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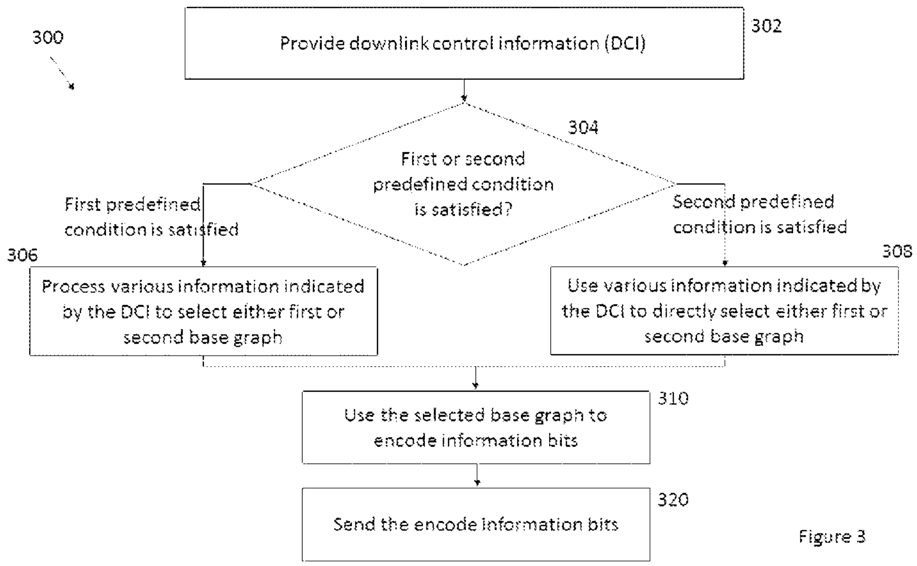

Figure 3

(57) Abstract: A system and method for allocating network resources are disclosed herein. In one embodiment, the system and method are configured to perform: determining a redundancy version and a new data indicator indicated by control information; determining a base graph of a low density parity check code based on which of a plurality of predefined conditions the redundancy version, and/or the new data indicator satisfy; and sending a signal comprising information bits that are encoded based on the determined base graph of the low density parity check code.

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SPECIFICATION

SYSTEM AND METHOD FOR PROCESSING CONTROL INFORMATION

TECHNICAL FIELD

The disclosure relates generally to wireless communications and, more particularly, to systems and methods for processing a signal containing control information.

BACKGROUND

In a communication system, a transmitter may encode a packet of data, also known as information bits, to obtain encoded bits, interleave the encoded bits, and map the interleaved bits to modulation symbols. The transmitter may then process and transmit the modulation symbols via a communication channel. The communication channel may distort the data transmission with a particular channel response and further degrade the data transmission with noise and interference. A receiver may obtain received symbols, which may be distorted and degraded versions of the transmitted modulation symbols. The receiver may process the received symbols to recover the transmitted information bits.

The encoding by the transmitter may allow the receiver to reliably recover the transmitted information bits with the degraded received symbols. The transmitter may perform encoding based on a Forward Error Correction (FEC) code that generates redundancy in the code bits, which is typically associated with a Hybrid Automatic Repeat Request (HARQ) technique. The receiver may utilize the redundancy to improve the likelihood of recovering the transmitted information bits.

Various types of FEC codes may be used for encoding. Some common types of FEC codes include convolutional code, Turbo code, and Low Density Parity Check (LDPC) code. A convolutional code or a Turbo code can encode a packet of k information bits and generate a coded packet of approximately r times k code bits, where 1/r is the code rate of the convolutional or Turbo code. A convolutional code can readily encode a packet of any size by passing each information bit through an encoder that can operate on one information bit at a time. A Turbo code can also support different packet sizes by employing two constituent encoders that can operate on one information bit at a time and a code interleaver that can support different packet sizes. An LDPC code may have better performance than convolutional and Turbo codes under certain operating conditions. An example of the LDPC code, typically known as a quasi-cyclic LDPC (QC-LDPC) code, that presents a constructive characteristic thereby allowing low-complexity encoding has gained particular attention.

In a New Radio (NR) communication system, when the transmitter and receiver respectively use the QC-LDPC code for encoding and decoding information bits, two predefined base graphs (BG's), typically known as BG1 (Base Graph 1) and BG2 (Base Graph 2), would be used, wherein the BG1 and BG2 correspond to respective base matrixes. For example, the transmitter selects one of BG1 and BG2 to be used based on various conditions (e.g., a code rate, a modulation order, etc.), lifts the selected BG to retrieve a parity check matrix, and uses the retrieved parity check matrix to encode the information bits to obtain an LDPC codeword. The receiver, on the other end, generally follows the similar operations (e.g., using one of BG1 and BG2) to decode and obtain the information bits.

In some cases, however, the transmitter and receiver may not use a same BG to encode and decode the information bits, respectively. For example, due to distortion or delay of the communication channel, when the receiver misses first transmitted information bits, the receiver may mistakenly treat retransmitted information bits as the first transmitted information bits. As such, the receiver may determine a wrong BG to decode the information bits, which may wrongly decode the information bits. Thus, existing systems and methods to encode and decode information bits using the QC-LDPC code are not entirely satisfactory.

SUMMARY OF THE INVENTION

The exemplary embodiments disclosed herein are directed to solving the issues relating to one or more of the problems presented in the prior art, as well as providing additional features that will become readily apparent by reference to the following detailed description when taken in conjunction with the accompany drawings. In accordance with various embodiments, exemplary systems, methods, devices and computer program products are disclosed herein. It is understood, however, that these embodiments are presented by way of example and not limitation, and it will be apparent to those of ordinary skill in the art who read the present disclosure that various modifications to the disclosed embodiments can be made while remaining within the scope of the invention.

In one embodiment, a method includes: determining a redundancy version and a new data indicator indicated by control information; determining a base graph of a low density parity check code based on which of a plurality of predefined conditions the redundancy version, and/or the new data indicator satisfy; and sending a signal comprising information bits that are encoded based on the determined base graph of the low density parity check code.

In yet another embodiment, a method includes: receiving control information indicative of a redundancy version and a current logic state of a new data indicator; determining a base graph of a low density parity check code based on which of a plurality of predefined conditions the redundancy version, and/or the new data indicator satisfy; and retrieving information bits from a received signal using the determined base graph of the low density parity check code.

BRIEF DESCRIPTION OF THE DRAWINGS

Various exemplary embodiments of the invention are described in detail below with reference to the following Figures. The drawings are provided for purposes of illustration only and merely depict exemplary embodiments of the invention to facilitate the reader's understanding of the invention. Therefore, the drawings should not be considered limiting of the breadth, scope, or applicability of the invention. It should be noted that for clarity and ease of illustration these drawings are not necessarily drawn to scale.

Figure 1 illustrates an exemplary cellular communication network in which techniques disclosed herein may be implemented, in accordance with an embodiment of the present disclosure.

Figure 2 illustrates block diagrams an exemplary base station and a user equipment device, in accordance with some embodiments of the present disclosure.

Figure 3 illustrates a flow chart of an exemplary method to transmit information bits encoded by a QC-LDPC code, in accordance with some embodiments of the present disclosure.

Figure 4 illustrates an exemplary diagram showing how a base graph 1 and a base graph each corresponds to a transport block size and a code rate, in accordance with some embodiments of the present disclosure.

Figure 5 illustrates a flow chart of an exemplary method to retrieve information bits from a signal encoded by a QC-LDPC code, in accordance with some embodiments of the present disclosure.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Various exemplary embodiments of the invention are described below with reference to the accompanying figures to enable a person of ordinary skill in the art to make and use the invention. As would be apparent to those of ordinary skill in the art, after reading the present disclosure, various changes or modifications to the examples described herein can be made without departing from the scope of the invention. Thus, the present invention is not limited to the exemplary embodiments and applications described and illustrated herein. Additionally, the specific order or hierarchy of steps in the methods disclosed herein are merely exemplary approaches. Based upon design preferences, the specific order or hierarchy of steps of the disclosed methods or processes can be re-arranged while remaining within the scope of the present invention. Thus, those of ordinary skill in the art will understand that the methods and techniques disclosed herein present various steps or acts in a sample order, and the invention is not limited to the specific order or hierarchy presented unless expressly stated otherwise.

Figure 1 illustrates an exemplary wireless communication network 100 in which techniques disclosed herein may be implemented, in accordance with an embodiment of the present disclosure. The exemplary communication network 100 includes a base station 102 (hereinafter "BS 102") and a user equipment device 104 (hereinafter "UE 104") that can communicate with each other via a communication link 110 (e.g., a wireless communication channel), and a cluster of notional cells 126, 130, 132, 134, 136, 138 and 140 overlaying a geographical area 101. In Figure 1, the BS 102 and UE 104 are contained within the geographic boundary of cell 126. Each of the other cells 130, 132, 134, 136, 138 and 140 may include at least one base station operating at its allocated bandwidth to provide adequate radio coverage to its intended users. For example, the base station 102 may operate at an allocated channel transmission bandwidth to provide adequate coverage to the UE 104. The base station 102 and the UE 104 may communicate via a downlink radio frame 118, and an uplink radio frame 124 respectively. Each radio frame 118/124 may be further divided into sub-frames 120/127 which may include data symbols 122/128. In the present disclosure, the BS 102 and UE 104 are described herein as non-limiting examples of "communication nodes," generally, which can practice the methods disclosed herein. Such communication nodes may be capable of wireless and/or wired communications, in accordance with various embodiments of the invention.

Figure 2 illustrates a block diagram of an exemplary wireless communication system 200 for transmitting and receiving wireless communication signals, e.g., OFDM/OFDMA signals, in accordance with some embodiments of the invention. The system 200 may include components and elements configured to support known or conventional operating features that need not be described in detail herein. In one exemplary embodiment, system 200 can be used to transmit and receive data symbols in a wireless communication environment such as the wireless communication environment 100 of Figure 1, as described above.

System 200 generally includes a base station 202 (hereinafter "BS 202") and a user equipment device 204 (hereinafter "UE 204"). The BS 202 includes a BS (base station) transceiver module 210, a BS antenna 212, a BS processor module 214, a BS memory module 216, and a network communication module 218, each module being coupled and interconnected with one another as necessary via a data communication bus 220. The UE 204 includes a UE (user equipment) transceiver module 230, a UE antenna 232, a UE memory module 234, and a UE processor module 236, each module being coupled and interconnected with one another as necessary via a data communication bus 240. The BS 202 communicates with the UE 204 via a communication channel 250, which can be any wireless channel or other medium known in the art suitable for transmission of data as described herein.

As would be understood by persons of ordinary skill in the art, system 200 may further include any number of modules other than the modules shown in Figure 2. Those skilled in the art will understand that the various illustrative blocks, modules, circuits, and processing logic described in connection with the embodiments disclosed herein may be implemented in hardware, computer-readable software, firmware, or any practical combination thereof. To clearly illustrate this interchangeability and compatibility of hardware, firmware, and software, various illustrative components, blocks, modules, circuits, and steps are described generally in terms of their functionality. Whether such functionality is implemented as hardware, firmware, or software depends upon the particular application and design constraints imposed on the overall system. Those familiar with the concepts described herein may implement such functionality in a suitable manner for each particular application, but such implementation decisions should not be interpreted as limiting the scope of the present invention.

In accordance with some embodiments, the UE transceiver 230 may be referred to herein as an "uplink" transceiver 230 that includes a RF transmitter and receiver circuitry that are each coupled to the antenna 232. A duplex switch (not shown) may alternatively couple the uplink transmitter or receiver to the uplink antenna in time duplex fashion. Similarly, in accordance with some embodiments, the BS transceiver 210 may be referred to herein as a "downlink" transceiver 210 that includes RF transmitter and receiver circuity that are each coupled to the antenna 212. A downlink duplex switch may alternatively couple the downlink transmitter or receiver to the downlink antenna 212 in time duplex fashion. The operations of the two transceivers 210 and 230 are coordinated in time such that the uplink receiver is coupled to the uplink antenna 232 for reception of transmissions over the wireless transmission link 250 at the same time that the downlink transmitter is coupled to the downlink antenna 212. Preferably there is close time synchronization with only a minimal guard time between changes in duplex direction.

