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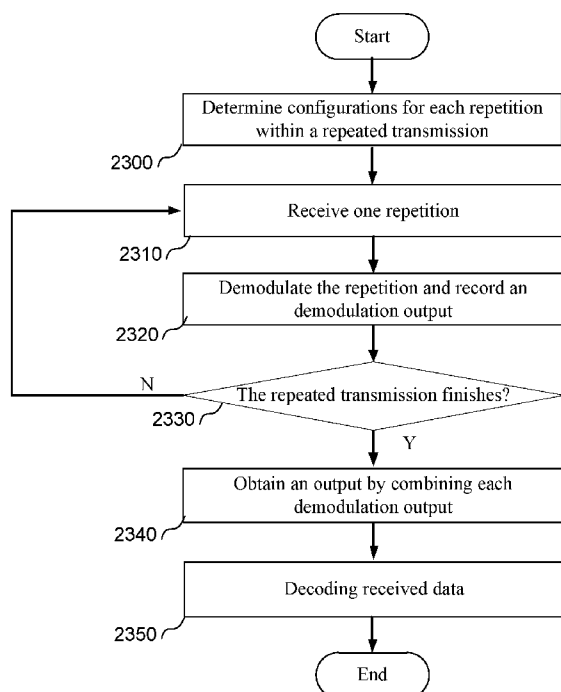


FIG. 23

(57) Abstract: Apparatus and methods are provided to implement a repeated transmission. In one embodiment, a repeated transmission of an information packet can be implemented based on one time block in time domain. One repetition is performed within one time block and each repetition within one time block is self decodable. A repetition time interval (RTI) in time domain is one time block. In a second embodiment, one repetition of an information packet is transmitted within resources distributed to a plurality of time blocks. The RTI length is more than one time block. A receiver side can start to decode the information packet after the plurality of time blocks are received. The information packet is repeatedly transmitted within one time block in a third embodiment. Then, there are multiple repetitions of the information packet within one time block or a basic RTI. Such repetition also repeats within multiple time blocks.

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METHODS FOR REPETITION DESIGN

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FIELD OF THE INVENTION

[0001] This disclosure relates generally to wireless communications and, more particularly, for a device to receive data efficiently.

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BACKGROUND AND RELATED ART

[0002] Some UEs, in the basements of residential buildings or locations shielded by foil-backed insulation, metalized windows or traditional thick-walled building construction, may experience significantly larger penetration losses on the radio interface than normal LTE devices. More resources/power is needed to support these UEs in the extreme coverage scenario with a repeated transmission, which has been identified as a common technique to compensate additional penetration losses. However, it's not decided yet about the detail design of a repeated transmission and how to receive data under the repeated transmission. For example, a same symbol sequence generated from an information packet is repeatedly transmitted in each repetition, or different symbol sequences generated from the information packet are transmitted within different repetitions. Further, whether there are multiple repetitions within one time block at time domain. A new mechanism for repeated transmissions or retransmissions is needed.

25

BRIEF SUMMARY OF THE INVENTION

[0003] The embodiments of this invention propose different repetition mechanisms based on different lengths of time blocks, detail redundancy values application, rate matching design and RE mapping scheme.

[0004] A method for receiving an information packet which is repeatedly transmitted is proposed, the method comprising: determining a repetition time interval (RTI) length for a repeated transmission of an information packet by a receiver in a wireless system; receiving one repetition within one RTI; demodulating the received one repetition,

after determining one RV value for the received one repetition, wherein the one RV value is from one RV sequence repeatedly used for the whole repeated transmission.

[0005] Apparatus and methods are provided to implement a repeated transmission. In one embodiment, a repeated transmission of an information packet can be implemented based on one time block in time domain. It means one repetition is performed within one time block and each repetition within one time block is self-decodable. Under such repetition mechanism, a repetition granularity in time domain is one time block. For easy description, a repetition time interval (RTI) is introduced. Under this embodiment, such repetition is based on a basic RTI with a length of one time block.

[0006] In a second embodiment, an information packet is repeatedly transmitted within a set of resources distributed to a plurality of time blocks, i.e., a subset of the information packet is transmitted in a subset of resources within each time block. Under this repetition mechanism, the RTI length is more than one time block and each transmission in one time block within a longer RTI is not self-decodable. Then, the receiver side can start to decode the information packet after the plurality of time blocks are received.

[0007] The repetition mechanisms in above embodiments can be named as an inter repetition mechanism with a basic RTI or a longer RTI. To support one-shot transmission of an information packet within one time block and reduce delay in time domain, the information packet is repeatedly transmitted within one time block in a third embodiment. Further, such repetition also repeats within a plurality of time blocks in case that repetition within one time block cannot compensate a coverage loss. Different from the inter repetition based on one or more time blocks, there are multiple repetitions of the information packet within one time block and it can be regarded as an intra repetition mechanism. Such repetition mechanism can improve power consumption at the receiver side due to a smaller latency. Further, scheduling at network will be simpler since connected devices with a coverage loss can be served in a time domain multiplexing scheme under such one shot transmission, considering connected devices are massive within a cell, and the size of the information packet is quite small.

BRIEF DESCRIPTION OF DRAWINGS

[0008] The invention can be more fully understood by reading the subsequent detailed

description and examples with references made to the accompanying drawings, wherein:

[0009] FIG. 1 is a block diagram illustrating a schematic diagram of a wireless communications system according to one embodiment of the present invention.

5 [00010] FIG. 2 shows an illustration example of a repetition transmission of an information packet.

[00011] FIG. 3 shows an illustration example of a repetition transmission of an information packet.

10 [00012] FIG. 4 shows an illustration example of a repetition transmission of an information packet.

[00013] FIG. 5 shows an illustration example of a repetition transmission of an information packet.

[00014] FIG. 6 shows an illustration example of physical resource location under a repeated transmission.

15 [00015] FIG. 7 shows an illustration example of physical resource location under a repeated transmission.

[00016] FIG. 8 shows an illustration example of resource allocation within one time block.

20 [00017] FIG. 9 shows an illustration example of resource allocation within one time block.

[00018] FIG. 10 shows an illustration example of resource allocation within one time block.

[00019] FIG. 11 shows an illustration example of signal regeneration under an inter repetition based on a longer RTI.

25 [00020] FIG. 12 shows an illustration example of signal generation under an intra repetition.

[00021] FIG. 13 shows an illustration example of determining a resource granularity under an intra repetition mechanism.

30 [00022] FIG. 14 shows an illustration example of determining a resource granularity under an intra repetition mechanism.

[00023] FIG. 15 shows an illustration example of determining a resource granularity under an intra repetition mechanism.

[00024] FIG. 16 shows an illustration example of RE mapping under a repeated transmission.

[00025] FIG. 17 shows an illustration example of a symbol-level mapping scheme.

[00026] FIG. 18 shows an illustration example of a RV sequence for a repeated transmission.

5 [00027] FIG. 19 shows an illustration example of a RV sequence for a repeated transmission.

[00028] FIG. 20 shows an illustration example of a RV sequence for a repeated transmission.

[00029] FIG. 21 shows an illustration example of a RV sequence for a repeated transmission.

10 [00030] FIG. 22 shows an illustration example of reception procedure under a repeated transmission.

[00031] FIG. 23 shows an illustration example of reception procedure under a repeated transmission.

15 DETAILED DESCRIPTION OF THE INVENTION

[00032] Several exemplary embodiments of the present disclosure are described with reference to FIGs. 1 through 23. It is to be understood that the following disclosure provides various embodiments as examples for implementing different features of the present disclosure. Specific examples of components and arrangements are described
20 in the following to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various described embodiments and/or configurations.

25 [00033] This description is made for the purpose of illustrating the general principles of the invention and should not be taken in a limiting sense. Note that the 3GPP specifications described herein are used to teach the spirit of the invention, and the invention is not limited thereto. The terminology used throughout this invention is an example to describe the proposed concepts and methods clearly, and doesn't limit its
30 application in other systems.

[00034] FIG. 1 is a block diagram illustrating a schematic diagram of a wireless communications system according to one embodiment of the present invention. The wireless communications system 100 includes one or more fixed base infrastructure units 110 and 111, forming one or more access networks 130 and 131 distributed over

a geographical region. The access network 130 and 131 may be a Universal Terrestrial Radio Access Network (UTRAN) in the WCDMA technology or an E-UTRAN in the Long Term Evolution (LTE)/LTE-A technology. The base unit may also be referred to an access point, base station, Node-B, eNode-B (eNB), or other terminologies used in the art. In some systems, one or more base stations are communicably coupled to a controller forming an access network that is communicably coupled to one or more core networks.

[00035] In FIG.1, one or more mobile stations 120 and 121 are connected wirelessly to base stations 110 and 111 for wireless service within a serving area, for example, a cell or within a cell sector. The mobile station may also be called as user equipment (UE), a wireless communication device, terminal or some other terminologies. Mobile station 120 and 121 send uplink data to base stations 110 and 111 via uplink channel 140 and 141 in the time and/or frequency domain. The serving base station 110 and 111 transmit downlink signals via a downlink channel 150 and 151. In one embodiment, the communication system utilizes Orthogonal Frequency Division Multiplexing Access (OFDMA) or a multi-carrier based architecture including Adaptive Modulation and Coding (AMC) on the downlink and next generation single-carrier (SC) based FDMA architecture for uplink transmissions. SC based FDMA architectures include Interleaved FDMA (IFDMA), Localized FDMA (LFDMA), DFT-spread OFDM (DFT-SOFDM) with IFDMA or LFDMA. In OFDMA based systems, remote units are served by assigning downlink or uplink radio resources that typically comprises a set of sub-carriers over one or more OFDM symbols. Exemplary OFDMA based protocols include the developing LTE/LTE-A of the 3GPP standard and IEEE 802.16 standard. The architecture may also include the use of spreading techniques such as multi-carrier CDMA (MC-CDMA), multi-carrier direct sequence CDMA (MC-DS-CDMA), Orthogonal Frequency and Code Division Multiplexing (OFCDM) with one or two dimensional spreading, or may be based on simpler time and/or frequency division multiplexing/multiple access techniques, or a combination of these various techniques. In alternate embodiments, communication system may utilize other cellular communication system protocols including, but not limited to, TDMA or direct sequence CDMA. The disclosure however is not intended to be limited to any particular wireless communication system.

[00036] In FIG. 1, the mobile communication network 100 is an OFDM/OFDMA system comprising a base station eNB 110 and eNB 111, and a plurality of mobile

station 120 and mobile station 121. In 3GPP LTE system based on OFDMA downlink, the radio resource is partitioned into subframes each of which is comprised of 2 slots and each slot has 7 OFDMA symbols in the case of normal Cyclic Prefix (CP). Each OFDMA symbol further consists of a number of OFDMA subcarriers
5 depending on the system bandwidth. The basic unit of the radio resource grid is called Resource Element (RE) which spans an OFDMA subcarrier over one OFDMA symbol. One type of the basic block of the radio resources for scheduling in LTE is called physical resource block (PRB), each of which contains several consecutive OFDM symbols in one subframe and several consecutive subcarriers in frequency
10 domain. Virtual resource blocks (VRB) is another type of the basic block of the radio resources definition in LTE system, which have two types: localized type and distributed type. For each type of virtual resource blocks, a pair of virtual resource blocks over two slots in a subframe is assigned together by a single virtual resource block number. One downlink assignment or an uplink grant consists of one or
15 multiple basic blocks of the radio resources, e.g., a set of PRBs.

Section 1: Repetition Mechanism in time domain

[00037] In embodiments of this invention, a repeated transmission means an initial repeated transmission of an information packet, and also a repeated retransmission of the information packet in case of failure decoding.

20 [00038] In one embodiment, a repeated transmission of an information packet can be implemented based on one time block in time domain. It means one repetition is performed within one time block and each repetition within one time block is self-decodable. Under such repetition mechanism, a repetition granularity in time domain is one time block. For easy description, such granularity is named as a repetition time
25 interval (RTI). Moreover, such repetition scheme can be regarded as an inter repetition mechanism based on one time block, or on a basic RTI. Then, a repetition number of the transmitted information packet bits is equal to a number of occupied time blocks with each carrying one repetition of the information packet. Here, a time block is a basic time unit at time domain. For example, a time block is a subframe in a
30 LTE system.

