of any one of Examples 13-14, and optionally, wherein the control module may keep the data buffer unchanged, at least in part in response to a determination that the indicator indicates that at least one of the code blocks is a retransmission block and the previous ACK/NACK bits associated with the previous code blocks have not been correctly received by the base station.

Example 16 may include the subject matter of any one of Examples 13-15, and optionally, wherein the code blocks may be the same as the previous code blocks, if the indicator indicates that the previous ACK/NACK bits have not been correctly received by the base station.

Example 17 may include the subject matter of any one of Examples 13-16, and optionally, wherein a code block of the code blocks with a higher retransmission attempt according to any of the example embodiments 13-16 may be received at earlier orthogonal frequency division multiplexing (OFDM) symbols.

Example 18 may include the subject matter of any one of Examples 13-17, and optionally, wherein the data buffer comprises a one-bit new data indicator (NDI) field which is to indicate a code block of the code blocks is a new code block or a retransmitted code block.

Example 19 may include the subject matter of any one of Examples 13-18, and optionally, wherein the data buffer comprises a one-bit redundancy version (RV) field which is to indicate a channel coding combination of a code block of the code blocks.

Example 20 may include the subject matter of any one of Examples 13-19, and optionally, wherein the indicator comprises a reset indicator which is to indicate whether the code blocks are new transmission blocks or not.

5 Example 21 may include the subject matter of any one of Examples 13-20, and optionally, wherein the indicator comprises a ACK/NACK correct reception indicator which is to indicate whether the base station has correctly received the ACK/NACK bits or not.

Example 22 may include the subject matter of any one of Examples 13-18, and optionally, wherein the base station is an evolved Node B.

10 Example 23 may include a base station comprising: a transceiver to transmit a plurality of first code blocks and a first indicator to a user equipment (UE), wherein the first indicator is further to indicate whether the first code blocks are new transmission blocks or not; and receive, from the UE, one or more acknowledgement/negative acknowledgement (ACK/NACK) bits indicating whether the first code blocks have been
15 successfully received by the UE or not; and a control module to generate a second indicator to indicate whether the ACK/NACK bits have been correctly received by the base station or not.

Example 24 may include the subject matter of Example 23, and optionally, wherein the control module may further generate a plurality of second code blocks at least in part
20 in response to a determination that the ACK/NACK have been successfully received by the base station; and the transceiver is further to transmit the second code blocks to the UE.

Example 25 may include the subject matter of any one of Examples 23-24, and optionally, wherein the second indicator is further to indicate whether at least one of the second code blocks is a retransmission block or not.

25 Example 26 may include the subject matter of any one of Examples 23-25, and optionally, wherein a code block of the first code blocks with a higher retransmission attempt is transmitted at earlier orthogonal frequency division multiplexing (OFDM) symbols.

Example 27 may include the subject matter of any one of Examples 23-26, and
30 optionally, wherein the transceiver is further to retransmit the first code blocks at least in part in response to a determination that the second indicator indicates that the ACK/NACK bits haven't been successfully received by the base station.

Example 28 may include the subject matter of any one of Examples 23-27, and optionally, wherein the first indicator indicating that the first code blocks are new

transmission blocks is transmitted at least in part in response to a determination that a hybrid automatic repeat request (HARQ) process is too complex.

Example 29 may include the subject matter of any one of Examples 23-28, and optionally, wherein the base station is an evolved Node B.

5 Example 30 may include a method, to be employed by a base station, comprising: segmenting a transport block (TB) into one or more sub-transport blocks (STBs), at least in part based on an acknowledgement/negative acknowledgement (ACK/NACK) parameter, wherein a STB of the STBs may comprise one or more code blocks of the TB; attaching one or more first-level cyclical redundancy check (CRC) bits to each of the
10 STBs; and transmitting the TB with the first-level CRC bits to a user equipment (UE).

Example 31 may include the subject matter of Example 30, and optionally, further comprising: attaching one or more second-level CRC bits to each of the code blocks; and transmitting the second-level CRC bits to the UE.

15 Example 32 may include the subject matter of any one of Examples 30-31, and optionally, wherein the ACK/NACK parameter is to indicate a number of ACK/NACK bits for STB successful/unsuccessful reception feedback from the UE.

Example 33 may include the subject matter of any one of Examples 30-32, and optionally, wherein the ACK/NACK parameter is to indicate a number of the code blocks associated with an ACK/NACK bit for STB successful/unsuccessful reception feedback
20 from the UE.

Example 34 may include the subject matter of any one of Examples 30-33, and optionally, wherein the base station is an evolved Node B (eNB).

Example 35 may include a method, to be employed by a user equipment (UE), comprising: receiving, from a base station, a transport block (TB) and one or more first-
25 level cyclical redundancy check (CRC) bits, wherein the TB comprises one or more sub-transport blocks (STBs) and a STB of the STBs comprises one or more code blocks of the TB; generating one or more first-level ACK/NACK bits at least in part based on the first-level CRC bits associated with the STBs; and transmitting the first-level ACK/NACK bits to the base station.

30 Example 36 may include the subject matter of Examples 35, and optionally, further comprising: receiving one or more second-level CRC bits from the base station, wherein the second-level CRC bits are associated with the code blocks.

Example 37 may include the subject matter of any one of Examples 35-36, and optionally, further comprising: determining that at least one first-level NACK bit is

generated to indicate unsuccessful reception of at least one STB of the STBs; generating one or more second-level ACK/NACK bits at least in part based on the second-level CRC bits associated with the code blocks within the at least one STB; and transmitting the second-level ACK/NACK bits to the base station.

5 Example 38 may include the subject matter of any one of Examples 35-37, and optionally, wherein a number of the STBs is determined at least in part based on an acknowledgement/negative acknowledgement (ACK/NACK) parameter.

 Example 39 may include the subject matter of any one of Examples 35-38, and optionally, wherein the ACK/NACK parameter is to indicate a number of the first-level
10 ACK/NACK bits for STB successful/unsuccessful reception feedback from the receiver.

 Example 40 may include the subject matter of any one of Examples 35-39, and optionally, wherein the ACK/NACK parameter is to indicate a number of the code blocks associated with a first-level ACK/NACK bit of the first-level ACK/NACK bits.

 Example 41 may include the subject matter of any one of Examples 30-31, and
15 optionally, wherein the base station is an evolved Node B.

 Example 42 may include a method, to be employed by a user equipment (UE), comprising: receiving a plurality of code blocks and an indicator from a base station; resetting a data buffer associated with the code blocks to an initial state, at least in part in response to a determination that the indicator indicates that the code blocks are new
20 transmission blocks; and, updating the data buffer at least in part in response to a determination that the indicator indicates that at least one of the code blocks is a retransmission block and one or more previous acknowledgement/negative acknowledgement (ACK/NACK) bits associated with a plurality of previous code blocks have been correctly received by the base station.