The UE transceiver 230 and the base station transceiver 210 are configured to communicate via the wireless data communication link 250, and cooperate with a suitably configured RF antenna arrangement 212/232 that can support a particular wireless communication protocol and modulation scheme. In some exemplary embodiments, the UE transceiver 608 and the base station transceiver 602 are configured to support industry standards such as the Long Term Evolution (LTE) and emerging 5G standards, and the like. It is understood, however, that the invention is not necessarily limited in application to a particular standard and associated protocols. Rather, the UE transceiver 230 and the base station transceiver 210 may be configured to support alternate, or additional, wireless data communication protocols, including future standards or variations thereof.

In accordance with various embodiments, the BS 202 may be an evolved node B (eNB), a serving eNB, a target eNB, a femto station, or a pico station, for example. In some embodiments, the UE 204 may be embodied in various types of user devices such as a mobile phone, a smart phone, a personal digital assistant (PDA), tablet, laptop computer, wearable computing device, etc. The processor modules 214 and 236 may be implemented, or realized, with a general purpose processor, a content addressable memory, a digital signal processor, an application specific integrated circuit, a field programmable gate array, any suitable programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof, designed to perform the functions described herein. In this manner, a processor may be realized as a microprocessor, a controller, a microcontroller, a state machine, or the like. A processor may also be implemented as a combination of computing devices, e.g., a combination of a digital signal processor and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a digital signal processor core, or any other such configuration.

Furthermore, the steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in firmware, in a software module executed by processor modules 214 and 236, respectively, or in any practical combination thereof. The memory modules 216 and 234 may be realized as RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, a hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. In this regard, memory modules 216 and 234 may be coupled to the processor modules 210 and 230, respectively, such that the processors modules 210 and 230 can read information from, and write information to, memory modules 216 and 234, respectively. The memory modules 216 and 234 may also be integrated into their respective processor modules 210 and 230. In some embodiments, the memory modules 216 and 234 may each include a cache memory for storing temporary variables or other intermediate information during execution of instructions to be executed by processor modules 210 and 230, respectively. Memory modules 216 and 234 may also each include non-volatile memory for storing instructions to be executed by the processor modules 210 and 230, respectively.

The network communication module 218 generally represents the hardware, software, firmware, processing logic, and/or other components of the base station 202 that enable bi-directional communication between base station transceiver 602 and other network components and communication nodes configured to communication with the base station 202. For example, network communication module 218 may be configured to support internet or WiMAX traffic. In a typical deployment, without limitation, network communication module 218 provides an 802.3 Ethernet interface such that base station transceiver 210 can communicate with a conventional Ethernet based computer network. In this manner, the network communication module 218 may include a physical interface for connection to the computer network (e.g., Mobile Switching Center (MSC)). The terms “configured for,” “configured to” and conjugations thereof, as used herein with respect to a specified operation or function, refer to a device, component, circuit, structure, machine, signal, etc., that is physically constructed, programmed, formatted and/or arranged to perform the specified operation or function.

Referring again to Figure 1, as discussed above, when a transmitter (e.g., the BS 102) uses a BG (base graph) of a QC-LDPC code to encode information bits and transmit to a receiver (e.g., the UE 104), the UE 104 may mistakenly use a wrong (e.g., inconsistent) BG to decode the information bits, wherein such encoded information bits has been retransmitted as the UE 104 misses a first transmission. In this regard, the present disclosure provides various embodiments of systems and methods to use downlink control information (DCI), which is transmitted from a BS and received by a UE, to cause the BS and UE to use a consistent BG to encode and decode information bits, respectively. More specifically, in accordance with some embodiments, the BS and UE may respectively use various information contained in the DCI to accurately determine the correct BG by checking whether the various information satisfies either a first or second predefined condition.

Figure 3 illustrates a flow chart of an exemplary method 300 performed by a BS to transmit information bits encoded by a QC-LDPC code, in accordance with some embodiments. The illustrated embodiment of the method 300 is merely an example. Therefore, it should be understood that any of a variety of operations may be omitted, re-sequenced, and/or added while remaining within the scope of the present disclosure.

In some embodiments, the method 300 starts with operation 302 in which downlink control information (DCI) is provided. According to some embodiments, the DCI includes various information such as, for example, a modulation and coding scheme (MCS) index (hereinafter "I_{MCS}"), a new data indicator (hereinafter "NDI"), a redundancy version (hereinafter "RV"), a number of physical resource blocks (hereinafter "PRB"), etc. The RV as used herein is typically referred to redundancy bits when HARQ is used to retransmit information bits. Next, the method 300 proceeds to determination operation 304 in which the BS determines whether a first or second predefined condition is satisfied. In some embodiments, the first predefined condition includes at least one of the following: whether the RV is equal to RV0, whether a current logic state of the NDI is equal to a logic "0," and whether the NDI presents a transition to a different logic state (e.g., whether the NDI has been toggled to a value different from a previously transmitted value, which indicates a first transmission); and the second predefined condition includes at least one of the following: whether the RV is equal to RV1, RV2, or RV3, whether a current logic state of the NDI is equal to a logic "1," and whether the NDI lacks a transition to a different logic state (e.g., whether the NDI has not been toggled to a value different from a previously transmitted value, which indicates a retransmission). In some embodiments, the presence of the NDI transition is typically referred to as a " toggled NDI," and the lack of the NDI transition is typically referred to as a "non-toggled NDI." When the first predefined condition is satisfied, the method 300 proceeds to operation 306; and when the second predefined condition is satisfied, the method 300 proceeds to operation 308. In some embodiments, in operation 306, the BS is configured to process the various information contained in the DCI to select one from the above-mentioned BG1 and BG2 that are predefined by the QC-LDPC code; and on the other hand, in operation 308, the BS is configured to use the various information contained in the DCI to directly select one from the above-mentioned BG1 and BG2 (i.e., no further processing on the various information). After the BG is selected either at operation 306 or 308, the method 300 continues to operation 310 in which the BS uses the selected BG to encode information bits. In some embodiments, in operation 310, in addition to at least one encoding process using the selected BG being performed, one or more further steps (e.g., a rate matching step, a interleaving step, a symbol modulation step, etc.) may be performed after the information bits have been encoded. The method 300 continues to operation 312 in which the BS sends the encoded information bits. As mentioned above, since one or more further steps are performed after the information bits are encoded, in some embodiments, the BS may send the encoded information bits as one or more symbols.

In some embodiments, when the first predefined condition is satisfied (operation 306), i.e., the RV being equal to RV0, the current logic state of the NDI being equal to a logic 0, and/or the NDI transitioning to a different logic state, the BS uses the I_{MCS} (indicated by the DCI) to determine a modulation order (Q_m) and a code rate (R). More specifically, the BS may refer to a predefined table (e.g., Table 1 as shown below) to determine which modulation order and code rate that the I_{MCS} corresponds to.

MCS Index I_{MCS}	Modulation Order Q_m	Code Rate R × [1024]
0	2	121
1	2	171
2	2	120
3	2	156.5
4	2	193
5	2	250.5
6	2	308
7	2	378.5
8	2	449
9	2	525.5
10	4	602
11	4	679
12	4	756
13	4	378
14	4	434
15	4	490
16	4	553
17	6	616
18	6	657.5
19	6	699
20	6	774.75
21	6	850.5
22	6	924.75
23	6	616.5
24	6	666

25	6	719
26	6	772
27	6	822.5
28	6	873
29	2	reserved
30	4	
31	6	

Table 1

As shown in Table 1, there are a total of 32 different values of I_{MCS}. In some embodiments, such 32 different values of I_{MCS} may be grouped into a plurality of subsets: I_{MCS}Set0 and I_{MCS}Set1. For example, I_{MCS}Set0 may be presented as I_{MCS}Set0={0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28} and I_{MCS}Set1 may be presented as I_{MCS}Set1={29, 30, 31}. It is noted that I_{MCS}Set0 and I_{MCS}Set1 have no intersection, and I_{MCS}Set0 and I_{MCS}Set1 form a union. In some embodiments, I_{MCS}Set1 may be grouped for retransmission data or for reserved use.

According to I_{MCS} (indicated by the DCI), a single combination of the modulation order (Q_m) and code rate (R) can be determined. Accordingly, the BS uses the PRB (also indicated by the DCI) to estimate a number of Resource Elements (N_{RE}), and determine a layer parameter "v," wherein such v is synonymous with "stream." In particular, for a Multiple-Input-Multiple-Output (MIMO) BS, at least two layers (i.e., v = 2) may be used, and such v is always less than or equal to a number of antennas of the MIMO BS. In some embodiments, the BS can use Q_m, R, N_{RE}, and v to determine a transport block size (TBS). More specifically, TBS = floor (TBS'/8) × 8, wherein TBS' = $N_{RE} \times v \times Q_m \times R$, and "floor" represents a floor function $\lfloor x \rfloor$ that gives the largest integer less than or equal to x. After the BS estimates TBS, in some embodiments, the BS can use R and TBS to select either BG1 or BG2, which will be discussed below with respect to Figure 4.

Figure 4 illustrates an exemplary diagram showing how BG1 and BG2 each corresponds to the TBS and R, in accordance with various embodiments. As shown in Figure 4, the BS may determine the BG to be used as BG1 when estimated TBS is between 292 and 3824 and estimated R is greater than 2/3, or when estimated TBS is greater than 3824 and estimated R is greater than 1/4; and the BS may determine the BG to be used as BG2 when estimated TBS is less than 292, when estimated TBS is between 292 and 3824 and estimated R is less than 2/3, or when estimated TBS is greater than 3824 and estimated R is less than 1/4.

On the other hand, in some embodiments, when the second predefined condition is satisfied (operation 308), i.e., the RV being equal to RV1, RV2, or RV3, the current logic state of the NDI being equal to a logic 1, and/or the NDI not transitioning to a different logic state, the BS uses the I_{MCS} (indicated by the DCI) to directly select either BG1 or BG2.

In an embodiment, the BS groups the 32 different values of I_{MCS} into a plurality of subsets: I_{MCS}Set2, I_{MCS}Set3, and I_{MCS}Set4. When the I_{MCS} (indicated by the DCI) belongs to I_{MCS}Set2, the BS selects the BG1; and when the I_{MCS} (indicated by the DCI) belongs to I_{MCS}Set3, the BS selects the BG2, wherein I_{MCS}Set4 may be grouped for retransmission data or for reserved use.

In an example, I_{MCS}Set2 may be grouped as each I_{MCS} in I_{MCS}Set2 being an even integer, i.e., I_{MCS}Set2={0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28}, I_{MCS}Set3 may be grouped as each I_{MCS} in I_{MCS}Set3 being an odd integer, i.e., I_{MCS}Set3={1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27}, and the reserved I_{MCS}Set4={29, 30, 31}. Alternatively, I_{MCS}Set3 may be grouped as each I_{MCS} in I_{MCS}Set3 being an even integer, i.e., I_{MCS}Set3={0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28}, I_{MCS}Set2 may be grouped as each I_{MCS} in I_{MCS}Set2 being an odd integer, i.e., I_{MCS}Set2={1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27}, and the reserved I_{MCS}Set4={29, 30, 31}. It is noted that any two of I_{MCS}Set2, I_{MCS}Set3, and I_{MCS}Set4 have no intersection, and I_{MCS}Set2, I_{MCS}Set3, and I_{MCS}Set4 form a union.

In another example, the grouped subsets I_{MCS}Set2 and I_{MCS}Set3 may satisfy the following criterion: at least b_0% of I_{MCS} in I_{MCS}Set2 that each has a remainder after a division of the respective I_{MCS} by an even integer "a" being less than "a/2", and at least b_1% of I_{MCS} in I_{MCS}Set3 that each has a remainder after a division of the respective I_{MCS} by the even integer "a" being greater than or equal to "a/2", and wherein b_0 is a real number greater than 75 and less than 100 and b_1 is a real number greater than 75 and less than 100. In yet another example, the grouped subsets I_{MCS}Set2 and I_{MCS}Set3 may satisfy the following criterion: at least 60% of a total number of I_{MCS} in I_{MCS}Set2 is greater than "N'," and at least 60% of a total number of I_{MCS} in I_{MCS}Set3 is less than "N'," and wherein N' is equal to a sum of the total number of I_{MCS} in I_{MCS}Set2 and the total number of I_{MCS} in I_{MCS}Set3.

In another embodiment, the BS may refer to a predefined table (e.g., Table 2 as shown below) to determine which BG (either BG1 or BG2) that the I_{MCS} corresponds to.