[00039] FIG. 2 shows an example of a repeated transmission of an information packet by an inter repetition mechanism based on one time block. In this figure, an information packet 210 is repeatedly transmitted within a duration 230. Specifically, a repeated transmission of information packet 210 comprises a repetition 220 at time

block 200, a repetition 211 at time block 201 and a repetition 213 at time block 202. Note that physical location of each repetition in frequency domain is different from each other in this figure.

[00040] In a second embodiment, an information packet is repeatedly transmitted within a set of resources distributed to a plurality of time blocks, i.e., a subset of the information packet is transmitted in a subset of resources within each time block. Under this repetition mechanism, the RTI length is more than one time block and each transmission in one time block within a longer RTI is not self-decodable. Then, at the receiver side, the receiver can start to decode the information packet after the plurality of time blocks are received. This repetition scheme is an inter repetition mechanism based on a longer RTI comprising multiple time blocks. Note that transmissions within one longer RTI are considered as one repetition. For easy description, each transmission within one time block within the longer RTI is named as a part of one repetition.

[00041] FIG. 3 shows an illustration of a repeated transmission of an information packet by an inter repetition based on a longer RTI. An information packet 310 comprises two information subsets 311 and 312, and transmitted repeatedly within a duration 340. Specifically, subsets 311 and 312 are repeated within different time blocks. Repetition of subset 311 comprises a repetition 320 at time block 300, a repetition 323 at time block 302, and a repetition 325 at time block 304, while repetition of subset 312 comprises a repetition 321 at time block 301, a repetition 324 at time block 303 and a repetition 326 at time block 305. In this example, a transmission 320 of information subset 311 in time block 300 and a transmission 321 of information subset 312 in time block 301 constitute a complete repetition of the whole information packet 310 based on a longer RTI with two time blocks.

[00042] To support one-shot transmission of an information packet within one time block and reduce delay in time domain, the information packet is repeatedly transmitted within one time block in a third embodiment. Further, such repetitions also repeat within a plurality of time blocks in case that multiple repetitions within one time block cannot compensate the coverage loss. Different from the inter repetition based on one or more time blocks, there are multiple repetitions of the information packet within one time block or a basic RTI.

[00043] Such repetition mechanism can improve power consumption at the receiver side due to a smaller latency. Further, scheduling at network will be simpler, since

connected devices with a coverage loss are served in a time domain multiplexing scheme under such one shot transmission, considering connected devices are massive within a cell, and size of an information packet is quite small. To support such repetition mechanism, an indicator within a control signaling can be used to inform the receiver side in one embodiment.

[00044] FIG. 4 and FIG. 5 show some examples of a repeated transmission of an information packet based on the intra repetition mechanism and the inter repetition mechanism. In FIG. 4, a repeated transmission of an information packet happens within a duration 440, wherein there are repetitions both within one time block and among time blocks. In this example, there are two repetitions within one time block. Within time block 400, there are repetitions 420 and 421. Moreover, there are repetitions 422 and 423 within time block 401, and repetitions 424 and 425 within time block 403. It can be observed that there are both intra repetitions and inter repetitions for information packet 410. Different from FIG. 4, there are only intra repetitions within one time block in FIG. 5. In detail, a repeated transmission of information packet 510 only occurs in time block 501, where there are repetitions 520, 521, 522 and 523 at different locations in frequency domain.

[00045] Note that time blocks for a repeated transmission can be contiguous in time domain in one embodiment, or discrete in time domain in another embodiment. At a receiver side, the receiver should determine which time block is occupied for a repeated transmission before reception.

Section 2: Resource allocation for a repeated transmission

[00046] Note that a resource size is assumed to be identical for one transmission, which is one complete repetition, a part of one repetition, or multiple repetitions in each occupied time block, in this invention. However, physical resource location of each transmission in frequency domain within each occupied time block can be different. In one embodiment, physical resource locations of other transmissions in frequency domain are identical to the first physical resource location for the first transmission within the first time block, which is a starting point of a repeated transmission. In another embodiment, physical resource location within other occupied time blocks are a predefined function of a first physical resource location in a first time block. Specifically, parameters of the predefined function comprise a starting index of the first physical resource location in frequency domain, and the index of occupied time blocks for repetitions. An example function of this predefined

function is as follow

$$R_n^{\text{start}} = (R_{1\text{st}}^{\text{start}} + I_n) \bmod N_{\text{BW}} \quad \text{Eq. (1)}$$

wherein R_n^{start} and $R_{1\text{st}}^{\text{start}}$ denote a start point of a physical resource location within n -th time block and 1st time block during a repeated transmission, and N_{BW} is a channel bandwidth. From this example, physical resource locations of other time blocks can be obtained by adding a shift based on the index of time block to the first physical resource location within the first time block.

[00047] Note that the first physical resource location is obtained by an indicator within a control signaling in one embodiment, or predefined in another embodiment. FIG. 6

and FIG. 7 show illustrations of physical locations of resources within different occupied time blocks for a repeated transmission. In FIG. 6, an information packet 610 is repeatedly transmitted by a repetition 620 in time block 600, a repetition 622 in time block 601 and a repetition 624 in time block 603. Specifically, resource locations of repetitions 620, 622 and 624 are identical in frequency domain. In FIG. 7, an information packet 710 is repeatedly transmitted by a repetition 720 in time block 700, a repetition 722 in time block 701 and repetition 724 in time block 703. Physical resource location 741 for repetition 722 is obtained by adding a shift with a value 2 to physical resource location 740 of repetition 720, while physical resource location 742 of repetition 724 is obtained by adding a shift with value 6 to 740.

[00048] Further, resources within one time block can be discrete in one embodiment and contiguous in another embodiment. Some examples are shown in FIG. 8 ~ FIG. 10. In FIG. 8, an information packet 800 is transmitted repeatedly by an inter repetition 810 based on one time block. Resources for one repetition 820 in time block 850 comprise two subsets 830 and 831, and these two subsets of resources are discrete in frequency domain. In FIG. 9, an information packet 900 is repeatedly transmitted by an intra repetition 910, and there are two repetitions within each time block. Specifically, in time block 950, resources for two repetitions 920 and 921 are distributed into 3 subsets of resources 930, 931 and 932 in frequency domain. In FIG.10, for an intra repetition 1010 for an information packet 1000, there are two repetitions in each time block. Specifically, resources 1030 in frequency domain for repetitions 1020 and 1021 in time block 1050 are contiguous.

[00049] Except for the resources in frequency domain, the receiver should also determine which time block to detect for reception. In one embodiment, time blocks

for a repeated transmission of an information packet are discrete in time domain. In another embodiment, a set of contiguous time blocks is used for a repeated transmission.

Section 3: RE mapping/ rating matching for a repeated transmission

5 [00050] Under an inter repetition mechanism based on a longer TTI, the length of a symbol sequence, which is generated from an information packet to be transmitted, depends on the size of overall resources within a longer RTI, wherein the overall resources comprise multiple subsets of resources with an identical size and located in occupied time blocks within a longer RTI, in one embodiment. Then, the symbol
10 sequence is divided into multiple parts equally, wherein a length of each part depends on a size of resources within one time block, and each part is transmitted in one time block within a longer RTI.

[00051] FIG. 11 shows an example of signal generation for an inter repetition based on a long RTI. In this figure, a symbol sequence 1101 with a length 1110 is generated
15 from an information packet 1100, and the symbol sequence comprises two parts 1103 with a length 1111 and 1104 with a length 1112. One repetition of 1101 comprises two time blocks, i.e., 1103 and 1104 are repeatedly transmitted within different time blocks. Specifically, 1103 is repeatedly transmitted by repetitions 1130 at time block 1150, 1132 at time block 1152 and 1134 at time block 1154, while 1104 is repeatedly
20 transmitted by repetitions 1131 at time block 1151, 1133 at time block 1153 and 1135 at time block 1155. Note that the length value 1110 of symbol sequence 1101 depends on the size 1142 of overall resource for one complete repetition within two time blocks, wherein the overall resources comprise resource 1140 and resource 1141. Sizes of overall resources for each longer RTI (time block 1150, 1151, 1152, 1153, 1154 and
25 1155) are identical.

[00052] Under an intra repetition mechanism, a basic resource granularity is proposed for one repetition of the information packet. Specifically, a length of a symbol sequence generated from the information packet depends on a size of the basic resource granularity in one embodiment. There is one or multiple of such basic
30 resource granularities within one time block to support one-shot transmission.

[00053] Note that the basic resource granularity is predefined between eNB and UE, and fixed during the whole repeated transmission in one embodiment. In another embodiment, the basic resource granularity is given by a control signaling, or in some cases, the basic resource granularity is adjusted dynamically. In a third embodiment,

the basic resource granularity is indicated by a higher layer signaling and changes semi-statically.

[00054] FIG. 12 gives an example of signal generation for an intra repetition mechanism. In this example, an information packet 1200 is repeatedly transmitted by a one-shot transmission within time block 1201 by 4 repetitions. Specifically, a symbol sequence 1201 with a length 1210 generated from 1200 is repeatedly 4 times within 4 subsets of resources 1220, 1221, 1222 and 1223, while the size of each subset of resource is size 1230. Further, the length 1210 is determined by size 1230. In this example, 1220, 1221, 1222 and 1223 are four basic resource granularities with size 1230.

[00055] To support such repetition within one time block, the size of the basic resource granularity and the size of the information packet should be determined. The sizes are indicated in a control signaling, while the sizes are same for all repetitions within different occupied time blocks within one repeated transmission. Note that one size of the basic resource granularity corresponds to the size of one information packet and such relationship is specified in one embodiment, and corresponds to multiple sizes of one information packet in another embodiment.

[00056] In another embodiment, the basic resource granularity is predefined with a specific size, and several sizes of an information packet are also specified. Under this design, the sizes of the information packet are indexed and indicated by an indicator within a control signaling for transmission.

[00057] FIG. 13 ~ FIG. 15 show illustrations of designing a resource granularity under an intra repetition mechanism. In FIG. 13, a table 1300 about the sizes for a basic resource granularity and information packet is predefined. In the table, block 1310 denotes sizes for a basic resource granularity with values 1311 ~1315, while block 1330 denotes sizes for an information packet with values 1331~1334. Block 1320 is indices for sizes of information packet. An indicator 1341 within a control signaling 1340 will indicate a size of an information packet to the receiver side, and another indicator 1342 informs the receiver the size of the resource granularity.

[00058] In FIG. 14, an indicator 1401 within a control signaling 1400 carries an index value for a receiver side to determine a size of an basic resource granularity and also a size for an information packet, and the receiver can determine detail values by checking a table 1420. For this example, sizes of the basic resource granularity and information packet are indexed with a one-to-one mapping relationship. Specifically,

in table 1420, block 1440 with sizes 1441, 1442 and 1443 corresponds to information packet sizes 1450 with value 1451, 1452 and 1453.

[00059] In FIG. 15, an indicator 1501 within a control signaling 1500 carries an index value to determine the size of the information packet. Predefined sizes for an information packet are 1541, 1542, 1543, and indexed in a table 1520 by indices 1531, 1532 and 1532. A receiver side can determine the size by an indicator 1501 within a control signaling. In this example, a size of a basic resource granularity is predefined.

[00060] To accommodate multiple repetitions within one time block, a reserved set of resources within one time block is predefined in one embodiment. In another embodiment, a set of resources is indicated by the control signaling. Note that the size of overall resources for multiple repetitions within one time block is multiple of the size of the basic resource granularity.

[00061] To map symbols to available REs in case there are multiple repetitions within one time block, a symbol sequence generated from the information packet is mapped to available REs in one embodiment. Such mapping scheme can be regarded as a sequence-level mapping or a sequence-level repetition. In another embodiment, symbols within the sequence are repeatedly one by one. Different from the sequence-level repetition, such repetition can be named as a symbol-level mapping.