25 Example 43 may include the subject matter of Examples 42, and optionally, further comprising: generating one or more ACK/NACK bits indicating whether the code blocks are successfully/unsuccessfully received; and transmitting the ACK/NACK bits to the base station.

 Example 44 may include the subject matter of any one of Examples 42-43, and
30 optionally, further comprising: keeping the data buffer unchanged, at least in part in response to a determination that the indicator indicates that at least one of the code blocks is a retransmission block and the previous ACK/NACK bits associated with the previous code blocks have not been correctly received by the base station.

Example 45 may include the subject matter of any one of Examples 42-44, and optionally, wherein the code blocks are the same as the previous code blocks, if the indicator indicates that the previous ACK/NACK bits have not been correctly received by the base station.

5 Example 46 may include the subject matter of any one of Examples 42-45, and optionally, wherein a code block of the code blocks with a higher retransmission attempt is received at earlier orthogonal frequency division multiplexing (OFDM) symbols.

Example 47 may include the subject matter of any one of Examples 42-46, and optionally, wherein the data buffer comprises a one-bit new data indicator (NDI) field
10 which is to indicate a code block of the code blocks is a new code block or a retransmitted code block.

Example 48 may include the subject matter of any one of Examples 42-47, and optionally, wherein the data buffer comprises a one-bit redundancy version (RV) field which is to indicate a channel coding combination of a code block of the code blocks.

15 Example 49 may include the subject matter of any one of Examples 42-48, and optionally, wherein the indicator comprises a reset indicator which is to indicate whether the code blocks are new transmission blocks or not.

Example 50 may include the subject matter of any one of Examples 42-49, and optionally, wherein the indicator comprises a ACK/NACK correct reception indicator
20 which is to indicate whether the base station has correctly received the ACK/NACK bits or not.

Example 51 may include the subject matter of any one of Examples 42-50, and optionally, the base station is an evolved Node B.

Example 52 may include a method, to be employed by a base station, comprising:
25 transmitting a plurality of first code blocks and a first indicator to a user equipment (UE), wherein the first indicator is further to indicate whether the first code blocks are new transmission blocks or not; receiving, from the UE, one or more acknowledgement/negative acknowledgement (ACK/NACK) bits indicating whether the first code blocks have been successfully received by the UE or not; and generating a
30 second indicator to indicate whether the ACK/NACK bits have been correctly received by the base station or not.

Example 53 may include the subject matter of Example 52, and optionally, further comprising: generating a plurality of second code blocks at least in part in response to a

determination that the ACK/NACK have been successfully received by the base station; and transmitting the second code blocks to the UE.

Example 54 may include the subject matter of any one of Examples 52-53, and optionally, wherein the second indicator is further to indicate whether at least one of the
5 second code blocks is a retransmission block or not.

Example 55 may include the subject matter of any one of Examples 52-54, and optionally, wherein a code block of the first code blocks with a higher retransmission attempt is transmitted at earlier orthogonal frequency division multiplexing (OFDM) symbols.

10 Example 56 may include the subject matter of any one of Examples 52-55, and optionally, further comprising: retransmitting the first code blocks at least in part in response to a determination that the second indicator indicates that the ACK/NACK bits haven't been successfully received by the base station.

Example 57 may include the subject matter of any one of Examples 52-56, and
15 optionally, wherein the first indicator indicating that the first code blocks are new transmission blocks is transmitted at least in part in response to a determination that a hybrid automatic repeat request (HARQ) process is too complex.

Example 58 may include the subject matter of any one of Examples 52-57, and optionally, wherein the base station is an evolved Node B.

20 Example 59 may comprise a computer-readable storage medium that stores instructions for execution by a processor to perform operations of a UE or a base station, the operations, when executed by the processor to execute any of the operations discussed above in any combination.

Example 60 may comprise an apparatus for a UE or a base station comprising
25 means for executing any of the operations discussed above in any combination.

Although certain embodiments have been illustrated and described herein for purposes of description, a wide variety of alternate and/or equivalent embodiments or implementations calculated to achieve the same purposes may be substituted for the embodiments shown and described without departing from the scope of the present
30 disclosure. This application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that embodiments described herein be limited only by the claims and the equivalents thereof.

CLAIMS:

What is claimed is:

1. An apparatus for a base station, comprising:
a control module to:
 - 5 segment a transport block (TB) into one or more sub-transport blocks (STBs), at least in part based on an acknowledgement/negative acknowledgement (ACK/NACK) parameter, wherein a STB of the STBs may comprise one or more code blocks of the TB; and
 - attach one or more first-level cyclical redundancy check (CRC) bits to each
 - 10 of the STBs.
2. The apparatus of claim 1, wherein the control module is further to attach one or more second-level CRC bits to each of the code blocks.
- 15 3. The apparatus of claim 1 or 2, wherein the ACK/NACK parameter is to indicate a number of ACK/NACK bits for STB successful/unsuccessful reception feedback from the UE.
4. The apparatus of claim 1 or 2, wherein the ACK/NACK parameter is to indicate a
- 20 number of the code blocks associated with an ACK/NACK bit for STB successful/unsuccessful reception feedback from a user equipment.
5. An apparatus of a user equipment (UE), comprising:
a control module to generate one or more first-level acknowledgement/negative
- 25 acknowledgement (ACK/NACK) bits at least in part based on one or more first-level cyclical redundancy check (CRC) bits associated with one or more sub-transport blocks (STBs) of a received transport block, wherein a STB of the STBs comprises one or more code blocks of the TB.
- 30 6. The apparatus of claim 5, further comprising a transceiver circuitry to:
receive the TB and the one or more first-level CRC bits from a base station;
transmit the first-level ACK/NACK bits to the base station; and

receive one or more second-level CRC bits from the base station, wherein the second-level CRC bits are associated with the code blocks.

7. The apparatus of claim 6, wherein the control module is further to:

5 determine that at least one first-level NACK bit is generated to indicate unsuccessful reception of at least one STB of the STBs; and

generate one or more second-level ACK/NACK bits at least in part based on the second-level CRC bits associated with the code blocks within the at least one STB; and wherein the transceiver is further to transmit the second-level ACK/NACK bits to the base
10 station.

8. The apparatus of claim 5 or 6, wherein a number of the STBs is determined at least in part based on an acknowledgement/negative acknowledgement (ACK/NACK) parameter.

15

9. The apparatus of claim 8, wherein the ACK/NACK parameter is to indicate a number of the first-level ACK/NACK bits for STB successful/unsuccessful reception feedback.

20

10. The apparatus of claim 8, wherein the ACK/NACK parameter is to indicate a number of the code blocks associated with a first-level ACK/NACK bit of the first-level ACK/NACK bits.