MCS Index I_{MCS}	**Modulation Order** Q_m	**Code Rate R** × **[1024]**	**Base Graph Index**
0	2	121	1
1	2	171	2
2	2	120	1
3	2	156.5	2
4	2	193	1
5	2	250.5	2
6	2	308	1
7	2	378.5	2
8	2	449	1
9	2	525.5	2
10	4	602	1
11	4	679	2
12	4	756	1
13	4	378	2
14	4	434	1
15	4	490	2
16	4	553	1
17	6	616	2
18	6	657.5	1
19	6	699	2
20	6	774.75	1
21	6	850.5	2
22	6	924.75	1
23	6	616.5	2
24	6	666	1

25	6	719	2
26	6	772	1
27	6	822.5	2
28	6	873	1
29	2	reserved	
30	4		
31	6		

Table 2

As shown in Table 2, each I_{MCS} not only corresponds to a single combination of modulation order (Q_m) and a code rate (R) but also to a respective BG index (either 1 or 2). In some embodiments, BG index 1 is associated with BG1, and BG index 2 is associated with BG2. It is noted that the above-described criteria that I_{MCS}Set2 and I_{MCS}Set3 follow may be applied to Table 2, in accordance with some embodiments.

Referring still to operation 308 of the method 300 in Figure 3 (i.e., the second predefined condition is satisfied), in some embodiments, the BS may use the I_{MCS} (indicated by the DCI) and the code rate (R), corresponding to the indicated I_{MCS}, to directly select either BG1 or BG2. More specifically, when R is greater than R_1, the BS selects BS1; and when R is less than or equal to R_2, the BS selects BS2, wherein R_1 and R_2 are each a real number less than 1, and R_1 is greater than R_2.

Referring still to operation 308 of the method 300 in Figure 3 (i.e., the second predefined condition is satisfied), in some embodiments, the BS may use the I_{MCS} and the number of physical resource blocks (PRB), both indicated by the DCI, to directly select either BG1 or BG2. More specifically, the BS selects BG1, when a remainder after division of I_{MCS} by 2 is equal to a remainder after division of PRB by 2; and the BS selects BG2, when a remainder after division of I_{MCS} by 2 is not equal to a remainder after division of PRB by 2. Alternatively, the BS selects BG2, when a remainder after division of I_{MCS} by 2 is equal to a remainder after division of PRB by 2; and the BS selects BG1, when a remainder after division of I_{MCS} by 2 is not equal to a remainder after division of PRB by 2.

Referring still to operation 308 of the method 300 in Figure 3 (i.e., the second predefined condition is satisfied), in some embodiments, the BS may use a relationship between a first efficiency value derived from a MCS table, which will be shown below, and a second efficiency value indicated in a channel quality indicator (CQI) table, which will be shown below, to directly select either BG1 or BG2. More specifically, the first efficiency value is calculated as a product of a modulation order (Q_m) and a code rate (R) that correspond to a single I_{MCS}, which is indicated by the DCI, and the second efficiency value is listed as one of a plurality of pre-calculated efficiency values in the CQI table. Accordingly, the BS may group the 32 different values of I_{MCS} into another plurality of subsets: I_{MCS}Set5, I_{MCS}Set6, I_{MCS}Set7, and I_{MCS}Set8, wherein each I_{MCS}'s corresponding first efficiency value in I_{MCS}Set5 is equal to any of the plurality of pre-calculated efficiency values in the CQI table (i.e., the second efficiency value), each I_{MCS}'s corresponding first efficiency value in I_{MCS}Set6 is equal to an average of any two adjacent ones of the plurality of pre-calculated efficiency values (i.e., the respective pre-calculated efficiency values of two adjacent CQI indexes) in the CQI table, each I_{MCS}'s corresponding first efficiency value in I_{MCS}Set7 is not equal to any first efficiency values included in I_{MCS}Set5 and I_{MCS}Set6, and I_{MCS}Set8 is reserved for retransmission or for future use.

In some embodiments, an exemplary CQI table with a maximum modulation order of 256QAM is shown in Table 3 and an exemplary MCS table for the use of sending a PDSCH (Physical Downlink Shared Channel) signal with a maximum modulation order of 8 (256QAM) is shown in Table 4. According to the above-discussed grouping principles, in some embodiments, I_{MCS}Set5 = {1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27}, I_{MCS}Set6 = {2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26}, I_{MCS}Set7 = { 0 }, and I_{MCS}Set8 = {28, 29, 30, 31}. Further, a maximum code rate in such an MCS table (e.g., Table 4) is equal to 0.95+Δx wherein Δx is a real number between -0.01 and +0.01. For example, as listed in Table 4, the maximum code rate indicated in the MCS table is equal to 972/1024 = 0.9492 wherein Δx=0.008.

CQI index	Modulation order	code rate x 1024	efficiency
0	out of range		
1	QPSK	78	0.1523
2	QPSK	193	0.3770
3	QPSK	449	0.8770
4	16QAM	378	1.4766
5	16QAM	490	1.9141
6	16QAM	616	2.4063
7	64QAM	466	2.7305
8	64QAM	567	3.3223
9	64QAM	666	3.9023
10	64QAM	772	4.5234
11	64QAM	873	5.1152
12	256QAM	711	5.5547
13	256QAM	797	6.2266
14	256QAM	885	6.9141
15	256QAM	972	7.5938

Table 3

MCS Index I_{MCS}	Modulation Order Q_m	code rate x 1024
0	2	120
1	2	193
2	2	321
3	2	449
4	2	603
5	4	378
6	4	434
7	4	490
8	4	553
9	4	616
10	4	658
11	6	466
12	6	517
13	6	567
14	6	617

MCS Index I_{MCS}	Modulation Order Q_m	code rate x 1024
15	6	666
16	6	719
17	6	772
18	6	823
19	6	873
20	8	683
21	8	711
22	8	754
23	8	797
24	8	841
25	8	885
26	8	929
27	8	972
28	2	reserved
29	4	
30	6	
31	8	

Table 4

In some embodiments, another exemplary CQI table with a maximum modulation order of 64QAM is shown in Table 5.

CQI index	Modulation order	code rate x 1024	efficiency
0	out of range		
1	QPSK	78	0.1523
2	QPSK	120	0.2344
3	QPSK	193	0.3770
4	QPSK	308	0.6016
5	QPSK	449	0.8770
6	QPSK	602	1.1758
7	16QAM	378	1.4766
8	16QAM	490	1.9141
9	16QAM	616	2.4063
10	64QAM	466	2.7305
11	64QAM	567	3.3223
12	64QAM	666	3.9023
13	64QAM	772	4.5234
14	64QAM	873	5.1152
15	64QAM	948	5.5547

Table 5

In some embodiments, another exemplary MCS table for the use of sending a PDSCH (Physical Downlink Shared Channel) signal with a maximum modulation order of 6 (64QAM) is shown in Table 6.

MCS Index I_{MCS}	Modulation Order Q_m	code rate x 1024
0	2	120
1	2	157
2	2	193
3	2	251

MCS Index I_{MCS}	Modulation Order Q_m	code rate x 1024
4	2	308
5	2	379
6	2	449
7	2	526
8	2	602
9	2	679
10	4	340
11	4	378
12	4	434
13	4	490
14	4	553
15	4	616
16	4	658
17	6	438
18	6	466
19	6	517
20	6	567
21	6	617
22	6	666
23	6	719
24	6	772
25	6	823
26	6	873
27	6	911
28	6	948
29	2	

MCS Index I_{MCS}	Modulation Order Q_m	code rate x 1024
30	4	reserved
31	6	

Table 6

In some embodiments, an exemplary MCS table for the use of sending a PUSCH (Physical Uplink Shared Channel) signal with a maximum modulation order of 6 (64QAM) using CP-OFDM (Cyclic Prefix Orthogonal Frequency Division Multiplexing) is shown in Table 7.

MCS Index I_{MCS}	Modulation Order Q_m	code rate x 1024
0	2	100
1	2	130
2	2	161
3	2	209
4	2	257
5	2	315
6	2	374
7	2	438
8	2	502
9	2	566
10	2	630
11	4	315
12	4	362
13	4	408
14	4	461
15	4	513
16	4	548
17	4	583
18	4	646

MCS Index I_{MCS}	Modulation Order Q_m	code rate x 1024
19	4	709
20	4	771
21	6	514
22	6	555
23	6	599
24	6	643
25	6	685
26	6	727
27	6	759
28	6	790
29	2	reserved
30	4	
31	6	

Table 7

In some embodiments, yet another MCS table for the use of sending a PUSCH (Physical Uplink Shared Channel) signal with a maximum modulation order of 8 (256QAM) using CP-OFDM (Cyclic Prefix Orthogonal Frequency Division Multiplexing) is shown in Table 8.

MCS Index I_{MCS}	Modulation Order Q_m	code rate x 1024
0	2	100
1	2	161
2	2	268
3	2	374
4	2	502
5	2	630
6	4	362
7	4	408

MCS Index I_{MCS}	Modulation Order Q_m	code rate x 1024
8	4	461
9	4	513
10	4	583
11	4	646
12	4	709
13	4	771
14	6	555
15	6	599
16	6	643
17	6	685
18	6	727
19	6	790
20	6	838
21	6	886
22	8	701
23	8	738
24	8	764
25	8	821
26	8	895
27	8	949
28	2	reserved
29	4	
30	6	
31	8	

Table 8

In some embodiments, yet another exemplary MCS table for the use of sending a PUSCH (Physical Uplink Shared Channel) signal with a maximum modulation order of 6 (64QAM) using

DFT-S-OFDM(Discrete Fourier Transformation Spread Orthogonal Frequency Division Multiplexing) is shown in Table 9.

MCS Index I_{MCS}	Modulation Order Q_m	code rate x 1024
0	1	200
1	1	260
2	2	161
3	2	209
4	2	257
5	2	315
6	2	374
7	2	438
8	2	502
9	2	566
10	2	630
11	4	315
12	4	362
13	4	408
14	4	461
15	4	513
16	4	548
17	4	583
18	4	646
19	4	709
20	4	771
21	6	555
22	6	599
23	6	643

MCS Index I_{MCS}	Modulation Order Q_m	code rate x 1024
24	6	685
25	6	727
26	6	759
27	6	790
28	1	reserved
29	2	
30	4	
31	6	

Table 9

In some embodiments, yet another exemplary MCS table for the use of sending a PUSCH (Physical Uplink Shared Channel) signal with a maximum modulation order of 8 (256QAM) using DFT-S-OFDM(Discrete Fourier Transformation Spread Orthogonal Frequency Division Multiplexing) is shown in Table 10.

MCS Index I_{MCS}	Modulation Order Q_m	code rate x 1024
0	1	200
1	2	161
2	2	268
3	2	374
4	2	502
5	2	630
6	4	362
7	4	461
8	4	513
9	4	583
10	4	646
11	4	709

MCS Index I_{MCS}	**Modulation Order** Q_m	**code rate x 1024**
12	4	771
13	6	555
14	6	599
15	6	643
16	6	685
17	6	727
18	6	790
19	6	838
20	6	886
21	8	701
22	8	738
23	8	764
24	8	821
25	8	895
26	8	949
27	1	reserved
28	2	
29	4	
30	6	
31	8	

Table 10

In some embodiments, once the BS selects the BG (either BG1 or BG2), the BG can use the QC-LDPC code, as known in the art, to encode the to-be transmitted information bits. Thus, steps performed by the BS to use the BG to encode the information bits will be herein briefly described:

Step 1. Calculate an intermediate parameter kb (when BG1 is selected, kb = 22; when BG2 is selected and TBS is equal to or less than 192, kb = 6; when BG2 is selected and TBS is greater than 192 and less than or equal to 560, kb = 8; when BG2 is selected and TBS is greater than 560 and less than or equal to 640, kb = 9; and when BG2 is selected and TBS is greater than 640, kb = 10).

Step 2. Calculate a lifting value Z. The lifting value Z is selected as a minimum integer greater than or equal to TBS/kb.

Step 3. Based on a plurality of predefined tables (e.g., Tables 3, 4, and 5 provided below), retrieve a parity check matrix H using the lifting value Z, which will be discussed as follows.