[00062] Some examples are given in FIG. 16 and Fig. 17. In FIG. 16, a symbol sequence 1610 with a length L is repeatedly transmitted by repetitions 1601 and 1602 at different frequency locations within one time block, wherein each repetition occupies one pair of PRB. Here, LTE system is considered. In this example, the symbol sequence is repeatedly mapped to available resources. In FIG. 17, a symbol sequence 1710 with a length L is repeatedly transmitted by repetitions 1701 and 1702 at different frequency locations within one time block, wherein each repetition occupies one PRB pair, based on LTE system. In this example, symbols within 1710 are mapped repeatedly one by one to available resources.

[00063] The mapping scheme is specified in one embodiment. No matter which mapping scheme is applied, a repetition number within one time block depends on the size of overall resources and the size of the basic resource granularity. Or the repetition number can be expressed by the size of overall resources within one time block and a length of the symbol sequence. An example function is given as follow

$$N_{\text{intra}} = \lfloor N_{\text{RE}} / N_{\text{symb}} \rfloor \quad \text{Eq. (2)}$$

wherein N_{RE} denotes a resource size expressed by a number of available REs within one time block, N_{symb} is a number of symbols or a sequence length.

Section 4: Transmission scheme and reception procedure for a repeated transmission (same symbol repetition by a chase combining, or HARQ like repetition with a coding gain)

[00064] In a wireless communication system, a receiver side, either a terminal or a base station, need to combine received data for decoding under HARQ retransmission, wherein a same redundancy version (RV) or different RVs will be used for retransmissions, compared to an initial transmission of a data packet or a sequence of information bits. Taking LTE system as an example, RV value for downlink transmission is indicated by the control signaling, carried by PDCCH. Or RV value can be predefined for uplink transmission.

[00065] To support a repeated transmission of an information packet, a RV sequence is repeatedly used for symbol generation in one embodiment, wherein elements within the RV sequence are different from each other, or some elements within the RV sequence share the same value. If all elements within the RV sequence are identical, only one RV value is used for repetitions actually, i.e., RV values for all repetitions are identical.

[00066] For a repeated retransmission of the information packet, a second RV sequence different from a first RV sequence for an initial repeated transmission can be used. Each RV sequence for each retransmission can be different or identical. Note that the length of the RV sequence is not larger than a repetition number, and the RV sequence is used repeatedly. If the length of the RV sequence is equal to one, it means only one RV is used for all repetitions within a repeated transmission or retransmission.

[00067] FIG. 18 and FIG. 19 show some examples of a repeated transmission with a RV sequence. In FIG. 18, a RV sequence 1840 with a length 1820 comprising RV elements 1841, 1842, 1843 and 1844 is repeatedly used for a repeated transmission 1890. Specifically, different symbol sequences are generated by different RV values. RV element 1841 is used for a repetition 1810 at time block 1800; RV element 1841 is used for a repetition 1811 at time block 1801; RV element 1843 is used for repetitions 1812 and 1814 at time blocks 1802 and 1805; RV element 1844 is used for repetitions 1813 and 1815 at time blocks 1803 and 1806. In this example, a repetition

number of the repeated transmission 1890 is a multiple of the RV sequence length 1820.

[00068] In FIG. 19, a RV sequence 1940 with a length 1920 comprising RV elements 1941, 1942, 1943 and 1944 is repeatedly used for a repeated transmission 1990.

5 Specifically, different symbol sequences are generated by different RV values. RV element 1941 is used for a repetition 1910 and 1914 at time block 1900 and 1904; RV element 1941 is used for a repetition 1911 at time block 1901; RV element 1943 is used for repetitions 1912 and 1915 at time blocks 1902 and 1906; RV element 1944 is used for repetitions 1913 at time blocks 1903. In this example, a repetition number of
10 the repeated transmission is not a multiple of RV sequence length 1920, and RV element 1943 is used for the last repetition 1915.

[00069] Under an inter repetition mechanism based on a basic RTI or a longer RTI, only one RV is used for one repetition within the basic RTI or the longer RTI. Under an intra repetition mechanism, one RV is used for multiple repetitions within one time
15 block in one embodiment. In another embodiment, a RV sequence is used repeatedly for the whole repetition, and different RV values are applied for different repetitions within one time block.

[00070] FIG. 20 and Fig. 21 show examples of an intra repetition with a RV sequence.

In FIG. 20, a RV sequence 2030 with a length 2020 is used for a repeated
20 transmission 2060, wherein 2060 is based on an inter repetition and an intra repetition.

Moreover, RV sequence 2030 comprises multiple RV elements 2040, 2041, 2042 and 2043, and these RV elements are used for different repetitions. In this example, the whole RV sequence is used repeatedly by applying different RV values for different repetitions within one time block. RV element 2040 is used a repetition 2010 at time
25 block 2000, and RV element 2041 is used for another repetition 2011 within the same time block; RV element 2042 is used for a repetition 2012 at time block 2001, and repetition 2015 at time block 2002, and RV element 2043 is used for another repetition 2013 within the same time block 2001, and repetition 2014 at time block 2002. Last two repetitions 2014 and 2015 within time block 2002 are based on RV
30 element 2043 and 2042 respectively, since repetition number of 2060 is multiple of 2020.

[00071] In FIG. 21, a RV sequence 2130 with a length 2120 is repeatedly used for a repetition 2160. Specifically, a RV element 2140 is used for repetitions 2110 and 2111 within time block 2100; a RV element 2141 is used for repetitions 2112 and

2113 at time block 2101; a RV element 2143 is used for repetitions 2114 and 2115 within time block 2102. Note that the number of occupied time blocks for 2160 is multiple of 2120, and the last RV element 2143 within 2130 is used for repetitions within the last occupied time block 2102 of 2160.

5 [00072] If each RV value for each repetition is identical, and each scrambling sequence for each repetition is also identical, a repeated transmission means a same symbol sequence is repeatedly transmitted in one embodiment. It can be regarded as an identical repetition. To generate a scrambling sequence for all repetitions, the scrambling sequence can be a function of a first time block index, wherein the first
10 time block is a starting point for a repeated transmission or retransmission. In another embodiment, different symbol sequences which are generated from the same information packet are transmitted in different repetitions. Here, different symbol sequences means different RV values are applied to explore a coding gain, or different scrambling sequences are used to randomize interference. Note that it's assumed that
15 a modulation order remains identical during repetitions for above designs.

[00073] To determine a RV sequence, a set of RV sequences is predefined and an indicator within a control signaling informs the receiver side about the used RV sequence implicitly in one embodiment. At the receiver side, the receiver can determine the used RV sequence by checking a RV sequence index carried by the
20 indicator. In another embodiment, a predefined rule is specified to get RV values for each repetition without any signaling.

[00074] Before to receive a repeated transmission of an information packet, at the receiver side, the receiver should first determine configurations for each repetition, wherein the configurations comprise scrambling sequence, RV value, and physical
25 resources including locations in time domain and frequency domain, repetition mechanism (inter repetition or intra repetition). If an identical repetition is applied, the receiver can combine received symbols from different repetitions directly in one embodiment, i.e., a symbol-level combination is performed. Also the receiver can combine outputs after demodulation in another embodiment. If an identical repetition
30 is not applied, the receiver should perform a combination after demodulation, i.e., a bit-level combination is performed, in a third embodiment.

[00075] A reception procedure at the receiver side in one embodiment can be described as follow:

- Step 1: determining configurations for each repetition based on control signaling or some predefined rules, like physical resource, scrambling sequence, RV sequence, etc.

5 - Step 2: receiving repetitions one by one at corresponding frequency-time resources.

- Step 3: determining whether it's possible to perform a symbol-level combination among repetitions?

- If yes, performing a symbol-level combination among received repetitions (Step 4), and then go to Step 6.

10 • If not, demodulating received data and obtaining a combination output by combining each demodulation output of each repetition (Step 5), and then go to Step 7.

- Step 6: demodulating received symbols, and then go to step 7 .

15 - Step 7: decoding received symbols based on output in Step 5 or Step 6, and end the procedure.

[00076] In another embodiment, a reception procedure at the receiver side in one embodiment can be described as follow

20 - Step 1: determining configurations for each repetition based on control signaling or some predefined rules, like physical resource, scrambling sequence, RV sequence, etc.

- Step 2: receiving repetitions one by one at corresponding frequency-time resources.

- Step 3: demodulating each received repetition.

- Step 4: combining each demodulation output of each received repetition.

25 - Step 5: decoding received data based on a combination output in Step 4.

[00077] Note that at the receiver side, the receiver can perform decoding by receiving some repetitions, without receiving all repetitions, to reduce time delay in a realistic system in one embodiment. If a successful decoding achieved, for example, CRC check is passed, the receiver can determine a successful reception of transmitted data, and can stop to receive rest repetitions.

30 **[00078]** FIG. 22 and FIG. 23 illustrate examples of a procedure of decoding an information packet under a repeated transmission. In FIG. 22, at the receiver side, the receiver determines configurations for each repetition within a repeated transmission

in Step 2200 before performing reception, and then starts to receive each repetition (Step 2210). If yes, go to a determination that an identical repetition is applied for the repeated transmission in Step 2220, the received will combine received repetitions by a symbol-level combination (Step 2230). Then, the receiver will judge whether the repetition finishes (Step 2230). If not to Step 2230, the receiver will continue to receive rest repetitions. If yes to Step 2230, a demodulation will be performed based on the symbol-level combination output (Step 2231). Further, received data will be decoded (step 2240) by inputting the demodulation output in Step 2231. If no to Step 2220, the receiver will demodulate each received repetition and buffer each demodulation output (Step 2222). Then, the receiver will judge whether the repetition finishes (Step 2250). If not to Step 2250, the receiver will continue to receive rest repetitions. If yes to Step 2250, an output will be obtained for data decoding (Step 2240) by combining each demodulation output of each repetition (Step 2260).

[00079] In FIG. 23, before receiving each repetition (Step 2310), at the receiver side, the receiver determines configurations for each repetition within a repeated transmission firstly (Step 2300). After receiving one repetition, a demodulation of the received repetition is performed and each output is buffered (Step 2320). Then, the receiver will determine whether all repetitions are received (Step 2330). If yes to Step 2330, a decoding will be performed (Step 2350) by combining each demodulation output (Step 2340) and the whole procedure stops. If not to Step 2330, the receiver continues to receive repetitions.

[00080] In above embodiments, the receiver starts to decode received data after all repetitions are received. Note that the receiver can also start to decode received data without receiving all repetitions. Once a successful decoding achieved, the receiver can stop to receive rest repetitions to reduce power consumption. Further, the receiver can send a positive acknowledgement to a transmitter to stop transmitting to improve resource efficiency and power consumption at the transmitter.

[00081] While the present disclosure and the best modes thereof have been described in a manner establishing possession and enabling those of ordinary skill to make and use the same, it will be understood and appreciated that there are equivalents to the exemplary embodiments disclosed herein and that modifications and variations may be made thereto without departing from the scope and spirit of the inventions, which are to be limited not by the exemplary embodiments but by the appended claims.

[00082] Those with skill in the art will understand that information and signals may be

represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields

5 or particles, or any combination thereof.

[00083] Those with skill in the art will further appreciate that the various illustrative logical blocks, modules, processors, means, circuits, and algorithm steps described in connection with the aspects disclosed herein may be implemented as electronic hardware (e.g., a digital implementation, an analog implementation, or a combination

10 of the two, which may be designed using source coding or some other technique), various forms of program or design code incorporating instructions (which may be referred to herein, for convenience, as “software” or a “software module”), or combinations of both. To clearly illustrate this interchangeability of hardware 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 or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a

15

20 departure from the scope of the present disclosure.

[00084] In addition, the various illustrative logical blocks, modules, and circuits described in connection with the aspects disclosed herein may be implemented within or performed by an integrated circuit (“IC”), an access terminal, or an access point. The IC may comprise a general purpose processor, a digital signal processor (DSP),

25 an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, electrical components, optical components, mechanical components, or any combination thereof designed to perform the functions described herein, and may execute codes or instructions that reside within the IC, outside of the

30 IC, or both. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may 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 such configuration.