11. A user equipment (UE), comprising:

25

a transceiver to receive a plurality of code blocks and an indicator from a base station; and

a control module to:

reset a data buffer associated with the code blocks to an initial state, at least in part in response to a determination that the indicator indicates that the code
30 blocks are new transmission blocks; and

update the data buffer at least in part in response to a determination that the indicator indicates that at least one of the code blocks is a retransmission block and one or more previous acknowledgement/negative acknowledgement (ACK/NACK)

bits associated with a plurality of previous code blocks have been correctly received by the base station.

12. The UE of claim 11, wherein the control module is further to generate one or more
5 ACK/NACK bits indicating whether the code blocks are successfully/unsuccessfully received; and, the transceiver is further to transmit the ACK/NACK bits to the base station.

13. The UE of claim 11 or 12, wherein the control module is further to keep the data
10 buffer unchanged, at least in part in response to a determination that the indicator indicates that at least one of the code blocks is a retransmission block and the previous ACK/NACK bits associated with the previous code blocks have not been correctly received by the base station.

14. The UE of claim 13, wherein the code blocks are the same as the previous code
15 blocks, if the indicator indicates that the previous ACK/NACK bits have not been correctly received by the base station.

15. The UE of claim any of claims 11-14, wherein a code block of the code blocks
20 with a higher retransmission attempt is received at earlier orthogonal frequency division multiplexing (OFDM) symbols.

16. The UE of claim any of claims 11-15, wherein the data buffer comprises a one-bit
25 new data indicator (NDI) field which is to indicate a code block of the code blocks is a new code block or a retransmitted code block.

17. The UE of any of claims 11-16, wherein the data buffer comprises a one-bit
redundancy version (RV) field which is to indicate a channel coding combination of a code block of the code blocks.

30 18. The UE of any of claims 11-17, wherein the indicator comprises a reset indicator which is to indicate whether the code blocks are new transmission blocks or not.

19. The UE of any of claims 11-18, wherein the indicator comprises an ACK/NACK correct reception indicator which is to indicate whether the base station has correctly received the ACK/NACK bits or not.

5 20. A base station, comprising:

a transceiver to transmit a plurality of first code blocks and a first indicator to a user equipment (UE), wherein the first indicator is further to indicate whether the first code blocks are new transmission blocks or not; and receive, from the UE, one or more acknowledgement/negative acknowledgement (ACK/NACK) bits indicating whether the first code blocks have been successfully received by the UE or not; and

a control module to generate a second indicator to indicate whether the ACK/NACK bits have been correctly received by the base station or not.

15 21. The base station of claim 20, wherein the control module is further to generate a plurality of second code blocks at least in part in response to a determination that the ACK/NACK have been successfully received by the base station; and the transceiver is further to transmit the second code blocks to the UE.

20 22. The base station of claim 21, wherein the second indicator is further to indicate whether at least one of the second code blocks is a retransmission block or not.

25 23. The base station of any of claims 20-22, wherein a code block of the first code blocks with a higher retransmission attempt is transmitted at earlier orthogonal frequency division multiplexing (OFDM) symbols.

24. The base station of any of claims 20-23, wherein the transceiver is further to retransmit the first code blocks at least in part in response to a determination that the second indicator indicates that the ACK/NACK bits haven't been successfully received by the base station.

30 25. The base station of any of claims 20-24, wherein the first indicator indicating that the first code blocks are new transmission blocks is transmitted at least in part in response to a determination that a hybrid automatic repeat request (HARQ) process is too complex.