In general, each BG is associated with a base graph matrix, H_{BG}. For BG1, the H_{BG} includes 46 rows and with row indexes $i = 0,1,2,...,45$ and 68 columns with column indexes $j = 0,1,2,...,67$. For BG2, the H_{BG} includes 42 rows with row indexes $i = 0,1,2,...,41$ and 52 columns with column indexes $j = 0,1,2,...,51$. The elements in the H_{BG} with row and column indexes given in Table 11 (for BG1) and Table 12 (fof BG 2) are of value 1, and all other elements in H_{BG} are of value 0. Then, The matrix H is obtained by replacing each element of H_{BG} with a $Z \times Z$ matrix, according to the following: each element of value 0 in H_{BG} is replaced by an all zero matrix $\mathbf{0}$ of size $Z \times Z$; each element of value 1 in H_{BG} is replaced by a circular permutation matrix $\mathbf{I}(P_{i,j})$ of size $Z \times Z$, where i and j are the row and column indexes of the element, and $\mathbf{I}(P_{i,j})$ is obtained by circularly shifting an identity matrix $\mathbf{I}$ of size $Z \times Z$ to the right $P_{i,j}$ times. The value of $P_{i,j}$ is given by $P_{i,j} = \mathrm{mod}(V_{i,j}, Z)$. The value of $V_{i,j}$ is given by Tables 3 and 4 according to a set index i_{LS}, which corresponds to a set of lifting values Z as shown in Table 13, and the base graph index (i.e., which BG is selected).

$\mathbf{H}_{BG}$		$V_{i,j}$								$\mathbf{H}_{BG}$		$V_{i,j}$							
Row index	Column index	Set index i_{LS}								Row index	Column index	Set index i_{LS}							
i	j	1	2	3	4	5	6	7	8	i	j	1	2	3	4	5	6	7	8
0	0	250	307	73	223	211	294	0	135	15	1	96	2	290	120	0	348	6	138
	1	69	19	15	16	198	118	0	227		10	65	210	60	131	183	15	81	220
	2	226	50	103	94	188	167	0	126		13	63	318	130	209	108	81	182	173
	3	159	369	49	91	186	330	0	134		18	75	55	184	209	68	176	53	142
	5	100	181	240	74	219	207	0	84		25	179	269	51	81	64	113	46	49
	6	10	216	39	10	4	165	0	83		37	0	0	0	0	0	0	0	0
	9	59	317	15	0	29	243	0	53	16	1	64	13	69	154	270	190	88	78
	10	229	288	162	205	144	250	0	225		3	49	338	140	164	13	293	198	152
	11	110	109	215	216	116	1	0	205		11	49	57	45	43	99	332	160	84
	12	191	17	164	21	216	339	0	128		20	51	289	115	189	54	331	122	5
	13	9	357	133	215	115	201	0	75		22	154	57	300	101	0	114	182	205

	15	195	215	298	14	233	53	0	135
	16	23	106	110	70	144	347	0	217
	18	190	242	113	141	95	304	0	220
	19	35	180	16	198	216	167	0	90
	20	239	330	189	104	73	47	0	105
	21	31	346	32	81	261	188	0	137
	22	1	1	1	1	1	1	0	1
	23	0	0	0	0	0	0	0	0
1	0	2	76	303	141	179	77	22	96
	2	239	76	294	45	162	225	11	236
	3	117	73	27	151	223	96	124	136
	4	124	288	261	46	256	338	0	221
	5	71	144	161	119	160	268	10	128
	7	222	331	133	157	76	112	0	92
	8	104	331	4	133	202	302	0	172
	9	173	178	80	87	117	50	2	56
	11	220	295	129	206	109	167	16	11
	12	102	342	300	93	15	253	60	189
	14	109	217	76	79	72	334	0	95
	15	132	99	266	9	152	242	6	85
	16	142	354	72	118	158	257	30	153
	17	155	114	83	194	147	133	0	87
	19	255	331	260	31	156	9	168	163
	21	28	112	301	187	119	302	31	216
	22	0	0	0	0	0	0	105	0
	23	0	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	0	0
2	0	106	205	68	207	258	226	132	189
	1	111	250	7	203	167	35	37	4
	2	185	328	80	31	220	213	21	225
	4	63	332	280	176	133	302	180	151
	5	117	256	38	180	243	111	4	236
	6	93	161	227	186	202	265	149	117
	7	229	267	202	95	218	128	48	179
	8	177	160	200	153	63	237	38	92
	9	95	63	71	177	0	294	122	24
	10	39	129	106	70	3	127	195	68
	13	142	200	295	77	74	110	155	6
	14	225	88	283	214	229	286	28	101
	15	225	53	301	77	0	125	85	33
	17	245	131	184	198	216	131	47	96
	18	205	240	246	117	269	163	179	125
	19	251	205	230	223	200	210	42	67
	20	117	13	276	90	234	7	66	230

	38	0	0	0	0	0	0	0	0
17	0	7	260	257	56	153	110	91	183
	14	164	303	147	110	137	228	184	112
	16	59	81	128	200	0	247	30	106
	17	1	358	51	63	0	116	3	219
	21	144	375	228	4	162	190	155	129
	39	0	0	0	0	0	0	0	0
18	1	42	130	260	199	161	47	1	183
	12	233	163	294	110	151	286	41	215
	13	8	280	291	200	0	246	167	180
	18	155	132	141	143	241	181	68	143
	19	147	4	295	186	144	73	148	14
	40	0	0	0	0	0	0	0	0
19	0	60	145	64	8	0	87	12	179
	1	73	213	181	6	0	110	6	108
	7	72	344	101	103	118	147	166	159
	8	127	242	270	198	144	258	184	138
	10	224	197	41	8	0	204	191	196
	41	0	0	0	0	0	0	0	0
20	0	151	187	301	105	265	89	6	77
	3	186	206	162	210	81	65	12	187
	9	217	264	40	121	90	155	15	203
	11	47	341	130	214	144	244	5	167
	22	160	59	10	183	228	30	30	130
	42	0	0	0	0	0	0	0	0
21	1	249	205	79	192	64	162	6	197
	5	121	102	175	131	46	264	86	122
	16	109	328	132	220	266	346	96	215
	20	131	213	283	50	9	143	42	65
	21	171	97	103	106	18	109	199	216
	43	0	0	0	0	0	0	0	0
22	0	64	30	177	53	72	280	44	25
	12	142	11	20	0	189	157	58	47
	13	188	233	55	3	72	236	130	126
	17	158	22	316	148	257	113	131	178
	44	0	0	0	0	0	0	0	0
23	1	156	24	249	88	180	18	45	185
	2	147	89	50	203	0	6	18	127
	10	170	61	133	168	0	181	132	117
	18	152	27	105	122	165	304	100	199
	45	0	0	0	0	0	0	0	0
24	0	112	298	289	49	236	38	9	32
	3	86	158	280	157	199	170	125	178
	4	236	235	110	64	0	249	191	2

	24	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0
3	0	121	276	220	201	187	97	4	128
	1	89	87	208	18	145	94	6	23
	3	84	0	30	165	166	49	33	162
	4	20	275	197	5	108	279	113	220
	6	150	199	61	45	82	139	49	43
	7	131	153	175	142	132	166	21	186
	8	243	56	79	16	197	91	6	96
	10	136	132	281	34	41	106	151	1
	11	86	305	303	155	162	246	83	216
	12	246	231	253	213	57	345	154	22
	13	219	341	164	147	36	269	87	24
	14	211	212	53	69	115	185	5	167
	16	240	304	44	96	242	249	92	200
	17	76	300	28	74	165	215	173	32
	18	244	271	77	99	0	143	120	235
	20	144	39	319	30	113	121	2	172
	21	12	357	68	158	108	121	142	219
	22	1	1	1	1	1	1	0	1
	25	0	0	0	0	0	0	0	0
4	0	157	332	233	170	246	42	24	64
	1	102	181	205	10	235	256	204	211
	26	0	0	0	0	0	0	0	0
5	0	205	195	83	164	261	219	185	2
	1	236	14	292	59	181	130	100	171
	3	194	115	50	86	72	251	24	47
	12	231	166	318	80	283	322	65	143
	16	28	241	201	182	254	295	207	210
	21	123	51	267	130	79	258	161	180
	22	115	157	279	153	144	283	72	180
	27	0	0	0	0	0	0	0	0
6	0	183	278	289	158	80	294	6	199
	6	22	257	21	119	144	73	27	22
	10	28	1	293	113	169	330	163	23
	11	67	351	13	21	90	99	50	100
	13	244	92	232	63	59	172	48	92
	17	11	253	302	51	177	150	24	207
	18	157	18	138	136	151	284	38	52
	20	211	225	235	116	108	305	91	13
	28	0	0	0	0	0	0	0	0
7	0	220	9	12	17	169	3	145	77
	1	44	62	88	76	189	103	88	146
	4	159	316	207	104	154	224	112	209

	11	116	339	187	193	266	288	28	156
	22	222	234	281	124	0	194	6	58
	46	0	0	0	0	0	0	0	0
25	1	23	72	172	1	205	279	4	27
	6	136	17	295	166	0	255	74	141
	7	116	383	96	65	0	111	16	11
	14	182	312	46	81	183	54	28	181
	47	0	0	0	0	0	0	0	0
26	0	195	71	270	107	0	325	21	163
	2	243	81	110	176	0	326	142	131
	4	215	76	318	212	0	226	192	169
	15	61	136	67	127	277	99	197	98
	48	0	0	0	0	0	0	0	0
27	1	25	194	210	208	45	91	98	165
	6	104	194	29	141	36	326	140	232
	8	194	101	304	174	72	268	22	9
	49	0	0	0	0	0	0	0	0
28	0	128	222	11	146	275	102	4	32
	4	165	19	293	153	0	1	1	43
	19	181	244	50	217	155	40	40	200
	21	63	274	234	114	62	167	93	205
	50	0	0	0	0	0	0	0	0
29	1	86	252	27	150	0	273	92	232
	14	236	5	308	11	180	104	136	32
	18	84	147	117	53	0	243	106	118
	25	6	78	29	68	42	107	6	103
	51	0	0	0	0	0	0	0	0
30	0	216	159	91	34	0	171	2	170
	10	73	229	23	130	90	16	88	199
	13	120	260	105	210	252	95	112	26
	24	9	90	135	123	173	212	20	105
	52	0	0	0	0	0	0	0	0
31	1	95	100	222	175	144	101	4	73
	7	177	215	308	49	144	297	49	149
	22	172	258	66	177	166	279	125	175
	25	61	256	162	128	19	222	194	108
	53	0	0	0	0	0	0	0	0
32	0	221	102	210	192	0	351	6	103
	12	112	201	22	209	211	265	126	110
	14	199	175	271	58	36	338	63	151
	24	121	287	217	30	162	83	20	211
	54	0	0	0	0	0	0	0	0
33	1	2	323	170	114	0	56	10	199
	2	187	8	20	49	0	304	30	132

	7	31	333	50	100	184	297	153	32
	8	167	290	25	150	104	215	159	166
	14	104	114	76	158	164	39	76	18
	29	0	0	0	0	0	0	0	0
8	0	112	307	295	33	54	348	172	181
	1	4	179	133	95	0	75	2	105
	3	7	165	130	4	252	22	131	141
	12	211	18	231	217	41	312	141	223
	16	102	39	296	204	98	224	96	177
	19	164	224	110	39	46	17	99	145
	21	109	368	269	58	15	59	101	199
	22	241	67	245	44	230	314	35	153
	24	90	170	154	201	54	244	116	38
	30	0	0	0	0	0	0	0	0
9	0	103	366	189	9	162	156	6	169
	1	182	232	244	37	159	88	10	12
	10	109	321	36	213	93	293	145	206
	11	21	133	286	105	134	111	53	221
	13	142	57	151	89	45	92	201	17
	17	14	303	267	185	132	152	4	212
	18	61	63	135	109	76	23	164	92
	20	216	82	209	218	209	337	173	205
	31	0	0	0	0	0	0	0	0
10	1	98	101	14	82	178	175	126	116
	2	149	339	80	165	1	253	77	151
	4	167	274	211	174	28	27	156	70
	7	160	111	75	19	267	231	16	230
	8	49	383	161	194	234	49	12	115
	14	58	354	311	103	201	267	70	84
	32	0	0	0	0	0	0	0	0
11	0	77	48	16	52	55	25	184	45
	1	41	102	147	11	23	322	194	115
	12	83	8	290	2	274	200	123	134
	16	182	47	289	35	181	351	16	1
	21	78	188	177	32	273	166	104	152
	22	252	334	43	84	39	338	109	165
	23	22	115	280	201	26	192	124	107
	33	0	0	0	0	0	0	0	0
12	0	160	77	229	142	225	123	6	186
	1	42	186	235	175	162	217	20	215
	10	21	174	169	136	244	142	203	124
	11	32	232	48	3	151	110	153	180
	13	234	50	105	28	238	176	104	98
	18	7	74	52	182	243	76	207	80