[00085] It is understood that any specific order or hierarchy of steps in any disclosed process is an example of a sample approach. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the processes may be rearranged while remaining within the scope of the present disclosure. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[00086] The steps of a method or algorithm described in connection with the aspects disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module (e.g., including executable instructions and related data) and other data may reside in a data memory such 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 computer-readable storage medium known in the art. A sample storage medium may be coupled to a machine such as, for example, a computer/processor (which may be referred to herein, for convenience, as a “processor”) such that the processor can read information (e.g., code) from and write information to the storage medium. A sample storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in user equipment. In the alternative, the processor and the storage medium may reside as discrete components in user equipment. Moreover, in some aspects any suitable computer-program product may comprise a computer-readable medium comprising codes relating to one or more of the aspects of the disclosure. In some aspects a computer program product may comprise packaging materials.

[00087] While the invention has been described in connection with various aspects, it will be understood that the invention is capable of further modifications. This application is intended to cover any variations, uses or adaptation of the invention following, in general, the principles of the invention, and including such departures from the present disclosure as come within the known and customary practice within the art to which the invention pertains.

CLAIMS

1.A method comprising:

determining a repetition time interval (RTI) length for a repeated

5 transmission of an information packet by a receiver in a wireless system;

receiving one repetition within one RTI; and

demodulating the received one repetition, after determining one RV value for the received one repetition, wherein the one RV value is from one RV sequence repeatedly used for the repeated transmission.

10 2.The method of claim 1, further comprising receiving repetitions under an intra repetition procedure involves:

determining an intra repetition mechanism by checking an indicator within a control signaling;

15 determining a basic resource granularity for one repetition under the intra repetition; and

receiving multiple repetitions within one RTI.

3.The method of claim 2, wherein a size of the basic resource granularity is indicated by an indicator within a control signaling for the information packet transmission.

20 4.The method of claim 1, further comprising demodulating one reception procedure involves:

collecting available resources in a contiguous way belonging to each symbol within a transmitted symbol sequence, wherein the symbol sequence is generated from the information packet;

25 obtaining a received symbol by combining collected available resources; and

demodulating received data by constructing received symbols one by one after combination.

5.The method of claim 1, further comprising demodulating one reception procedure involves:

30 collecting available resources in a discrete way belonging to each symbol within a transmitted symbol sequence, wherein the symbol sequence is generated from the information packet;

obtaining a received symbol by combining collected available resources; and

demodulating received data by constructing received symbols one by one after combination.

6.The method of claim 1, wherein a value for the one RV sequence is 0, 2, 3, 1.

5 7.The method of claim 1, further comprising obtaining one RV sequence procedure involves:

receiving a control signaling for the information packet transmission, wherein the control signaling comprises a RV sequence index indicator; and

obtaining the one RV sequence by looking up a RV sequence table indexed by the RV sequence indicator.

10 8.The method of claim 1, wherein a repetition number of the repeated transmission is a multiple of a length of the one RV sequence.

9.The method of claim 1, wherein a repetition number of the repeated transmission is not a multiple of a length of RV sequence.

10.The method of claim 2, further comprising:

15 determining one RV value for multiple repetitions within one RTI under the intra repetition mechanism.

11.The method of claim 2, further comprising:

determining one RV value for each repetition within one RTI under the intra repetition mechanism.

20 12.The method of claim 1, wherein a symbol sequence generated from the information packet is repeatedly transmitted in repetitions within the repeated transmission.

25 13.The method of claim 1, wherein different symbol sequence are generated from the information packet and transmitted in different repetitions within the repeated transmission.