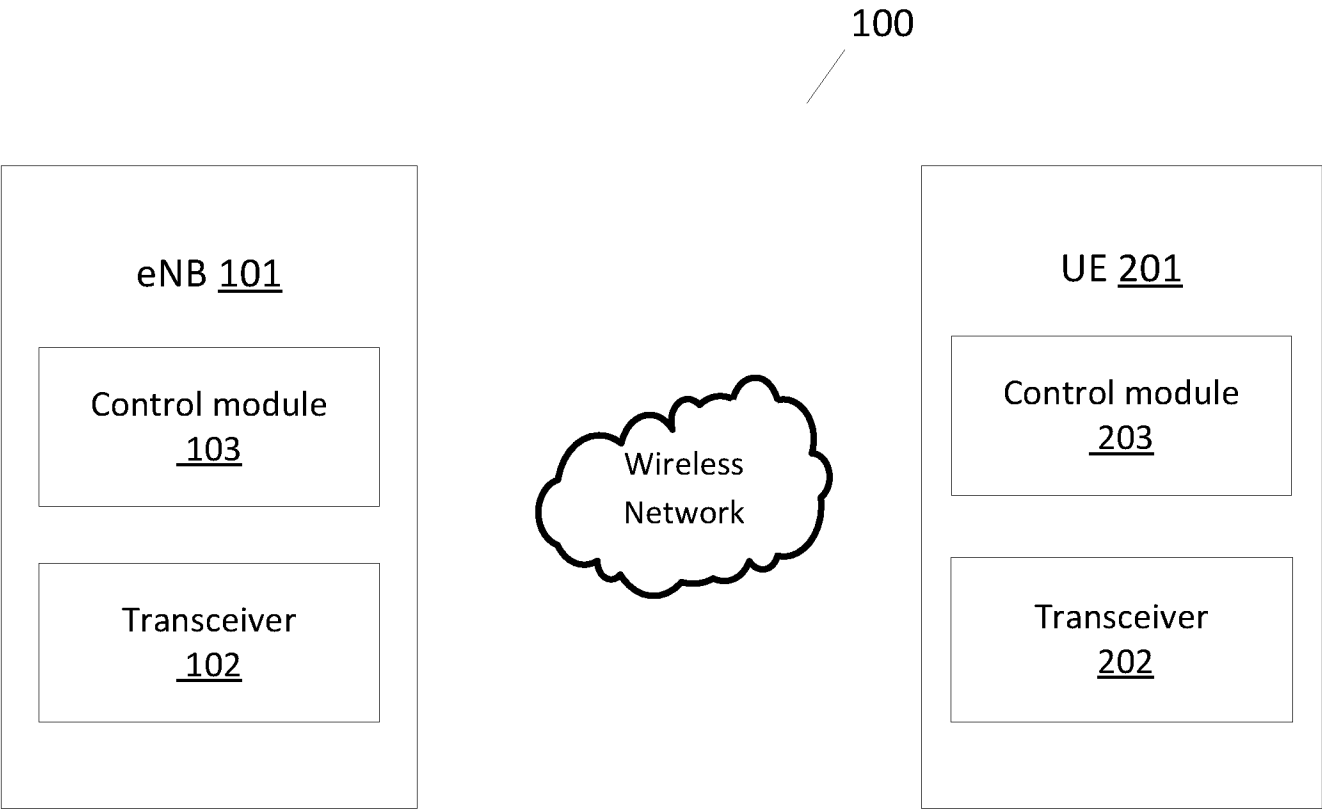


Fig.1

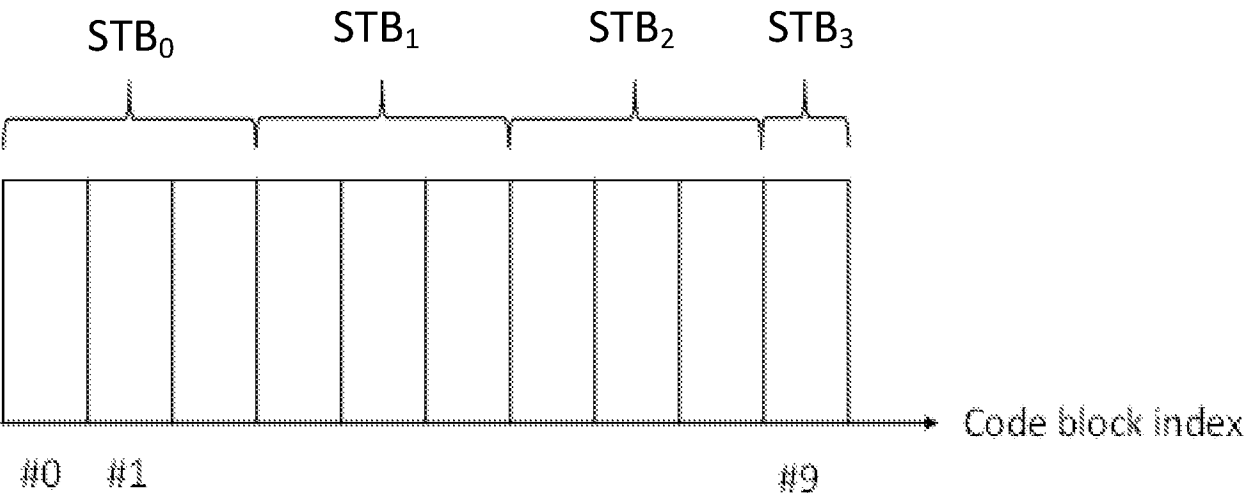


Fig.2

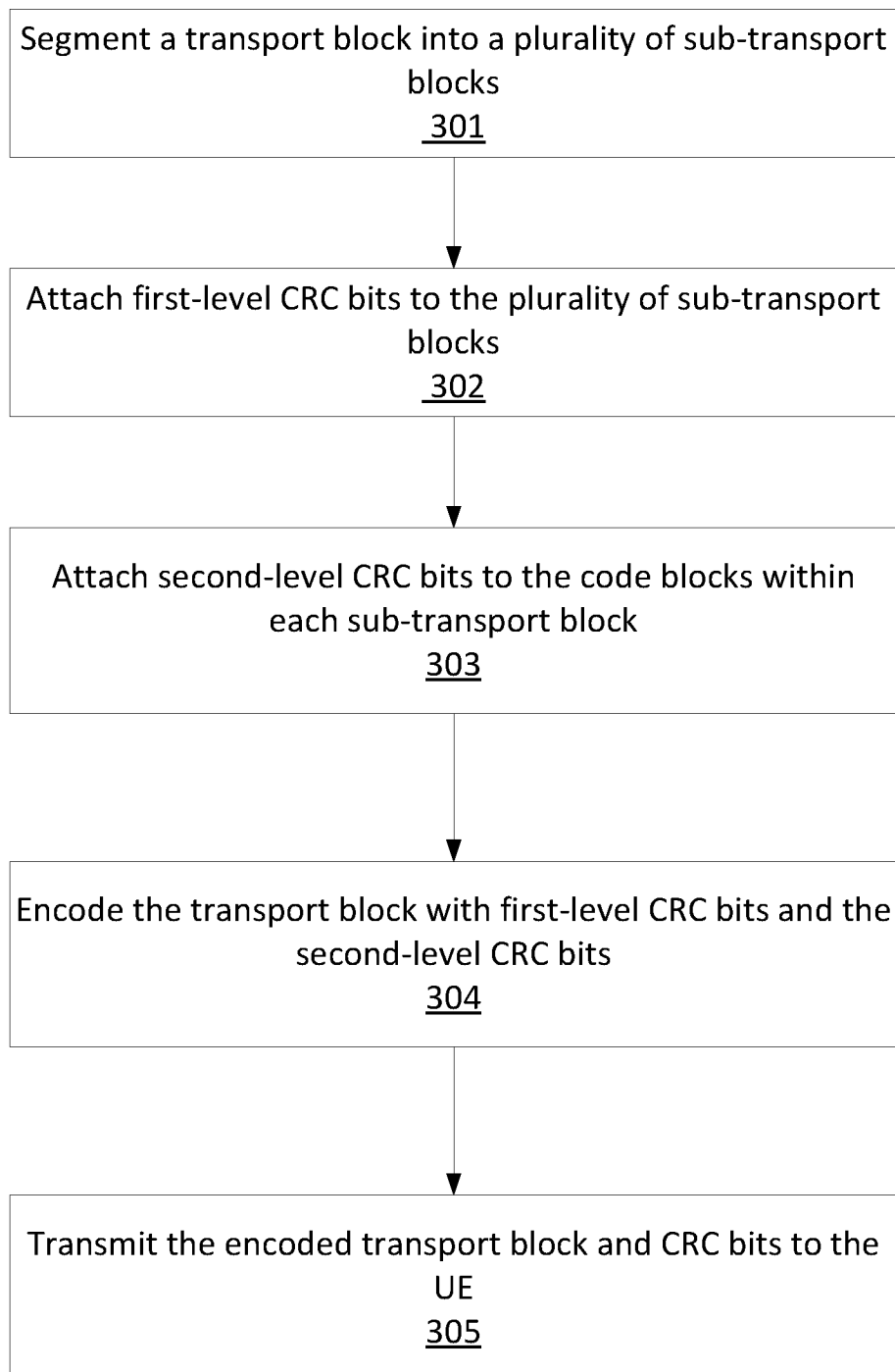


Fig. 3

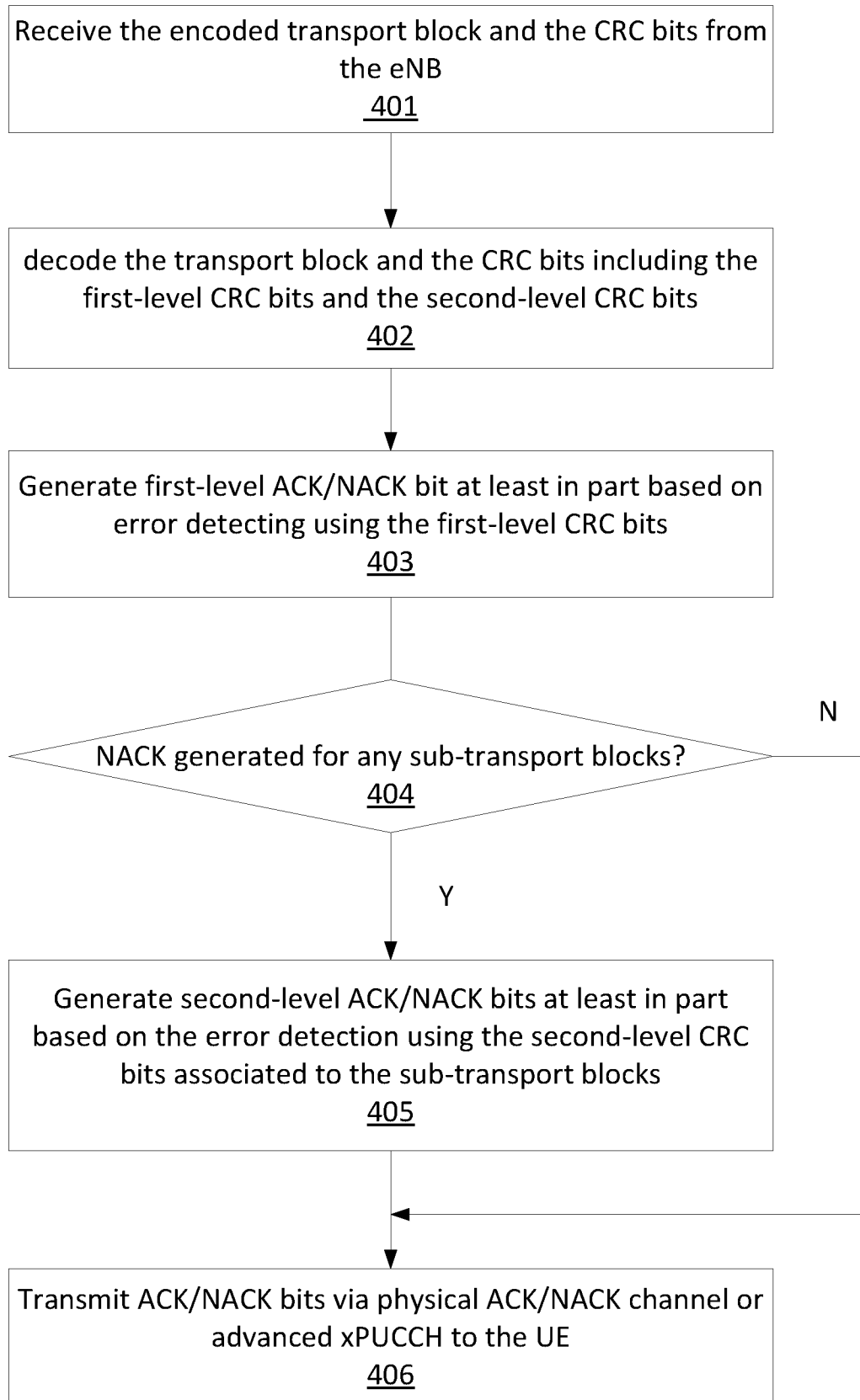


Fig. 4

eNB 101

UE 201

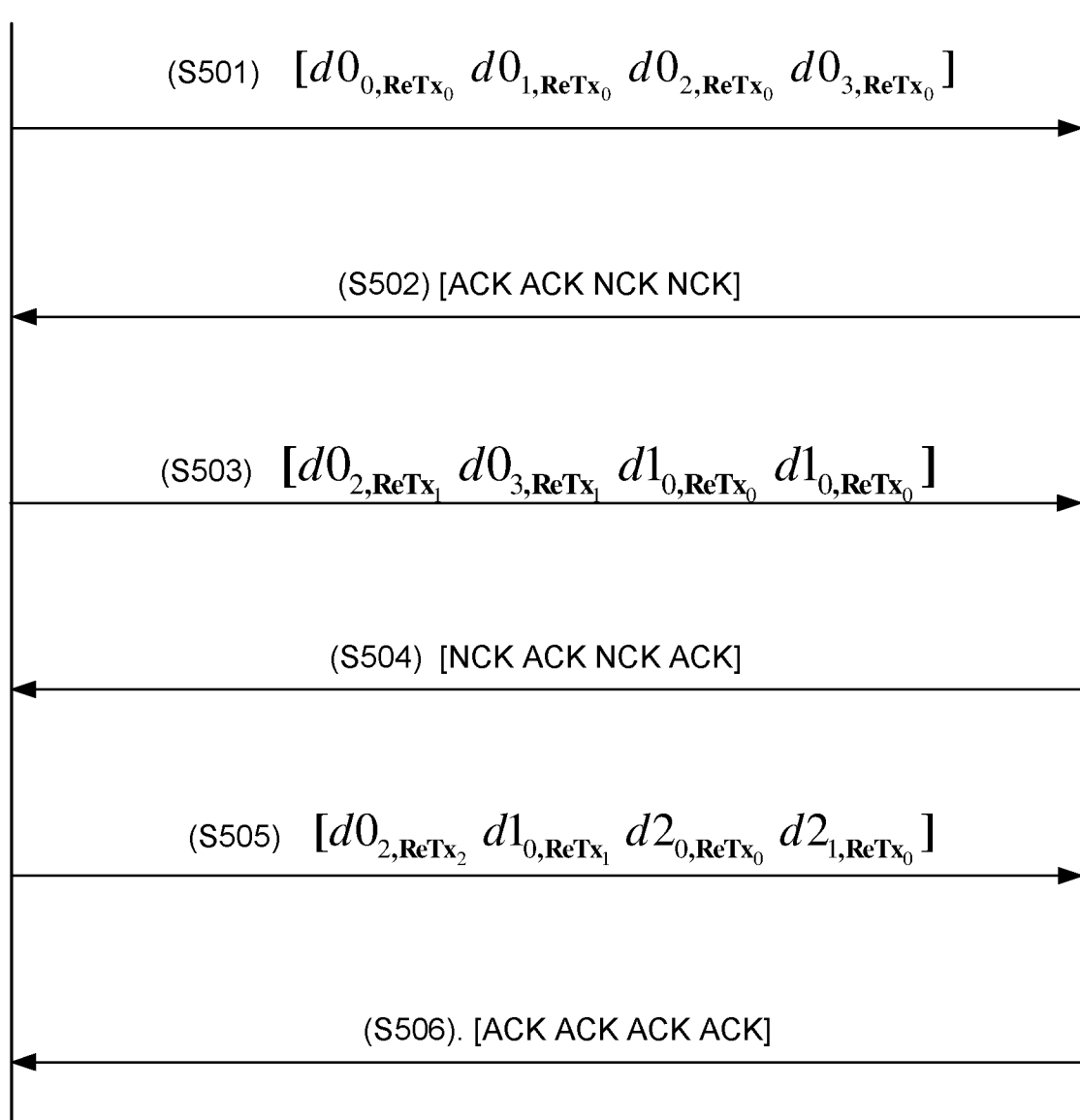


Fig.5

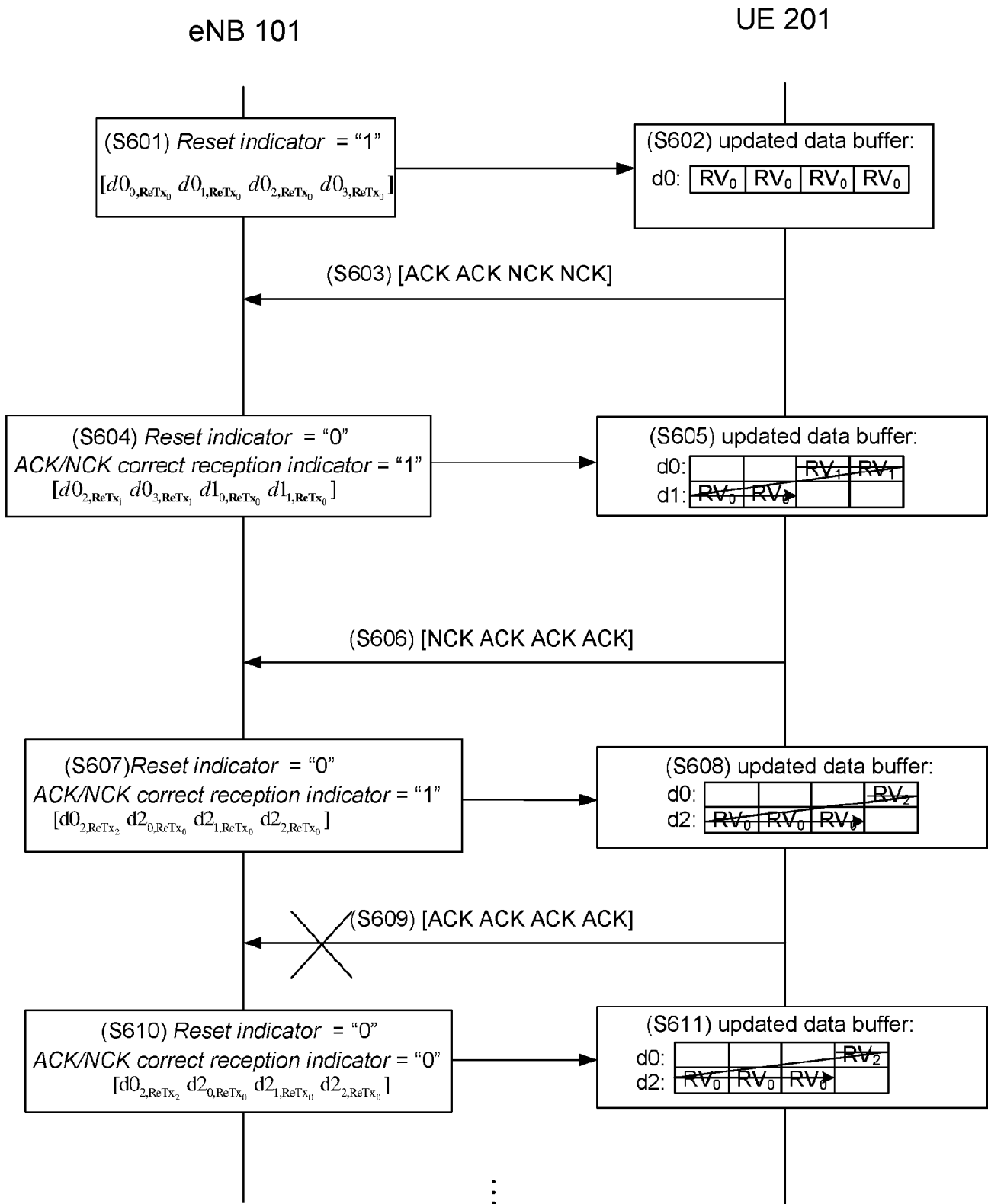