	11	41	361	140	161	76	141	6	172
	21	211	105	33	137	18	101	92	65
	55	0	0	0	0	0	0	0	0
34	0	127	230	187	82	197	60	4	161
	7	167	148	296	186	0	320	153	237
	15	164	202	5	68	108	112	197	142
	17	159	312	44	150	0	54	155	180
	56	0	0	0	0	0	0	0	0
35	1	161	320	207	192	199	100	4	231
	6	197	335	158	173	278	210	45	174
	12	207	2	55	26	0	195	168	145
	22	103	266	285	187	205	268	185	100
	57	0	0	0	0	0	0	0	0
36	0	37	210	259	222	216	135	6	11
	14	105	313	179	157	16	15	200	207
	15	51	297	178	0	0	35	177	42
	18	120	21	160	6	0	188	43	100
	58	0	0	0	0	0	0	0	0
37	1	198	269	298	81	72	319	82	59
	13	220	82	15	195	144	236	2	204
	23	122	115	115	138	0	85	135	161
	59	0	0	0	0	0	0	0	0
38	0	167	185	151	123	190	164	91	121
	9	151	177	179	90	0	196	64	90
	10	157	289	64	73	0	209	198	26
	12	163	214	181	10	0	246	100	140
	60	0	0	0	0	0	0	0	0
39	1	173	258	102	12	153	236	4	115
	3	139	93	77	77	0	264	28	188
	7	149	346	192	49	165	37	109	168
	19	0	297	208	114	117	272	188	52
	61	0	0	0	0	0	0	0	0
40	0	157	175	32	67	216	304	10	4
	8	137	37	80	45	144	237	84	103
	17	149	312	197	96	2	135	12	30
	62	0	0	0	0	0	0	0	0
41	1	167	52	154	23	0	123	2	53
	3	173	314	47	215	0	77	75	189
	9	139	139	124	60	0	25	142	215
	18	151	288	207	167	183	272	128	24
	63	0	0	0	0	0	0	0	0
42	0	149	113	226	114	27	288	163	222
	4	157	14	65	91	0	83	10	170
	24	137	218	126	78	35	17	162	71

	34	0	0	0	0	0	0	0	0		64	0	0	0	0	0	0	0	0
13	0	177	313	39	81	231	311	52	220	43	1	151	113	228	206	52	210	1	22
	3	248	177	302	56	0	251	147	185		16	163	132	69	22	243	3	163	127
	7	151	266	303	72	216	265	1	154		18	173	114	176	134	0	53	99	49
	20	185	115	160	217	47	94	16	178		25	139	168	102	161	270	167	98	125
	23	62	370	37	78	36	81	46	150		65	0	0	0	0	0	0	0	0
	35	0	0	0	0	0	0	0	0	44	0	139	80	234	84	18	79	4	191
14	0	206	142	78	14	0	22	1	124		7	157	78	227	4	0	244	6	211
	12	55	248	299	175	186	322	202	144		9	163	163	259	9	0	293	142	187
	15	206	137	54	211	253	277	118	182		22	173	274	260	12	57	272	3	148
	16	127	89	61	191	16	156	130	95		66	0	0	0	0	0	0	0	0
	17	16	347	179	51	0	66	1	72	45	1	149	135	101	184	168	82	181	177
	21	229	12	258	43	79	78	2	76		6	151	149	228	121	0	67	45	114
	36	0	0	0	0	0	0	0	0		10	167	15	126	29	144	235	153	93
15	0	40	241	229	90	170	176	173	39		67	0	0	0	0	0	0	0	0

Table 11

$\mathbf{H}_{BG}$		$V_{i,j}$								$\mathbf{H}_{BG}$		$V_{i,j}$							
Row index	Column index	Set index i_{LS}								Row index	Column index	Set index i_{LS}							
i	j	1	2	3	4	5	6	7	8	i	j	1	2	3	4	5	6	7	8
0	0	9	174	0	72	3	156	143	145	16	26	0	0	0	0	0	0	0	0
	1	117	97	0	110	26	143	19	131	17	1	254	158	0	48	120	134	57	196
	2	204	166	0	23	53	14	176	71		5	124	23	24	132	43	23	201	173
	3	26	66	0	181	35	3	165	21		11	114	9	109	206	65	62	142	195
	6	189	71	0	95	115	40	196	23		12	64	6	18	2	42	163	35	218
	9	205	172	0	8	127	123	13	112		27	0	0	0	0	0	0	0	0
	10	0	0	0	1	0	0	0	1	18	0	220	186	0	68	17	173	129	128
	11	0	0	0	0	0	0	0	0		6	194	6	18	16	106	31	203	211
1	0	167	27	137	53	19	17	18	142		7	50	46	86	156	142	22	140	210
	3	166	36	124	156	94	65	27	174		28	0	0	0	0	0	0	0	0
	4	253	48	0	115	104	63	3	183	19	0	87	58	0	35	79	13	110	39
	5	125	92	0	156	66	1	102	27		1	20	42	158	138	28	135	124	84
	6	226	31	88	115	84	55	185	96		10	185	156	154	86	41	145	52	88
	7	156	187	0	200	98	37	17	23		29	0	0	0	0	0	0	0	0
	8	224	185	0	29	69	171	14	9	20	1	26	76	0	6	2	128	196	117
	9	252	3	55	31	50	133	180	167		4	105	61	148	20	103	52	35	227
	11	0	0	0	0	0	0	0	0		11	29	153	104	141	78	173	114	6
	12	0	0	0	0	0	0	0	0		30	0	0	0	0	0	0	0	0
2	0	81	25	20	152	95	98	126	74	21	0	76	157	0	80	91	156	10	238
	1	114	114	94	131	106	168	163	31		8	42	175	17	43	75	166	122	13
	3	44	117	99	46	92	107	47	3		13	210	67	33	81	81	40	23	11

	4	52	110	9	191	110	82	183	53
	8	240	114	108	91	111	142	132	155
	10	1	1	1	0	1	1	1	0
	12	0	0	0	0	0	0	0	0
	13	0	0	0	0	0	0	0	0
3	1	8	136	38	185	120	53	36	239
	2	58	175	15	6	121	174	48	171
	4	158	113	102	36	22	174	18	95
	5	104	72	146	124	4	127	111	110
	6	209	123	12	124	73	17	203	159
	7	54	118	57	110	49	89	3	199
	8	18	28	53	156	128	17	191	43
	9	128	186	46	133	79	105	160	75
	10	0	0	0	1	0	0	0	1
	13	0	0	0	0	0	0	0	0
4	0	179	72	0	200	42	86	43	29
	1	214	74	136	16	24	67	27	140
	11	71	29	157	101	51	83	117	180
	14	0	0	0	0	0	0	0	0
5	0	231	10	0	185	40	79	136	121
	1	41	44	131	138	140	84	49	41
	5	194	121	142	170	84	35	36	169
	7	159	80	141	219	137	103	132	88
	11	103	48	64	193	71	60	62	207
	15	0	0	0	0	0	0	0	0
6	0	155	129	0	123	109	47	7	137
	5	228	92	124	55	87	154	34	72
	7	45	100	99	31	107	10	198	172
	9	28	49	45	222	133	155	168	124
	11	158	184	148	209	139	29	12	56
	16	0	0	0	0	0	0	0	0
7	1	129	80	0	103	97	48	163	86
	5	147	186	45	13	135	125	78	186
	7	140	16	148	105	35	24	143	87
	11	3	102	96	150	108	47	107	172
	13	116	143	78	181	65	55	58	154
	17	0	0	0	0	0	0	0	0
8	0	142	118	0	147	70	53	101	176
	1	94	70	65	43	69	31	177	169
	12	230	152	87	152	88	161	22	225
	18	0	0	0	0	0	0	0	0
9	1	203	28	0	2	97	104	186	167
	8	205	132	97	30	40	142	27	238
	10	61	185	51	184	24	99	205	48

	31	0	0	0	0	0	0	0	0
22	1	222	20	0	49	54	18	202	195
	2	63	52	4	1	132	163	126	44
	32	0	0	0	0	0	0	0	0
23	0	23	106	0	156	68	110	52	5
	3	235	86	75	54	115	132	170	94
	5	238	95	158	134	56	150	13	111
	33	0	0	0	0	0	0	0	0
24	1	46	182	0	153	30	113	113	81
	2	139	153	69	88	42	108	161	19
	9	8	64	87	63	101	61	88	130
	34	0	0	0	0	0	0	0	0
25	0	228	45	0	211	128	72	197	66
	5	156	21	65	94	63	136	194	95
	35	0	0	0	0	0	0	0	0
26	2	29	67	0	90	142	36	164	146
	7	143	137	100	6	28	38	172	66
	12	160	55	13	221	100	53	49	190
	13	122	85	7	6	133	145	161	86
	36	0	0	0	0	0	0	0	0
27	0	8	103	0	27	13	42	168	64
	6	151	50	32	118	10	104	193	181
	37	0	0	0	0	0	0	0	0
28	1	98	70	0	216	106	64	14	7
	2	101	111	126	212	77	24	186	144
	5	135	168	110	193	43	149	46	16
	38	0	0	0	0	0	0	0	0
29	0	18	110	0	108	133	139	50	25
	4	28	17	154	61	25	161	27	57
	39	0	0	0	0	0	0	0	0
30	2	71	120	0	106	87	84	70	37
	5	240	154	35	44	56	173	17	139
	7	9	52	51	185	104	93	50	221
	9	84	56	134	176	70	29	6	17
	40	0	0	0	0	0	0	0	0
31	1	106	3	0	147	80	117	115	201
	13	1	170	20	182	139	148	189	46
	41	0	0	0	0	0	0	0	0
32	0	242	84	0	108	32	116	110	179
	5	44	8	20	21	89	73	0	14
	12	166	17	122	110	71	142	163	116
	42	0	0	0	0	0	0	0	0
33	2	132	165	0	71	135	105	163	46
	7	164	179	88	12	6	137	173	2

	11	247	178	85	83	49	64	81	68		10	235	124	13	109	2	29	179	106
	19	0	0	0	0	0	0	0	0		43	0	0	0	0	0	0	0	0
10	0	11	59	0	174	46	111	125	38	34	0	147	173	0	29	37	11	197	184
	1	185	104	17	150	41	25	60	217		12	85	177	19	201	25	41	191	135
	6	0	22	156	8	101	174	177	208		13	36	12	78	69	114	162	193	141
	7	117	52	20	56	96	23	51	232		44	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	35	1	57	77	0	91	60	126	157	85
11	0	11	32	0	99	28	91	39	178		5	40	184	157	165	137	152	167	225
	7	236	92	7	138	30	175	29	214		11	63	18	6	55	93	172	181	175
	9	210	174	4	110	116	24	35	168		45	0	0	0	0	0	0	0	0
	13	56	154	2	99	64	141	8	51	36	0	140	25	0	1	121	73	197	178
	21	0	0	0	0	0	0	0	0		2	38	151	63	175	129	154	167	112
12	1	63	39	0	46	33	122	18	124		7	154	170	82	83	26	129	179	106
	3	111	93	113	217	122	11	155	122		46	0	0	0	0	0	0	0	0
	11	14	11	48	109	131	4	49	72	37	10	219	37	0	40	97	167	181	154
	22	0	0	0	0	0	0	0	0		13	151	31	144	12	56	38	193	114
13	0	83	49	0	37	76	29	32	48		47	0	0	0	0	0	0	0	0
	1	2	125	112	113	37	91	53	57	38	1	31	84	0	37	1	112	157	42
	8	38	35	102	143	62	27	95	167		5	66	151	93	97	70	7	173	41
	13	222	166	26	140	47	127	186	219		11	38	190	19	46	1	19	191	105
	23	0	0	0	0	0	0	0	0		48	0	0	0	0	0	0	0	0
14	1	115	19	0	36	143	11	91	82	39	0	239	93	0	106	119	109	181	167
	6	145	118	138	95	51	145	20	232		7	172	132	24	181	32	6	157	45
	11	3	21	57	40	130	8	52	204		12	34	57	138	154	142	105	173	189
	13	232	163	27	116	97	166	109	162		49	0	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	0	0	40	2	0	103	0	98	6	160	193	78
15	0	51	68	0	116	139	137	174	38		10	75	107	36	35	73	156	163	67
	10	175	63	73	200	96	103	108	217		13	120	163	143	36	102	82	179	180
	11	213	81	99	110	128	40	102	157		50	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0	41	1	129	147	0	120	48	132	191	53
16	1	203	87	0	75	48	78	125	170		5	229	7	2	101	47	6	197	215
	9	142	177	79	158	9	158	31	23		11	118	60	55	81	19	8	167	230
	11	8	135	111	134	28	17	54	175		51	0	0	0	0	0	0	0	0
	12	242	64	143	97	8	165	176	202										

Table 12

Set index (i_{LS})	*Set of lifting sizes (Z)*
1	{2, 4, 8, 16, 32, 64, 128, 256}
2	{3, 6, 12, 24, 48, 96, 192, 384}
3	{5, 10, 20, 40, 80, 160, 320}
4	{7, 14, 28, 56, 112, 224}
5	{9, 18, 36, 72, 144, 288}
6	{11, 22, 44, 88, 176, 352}
7	{13, 26, 52, 104, 208}
8	{15, 30, 60, 120, 240}

Table 13

After the parity check matrix H is determined, the information bits can be encoded as an QC-LDPC codeword. Next, as discussed above, the rate matching step, the interleaving step, and the symbol modulation step are respectively performed on the QC-LDPC codeword to generate one or more modulated symbols for transmission.