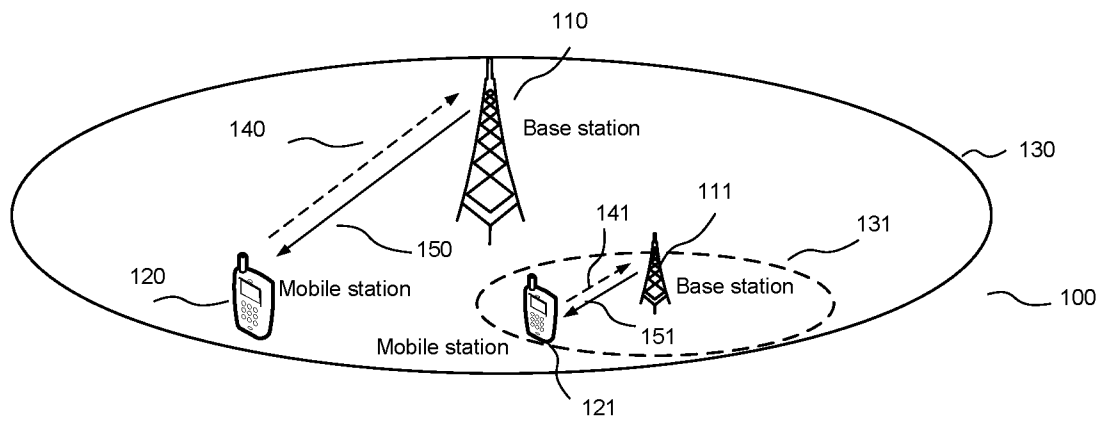


FIG. 1

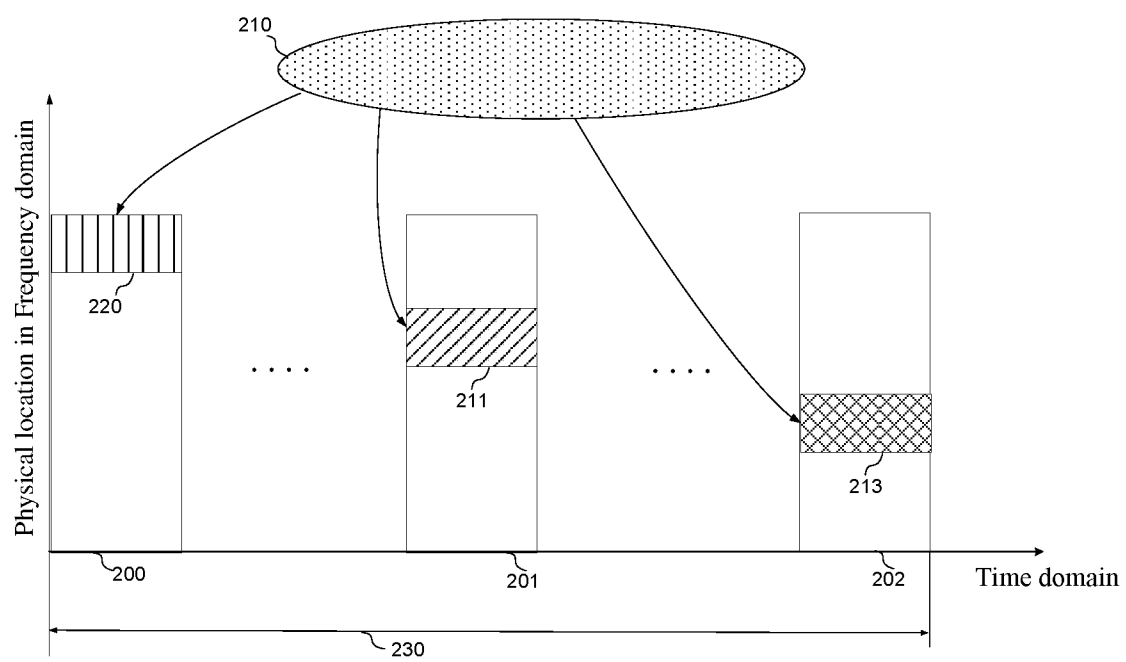


FIG. 2

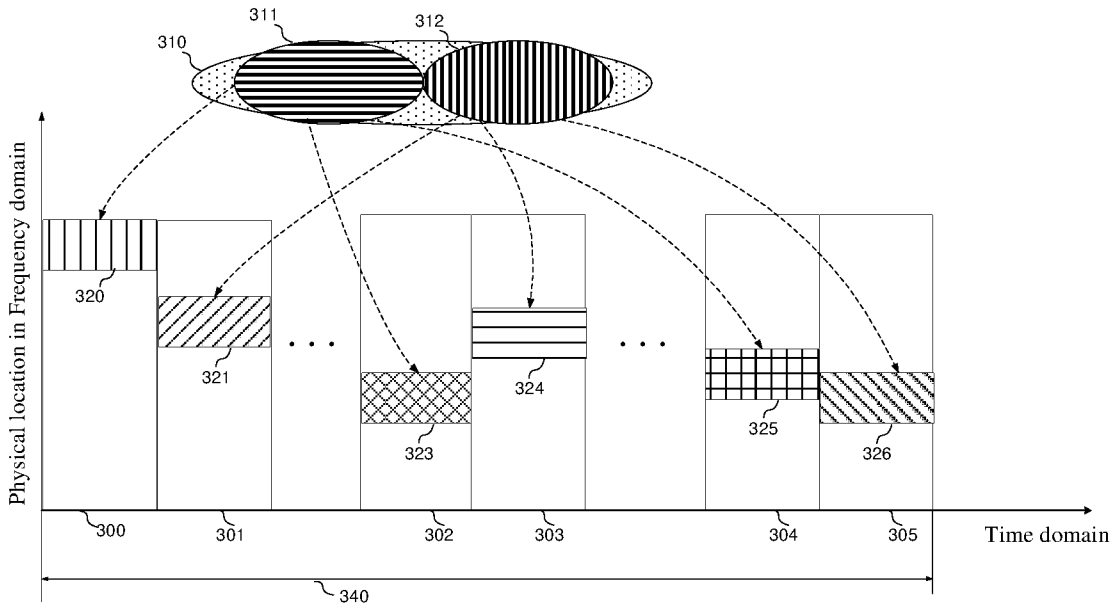


FIG. 3

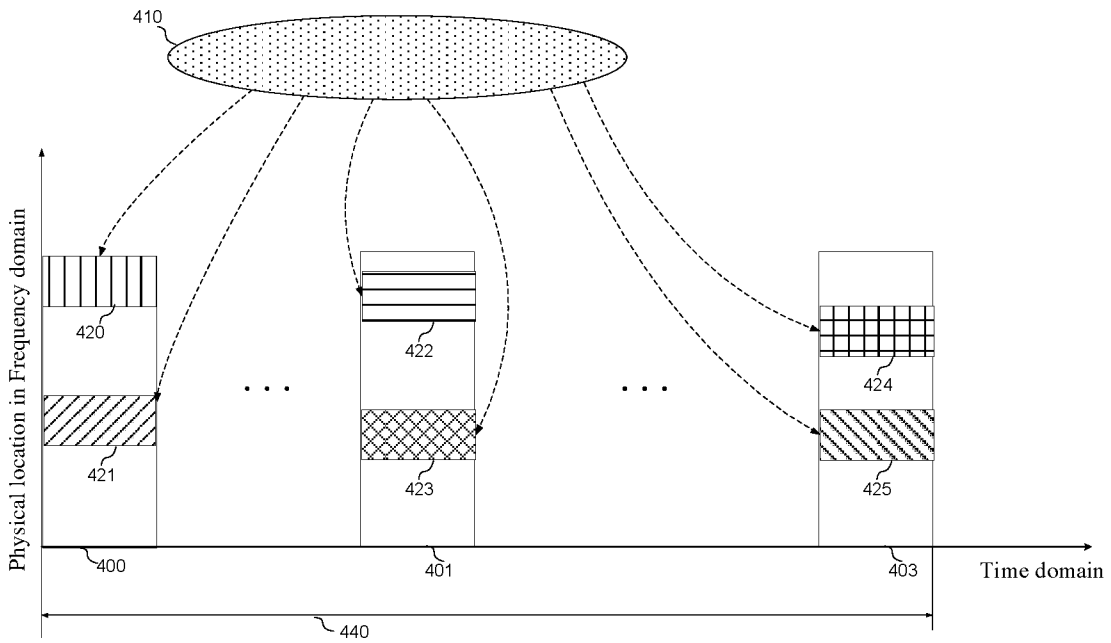


FIG. 4

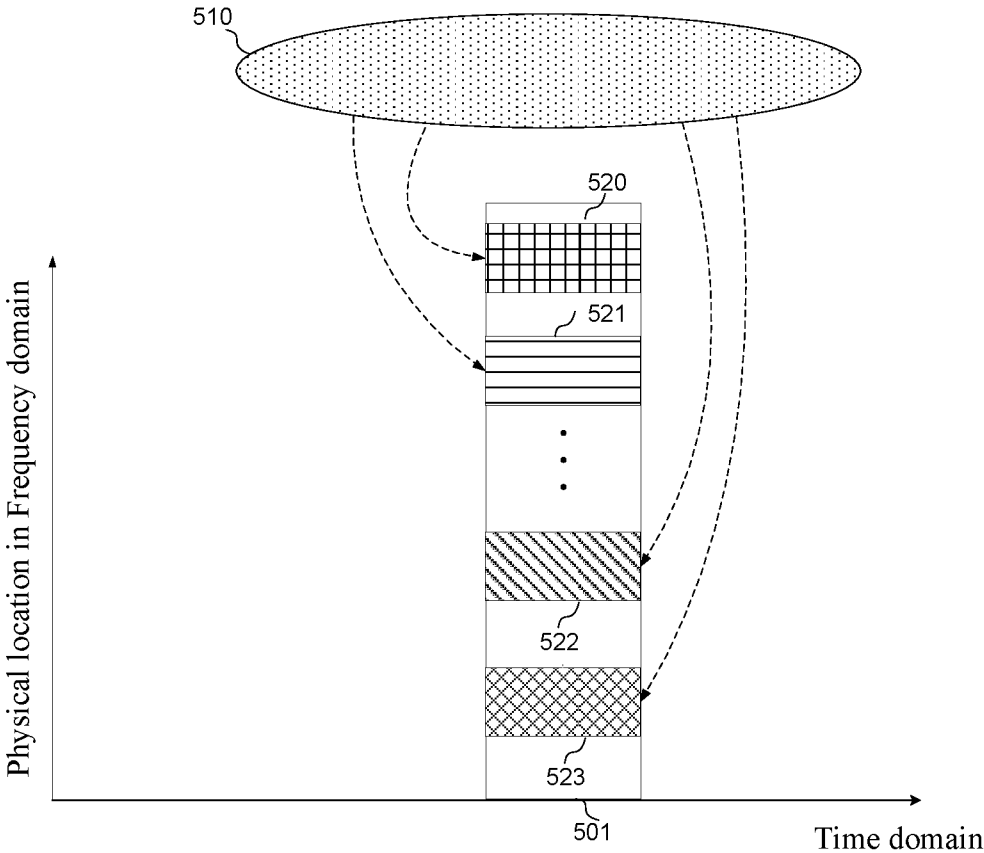


FIG. 5

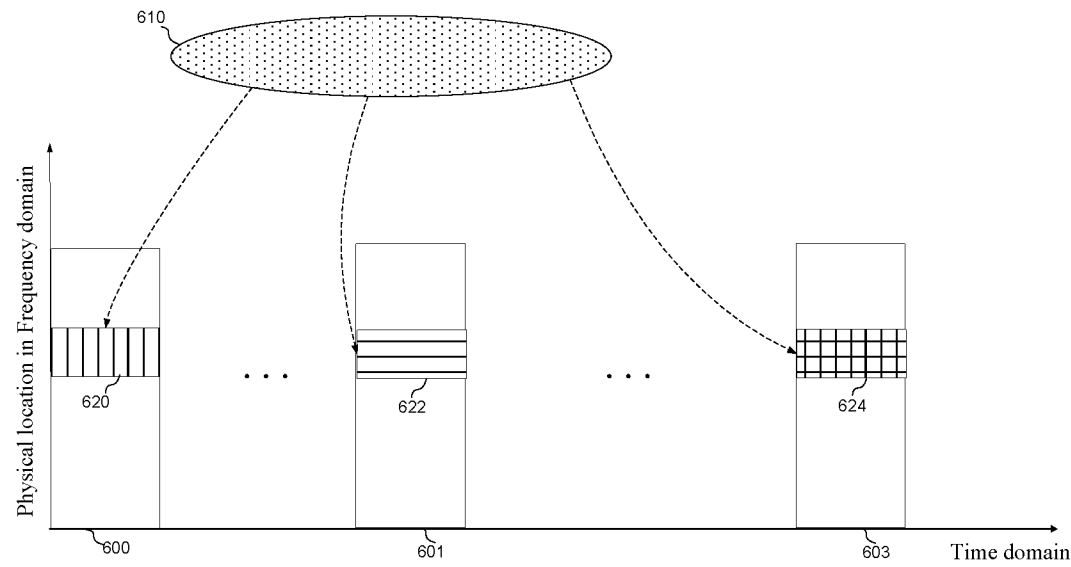


FIG. 6

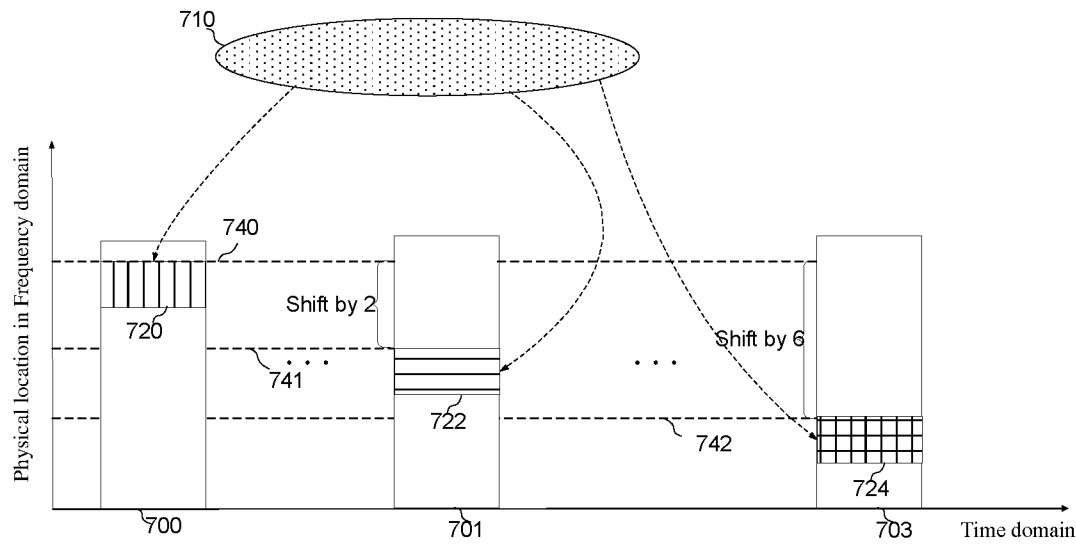


FIG. 7

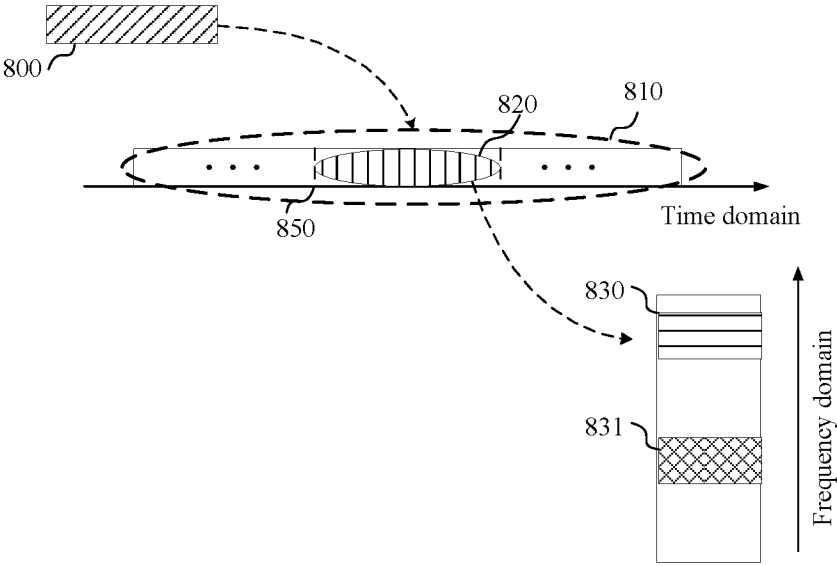


FIG. 8

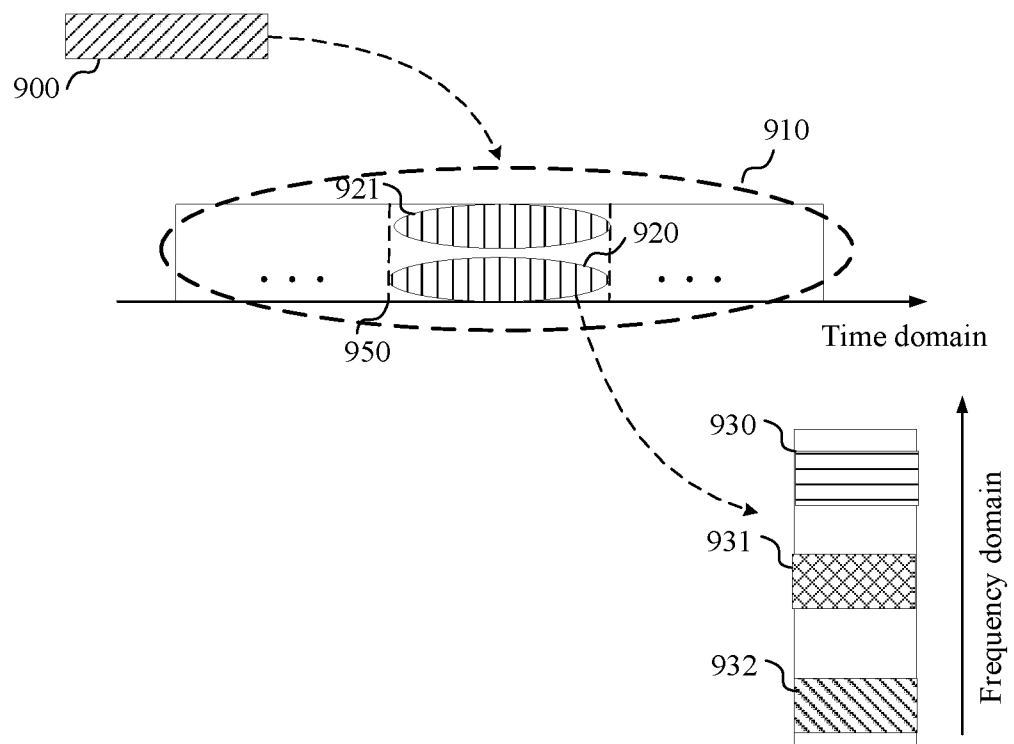


FIG. 9

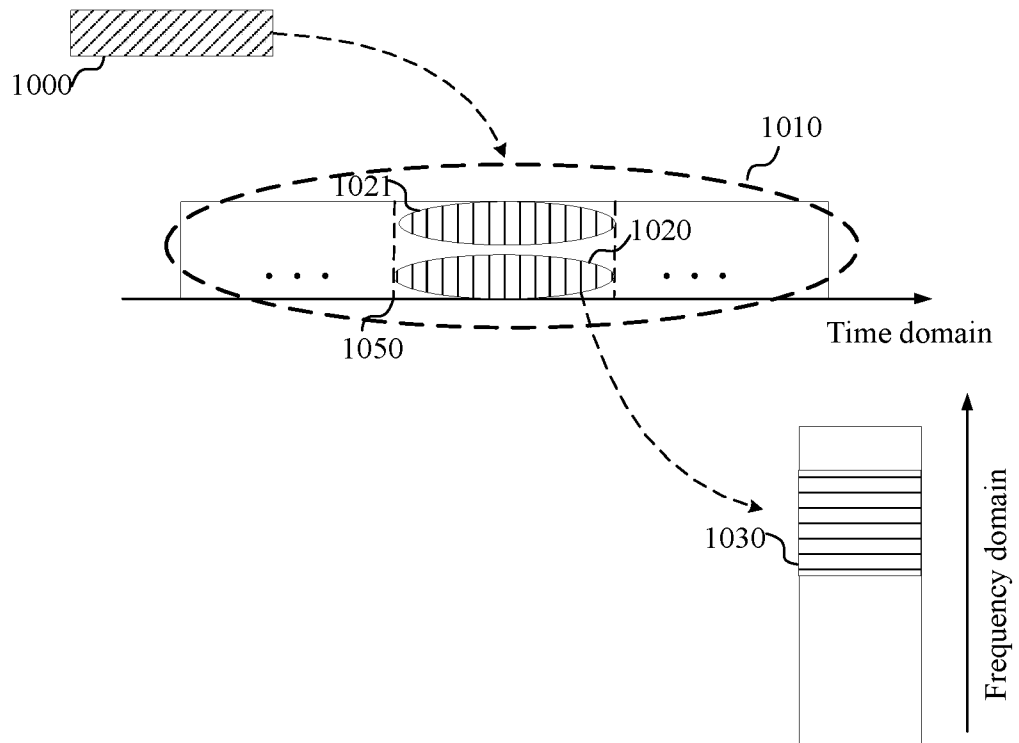


FIG. 10

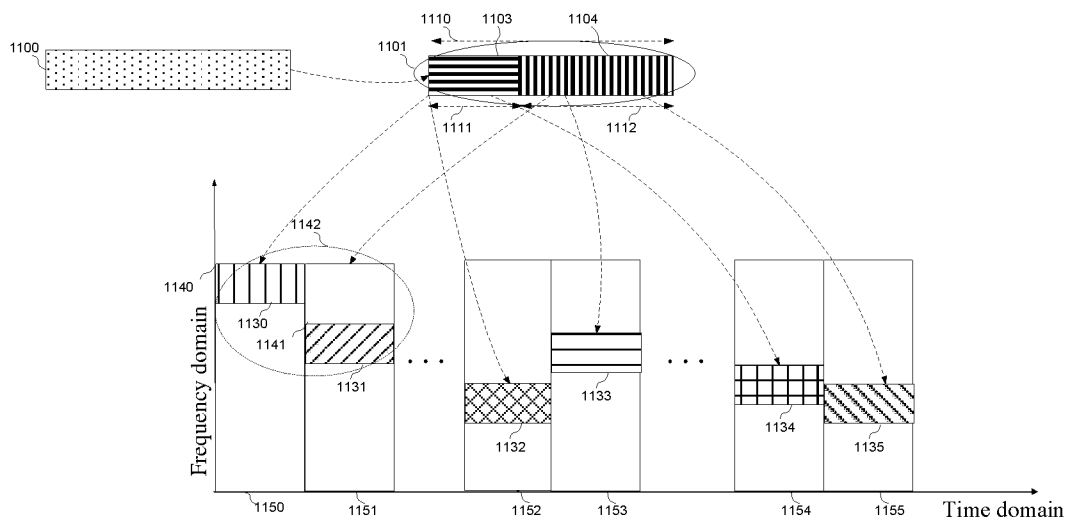


FIG. 11

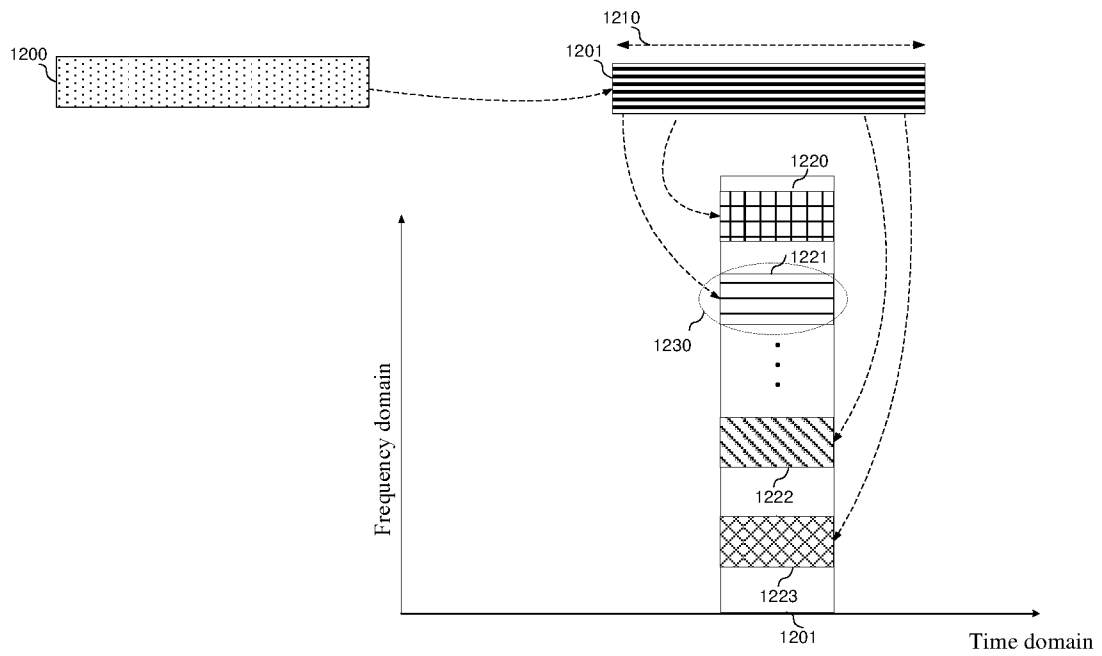


FIG. 12

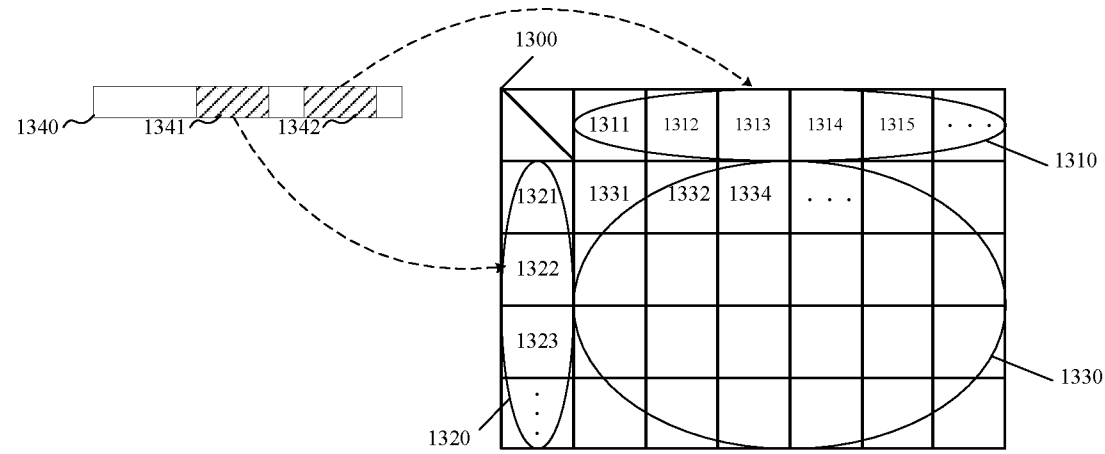


FIG. 13

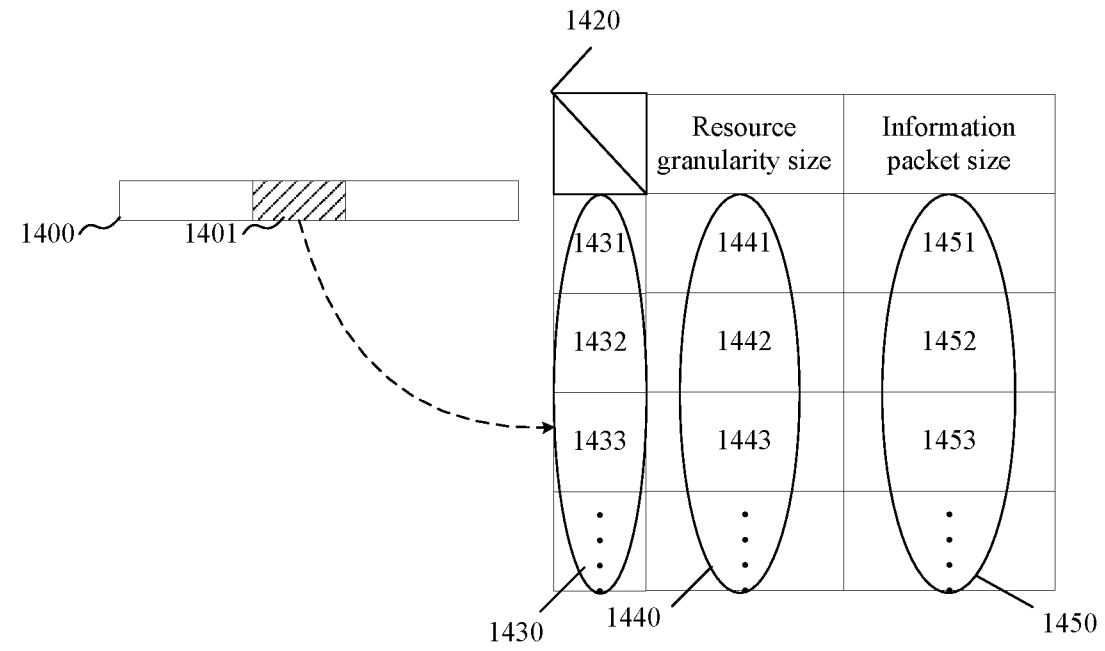


FIG. 14