Fig.6

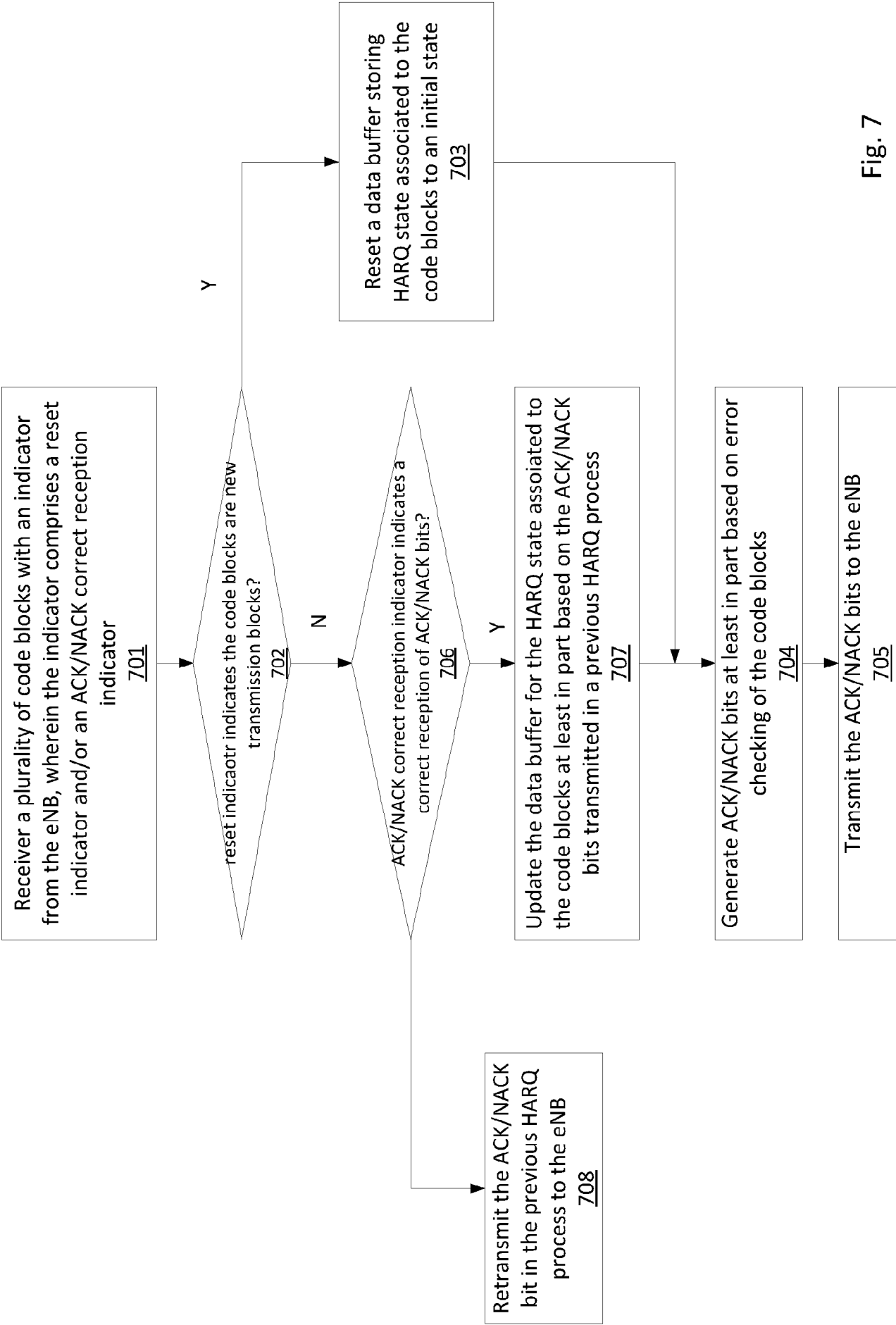


Fig. 7

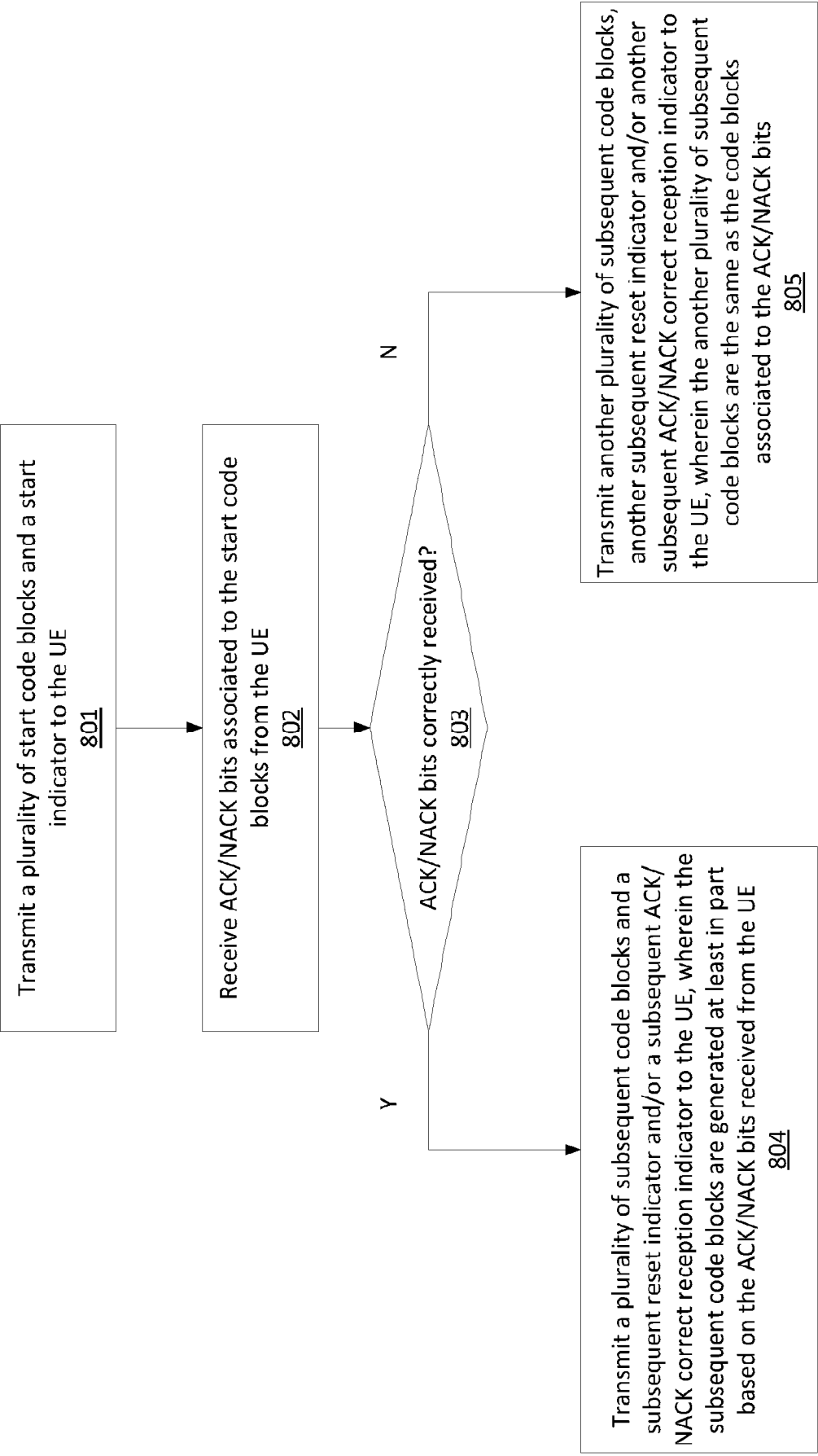


Fig.8

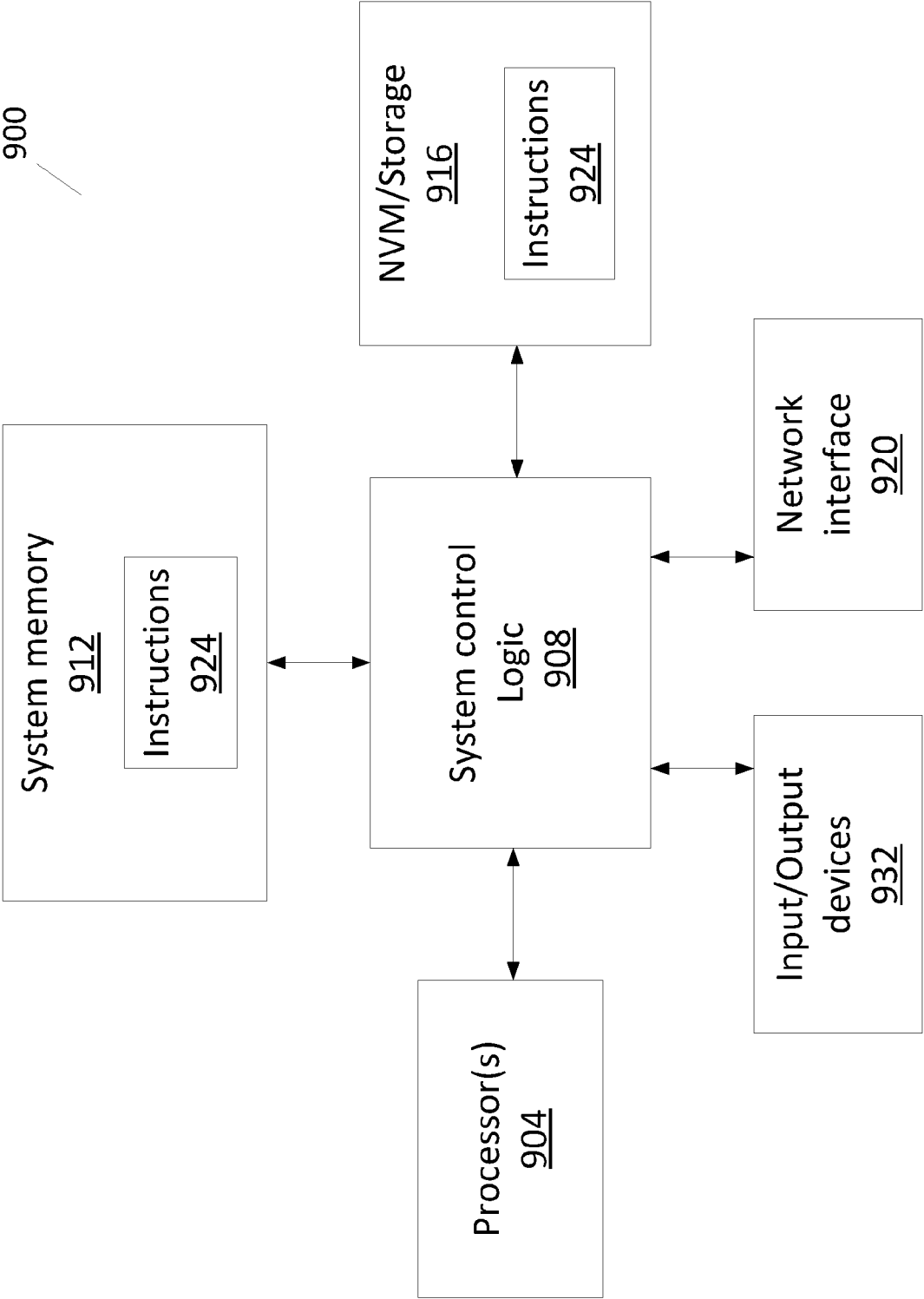


Fig. 9

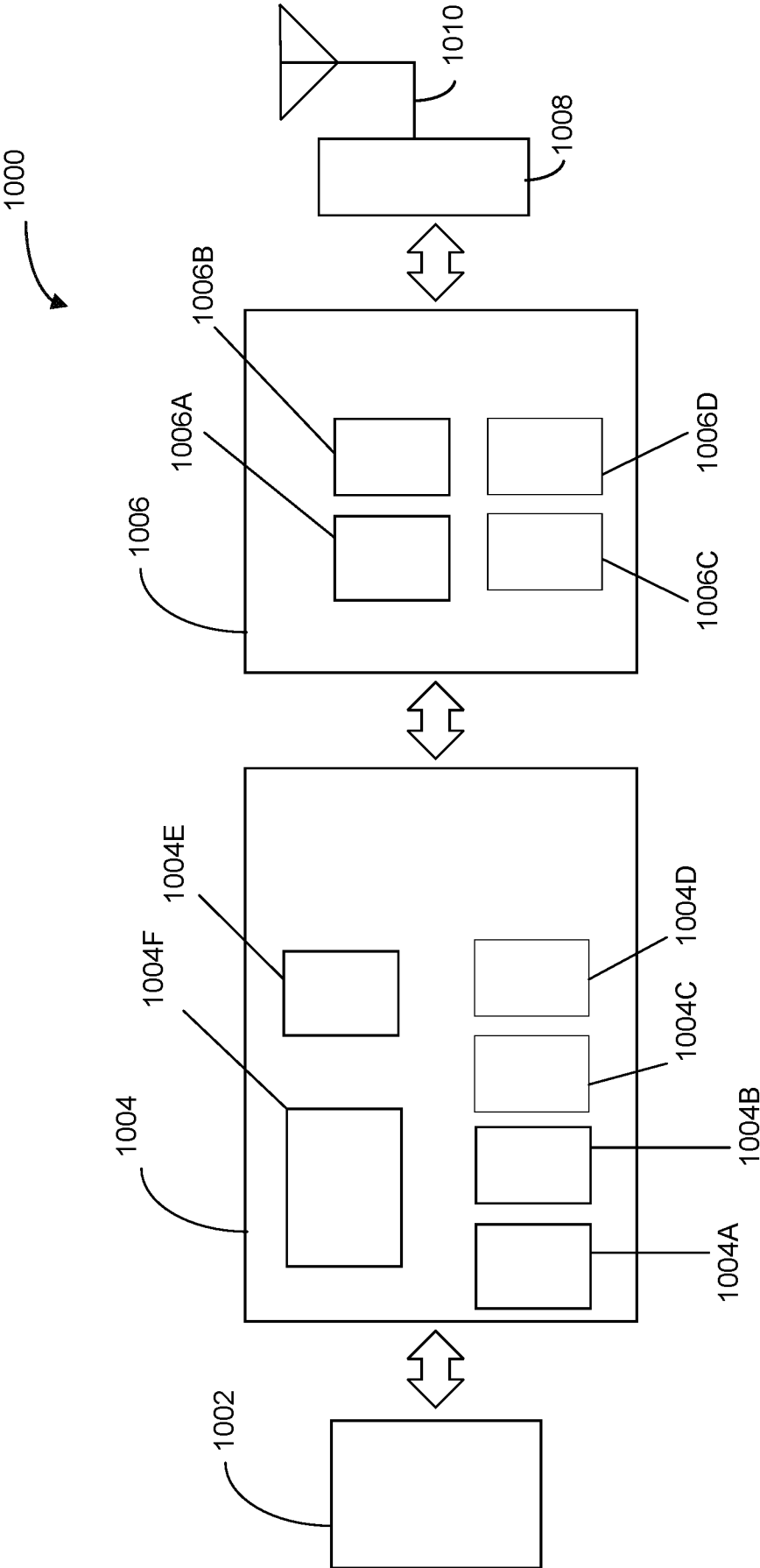


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2016/077422

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; G06F

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)

CNTXT, CNABS, CNKI, VEN: transport block, sub w transport block, segment, divid+, acknowledgement, negative, cyclical redundancy check, ACK, NACK, CRC, indicat+, buffer, new, retransmission, retransmit+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 101034959 A (HUAWEI TECHNOLOGIES CO., LTD.) 12 September 2007 (2007-09-12) description, pages 1-12 and figures 1-3	1-10
A	CN 103037513 A (ALCATEL-LUCENT SHANGHAI BELL CO., LTD.) 10 April 2013 (2013-04-10) the whole document	1-25
A	CN 101784077 A (ZTE CORP.) 21 July 2010 (2010-07-21) the whole document	1-25
A	US 2015092633 A1 (SAMSUNG ELECTRONICS CO., LTD.) 02 April 2015 (2015-04-02) the whole document	1-25

☐ 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

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