Figure 5 illustrates a flow chart of an exemplary method 500 performed by a UE to retrieve information bits from a signal encoded by a QC-LDPC code, in accordance with some embodiments. The illustrated embodiment of the method 500 is merely an example. Therefore, it should be understood that any of a variety of operations may be omitted, re-sequenced, and/or added while remaining within the scope of the present disclosure. Since the method 500 performed by the UE is substantially similar to the method 300 performed by the BS except that encoding is replaced with decoding, the method 500 will be briefly discussed as follows.

In some embodiments, the method 500 starts with operation 502 in which downlink control information (DCI) is received. According to some embodiments, the DCI includes various information such as, for example, a modulation and coding scheme (MCS) index (hereinafter "I_{MCS}"), a new data indicator (hereinafter "NDI"), a redundancy version (hereinafter "RV"), a number of physical resource blocks (hereinafter "PRB"), etc. Next, the method 500 proceeds to determination operation 504 in which the UE determines whether a first or second predefined condition is satisfied. In some embodiments, the first predefined condition includes at least one of the following: whether the RV is equal to RV0, whether a current logic state of the NDI is equal to a logic "0," and whether the NDI presents a transition to a different logic state (e.g., whether the NDI has been toggled to a value different from a previously received value, which indicates a first transmission); and the second predefined condition includes at least one of the following: whether the RV is equal to RV1, RV2, or RV3, whether a current logic state of the NDI is equal to a logic “1,” and whether the NDI lacks a transition to a different logic state (e.g., whether the NDI has been toggled to a value different from a previously received value, which indicates a retransmission). When the first predefined condition is satisfied, the method 500 proceeds to operation 506; and when the second predefined condition is satisfied, the method 500 proceeds to operation 508. In some embodiments, in operation 506, the UE is configured to process the various information contained in the DCI to select one from the above-mentioned BG1 and BG2 that are predefined by the QC-LDPC code; and on the other hand, in operation 508, the UE is configured to use the various information contained in the DCI to directly select one from the above-mentioned BG1 and BG2 (i.e., no further processing on the various information). It is noted that the above-described techniques performed by the BS in operation 306 can also be performed by the UE in operation 506 to select a BG, and the above-described techniques performed by the BS in operation 308 can also be performed by the UE in operation 508 to select a BG while remaining within the scope of the present disclosure. After the BG is selected either at operation 506 or 508, the method 500 continues to operation 510 in which the UE uses the selected BG to retrieve information bits from a signal encoded by the QC-LDPC code. In some embodiments, in operation 510, in addition to at least one decoding process using the selected BG being performed, one or more further steps (e.g., a symbol de-modulation step, a step to estimate a corresponding parity check matrix as mentioned above, a de-interleaving step, a de-rate matching step, etc.) may be performed before the information bits are decoded.

While various embodiments of the invention have been described above, it should be understood that they have been presented by way of example only, and not by way of limitation. Likewise, the various diagrams may depict an example architectural or configuration, which are provided to enable persons of ordinary skill in the art to understand exemplary features and functions of the invention. Such persons would understand, however, that the invention is not restricted to the illustrated example architectures or configurations, but can be implemented using a variety of alternative architectures and configurations. Additionally, as would be understood by persons of ordinary skill in the art, one or more features of one embodiment can be combined with one or more features of another embodiment described herein. Thus, the breadth and scope of the present disclosure should not be limited by any of the above-described exemplary embodiments.

It is also understood that any reference to an element herein using a designation such as "first," "second," and so forth does not generally limit the quantity or order of those elements. Rather, these designations can be used herein as a convenient means of distinguishing between two or more elements or instances of an element. Thus, a reference to first and second elements does not mean that only two elements can be employed, or that the first element must precede the second element in some manner.

Additionally, a person having ordinary skill in the art would understand that information and signals can be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits and symbols, for example, which may be referenced in the above description can be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

A person of ordinary skill in the art would further appreciate that any of the various illustrative logical blocks, modules, processors, means, circuits, methods and functions described in connection with the aspects disclosed herein can be implemented by electronic hardware (e.g., a digital implementation, an analog implementation, or a combination of the two), firmware, various forms of program or design code incorporating instructions (which can be referred to herein, for convenience, as "software" or a "software module), or any combination of these techniques. To clearly illustrate this interchangeability of hardware, firmware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware, firmware or software, or a combination of these techniques, depends upon the particular application and design constraints imposed on the overall system. Skilled artisans can implement the described functionality in various ways for each particular application, but such implementation decisions do not cause a departure from the scope of the present disclosure.

Furthermore, a person of ordinary skill in the art would understand that various illustrative logical blocks, modules, devices, components and circuits described herein can be implemented within or performed by an integrated circuit (IC) that can include a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, or any combination thereof. The logical blocks, modules, and circuits can further include antennas and/or transceivers to communicate with various components within the network or within the device. A general purpose processor can be a microprocessor, but in the alternative, the processor can be any conventional processor, controller, or state machine. A processor can also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other suitable configuration to perform the functions described herein.

If implemented in software, the functions can be stored as one or more instructions or code on a computer-readable medium. Thus, the steps of a method or algorithm disclosed herein can be implemented as software stored on a computer-readable medium. Computer-readable media includes both computer storage media and communication media including any medium that can be enabled to transfer a computer program or code from one place to another. A storage media can be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can include RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to store desired program code in the form of instructions or data structures and that can be accessed by a computer.

In this document, the term "module" as used herein, refers to software, firmware, hardware, and any combination of these elements for performing the associated functions described herein. Additionally, for purpose of discussion, the various modules are described as discrete modules; however, as would be apparent to one of ordinary skill in the art, two or more modules may be combined to form a single module that performs the associated functions according embodiments of the invention.

Additionally, memory or other storage, as well as communication components, may be employed in embodiments of the invention. It will be appreciated that, for clarity purposes, the above description has described embodiments of the invention with reference to different functional units and processors. However, it will be apparent that any suitable distribution of functionality between different functional units, processing logic elements or domains may be used without detracting from the invention. For example, functionality illustrated to be performed by separate processing logic elements, or controllers, may be performed by the same processing logic element, or controller. Hence, references to specific functional units are only references to a suitable means for providing the described functionality, rather than indicative of a strict logical or physical structure or organization.

Various modifications to the implementations described in this disclosure will be readily apparent to those skilled in the art, and the general principles defined herein can be applied to other implementations without departing from the scope of this disclosure. Thus, the disclosure is not intended to be limited to the implementations shown herein, but is to be accorded the widest scope consistent with the novel features and principles disclosed herein, as recited in the claims below.

CLAIMS

1. A method, comprising:

determining a redundancy version and a new data indicator indicated by control information;

determining a base graph of a low density parity check code based on which of a plurality of predefined conditions the redundancy version, and/or the new data indicator satisfy; and

sending a signal comprising information bits that are encoded based on the determined base graph of the low density parity check code.

2. The method of claim 1, wherein a first one of the plurality of predefined conditions comprises at least one of: the redundancy version being equal to a redundancy version 0, the new data indicator being equal to a low logic state, and the new data indicator being toggled.

3. The method of claim 2, wherein according to the first one of the plurality of predefined conditions being satisfied, the method further comprises:

determining a modulation order and a code rate based on a modulation and coding scheme index that is indicated by the control information;

determining a transport block size based on at least the modulation order and the code rate;

based on the code rate and the transport block size, determining the base graph as either a first or a second predefined base graph of the low density parity check code.

4. The method of claim 2, wherein a second one of the plurality of predefined conditions comprises at least one of: the redundancy version being equal to a redundancy version 1, a redundancy version 2, or a redundancy version 3, the new data indicator being equal to a high logic state, and the new data indicator being not toggled.

5. The method of claim 4, wherein according to the second one of the plurality of predefined conditions being satisfied, the method further comprises:

determining the base graph as either a first or a second predefined base graph of the low density parity check code directly according to a modulation and coding scheme index that is indicated by the control information.

6. The method of claim 5, further comprises:

determining the base graph as the first predefined base graph of the low density parity check code when the modulation and coding scheme index belongs to a first subset of a plurality of predefined modulation and coding scheme indexes; and

determining the base graph as the second predefined base graph of the low density parity check code when the modulation and coding scheme index belongs to a second subset of the plurality of predefined modulation and coding scheme indexes.

7. The method of claim 6, wherein each predefined modulation and coding scheme index in the first subset is an even integer and each predefined modulation and coding scheme index in the second subset is an odd integer, or each predefined modulation and coding scheme index in the first subset is an odd integer and each predefined modulation and coding scheme index in the second subset is an even integer.

8. The method of claim 6, wherein in the first subset, a number of a further subset of predefined modulation and coding scheme indexes is at least b_0% of a total number of the predefined modulation and coding scheme indexes in the first subset and a remainder after a division of each of the further subset of the first subset of predefined modulation and coding scheme indexes by an even integer is less than a half of the even integer, and in the second subset, a number of a further subset of predefined modulation and coding scheme indexes is at least b_1% of a total number of the predefined modulation and coding scheme indexes in the second subset and a remainder after a division of each of further subset of the second subset of predefined modulation and coding scheme indexes by the even integer is equal to or greater than the half of the even integer, and wherein b_0 is a first real number greater than 75 and less than 100 and b_1 is a second real number greater than 75 and less than 100.

9. The method of claim 6, wherein in the first subset, a number of a further subset of predefined modulation and coding scheme indexes is at least 60% of a total number of the predefined modulation and coding scheme indexes in the first subset and each of the further subset of the first subset of predefined modulation and coding scheme indexes is greater than N', and in the second subset, a number of a further subset of predefined modulation and coding scheme indexes is at least 60% of a total number of the predefined modulation and coding scheme indexes in the second subset and each of the further subset of the second subset of predefined modulation and coding scheme indexes is less than N', and wherein N' is equal to a sum of the total number of the predefined modulation and coding scheme indexes in the first subset and the total number of the predefined modulation and coding scheme indexes in the second subset.

10. The method of claim 7, wherein according to the second one of the plurality of predefined conditions being satisfied, the method further comprises:

determining the base graph as either a first or a second predefined base graph of the low density parity check code directly according to a modulation and coding scheme table that indicates a relationship between a modulation and coding scheme index, indicated by the control information, and a base graph index.

11. The method of claim 4, wherein according to the second one of the plurality of predefined conditions being satisfied, the method further comprises:

determining the base graph as either a first or a second predefined base graph of the low density parity check code directly based on a modulation and coding scheme index, indicated by the control information, and a code rate corresponding to the modulation and coding scheme index.

12. The method of claim 11, further comprising:

according to the code rate being greater than a first threshold, determining the base graph as the first predefined base graph; and

according to the code rate being less than or equal to a second threshold, determining the base graph as the second predefined base graph,

wherein the first and second thresholds are each a real number less than 1.