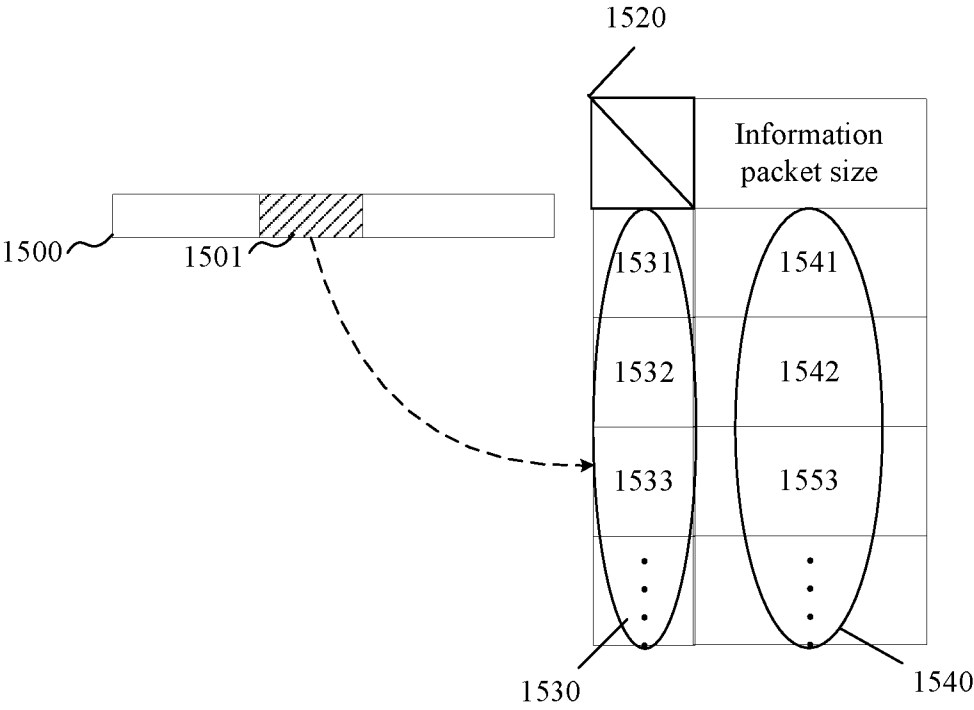


FIG. 15

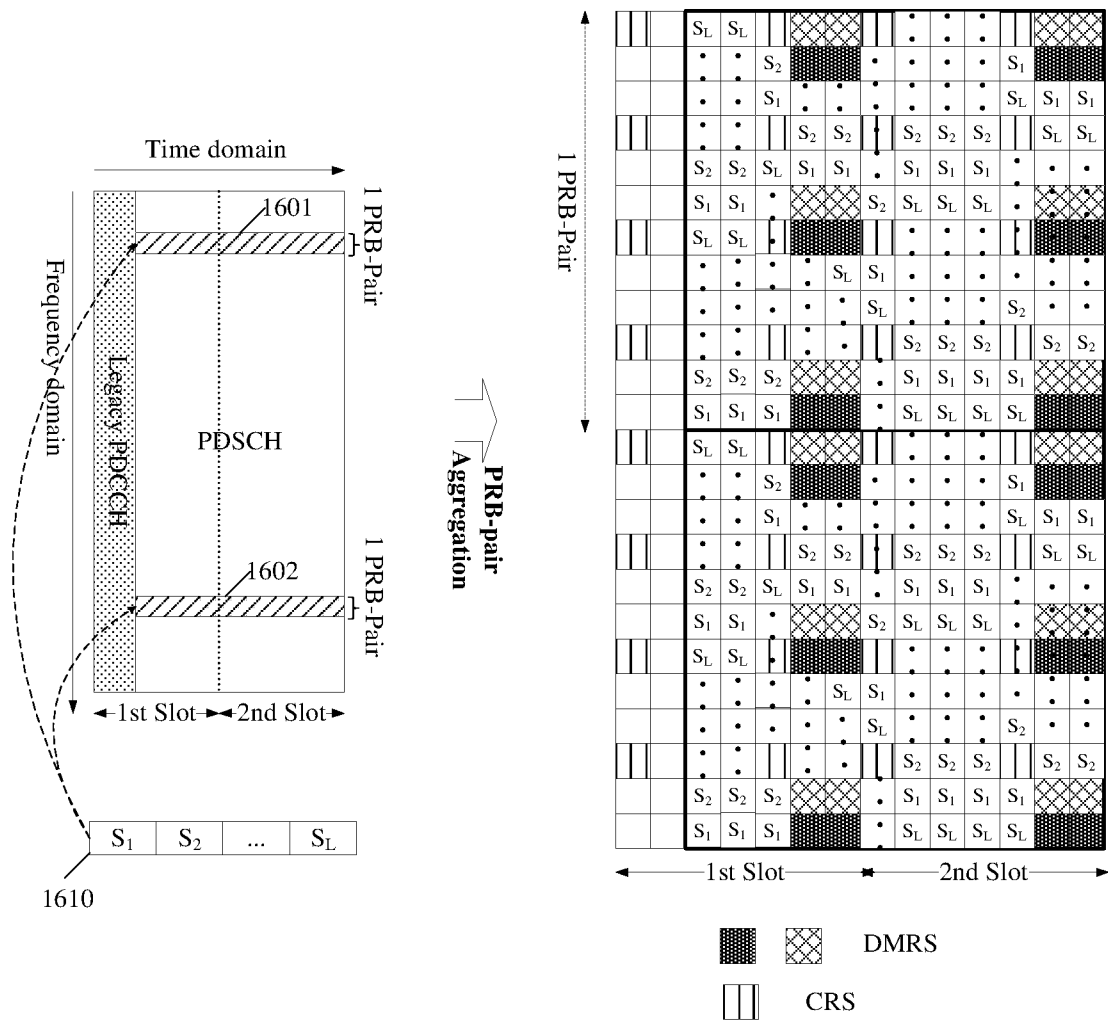


FIG. 16

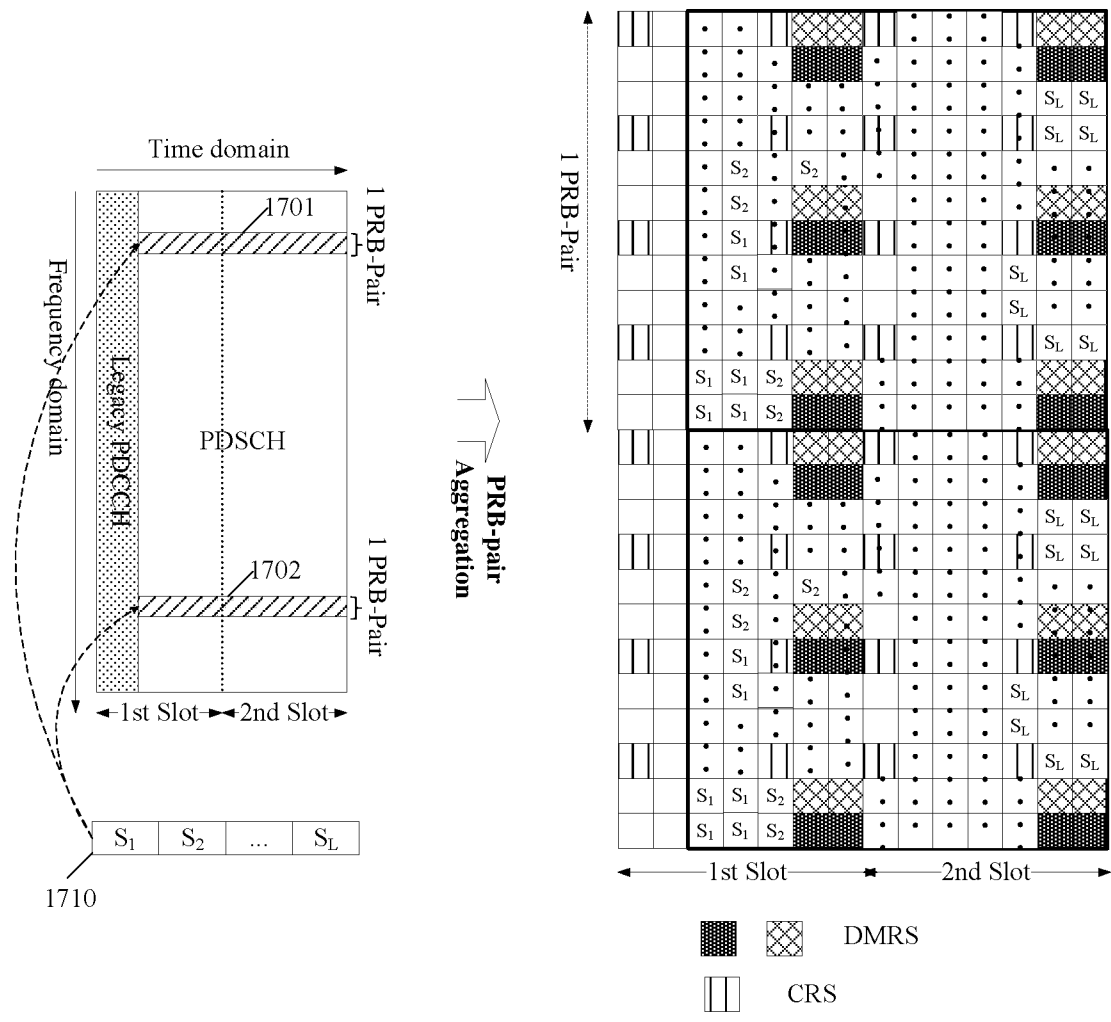


FIG. 17

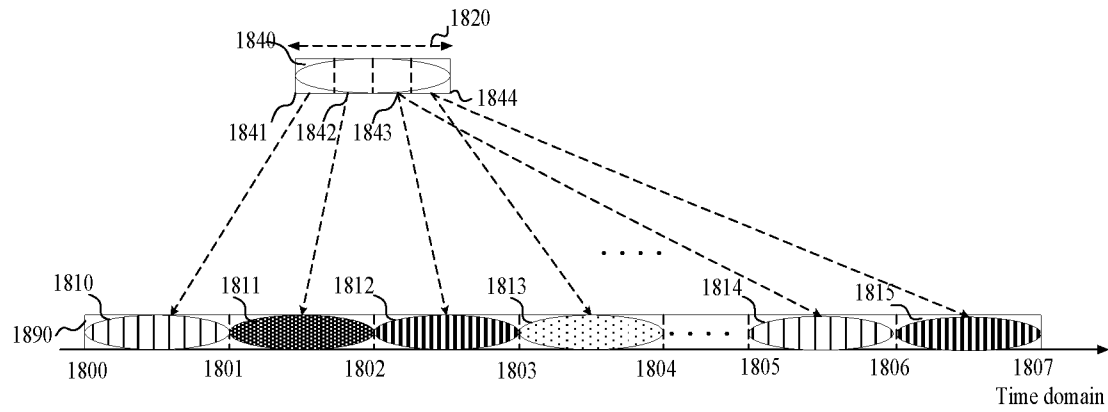


FIG. 18

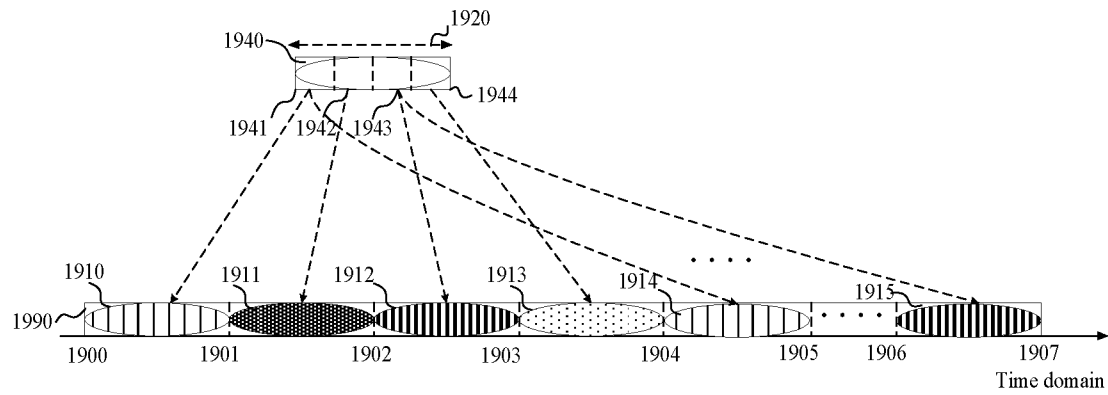


FIG. 19

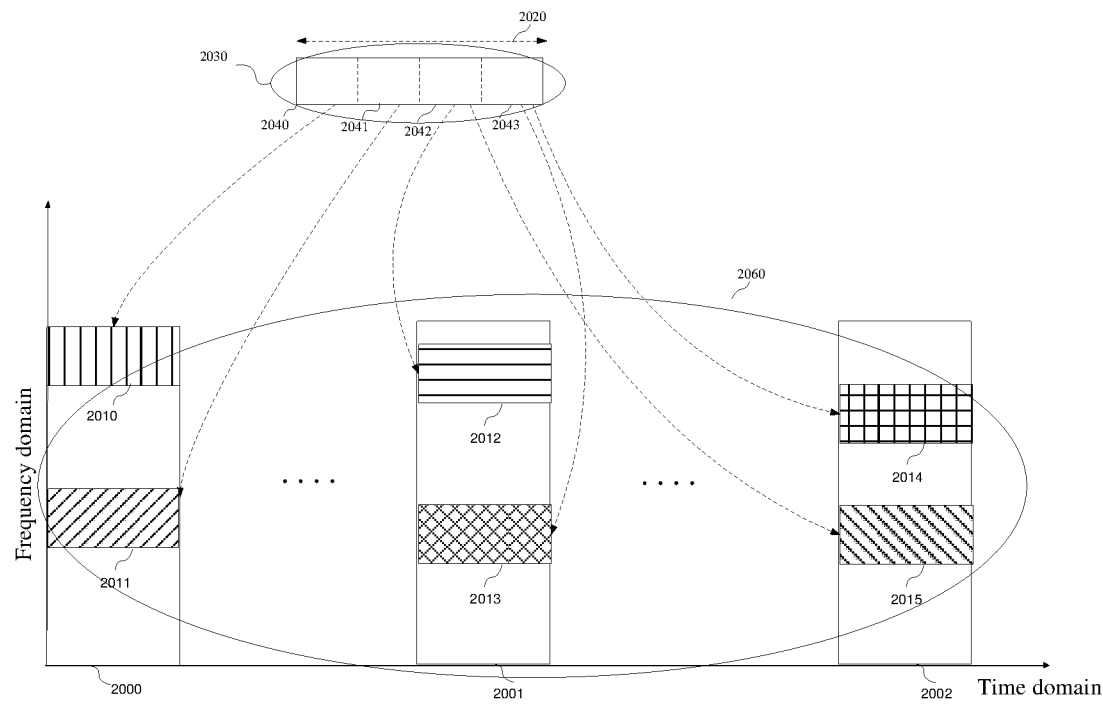


FIG. 20

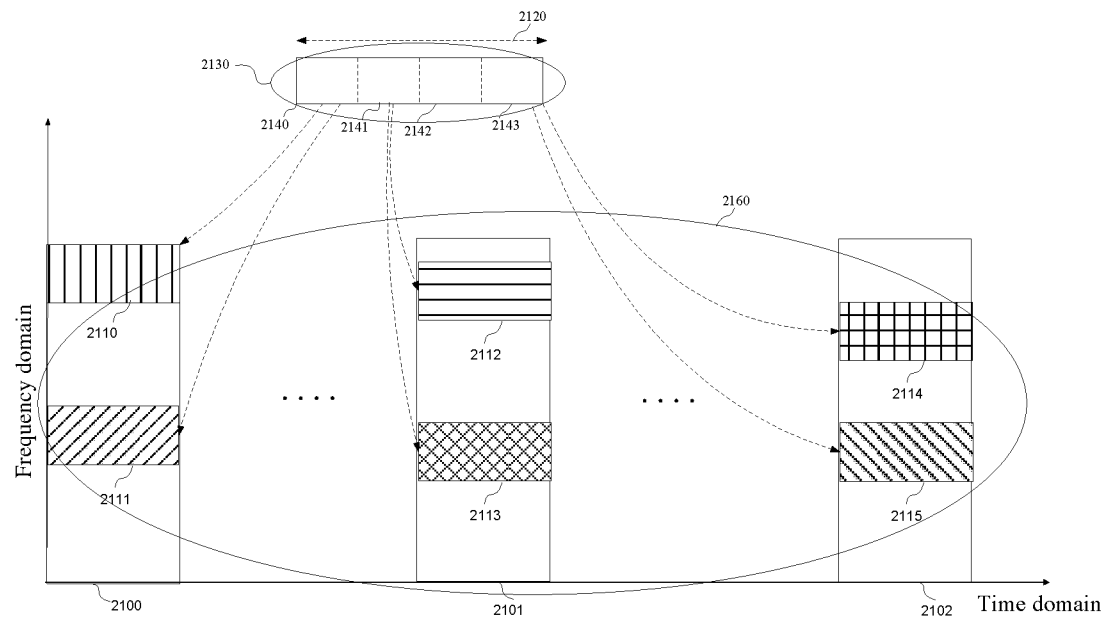


FIG. 21

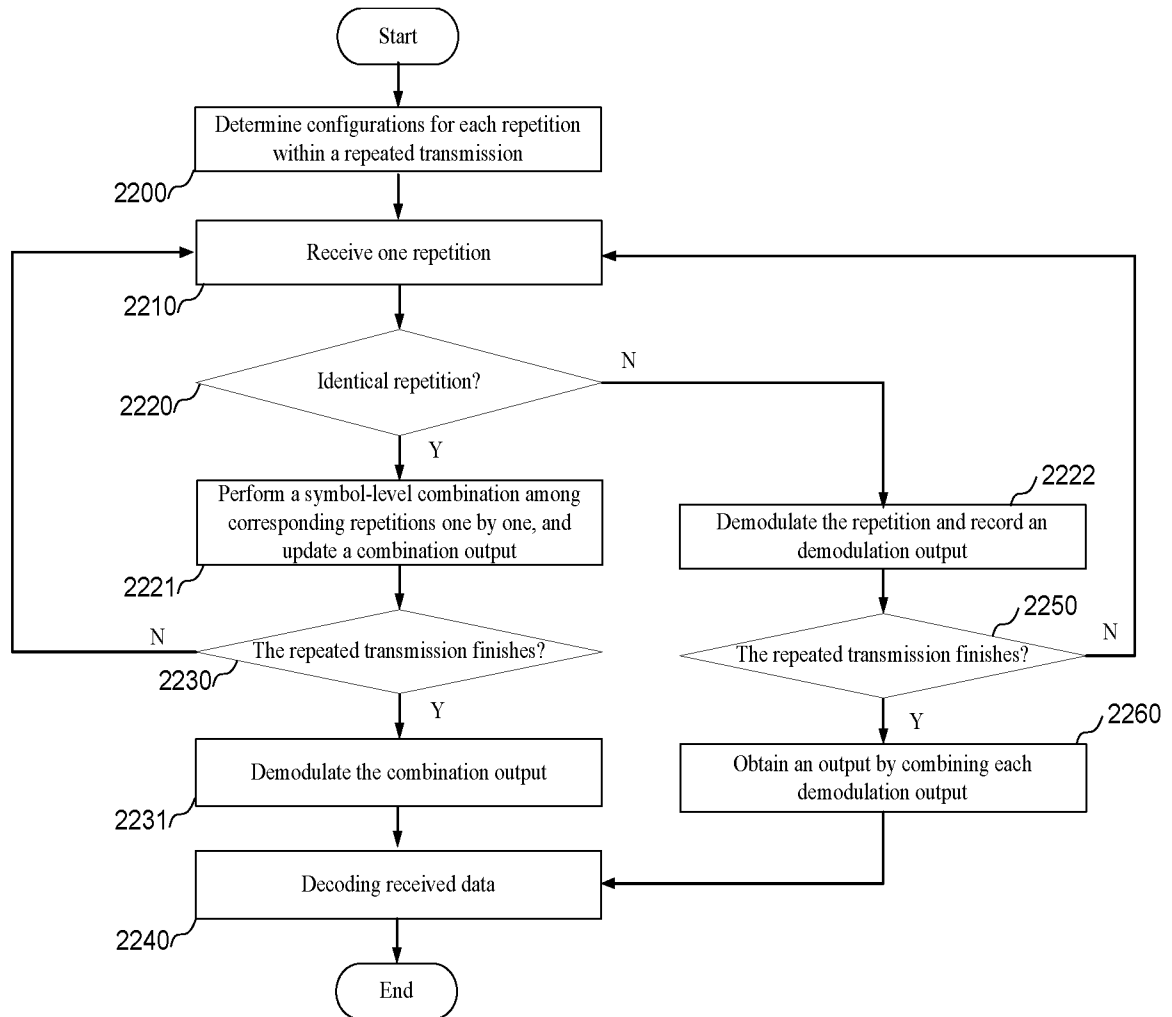


FIG. 22

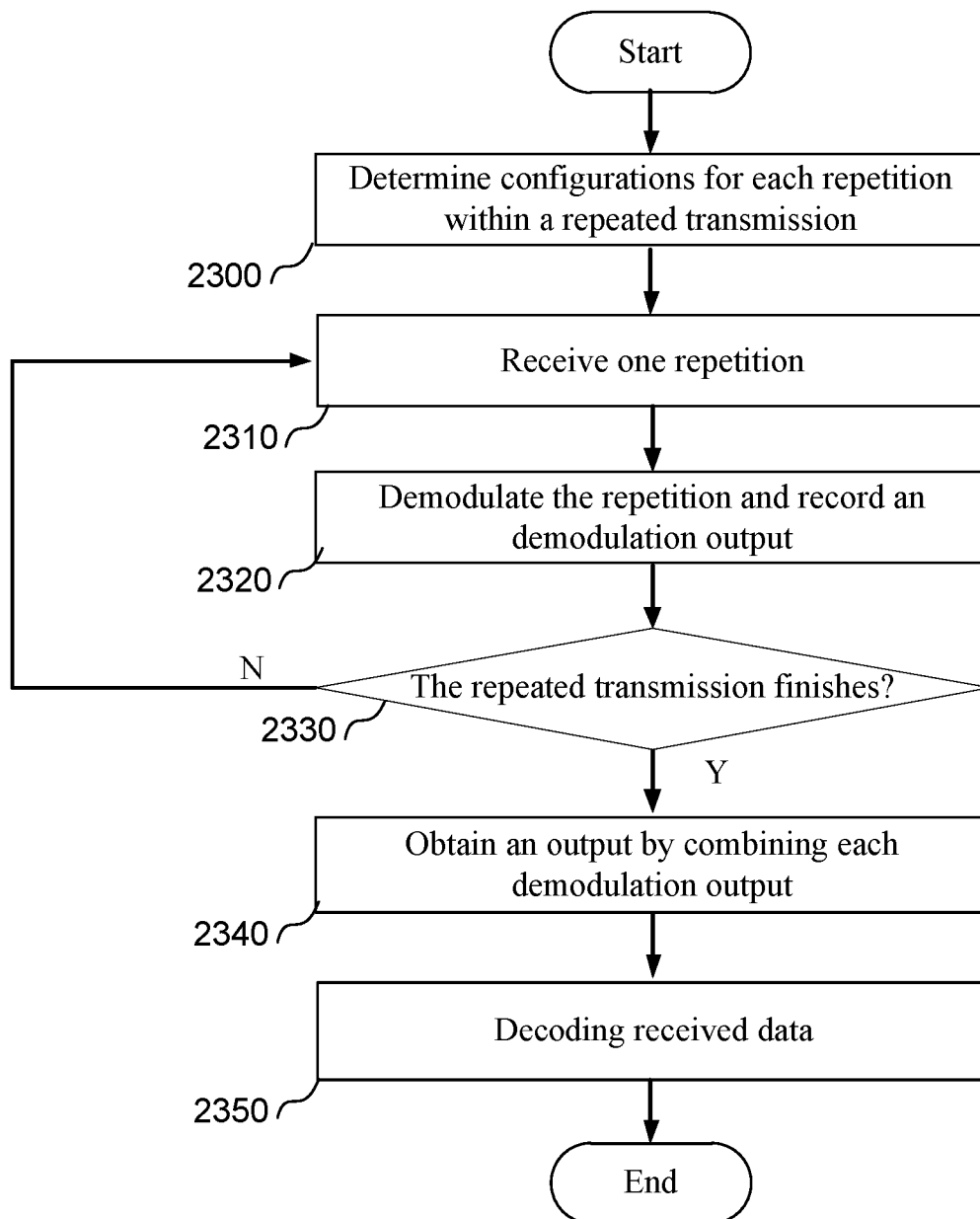


FIG. 23

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2015/071973

A. CLASSIFICATION OF SUBJECT MATTER

H04L 1/08(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; H04W; H04Q

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)