13. The method of claim 12, wherein the first threshold is greater than the second threshold.

14. The method of claim 4, wherein according to the second one of the plurality of predefined conditions being satisfied, the method further comprises:

determining the base graph as either a first or a second predefined base graph of the low density parity check code directly based on a modulation and coding scheme index and a number of physical resource blocks that are both indicated by the control information.

15. The method of claim 14, further comprising:

according to a remainder after division of the modulation and coding scheme index by 2 being equal to a remainder after division of the number of physical resource blocks by 2, determining the base graph as the first predefined base graph; and

according to the remainder after division of the modulation and coding scheme index by 2 being not equal to the remainder after division of the number of physical resource blocks by 2, determining the base graph as the second predefined base graph.

16. The method of claim 14, further comprising:

according to a remainder after division of the modulation and coding scheme index by 2 being not equal to a remainder after division of the number of physical resource blocks by 2, determining the base graph as the first predefined base graph; and

according to the remainder after division of the modulation and coding scheme index by 2 being equal to the remainder after division of the number of physical resource blocks by 2, determining the base graph as the second predefined base graph.

17. The method of claim 4, wherein according to either the first or second one of the plurality of predefined conditions being satisfied, the method further comprises:

determining the base graph as either a first or a second predefined base graph of the low density parity check code based on a relationship between a first efficiency value derived from a modulation and coding scheme table and a second efficiency value indicated in a channel quality indicator table,

wherein the first efficiency value is derived as a product of a modulation order being multiplied by a code rate, and wherein in the modulation and coding scheme table, the modulation order and code rate correspond to a respective modulation and coding scheme index.

18. The method of claim 17, wherein the modulation and coding scheme table comprises a plurality of modulation and coding scheme indexes that are grouped into at least three subsets and the channel quality indicator table comprises a plurality of second efficiency values, and wherein a corresponding first efficiency value of each modulation and coding scheme index in a first subset is equal to any of the plurality of second efficiency values in the channel quality indicator table, a corresponding first efficiency value of each modulation and coding scheme index in a second subset is equal to an average of any two adjacent ones of the plurality of second efficiency values in the channel quality indicator table, a corresponding first efficiency value of each modulation and coding scheme index in a third subset is not equal to any first efficiency value associated with the first and second subsets.

19. The method of claim 17, wherein a maximum code rate in the modulation and coding scheme table is equal to $0.95+\Delta x$, wherein Δx is a real number between -0.01 and +0.01.

20. The method of claim 19, wherein the modulation and coding scheme table and the channel quality indicator table are each used by a downlink transmission with a maximum modulation order being equal to 8.

21. A computing device configured to carry out the method of any one claims 1 through 20.

22. A non-transitory computer-readable medium having stored thereon computer-executable instructions for carrying out the method of any one claims 1 through 20.

23. A method, comprising:

receiving control information indicative of a redundancy version and a current logic state of a new data indicator;

determining a base graph of a low density parity check code based on which of a plurality of predefined conditions the redundancy version, and/or the new data indicator satisfy; and

retrieving information bits from a received signal using the determined base graph of the low density parity check code.

24. The method of claim 23, wherein a first one of the plurality of predefined conditions comprises at least one of: the redundancy version being equal to a redundancy version 0, the new data indicator being equal to a low logic state, and the new data indicator being toggled.

25. The method of claim 24, wherein according to the first one of the plurality of predefined conditions being satisfied, the method further comprises:

determining a modulation order and a code rate based on a modulation and coding scheme index that is indicated by the control information;

determining a transport block size based on at least the modulation order and the code rate;

based on the code rate and the transport block size, determining the base graph as either a first or a second predefined base graph of the low density parity check code.

26. The method of claim 24, wherein a second one of the plurality of predefined conditions comprises at least one of: the redundancy version being equal to a redundancy version 1, a redundancy version 2, or a redundancy version 3, the new data indicator being equal to a high logic state, and the new data indicator being not toggled.

27. The method of claim 26, wherein according to the second one of the plurality of predefined conditions being satisfied, the method further comprises:

determining the base graph as either a first or a second predefined base graph of the low density parity check code directly according to a modulation and coding scheme index that is indicated by the control information.

28. The method of claim 27, further comprises:

determining the base graph as the first predefined base graph of the low density parity check code when the modulation and coding scheme index belongs to a first subset of a plurality of predefined modulation and coding scheme indexes; and

determining the base graph as the second predefined base graph of the low density parity check code when the modulation and coding scheme index belongs to a second subset of the plurality of predefined modulation and coding scheme indexes.

29. The method of claim 28, wherein each predefined modulation and coding scheme index in the first subset is an even integer and each predefined modulation and coding scheme index in the second subset is an odd integer, or each predefined modulation and coding scheme index in the first subset is an odd integer and each predefined modulation and coding scheme index in the second subset is an even integer.

30. The method of claim 28, wherein in the first subset, a number of a further subset of predefined modulation and coding scheme indexes is at least b_0% of a total number of the predefined modulation and coding scheme indexes in the first subset and a remainder after a division of each of the further subset of the first subset of predefined modulation and coding scheme indexes by an even integer is less than a half of the even integer, and in the second subset, a number of a further subset of predefined modulation and coding scheme indexes is at least b_1% of a total number of the predefined modulation and coding scheme indexes in the second subset and a remainder after a division of each of further subset of the second subset of predefined modulation and coding scheme indexes by the even integer is equal to or greater than the half of the even integer, and wherein b_0 is a first real number greater than 75 and less than 100 and b_1 is a second real number greater than 75 and less than 100.

31. The method of claim 28, wherein in the first subset, a number of a further subset of predefined modulation and coding scheme indexes is at least 60% of a total number of the predefined modulation and coding scheme indexes in the first subset and each of the further subset of the first subset of predefined modulation and coding scheme indexes is greater than N', and in the second subset, a number of a further subset of predefined modulation and coding scheme indexes is at least 60% of a total number of the predefined modulation and coding scheme indexes in the second subset and each of the further subset of the second subset of predefined modulation and coding scheme indexes is less than N', and wherein N' is equal to a sum of the total number of the predefined modulation and coding scheme indexes in the first subset and the total number of the predefined modulation and coding scheme indexes in the second subset.

32. The method of claim 26, wherein according to the second one of the plurality of predefined conditions being satisfied, the method further comprises:

determining the base graph as either a first or a second predefined base graph of the low density parity check code directly according to a modulation and coding scheme table that indicates a relationship between a modulation and coding scheme index, indicated by the control information, and a base graph index.

33. The method of claim 26, wherein according to the second one of the plurality of predefined conditions being satisfied, the method further comprises:

determining the base graph as either a first or a second predefined base graph of the low density parity check code directly based on a modulation and coding scheme index, indicated by the control information, and a code rate corresponding to the modulation and coding scheme index.

34. The method of claim 33, further comprising:

according to the code rate being greater than a first threshold, determining the base graph as the first predefined base graph; and

according to the code rate being less than or equal to a second threshold, determining the base graph as the second predefined base graph,

wherein the first and second thresholds are each a real number less than 1.

35. The method of claim 34, wherein the first threshold is greater than the second threshold.

36. The method of claim 26, wherein according to the second one of the plurality of predefined conditions being satisfied, the method further comprises:

determining the base graph as either a first or a second predefined base graph of the low density parity check code directly based on a modulation and coding scheme index and a number of physical resource blocks that are both indicated by the control information.

37. The method of claim 36, further comprising:

according to a remainder after division of the modulation and coding scheme index by 2 being equal to a remainder after division of the number of physical resource blocks by 2, determining the base graph as the first predefined base graph; and

according to the remainder after division of the modulation and coding scheme index by 2 being not equal to the remainder after division of the number of physical resource blocks by 2, determining the base graph as the second predefined base graph.

38. The method of claim 36, further comprising:

according to a remainder after division of the modulation and coding scheme index by 2 being not equal to a remainder after division of the number of physical resource blocks by 2, determining the base graph as the first predefined base graph; and

according to the remainder after division of the modulation and coding scheme index by 2 being equal to the remainder after division of the number of physical resource blocks by 2, determining the base graph as the second predefined base graph.

39. The method of claim 26, wherein according to either the first or second one of the plurality of predefined conditions being satisfied, the method further comprises:

determining the base graph as either a first or a second predefined base graph of the low density parity check code, a modulation order and a code rate based on a relationship between a first efficiency value derived from a modulation and coding scheme table and a second efficiency value indicated in a channel quality indicator table,

wherein the first efficiency value is derived as a product of a modulation order being multiplied by a code rate, and wherein in the modulation and coding scheme table, the modulation order and code rate correspond to a respective modulation and coding scheme index.

40. The method of claim 39, wherein the modulation and coding scheme table comprises a plurality of modulation and coding scheme indexes that are grouped into at least three subsets and the channel quality indicator table comprises a plurality of second efficiency values, and wherein a corresponding first efficiency value of each modulation and coding scheme index in a first subset is equal to any of the plurality of second efficiency values in the channel quality indicator table, a corresponding first efficiency value of each modulation and coding scheme index in a second subset is equal to an average of any two adjacent ones of the plurality of second efficiency values in the channel quality indicator table, a corresponding first efficiency value of each modulation and coding scheme index in a third subset is not equal to any first efficiency value associated with the first and second subsets.

41. The method of claim 39, wherein a maximum code rate in the modulation and coding scheme table is equal to $0.95+\Delta x$, wherein Δx is a real number between -0.01 and +0.01.

42. The method of claim 41, wherein the modulation and coding scheme table and the channel quality indicator table are each used by a downlink transmission with a maximum modulation order being equal to 8.

43. A computing device configured to carry out the method of any one claims 23 through 42.

44. A non-transitory computer-readable medium having stored thereon computer-executable instructions for carrying out the method of any one claims 23 through 42.

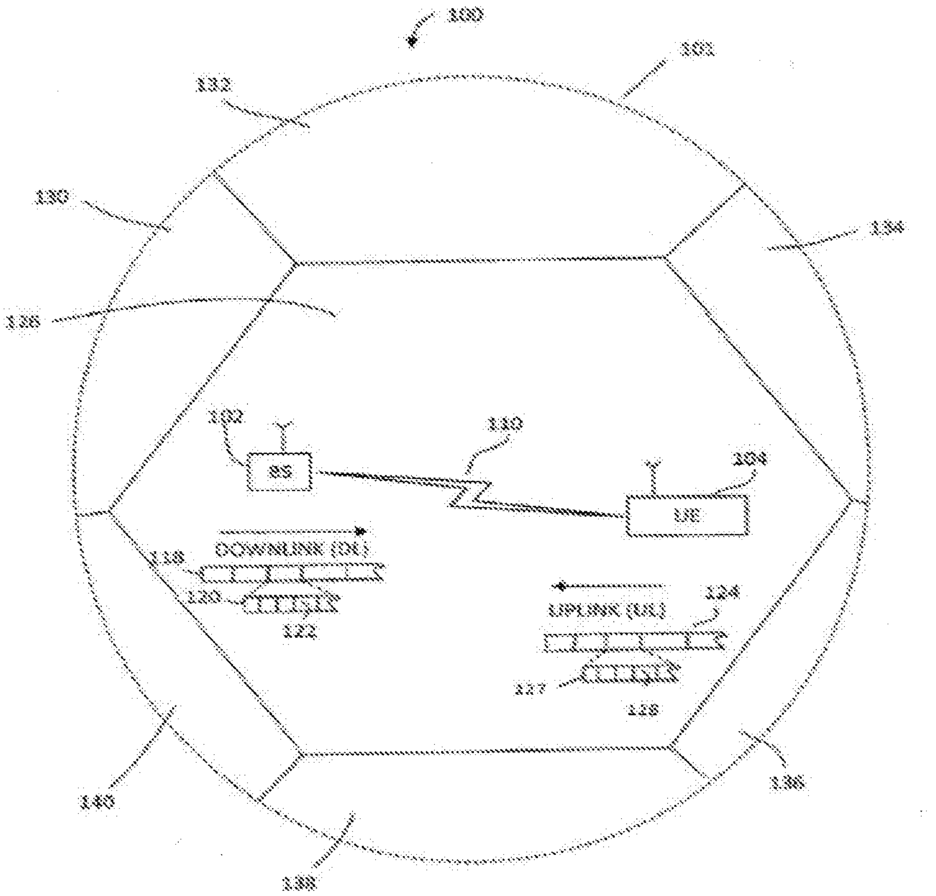
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Figure 1