CNPAT;WPI;EPODOC;IEEE:demodulat+, output, transmission, RV, interval, symbol?, RTI, time, block, repetition?, repeat+, value, data?, version, inter, redundancy, intra

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014328430 A1 (LG ELECTRONICS INC.) 06 November 2014 (2014-11-06) description, paragraph [0158]	1-13
A	US 2009257408 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 15 October 2009 (2009-10-15) the whole document	1-13
A	US 2010003977 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 07 January 2010 (2010-01-07) the whole document	1-13
A	CN 104301082 A (LG ELECTRONICS INC.) 21 January 2015 (2015-01-21) the whole document	1-13

☐ 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

07 September 2015

Date of mailing of the international search report

27 October 2015

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2015/071973

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2014328430	A1	06 November 2014	WO	2013081364	A1	06 June 2013
				KR	20140109911	A	16 September 2014
US	2009257408	A1	15 October 2009	WO	2009126902	A2	15 October 2009
				TW	201004209	A	16 January 2010
				TW	201306515	A	01 February 2013
				AR	071469	A1	23 June 2010
US	2010003977	A1	07 January 2010	WO	2010005927	A1	14 January 2010
				US	2014328244	A1	06 November 2014
CN	104301082	A	21 January 2015	CN	102474376	A	23 May 2012
				KR	20110009025	A	27 January 2011
				EP	2457340	A2	30 May 2012
				US	2011013615	A1	20 January 2011
				WO	2011010855	A2	27 January 2011
				US	2014161067	A1	12 June 2014