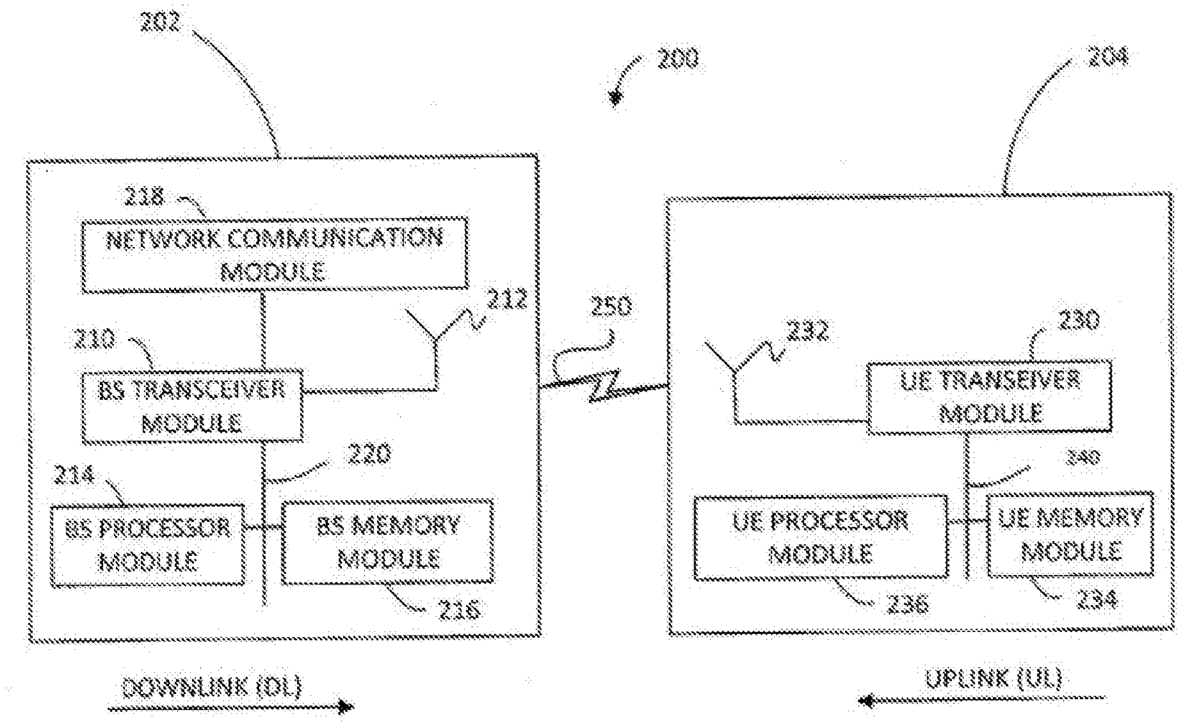

Figure 2

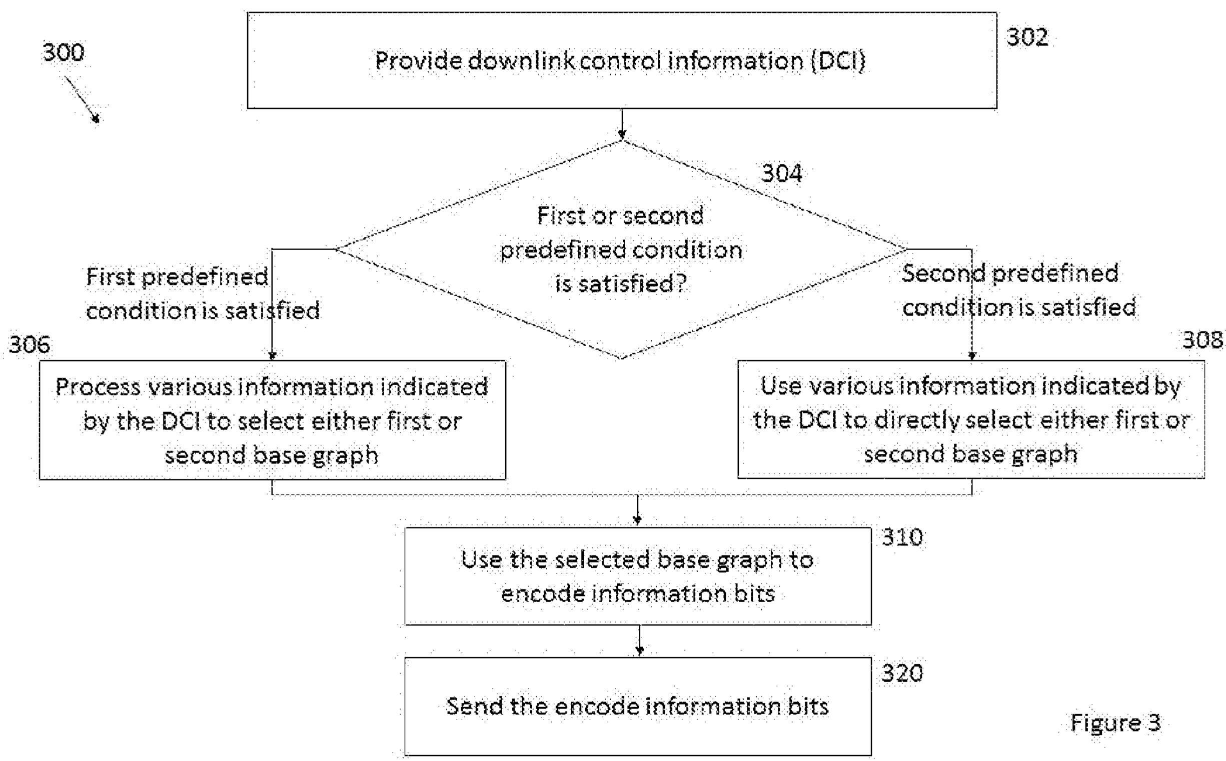

Figure 3

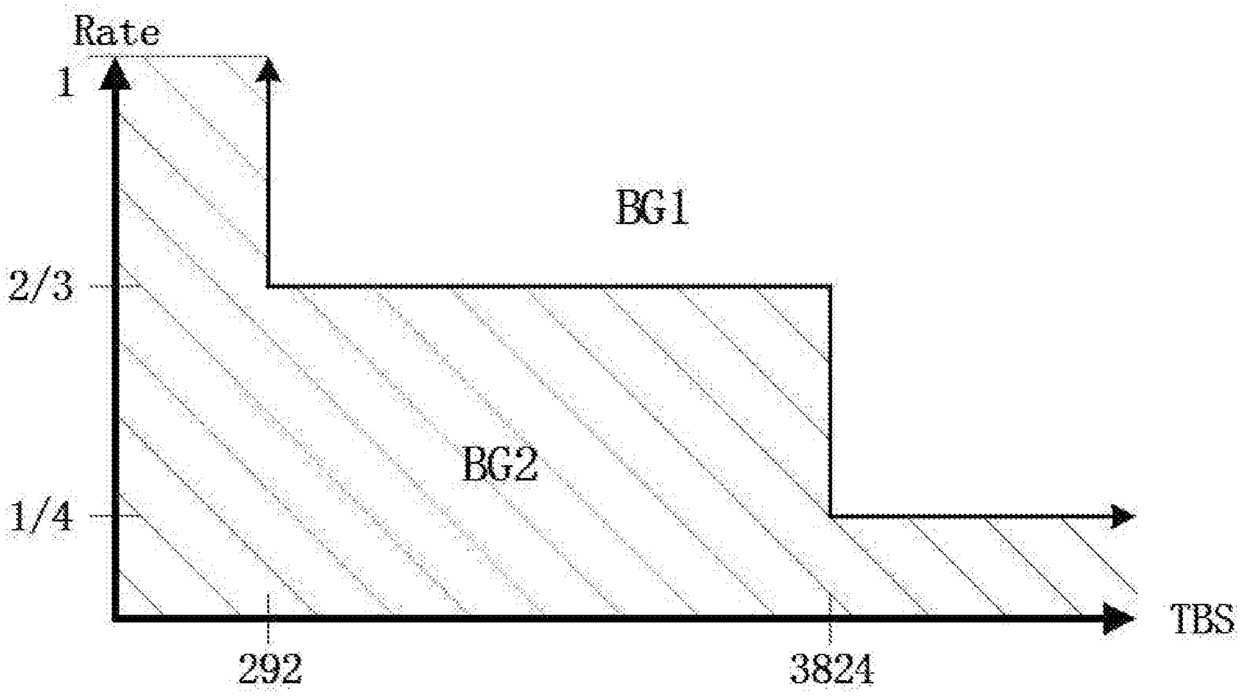

Figure 4

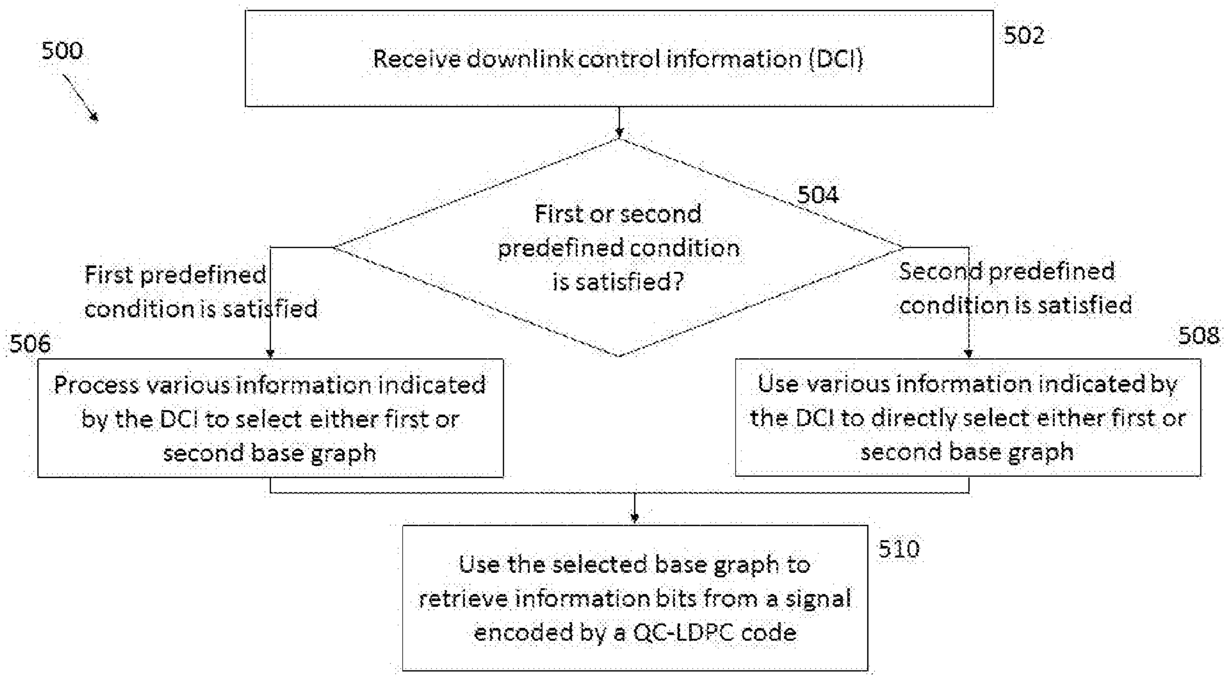

Figure 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/111756

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/12(2009.01)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)

H04W

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

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

CNTXT;CNABS,CNKI,VEN:new data, check code, low,density, parity, indicator, data indicator, redundancy version

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2017223673 A1 (OFINNO TECHNOLOGIES LLC) 03 August 2017 (2017-08-03) the whole document	1-44
A	CN 106899390 A (HUAWEI TECH CO., LTD.) 27 June 2017 (2017-06-27) the whole document	1-44
A	WO 2017088696 A1 (HUAWEI TECH CO., LTD.) 01 June 2017 (2017-06-01) the whole document	1-44

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

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 July 2018	**09 August 2018**

Name and mailing address of the ISA/CN	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/111756

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US 2017223673 A1	03 August 2017	None	
CN 106899390 A	27 June 2017	WO 2017107904 A1	29 June 2017
WO 2017088696 A1	01 June 2017	CN 106788913 A	31 May 2017